Explaining Cost Overruns in Highway Projects: A Geo-Spatial Regression Modelling and Cognitive Mapping of Latent Pathogens and Contextual Drivers

Amadi Alolote Ibim

Ph.D. Thesis **2016**

Explaining Cost Overruns in Highway Projects: A Geo-Spatial Regression Modelling and Cognitive Mapping of Latent Pathogens and Contextual Drivers

Amadi Alolote Ibim

School of the Built Environment
College of Science and Technology
University of Salford, UK.

Submitted in Partial Fulfillment of the Requirements of the Degree of Doctor of Philosophy, October 2016

Table of Contents

List of Figures

List of Tables

Acknowledgement

I would like to acknowledge all persons who have directly and indirectly contributed to the successful completion of this study.

I would like to acknowledge the effort of my supervisor, Dr Anthony Higham, for his academic guidance and moral support, throughout the writing of this thesis. His critical and articulate guidance during the past year and half, has contributed immensely to developing my skills as a researcher. I would also like to express my sincere gratitude to Professor D. Eaton, for his tireless effort at initially moulding my research skills, during the first year of conducting this study.

I would also like to thank all those who have aided in the data collection process during the field work, and the School of the Built Environment, for providing a conducive learning environment for the conduct of this study. I also acknowledge the Rivers State University of Science and Technology, Port Harcourt, on whose platform, I was granted leave to pursue this degree.

Lastly and most importantly, I wish to express my deepest gratitude to my family: My husband, Mr Kelvin Amadi, who has remained a rock and a steady presence urging me on, all through the trials that trailed this journey; My children Blossom, Wealth and Alvin Amadi, who have always been a source of inspiration and joy to their mum; My father Mr Ibim Monday Amieye, whose prayers for his daughter has never ceased; My sisters and my brother, who have always had my best interest at heart; and my cousins, the George-Kellys, for their support and words of inspiration.

Dedication

I dedicate this work to the Almighty God, who has granted me the grace and the fortitude to complete this study. Also in memory of my late mother, Mrs Belema Perfect Amieye, who is no longer here to witness the Lord's doing. To God be the Glory- Amen.

Declaration

The work presented in this thesis titled "Explaining Cost Overruns in Highway Projects: A Geo-Spatial Regression Modelling and Cognitive Mapping of Latent Pathogens and Contextual Drivers", is to the best of the researcher's knowledge and belief, original. I hereby faithfully declare that this thesis is my own work and effort, and has never been previously written by another person, published or submitted for the award of any academic degree, excluding where due acknowledgements has been made in this thesis text.

Signed: …………………………………………………..

Date: ..…………………………………………………….

Publications and Presentations

Amadi, A.I. and Eaton, D. (2015). Accuracy of Estimates in the Development Phases of Highway Projects: What Critical Cost Overrun Phase? Proceedings of the 12th International Postgraduate Research Conference (IPGRC15), School of the Built Environment, at the University of Salford, Media City, UK.

Amadi, A.I. and Eaton, D. (2015). Potentials for Added Value in Highway Investments Predicated on Ground Condition in the Niger Delta. What Critical Cost Overrun Phase? Proceedings of the 12th International Postgraduate Research Conference (IPGRC15), School of the Built Environment, at the University of Salford, Media City, UK.

Amadi, A.I. and Higham, A. (2015). Current State of Conceptual Estimating Practice: A proposed Alternative Methodology predicated on Geotechnical Input. 8th Manchester Metropolitan University. Postgraduate Research Conference. MMU Business School, UK.

Amadi, A.I. (2016). Proposing an Engineering Geologic Mapping Based Costing Prototype: Towards a Change from Traditional Highway Costing Practices. Salford Postgraduate Annual Research Conference .14-16 June 2016. Media City. UK.

Amadi, A.I. (2016). Exploring Geologic-Cost factors in flood prone Housing construction in Coastal Communities of the Niger Delta. Proceedings of the CHOBE/ARCOM Doctoral Workshop. Going North for Sustainability Doctoral Workshop. 30th June 2016. London South Bank University, London.

Amadi, A. I and Higham, A. (2016) Geotechnical Characterization of Cost Overrun Drivers in Highway Projects: Predicated on Heterogeneous Ground Conditions in the Niger Delta Region of Nigeria. *In*: PW Chan and C J Neilson (Eds.) *Proceedings of the 32nd Annual ARCOM Conference,* 5-7 September 2016, Manchester, UK, Association of Researchers in Construction Management, Vol 1, 321-330.

List of Abbreviations

AACE	Association for the Advancement of Cost Engineering
ACEC	American Council of Engineering Companies
ADB	African Development Bank
AICD	African Infrastructure Country Diagnostic
ADOT	Alabama State Department of Transportation
ASCE	American Society of Civil Engineers Institute
AASHTO	American Association of State Highway and Transportation Officials
BBC	British Broadcasting Corporation
BMWT	Bayelsa State Ministry of Works and Transport
BSCL	Brown Sandy Clay Loam
CAQDAS	Computer Aided Qualitative Data Analysis Software
CBN	Central Bank of Nigeria
CEVP	Cost Estimate Validation Process
CIOB	Chartered Institute of Building
CBR	California Bearing Ratio
CBR	Case based reasoning
CDOT	California Department of Transport
DSC	Differing Site Condition Clause
DBB	Design-Bid-Build
DB	Design and Build
DFID	Department for International Development
DOT	Department of Transportation
DOE	Department of Energy
DOPC	Dark Organic Peaty Clay
DETR	Department of the Environment, Transport and the Regions
DMRB	Design Manual for Roads and Bridges
EDF	Executive Director Finance
EDP	Executive Director Projects
EJCDC	Engineers Joint Contract Documents Committee
FHWA	Federal Highway Administration
FMW	Federal Ministry of Works

FIDIC	International Federation of Consulting Engineers
FS	Free Swell
GAO	Government Accountability Office
GI	Geotechnical Input
GIR	Ground Investigation Report
GCC	Government General Conditions of Contract
JCT	Joint Contract Tribunal
IDOT	Illinois Department of Transportation
IRG	Infrastructure Risk Group
IGST	Institute of Geosciences and Space Technology.
ICE	Institution of Civil Engineers
LL	Liquid Limit
LGFSC	Light Grey Fine Sand and Clay
MDD	Maximum Dry Density
NAO	National Audit Office
NEDO	National Economic Development Office
NHCRP	National Highway Cooperative Research Program
NBRRI	Nigerian Building and Road Research Institute
NDES	Niger Delta Environmental Survey.
NRDMP	Niger Delta Regional Development Master Plan
NCE	New Civil Engineer
NDDC	Niger Delta Development Commission
OMC	Optimum Moisture Content
NSE	Nigeria Society of Engineers
PPAC	Presidential Projects Assessment Committee
RMW	Rivers State: Ministry of Works
TRL	Transport Research Laboratory
TRRL	Transportation and Road Research laboratory
UNDP	United Nations Development Programme.
USDOT	United States Department of Transportation
USIP	United States Institute of Peace
RGDP	Real Gross Domestic Product

GDP	Gross Domestic Product
OMPADEC	Oil Mineral Producing Areas Development Commission
PI	Plasticity Index
PL	Plastic Limit
PTF	Presidential Task Force
SPDC	Shell Petroleum Development Company
UAE	United Arab Emirates
RBSCL	Reddish Brown Sandy Clay Loam
USCS	Unified Soil Classification System
WisDOT	Wisconsin Department of Transportation
VDOT	Virginia Department of Transport
LWD	Length Width Depth
WBS	Work Breakdown Structure
NEC	New Engineering Contract
NSPE	National Society of Professional Engineers
GBPEC	Geotechnical Best Practice Evaluation Criteria

Abstract

The research set off with the rationale of understanding the cause of the unusually high cost overruns experienced in highway projects, executed in the tropical wetland setting of the Niger Delta region of Nigeria. An expansive range of research from academe, revealed a strong dialectical debate between the theoretical and technical schools of thought, as to what propagates relatively higher cost overruns in public infrastructure projects. The theorists posit that optimism bias and deliberate misrepresentation by project planners, largely accounts for cost overruns in transportation infrastructure projects, and not geology/geotechnical risk as tendered by the technical school. Yet the literature continues to report inadequate geotechnical risk containment resulting in considerable post-contract cost overruns in highway projects. As a result of this contradiction, and the lack of a robust empirical analysis to this effect, this research was carried out to explore the statistical validity of geotechnical risk factors in explaining cost overruns recorded in highway projects executed in the Niger Delta region. Using the case study research strategy, 16 interviews were conducted within the 3 highway agencies in the region, longitudinal cost data was also gathered from 61 completed highway projects, along with geotechnical index data on the engineering properties of sub-grade soils at project locations. These were comprehensively analysed using an innovative multi-method approach: Thematic analysis; Documentary/archival analysis; Spatial analysis of geotechnical data sets, designed to quantitatively converge in a triangulatory log-regression model. The results of regression analysis identified that latent pathogens such as heterogeneous ground conditions and non-adherence to geotechnical best practices, amidst a wide array of unanticipated social constructs, account for the majority of the recorded variance between the initial estimates and the project's final account. The interplay of the emergent social constructs with the latent pathogens was further cognitively mapped out, using content analysis, to visually conceptualise the relative weightiness of the intricate complexity of the contextual dynamics, driving the unusually high level of cost overruns experienced in highway project delivery in the Niger Delta. The study concluded that the phenomenon of cost overruns in highway projects is multi-hydra headed, driven by a complexity of technical and contextual social variables, and not the simplistic explanations implied by the dichotomous arguments in the literature. It was thus recommended that tackling cost overruns in highway projects require far more than the scientific application of technical risk management tools, and should therefore, further incorporate concerted and specifically targeted efforts at curbing the intrinsic contextual triggers within, and external to highway organisations.

Chapter 1

Introduction

1.1 Background to the Study

The cost performance of construction projects is emphasized by Baccarani (2004), as a key success criterion for project sponsors, against the background that construction projects are known for running over budget estimates. Inaccuracy in projected cost estimates, under conditions of uncertainty, typically expressed as cost overruns, is an issue of primary concern for clients, project managers, contractors, and all other stakeholders in construction works (National Highway Cooperative Research Program, 2004; Georgia Department of Transportation, 2007). Cost overrun is measured as actual out-turn costs, minus estimated costs, as a percentage of estimated costs (Cantarelli *et al*., 2010:6). The negative consequences of cost overruns in highway projects has led some to question the efficiency of public highway commissioners, through the developed and developing world, leading to questions about the ability of such organisations to initiate and deliver highway infrastructure projects. The phenomenon of cost overruns in highway projects has consequently attracted profuse scholarly attention over time, from researchers: Wachs (1989); Mackie and Preston (1998); Bruzelius *et al.* (2002); Flyvbjerg *et al*. (2002); Anderson *et al.* (2006), as well as numerous other recent works, who have led the discussion of the factors accounting for cost overruns in transportation projects.

As the literature evidences, a multiplicity of factors may introduce the risk element in budgeted estimates, that potentially affects the cost effectiveness of project delivery at completion (Chou, 2002). Therefore, the extent to which cost overruns can be subverted is bounded by the contextual risk settings, that are intrinsic in the factors accounted for in pre-contract estimates (Asmar *et al.*, 2011). One such limiting factor in highway projects, is ground conditions, which in the Niger Delta region of Nigeria, has been shown to have had a significant impact on highway development (Oguara, 2002; Teme, 2002; Youdoewei, 2013; Ngerebara *et al*., 2014). The Niger Delta is an archetypal tropical Delta, crisscrossed by a myriad of streams, rivers and inland water channels (Oguara, 2002). As depicted in Figure 1.1, its terrain consists of varying geological formations, with a significant proportion having difficult expansive clayey sub-soils (Teme, 2002).

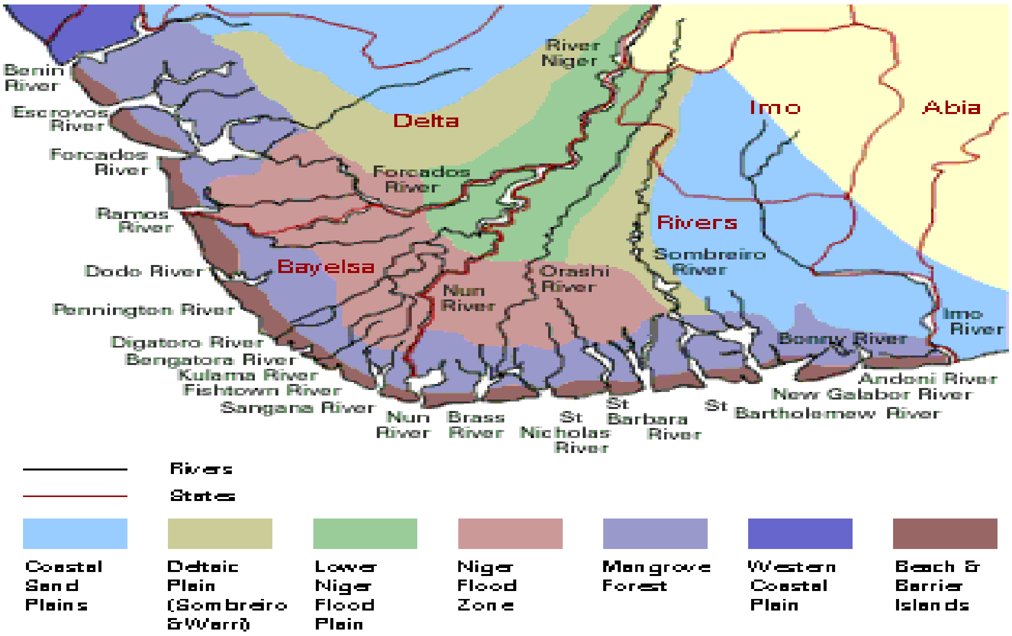


Figure 1.1: Map of Niger Delta Showing Heterogeneous Terrain

(Niger Delta Home Page, 2015)

This implies that any form of construction work in this heterogeneous terrain will invariably encounter distinct technical and financial connotations (Oguara, 2002; Youdoewei, 2013; Ngerebara *et al.*, 2014). Consequently, Oguara (2002) stressed that road development in some areas would require expensive specification, designs and specialized construction methods to account for this environmental configuration. Cost projection for road development by highway agencies in the region, implies a need to reflect these ground related factors during estimate preparation **(**Youdoewei, 2013; Ngerebara *et al.*, 2014).

Considering the significant impact that the terrain has on construction costs in the Niger Delta, the views of several authors in the local literature are convergent in underscoring the need to manage and analyse uncertainties associated with the difficult geology (Oguara, 2002; Teme, 2002; Youdoewei, 2013; Ngerebara *et al*., 2014). This view, has also been emphasised in related studies exploring Niger Delta soils including the work of Arumala and Akpokodje (1987), Agbola and Olurin (2003), as well as Unoanwanaile (2009). The escalated costs associated with road construction has also been repeatedly reported by the Niger Delta Development Commission (NDDC, 2006), a regional highway development agency, as being due to the mainly adverse ground conditions in the region. Given the potential correlation between escalating costs and the region's geology espoused in the literature, it is clear that further research is required to identify potential avenues of avoidable cost overruns due to ground conditions, from a scholarly perspective, to close this gap in existing knowledge, whilst also contributing to existing practice in the region by providing a road map to improvements in the financial management of highway infrastructure projects.

The need for the study is evident, against the backdrop of the literature on geotechnical best practices, which shows that geotechnical input should form a fundamental basis on which highway project designs and estimates, be predicated throughout the phases of project development, in order to minimise cost overruns (Nicholson, *et al.*, 1976; ICE, 1999; Venmans, 2006). The Institution of Civil Engineers (1999) advised that project developers should assess '*what is known and unknown about a site*', and '*what needs to be known*', via ground investigations, before initiating highway projects to avert cost overruns due to unforeseen ground conditions. Empirical studies, evaluating cost overrun trends and variation orders in completed highway projects, are convergent in stating that ground conditions, ranks high amongst the technical risk leading to underestimation/cost overruns in highway projects (NEDO, 1983; ICE, 1991; Peacock, and Whyte, 1992; NAO, 1994; Isakson, 2002).

At the conceptual phase of project development, both Evans and Peck (2008) and Romero and Stolz (2009), emphasized the need for adequate preliminary investigations to produce representative estimates that reflect likely geotechnical requirements inherent at proposed sites. This logically implies that variable ground conditions, typically present in the highly heterogeneous ground profile of the Niger Delta will have cost implications during budget estimation for highway projects. This is because, it is a requirement of best practice that a correspondingly varying profiling of estimates, in response to the likely variation in standard civil engineering design solutions, should be elicited. As such Romero and Stolz (2009) discouraged the use of '*off the shelve'* historical cost figures. Given this, such practice was described as amounting to producing '*no more than a guestimate'* which will eventually lead to significant budget shortfalls in the long run. Romero and Stolz (2009) thus asserted that it would be unrealistic for budgetary estimates to be uniformly forecasted, without due cognisance of the need for a differentiated costing profile in transportation projects, given their high degree of interface with ground conditions. It is thus suspected that an understanding of subsoil condition, and their engineering implications during the project financial evaluation process, is one of the knowledge gaps in the practice of highway agencies in the Niger Delta, that needs to be overcome. This is necessary if these organisations are to generate conceptual estimates that are better aligned with later detailed estimates, tender estimates and final accounts for projects.

At the detailed design phase, comprehensive and adequate ground investigations have been recommended as best practice by the ICE (1999). With the ICE (1999), asserting that ground investigations must be conducted as operations of discovery, which are a fundamental prerequisite, to ensuring subsoil conditions are fully reflected in designs and contract cost predictions. Literature abounds which covers a wide range of the links between lack of site investigation, and unexpected costs that can occur thereof (Clark, 1998; Peacock, and Whyte, 1992; Clayton, 1996; Ashton and Gidado, 2002; Isakson, 2002; Gransberg and Gad, 2014). Clark (1998) used case histories to investigate how construction works commencing in the absence of desk studies, and based on minimal ground investigation can lead to costs that could be saved if ground conditions had been properly investigated and formed the basis for both engineering designs and cost analysis. This assertion was also reinforced by Clayton (1996), who used project data to show a very high degree of correlation, between expenditure on ground investigations and cost overruns. Finally, Oguara (2002) opined that inherent to recognising the significant geotechnical challenges in the terrain of the Niger Delta, it would be logical that emphasis be placed on adequately investigating ground conditions, prior to designs, by highway agencies in the region. This was suggested as a primary step in resolving the issues associated with the infrastructure backlog, project abandonments and incessant road failures.

At the tendering and contracting phase, ground conditions have been established in the literature, as a major financial risk in highway contracts (Peacock and Whyte, 1992; ICE, 1999; Isakson, 2002; Romero and Stolz, 2009). Case law is rife with resolved and unresolved contractual disputes arising due to lack of adequate geotechnical risk containment during procurement. Adopting an appropriate mechanism for managing ground related risk in contracts has thus being noted as having the potential to constitute a risk containment measure, necessary to avert cost overruns. Best practice thus advocates that there is a need for the inclusion of ground investigation reports, accompanied by differing site condition clauses in bid documentation, and using multi-dimensional algorithms in contractor selection with explicitly defined geotechnical qualification requirements (Romero and Stolz 2009; Gransberg and Gad 2014). This was argued as necessary, for both parties to a contract (highway organisations and road contractors) to have a better informed basis of contracting, with costly delays, claims and variations leading to cost overruns, subverted.

As best practice, documented in the literature evidences, it can be deduced that various potential avenues for ensuring geotechnical input, necessary to minimise cost overruns, and as mechanisms of adding value for money invested on highway development in the Niger Delta, exists at:

- The preliminary estimating phase (conceptual cost forecasts);
- The design stage (appropriate designs);
- The tendering and contracting phase (in terms of risk containment).

Yet, the literature continues to report inadequate use of geotechnical risk containment in highway projects, resulting in considerable post-contract cost overruns. As a result of this confusion within the existing literature, and the lack of a robust empirical analysis to this effect, this study resolved to explore the statistical validity of these geotechnical risk factors in explaining cost overruns in highway projects, contextualised in the geologic setting of the Niger Delta region of Nigeria. It is the researcher's belief that the Niger Delta region of Nigeria, by virtue of its terrain, is an embodiment of a geologic setting representative of the intricacies of geotechnical risk, and what it foreshadows for the financial management of highway projects. The Niger Delta is thus used as a test bed for empirical verification in this study. The ultimate cost efficiency of highway project delivery in the Niger Delta, is thus hypothesized to be highly predicated on the approach adopted to managing the financial risks inherent in the deltaic ground conditions of the region.

1.2 Statement of the Problem

The problem of high investments in road construction in the Niger Delta, has become a subject of grave concern to government. Sunjka and Jacob (2013) reported that presently, the budgetary allocation for roads in the region ranges between 60 -70% of annual capital expenditure on infrastructure. Yet, extensive areas of the Niger Delta basin are not traversed by roads, due to construction difficulties and complimentary costs associated with road construction in the region, mostly attributed to the prevalence of expansive clayey sub-soils (Oguara, 2002: Central Bank of Nigeria, 2003; Fatokun and Bolarinwa, 2011). This as reported, has consequently affected the ability of past governments to develop an adequate road network necessary to satisfy the need for rapid economic development in the region (Ngerebara et al., 2014). Mode of transportation in communities situated in these remote riverine sections of the region, is predominantly by canoes, as shown in Figure 1.2. The problematic terrain has been identified as contributory to this low level of road infrastructure development (Emujakporue, 2012; Ngerebara, et al., 2014*).*

Figure 1.2: Typical Transportation Mode in the Meander Belts of the Niger Delta
(Africa Check Home Page, 2014)

However, despite the environmental handicaps of the region, in recent times there has been a renewed drive to open up and link these remote areas of the Niger Delta to foster their economic development (NDDC, 2013). Consequently, a multiplicity of roads is being constructed concurrently across the Niger Delta by the various highway agencies in the region.

1.2.1 The Facts and Figures

The local literature, however, indicates that it is not the initiation of road projects that is currently a problem in the Niger Delta region. The fundamental problem being their completion, with funding shortfalls responsible for the vast majority of delayed or abandoned projects (Ayodele and Alabi, 2011; Ihuah and Benibo, 2014). For local communities, these uncompleted road projects constitute a hindrance to vehicular and human traffic, as well as impact negatively on economic activities. As Figure 1.3 shows, following abandonment, these partially complete projects are not securely protected until additional funds can be approved. Rather the partially constructed highway is unofficially handed over to the local community. As a result, the incomplete structure degenerates, often to such an extent that the highway, designed to help the local community, becomes a death trap (Momoh *et al.*, 2008; Emujakporue, 2012).

Figure 1.3: Degenerating Uncompleted and Abandoned Road Projects in the Niger Delta

Onokola (2012), noted the tedium associated with the disruption of economic activities, as the mobility of products and services such as farm produce from rural to urban centres, are stalled. The Central Bank of Nigeria (2013), estimated the annual financial loss due to the incompletion and abandonment of road projects, at approximately N80 billion ($533 million), with resultant additional vehicle operating costs of a further N53.8 billion ($360 million), cumulating in an approximate total loss per annum of N133.8 billion ($893 million). This figure, according to the CBN (2013) is exclusive of the associated man-hour losses in traffic, psychological and physical trauma undergone in plying such roads, and other multiplier negative impacts on economic productivity.

Okon (2009) determined the total length of roads, along with the number of other infrastructure projects initiated by the Niger Delta Development Commission's (NDDC), a regional highway development agency in the region, between 2001 – 2008. Additionally, Okon (2009) established the actual number of projects or kilometres of road completed over this time period. This data, presented in Table 1.1, illustrates the failure of highway agencies, such as the NDDC, to deliver these major infrastructure projects. For instance, the data evidences that only 28% of commissioned water supply and 42% of electrification projects actually achieved completion between 2001 and 2008.

Table 1.1 Infrastructure Backlog of Uncompleted Projects in the Niger Delta (2001 – 2008)

Infrastructure type	Total no. Initiated	Completed	Percentage Completed
Roads	156 (3,000Km)	780 Km	26
Bridges	47	-	0
Water Supply	283	78	28
Electrification	316	137	42

(Source: Okon, 2009)

A different study by Goddey (2011), also reported the number of infrastructure projects executed by the NDDC over the same time frame, as shown in Table 1.2.

Table 1.2: Number of Physical Projects Executed by the NDDC (2001 – 2008)

Projects	**Number Completed**
Water	22
Electrification	12
Jetties	6
Road/Bridges	37
Canalisation	1
Shore protection	2
TOTAL	176

(Source: Goddey, 2011)

The researcher notes that there are discrepancies in the number of completed projects reported in the two studies, for similar types of work, with by Goddey (2011) reporting lower completion rates that those determined by Okon (2009). Yet it is also worthy of note that Goddey (2011) did not show the number of roads initiated relative to those completed, which has prevented the researcher determining the overall accuracy of Goddey's figures. However, from Okon's analysis it is clear, only 26% of the commissioned roads in this period have been completed. This dismal completion rate, further reinforced in a recent independent European Union (2011) evaluation of infrastructure projects in the Niger Delta region, again revealed a significant number of road projects in the region remain incomplete and abandoned by various tiers of government (Federal, State, and Local Government). An extract from the EU report is shown in Table 1.3.

Table1.3: Abandoned and Uncompleted Road Projects in the Niger Delta (2000-2011)

Communities Assessed	**Federal Govt**	**NDDC**	**State Govt**	**Local Govt**
BAYELSA STATE Kolokuma / LGA (10 communities)	14	0	16	1
BAYELSA STATE / Sagbama LGA (10 communities)	12	4	18	3
RIVERS STATE / Obio-Akpor LGA (6 communities)	3	7	13	1
RIVERS STATE / Ahoada East LGA (9 communities)	2	0	9	3
TOTAL	31	13	56	8

(Source: EU Report, 2011)

Despite the abysmal completion rates for road construction projects in the Niger Delta region, as Falade (2016) discovered, completion does not always indicate success. With most, if not all, completed highway projects recording exceedingly high cost overrun figures, a concern currently being investigated by the Nigerian Senate. In 2012, a Presidential Projects Assessment Committee (PPAC) was set up, which showed that between 2005 and 2011, 609 projects were initiated in the region of which 222 (37%) have been completed, 102 (16%) are on-going and 285 (47%) have been abandoned. The report thus showed the abysmal performance of the Niger Delta Development Commission (NDDC) since inception in 2001. The report further highlighted:

> *"…the unjustifiable introduction of astronomical variations on the contracts sum of most projects over short periods of time, with some of these variations effected prior to project commencement"* (PPAC, 2012:13).

1.2.2 The Perceived Underlying Issues/ Need for the Study

Whilst these statistics may be giving an impression of complacency or corruption on the part of the highway agencies in the Niger Delta, adverse ground conditions in the region have been repeatedly identified by the highway agencies as the explanation behind these extreme cost escalations. Okon (2009) had quoted cost overrun figures as high as 500% associated with some of the completed highway projects in the Niger Delta region, and attributed this to the various geologic environments in the region, which bears significantly higher risks than other parts of Nigeria. Joseph (2012), as well as Ihuah and Benibo (2014) have equally corroborated this stance in empirical studies investigating the causes of project cost overruns, delays and abandonments in the Niger Delta region. Vulnerability to ravaging environmental (flood and erosion) related disaster; adverse weather conditions; inaccessible and geo-hazardous impassable wetland terrain, were some of the distinct attributes of the region, cited as responsible for the current state of highway project delivery.

However, several other empirical studies in the local literature (Mansfield *et al*., 1994; Okpala and Aniekwu, 1998; Ajibade and Odeyinka, 2006), have consistently identified issues related to lack of geotechnical best practices, such as: weak and insufficient technical studies and preliminary engineering, design and specification deficiencies as well as inaccurate budgetary and engineering design estimates as contributing to the high spate of project delays and abandonment in Nigeria.

Despite these consistent referrals to lack of best practices, the scale of the problem experienced by highway agencies has not been established in the literature. As such whether adequate geotechnical evaluation is ensured, before the commencement of road works in the region remains in doubt, and would need to be established in the field work. This is logically linked to the rather robust body of literature centred on investigating the high incidence of premature road failure in the region (Ajayi, 1987; Abam, 2005; Aigbedion, 2007; Emujakporue, 2012), although beyond the scope of this research. Sunjka and Jacob (2013), in a study investigating the causes of project delays in the Niger Delta, revealed changes in specifications and designs which were not considered originally, have impeded the time effective delivery of road works in the region, further reinforcing the researcher's perception. It was suggested:

> *"Improper design stalls project execution in the Niger Delta because of the time it takes for such design to be reviewed, amended and accepted for construction works" (*Sunjka and Jacob, 2013: 641).

Validation of this assertion will thus be inferred in relation to the stipulated highway standard, recommended by the Federal Government for the construction of highways in Nigeria. The Transportation and Road Research Laboratory (TRRL, 1993) Overseas Road Note 31 guide, sets out a catalogue of design configurations suitable for the various subgrade soils inherent in the tropical setting of Nigeria. The application and level of adherence to this standard by highway agencies in the Niger Delta, which should logically be based on adequate ground investigation as a pre-requisite for detailed designs and costing for proposed roads, however is not known. This is therefore investigated as part of the field work.

Claims and variations arising during construction phase for road works in the Niger Delta region have also been mostly linked to ground conditions in the literature, which have invariably negatively impacted on both project duration and cost (Dlakwa and Culpin, 1990; Sunjka and Jacob, 2013). This is particularly the case in the coastal and meander zones of the Niger Delta which currently has a significant infrastructure backlog (EU Report, 2011; Ngerebara *et al*., 2014). Literature and physical evidence show that there exists a rather significant spate of extensive project delays and abandonment in these areas, which has retarded the economic development of the local riverine communities to be serviced by such roads (Ossai, 2012).

Mansfield *et al.* (1994) further revealed that unclear definitions of contract terms and technical details by the client, were some of the factors causing significant cost overruns leading to delays and abandonment of highway projects in Nigerian public projects. Mansfield *et al.* (1994) specifically noted the consequent high level of financial risk exposure to the clients (highway agencies) in contracts awarded on a rather arbitrary basis. The basis of contract award and execution by highway agencies in the Niger Delta has thus being generally criticised, as being poorly packaged due to a lack of relevant technical know-how on procurement best practices, with contractors standing to benefit from this shortcoming (Okon, 2009; Sunjka and Jacob, 2013).

This was further reinforced by the World Bank's (2000), in a Country Procurement Assessment Report (CPAR) for Nigeria**.** Collectively these studies assert that there exists a need to align best practice into highway project delivery in the region.

As a result of the extensive local literature supporting the link between geology, the lack of geotechnical best practices, and cost and time overruns, it can be argued that in the context of the Niger Delta, the prevalence of the outlined ground related issues in practice, would culminate in a significant disparity between initial budgeted estimates, design estimates, and tender estimates in relation to final cost. As the ICE (1991:12) succinctly enunciates: "*The ground is a place where things are likely to go wrong, the worst the ground, the higher the risk*"

1.3 Suspected Gaps in the Practices of the Highway Agencies

Based on the perceived discrepancies in the theoretical and practical approach to the containment of associated ground related risks in cost estimates, several "geotechnical cost drivers" have been identified, and constitutes the rationale of the study. The researcher has thus identified the following gaps in knowledge, suspected as existing in the practice of the highway agencies that need to be verified and addressed, as the primary cost overrun drivers contributing significantly to spate of project delays and abandonment in the geologic context of the Niger Delta.

Table 1.4: Identified Cost Drivers/Potentials for Added Value in Highway Investment

Project Phase	Suspected Gaps in Knowledge	Potential for Added Value
Conceptual Phase	Use of non-differentiated/uniform cost per kilometre of road length estimate that is not reflective of the typically heterogeneous ground profile.	Improved Accuracy of budget Estimates
Design Phase	Adequacy of ground investigations prior to highway design and detailed estimate preparation; Non-Adherence of pavement designs to the adopted National Highway Standard (TRRL, 1993) in relation to sub-soils.	More Appropriate Designs and Accurate Pre-Bid Estimates
Tendering and Contracting Phase	Non-inclusion of GIR and DSC clauses in contract documentation; Inadequate geotechnical criteria in contractor selection	Better Risk Containment in Tender Estimates, which minimises claims and variations.

GIR: Ground Investigation Reports DSC: Differing Site Condition Clause

Verification of these suspected gaps in knowledge, summarised in Table 1.4, which principally revolve around subsoil conditions of the Niger Delta region and relevant geotechnical practices, constitute the rationale of the study. In view of the current state of highway project delivery in the Niger Delta, these are thus presupposed as being the more profound technical factors, underlying the significant cost escalations, that need to be investigated. Scrutinising the practises of the highway agencies, therefore constitutes a first step, towards understanding the propagation of significant cost overruns in the Niger Delta, against the backdrop of the virtually non-existent literature, on the estimating and design practices specific to these highway agencies. Filling this identified gap in the local literature, thus establishes the central theme of the subsequent field work, necessary to provide a descriptive account of current practice, relative to the dictates of geotechnical best practice, to serve as a platform to evaluate the need for improvement.

1.4 Aim and Objectives of the Study

The aim of the study is to explain the propagation of cost overruns in highway projects using a geotechnical narrative predicated on the financial risk implications of the heterogeneous geology of the Niger Delta wetland**.** Specifically, the study has the following objectives:

1. To synthesize the background literature on investment in highway development in Nigeria, and the prevalence of delays and abandonment in project delivery, with emphasis on the Niger Delta region due to its peculiar geologic setting.

2. To critically evaluate the theoretical and methodological lenses that have been used in previous studies, to explain the propagation of cost overruns in highway projects, as a platform for highlighting significant gaps which have implications for this study.

3. To critically evaluate and select an adequate philosophical/methodological orientation relevant to provide rich insights into the phenomena of cost overruns in highway projects executed in the Niger Delta.

4. To analyse the geotechnical characteristics of the heterogeneous configuration of the Niger Delta terrain, to highlight its inherent peculiarity for triggering cost overruns.

5. To identify potential shortcomings in geotechnical practice, which can serve to trigger cost overruns in highway projects.

6. To examine the level of adherence/deviations in the practices of highway agencies in the Niger Delta, in line with the precepts of geotechnical best practice.

7. To develop a statistically valid model and cognitive map of deduced geotechnical pathogens, predicted on the heterogeneous geologic configuration of the Niger Delta region, to account for the level of variance induced in cost overruns.

1.5 Research Questions

1. What is the background to Nigeria's investment in highway development, and what are the peculiarities associated with the geologic setting of the Niger Delta region, that account for the prevalence of delays and abandonment in project delivery?

2. What theoretical and methodological lenses have been used to explain the propagation of cost overruns in highway projects in previous studies, to serve as a platform for highlighting significant gaps, which have implications for this study.

3. What philosophical/methodological orientation is relevant to provide rich insights into the phenomena of cost overruns in highway projects executed in the Niger Delta?

4. What peculiar geotechnical characteristics of the heterogeneous Niger Delta terrain inherently compounds the propensity of highway projects to run over budget?

5. What shortcomings in geotechnical practice, can potentially trigger cost overruns in highway projects?

6. To what extent have the highway agencies in the Niger Delta region adhered to /deviated from relevant geotechnical best practices?

7. How statistically valid are the deduced geotechnical pathogens, predicted on the heterogeneous geologic configuration of the Niger Delta region, in accounting for cost overrun trends in the Niger Delta, and how can these be cognitively mapped out?

1.6 Methods, Research Design, and Outline Structure of the Thesis

The research objectives, designed to provide answers to the research questions are achieved using a multi-method mix of geo-spatial, qualitative and quantitative methods/approaches outlined in Table 1.5.

Table1.5: Approach to Achieving Research Objectives/Answer Research Questions

Research Objectives/Questions	Method/Approach
To synthesize the background literature on investment in highway development in Nigeria and the prevalence of delays and abandonment in project delivery with emphasis on the Niger Delta region due to its peculiar geologic setting**. (Q1**)	***Literature Review*** ***(Descriptive/Explanatory)***
To critically evaluate the theoretical and methodological lenses that have been used in previous studies to explain the propagation of cost overruns in highway projects, as a platform for highlighting significant gaps which have implications for this study. **(Q2)**	***Theoretical Literature Review*** ***(Critical Analysis)***
To critically evaluate and select an adequate philosophical/methodological orientation relevant to provide rich insights into the phenomena of cost overruns in highway projects executed in the Niger Delta. ***(Q3)***	***Review of literature on Methodology*** ***(Critical Evaluation)***
To analyse the heterogeneous configuration of the Niger Delta terrain, and the peculiar practicalities necessary for highway construction, as a case study justification of its inherent geologic distinctiveness for triggering cost overruns. **(Q4)**	***Geologic Literature Vs Field Work Analysis:*** ***(Geo-spatial Statistical Analysis)***
To identify the specific mediums of financial risk containment of geologic risks, from best practice, which emphasize the need for adequate geotechnical input in highway projects, as potential triggers to cost overruns **(Q5**).	***Literature on Best Practices*** ***(Exploratory)***
To examine the level of adherence/deviations in the design/costing practices of highway agencies in the Niger Delta, in line with the precepts of the identified geotechnical best practices, as a basis of ascertaining the suspected gaps in knowledge presupposed as the underlying cost overrun drivers. (**Q6)**	***(Deductive) Interview Analysis*** ***(Thematic Analysis)***
To develop a statistically valid model and cognitive map of geotechnical best practice based drivers to cost overruns, predicted on the heterogeneous geologic configuration of the Niger Delta region, as basis of accounting for the level of variance induced by geotechnical triggers. **Q7)**	***Regression Analysis, Content Analysis and Cognitive Mapping*** ***(Data Triangulation)***

The overall structure of the thesis in terms of the configuration of the chapters follows, the conceptual outline of the research methodology projected by the researcher as a mind map relating the key elements of the study, as shown in Figure 1.4. However, a reflexive adaptation of the research design was warranted in response to unanticipated non-geotechnical themes that emerged during the analysis of the interviews, as highlighted in Figure 1.4.

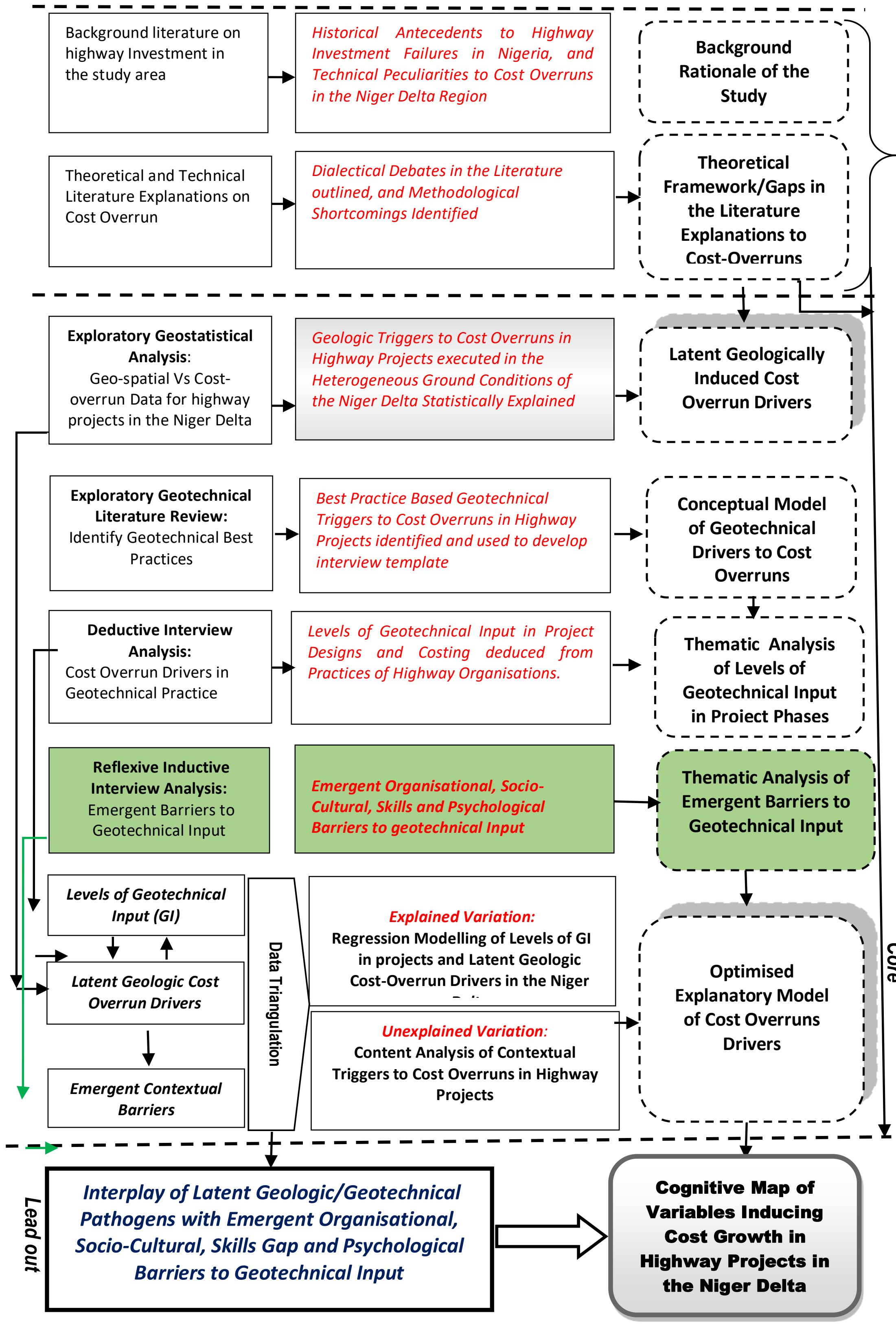


Figure1.4: Conceptual Mind Map of the Research Design

An inductive thematic analysis of emergent barriers, beyond the initial aim of the study, was thus carried out to incorporate the unanticipated social constructs, as part of the research findings. As shown in the research design, the findings from the initial analysis: the exploratory geo-statistical analysis of cost overrun data versus geotechnical index variables, and the deductive thematic analysis of geotechnical themes from the interviews were triangulated using regression analysis to explain the variance in cost overruns explained. The unexplained variation due to the emergent themes were further analysed using content analysis to proportionally assign weightings, as basis of cognitive mapping. The outcomes of the study, were a log-linear regression model of geotechnical pathogens, and a visual conceptual projection of the interplay between the geotechnical and emergent socio-constructs, through the pre and post contract phases of highway projects in the Niger Delta. The chapters of the thesis as shown in Figure 1.5 were thus structured in response to this reflexive adaptation of the research design.

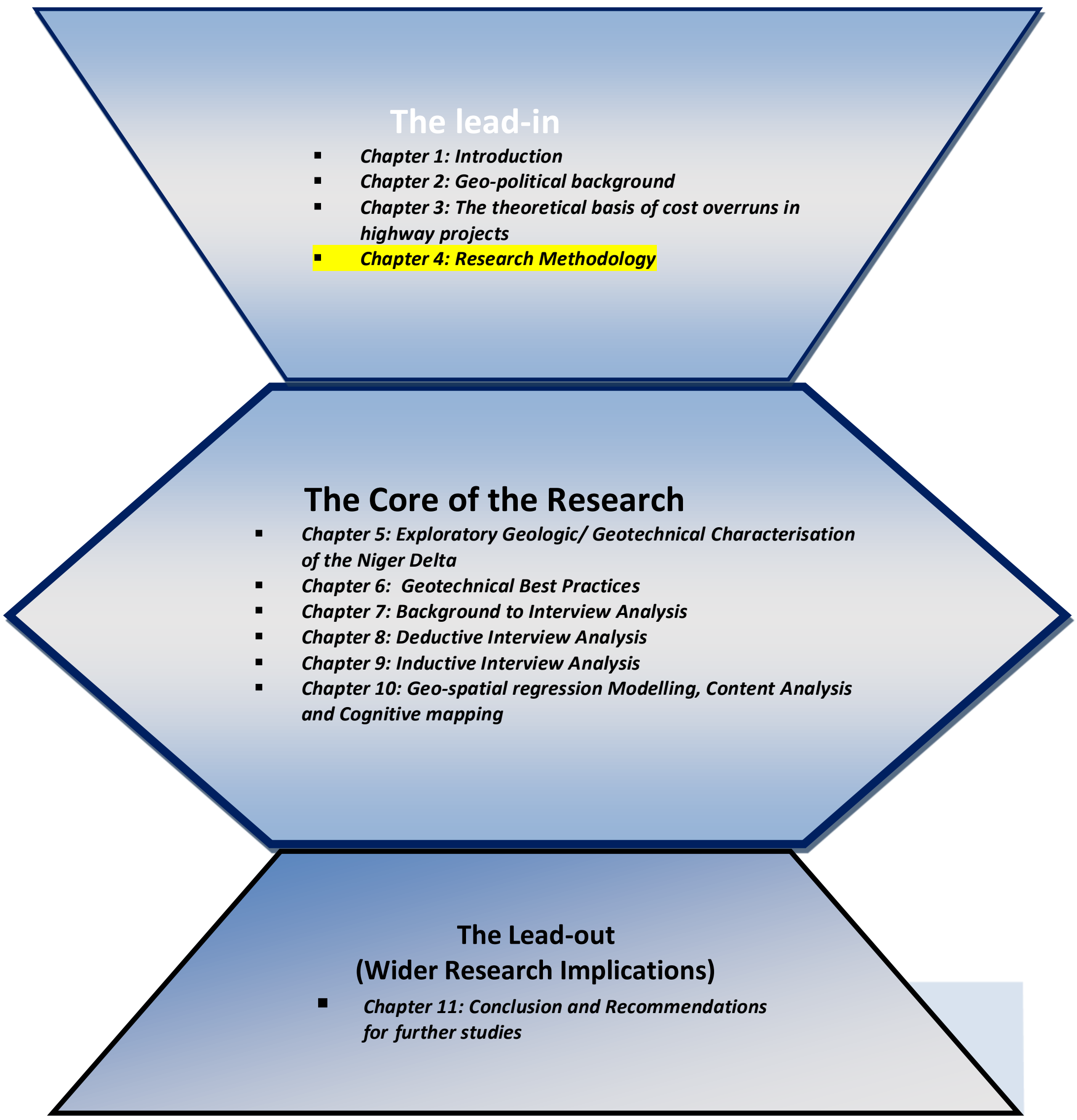


Figure 1.5: Thesis Structure

1.7 Study Scope

The study is confined to investigating highway projects executed in the Niger Delta region of Nigeria, which sets the spatial limits of in-depth analysis, with emphasis on the geologic conditions prevailing in the wetland terrain of the region. On this basis, a spatial definition of the region from a geotechnical perspective is used as a criterion for delimiting the geographic boundaries of the study area. Therefore, other definitions of the region, as used in geopolitical premise, are excluded from within the scope of the research.

1.8 Limitations, Exclusions, Constraints and Reservations

Some disciplines may rightly find their own fields of study inadequately represented in this research. This research, although transdisciplinary, is not an in-depth study of geotechnical engineering, geology, civil engineering, or contract law, but rather an attempt to apply scientific knowledge which overlaps between these different fields, in explaining the propagation of cost overruns in highway projects. The following are thus the limiting basic assumptions and intent of the research in the subject domains that the study cuts across, and which are set to define the intellectual realm of the study:

- The study has been limited to road works, although a few instances of illustrations with building and other civil engineering works may be apparently used. It does not provide a technical narrative directly applicable to bridges and other types of highway structures;

- Ground related risk have adverse consequences for project cost; completion times; environment; health and safety. This study's definition and focus on ground related risks, however emphasizes its cost implication, and is placed in the context of the need for geotechnical input as a medium of financial risk containment in the pre-contract phases of highway project estimate development. The study herein, is thus limited to exploring avenues of ensuring geotechnical input, predicated on the improved accuracy of construction cost, which has significant bearing on cost overruns;

- The study, although noting the relevance of the technical aspects of planning, execution and reporting of ground investigations, excludes this aspect from the study. The supporting literature on the need for ground investigation is thus limited to its financial risk implications and relevance for improving the accuracy of estimates and does not transgress outside this scope. It is therefore analysed only to the extent to which it supports or explains the researcher's stance;

- The researcher considers it pivotal to consider the contractual environment surrounding the incorporation of ground investigation reports as a medium of risk containment for highway projects. The literature in this section, although adopting a legal perspective, is explored only to the extent to which it borders on containing financial risks due to ground related uncertainties. The literature herein is limited and as such does not delve deeper into the legal intricacies of contract law, as this is outside the scope of the study.

- Although procurement systems have not been a major focus within this research study, their significance upon the geotechnical risk allocation configuration, in the responsibility for carrying out of ground investigations cannot be overlooked. The study however limits discussions on procurement systems to the extent to which it affects ground investigation, the associated risk allocation and its implied connotation for cost overruns.

Chapter 2

Administrative Background to Highway Development in the Niger Delta Region of Nigeria

2.0 Introduction

Before proceeding to critically analyse the theoretical underpinning of the study from the scholarly literature, this chapter sets the scene and context of the study by describing the regional and socio-economic background of the Niger Delta region, within the wider context of highway development in Nigeria as a developing country. Against this backdrop, the historical antecedents to the current institutional structure of highway development and administration in the Nigeria are traced. The existing development framework for investment in transportation infrastructure is captured, with emphasis on the budgetary practices evident in developing countries. A description of road infrastructure in the Niger Delta region evident in the literature, is used to provide a more substantive contextual setting, and to further highlight the inherent practical platform on which the need for the study is predicated.

2.1 Road Infrastructure Investment in Developing Countries: The Context of Nigeria

The limit, to which socio-economic growth can be fostered, is hinged on an efficient road network in a locality, which acts as a basic catalyst for civilisation (Roberts, 1999). Canning and Fay (1993) examined the economic impact of the level of development of transportation network on national growth, by assessing the marginal product of transportation infrastructure for 96 countries. His study revealed that the rates of return were normal, significant and moderate in developing, industrialized, and underdeveloped countries. In addition, the study revealed that although on a short term basis, transportation infrastructure had minimal impact on output, it promotes increased growth rate and output in the long-run. He thus concluded that:

> "Transportation infrastructure is indispensable in ensuring smooth economic operation, and its sufficient establishment is the genesis of economic advancement of a developing economy. Countries with greater mobility are in better position to develop than others with scarce mobility" *(Canning and Fay, 1993:21).*

Most European and developed economies of the world are characterised by quite dense road network, mostly created along with railways and canals, as a result of the demands on transportation created during the era of the industrial revolution (Millard, 1993). Consequently, Millard (1993) stated that the proportion of new roads in these countries is not particularly large, most of which has been to provide a system of inter unban roads and to serve the need of an expanding urban population. Although new road building still continues till present times, Millard (1993) revealed that majorly activities of highway agencies lie in the maintenance and rehabilitation of existing roads.

At the other extreme, is the scenario in developing countries, in which the building of new roads is a basic need for development, requisite to ensure the everyday mobility of people in the production and distribution of goods, and is therefore an emphasis of governments (Roberts, 1999). Policy measures in these countries as reiterated by Oni and Okanlawon (2008) are principally focused towards creating a viable environment to stimulate economic development. Figure 2.1 is a statistic on the average annual expenditure on road construction as a percentage of GDP in Sub-Saharan Africa, based on a report prepared by the African Infrastructure Country Diagnostic (AICD, 2008).

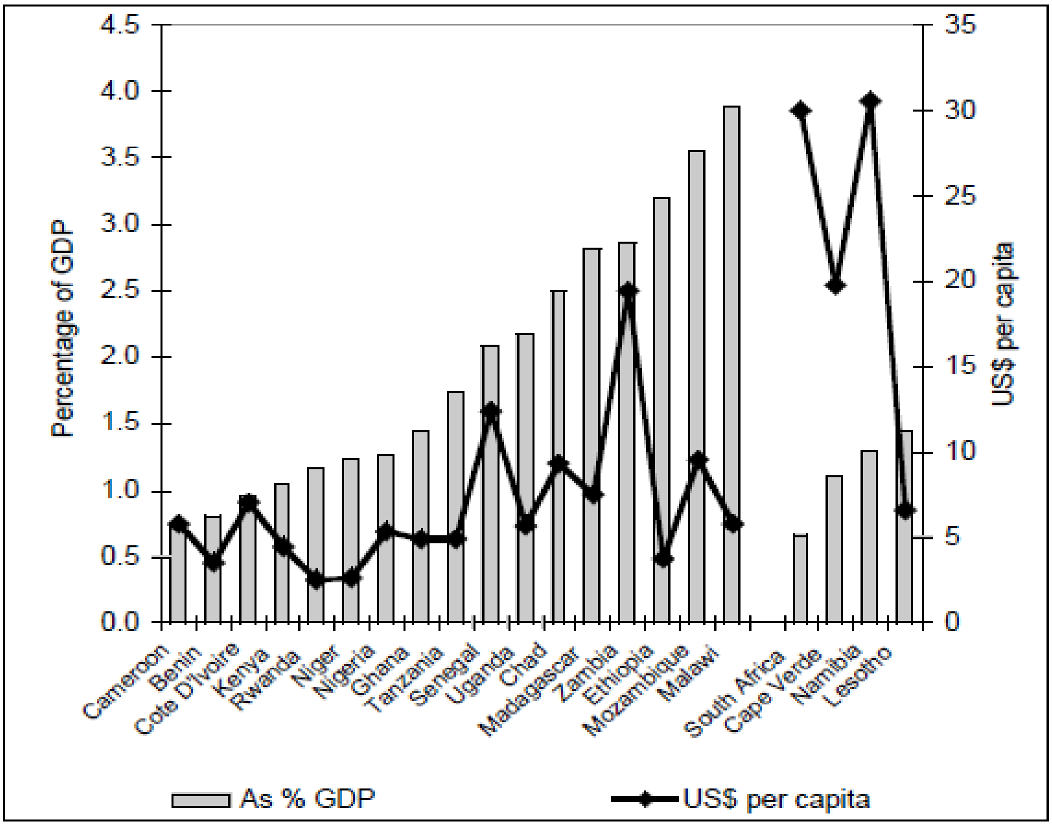


Figure 2.1: Average Annual Expenditure on road construction as a percentage of GDP in Sub-Saharan Africa (Source: AICD, 2008)

The statistics show that the annual expenditure on road construction in Sub-Saharan Africa is between 0.75 to 4%, with an average of 2.5%, compared to the 1% average in developed and industrialised countries (AICD, 2008). According to David-West (2014), and Millard (1993), this is because whilst road building had reached an advanced level in developed countries, it was only just beginning in the developing countries, particularly the ex-colonial countries following the attainment of independence. A report by the African Development Bank (ADB, 2013) at the World Economic Forum stressed that road infrastructure apart from being fundamental to ensuring social well-being and cohesion of populations is a vital support for economic activities particularly for African countries. As such the report which focused on enhancing competiveness in the productive capacity of developing countries in Africa, revealed that the low level of road network development has had a negative impact of an estimated 2% reduction in the annual growth rate. Potential productivity increases of up to 40% with the provision of an adequate road network, was forecasted. It was stated that:

> "*Inadequate infrastructure has raised the transaction costs of business in most African economies. Today African countries exhibit the lowest levels of productivity of all low-income countries and are among the least competitive economies in the world*" (ADB, 2013:32).

The efficiency of road transportation thus plays a significant role in economic development. The nomenclature of the literature on transport sector investment in Nigeria, further corroborates this. Willoughby (2005) carried out an empirical study to establish the statistical relationship between road development and the level of economic activity. His study concluded that the maturity of road network in a country is a basic index of its level of development. Using a multivariate model of simultaneous equations, Adegbemi *et al*. (2012), also examined the contributory role of road infrastructure towards the productive economic capacity of Nigeria. Findings from the study indicated that there is a direct causal relationship between level of investment in infrastructure and economic growth. A more recent empirical study by Uma *et al.* (2014) analysed the economic impact of transportation network in Nigeria over the years, based on sub-sector output, using time series data for road transport, rail transport, air transport, and waterway, ranging from 1981-2009. The study findings revealed that road transport impacted most significantly on the real gross domestic product (RGDP) and recommended a crucial need for investments in road network development as a panacea for accelerating economic growth in Nigeria.

Njoku and Ikeji (2012) however showed that there is an overall negative trend in the contribution of the transport infrastructure to GDP over the years, as depicted in Figure 2.2.

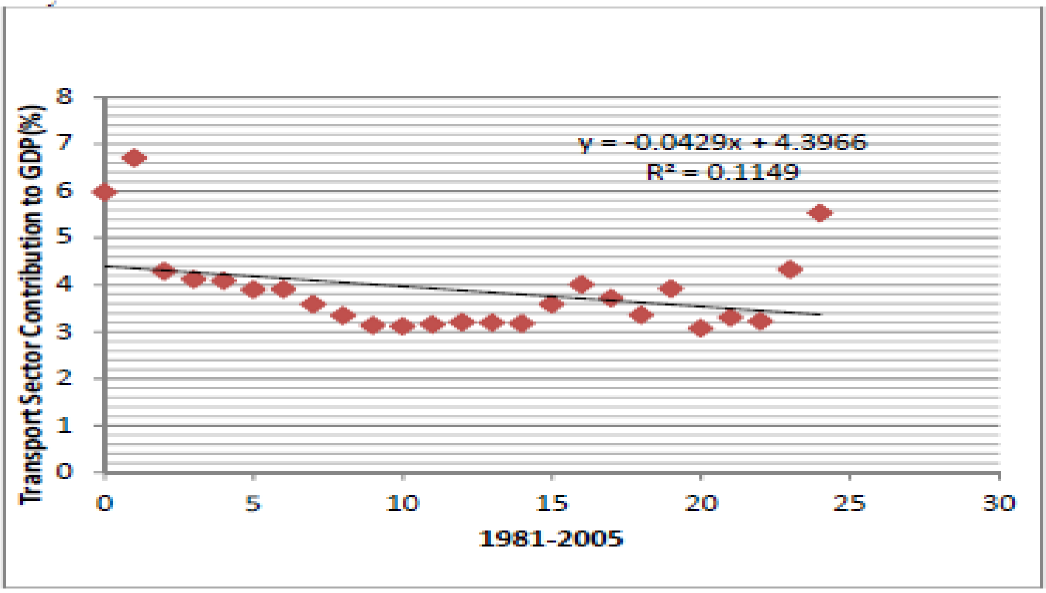


Figure 2.2: Trends in Transport Sector Contribution to GDP

Source: Njoku and Ikeji (2012)

Ighodaro (2009) using a vector error correction model, statistically analysed the stages of road network development in the three earlier national development plans. His study also indicated that past efforts in road development had impacted more significantly on Nigeria's economy within these time frames, compared to more recent times.

2.2 Historical Perspective to Highway Development Investment in Nigeria

Road systems have been traced to have begun in Nigeria in the early nineteenth century following post World War-1 efforts at development by the then colonial masters ruling the country (CBN, 2003). This was intended to facilitate trade activities via feeder road network for the new rail roads. History points to the fact that before this timeframe there were no existing motorable roads in Nigeria. From historical literature, the following eras of highway development in Nigeria can be discerned:

- **Earliest Pre-Colonial Times***:* The earliest documented effort at highway development according to Anyanwu et al. (1997). The total road length within this time frame increased from 6,160 km to 9,453 km.

- **Pre-Colonial Expansion**: After the initial road construction era in earlier times, there followed a phase of road network expansion to cover major cities and trade routes. As at 1951, the total road network had increased by a significant ratio with 15,785 km of bituminous roads and 75,200 km of earth/gravel roads in place. The Central Bank of Nigeria (CBN, 2003) however reported that roads constructed in this era were lacking in standard, were all single lane roads, constructed on weak subgrades, often with poor horizontal and vertical alignments, and characterised by sharp bends as well as poor drainage.

- **Post-Colonial Era**: This was the era following the attainment of independence in 1960, during which various national development plans and programmes designed to improve the transportation sector, particularly focusing on road development, marked an increase in the aggregate economic activity. The National Transport Policy based on the rolling plans 1991 - 1999, reveals the priority given to road development in the transport sector budget based on percentage investment allocation. These development plans were predicated on the significant revenue accruing to the federal government, following the discovery of oil in the Niger Delta region. The total paved road density increased from about 17 km per 1000 km^2 in 1960 to about 160 km per 1000 km2 in 1979. The quality of roads in this era improved with the construction of the roads carried out by foreign construction firms.

- **Post- Civil War**: Following the outbreak of the civil war in the 1970's and its eventual end, there was a renewed emphasis on road development in Nigeria. A total of N332.588, representing 68.59% of N485.189 million transportation sector budget, was invested principally on road construction in the Second National Development Plan (1970-74). Subsequent rolling plans 1990-1993, 1994-1996 and 1996-1998 accounted for 50.6%, 57% and 40.1% respectively (Ighodaro, 2009; Onokala, 2012; Oni and Okanlawon, 2013).

- **Contemporary Times:** Road building in Nigeria has continued till date with a proportional increase in the ratio of paved to unpaved roads. The total road network in Nigeria as shown in Figure 2.3 is presently estimated at 200,000km and accounts for 95% of both passenger and freight movements (Federal Ministry of Works, 2014).

Figure 2.3: Nigeria's Road Network **Source: www.mapsofworld.com/Nigeria**

The major reason being the inadequacy of other forms of transportation principally the rail system, which became mostly non-functional since the 1970's. Over this period, road transport has increasingly accounted for the highest percent of goods conveyed to the seaports, while other transportation modes: water and railways are minimally used, as depicted in Figure 2.4.

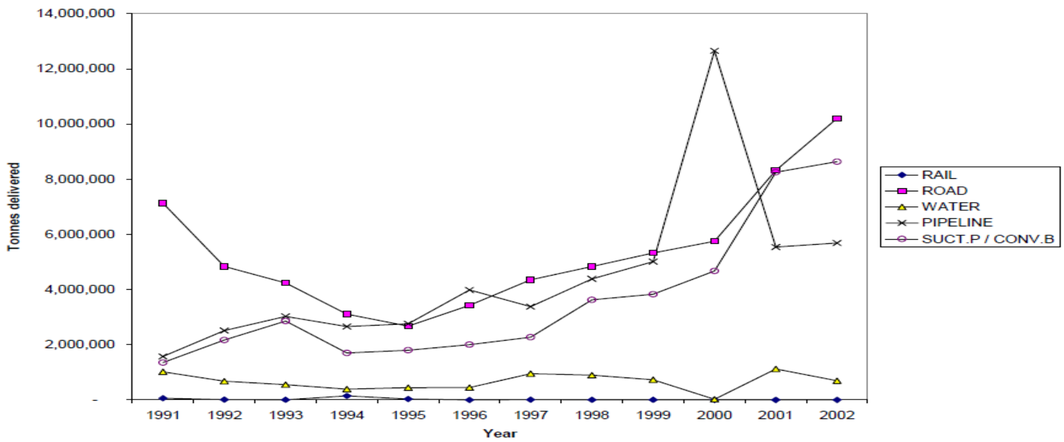


Figure 2.4: Analysis of Cargo Delivered at Nigerian Seaports (1991-2002)

(Source: Oni and Okanlawon, 2013)

2.3 Administrative Framework for Highway Development in Nigeria

The responsibility for road development in Nigeria is shared concurrently amongst the three tiers of government based on the Constitution of the Federal Republic of Nigeria (1999). As Figure 2.5 shows, the different tiers of government have independent and segregated responsibilities for the construction and management of roads.

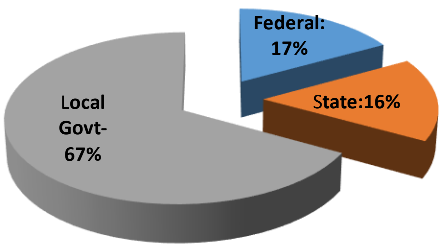


Table 2.1: Total National Road Network

Type	Federal (Km)	State (Km)	Local (Km)	Total (Km)	%
Paved Roads	29,741	11,400	_____	41,141	20%
Unpaved Roads	05,600	20,100	_____	25,700	13%.
Urban Roads	_____	_____	21,900	21,900	11%
Rural Roads	_____	_____	72,800	72,800	37%
Village Roads	_____	_____	35,900	35,900	19%
Total (Km)	34,341	30,500	130,600	197,441	100%
Percentage	17%	16%	67%		

Figure 2.5: Road Ownership in Nigeria **(Source: FMW, 2013)**

Roads in Nigeria are classified on the basis of administration. The total national road network is approximately 200,000km made up of 17%, 16% and 67% for Federal, State and Local Government respectively, represented as a pie chart in Figure 2.5 (Federal Ministry of Works, 2013). The statistics from Table 2.1 indicate that 20% of the 197, 441km of roads are paved mostly in bituminous layers, while the majority of the networks are earth roads. The Federal tier of Government executed a higher percentage of the entire paved road network in the country. The 36 States and the 774 Local Government Areas are responsible for those not constructed by the federal government. In tandem with this administrative framework, road classification follows a hierarchical designation:

- **Trunk A and F Roads**: - Trunk 'A' roads are roads constructed and maintained by the federal government and forms the major network around which other categories of roads are built. Trunk 'F' roads refer to highways initially owned and maintained by the state governments, whose ownership were subsequently transferred to Federal government and standards upgraded. This class of roads transverse the entire land mass of Nigeria as shown in Figure 2.6. They form a network of connectivity for ports, state capitals and links with neighbouring countries. The responsibility for these roads is vested in the Federal Ministry of Works (FMW).

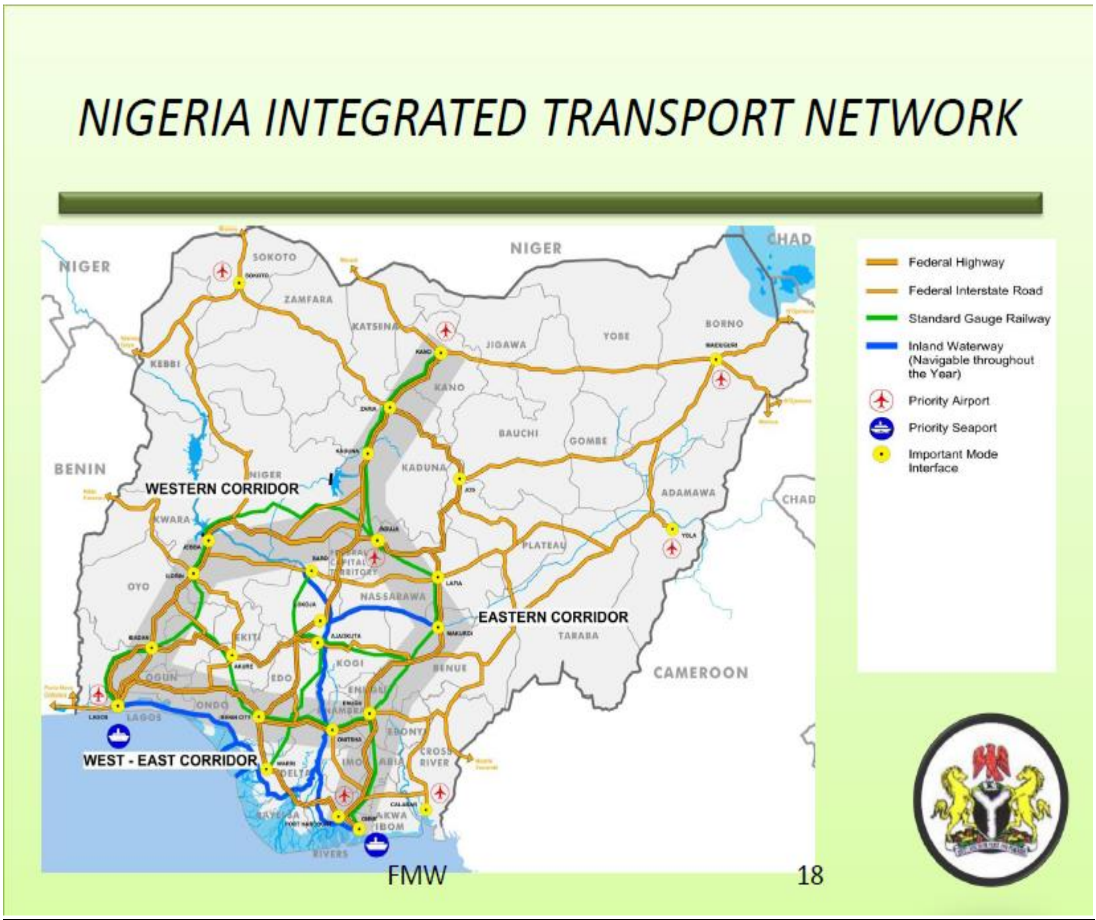


Figure: 2.6 Federal Road Network in Nigeria **(Source: FMW, 2013)**

- **Trunk B Roads**: These are the roads within the states connecting major towns and cities of the states. They also connect the cities of the states to federal highways and serve as the main arteries of traffic to and from district roads. Trunk B roads are maintained by the State Government and are usually of 3 or 2-lane with width.

- **Trunk C Roads**: These are referred to as local government or community roads, and are required to be constructed with similar specifications as trunk B roads. Trunk C roads are designed to connect areas of production and market with higher order roads such as state highways. Approximately 60% of Nigerian roads are made up of trunk C roads as a medium of interconnectivity between neighbouring villages within the geographic boundaries of a state. These roads promote rural economy and equally serve as links between urban and rural areas in the transportation of agricultural produce. They also include rural or feeder roads which are mostly unpaved manufactured routes, tracks and path-roads whose accessibility and utility is often seasonal. However, depending on the duration of the rains, these roads can be rendered completely unusable, and can have severe impact on the mobility of farm produce harvested from affected areas (Oni and Okanlawon, 2008).

2.4 Geographic Setting of Highway Development in Nigeria

Nigeria is a coastal state on the shores of the Gulf of Guinea located in West Africa, with Benin to the West, Niger to the North, Chad to the North East and Cameroon to the East and South East as shown in Figure 2.7. It is located between latitudes $4 – 14^0$ north of the equator and longitudes $2^0 21^/ – 14^0 30^/$ E of the Greenwich Meridian. It has an Area of $923m^2$ (356,669 sq. miles) placing it 14^{th} in size among African countries.

Figure 2.7: Map of Nigeria Showing Geographic Boundaries (FMW, 2013)

Nigeria is a country of physical contrast, owing mainly to the vastness of its land mass. This can be illustrated through the delineation of physical regions defining the geographic belts of Nigeria, naturally taken to be based on climate which in turn determines vegetation and soils.

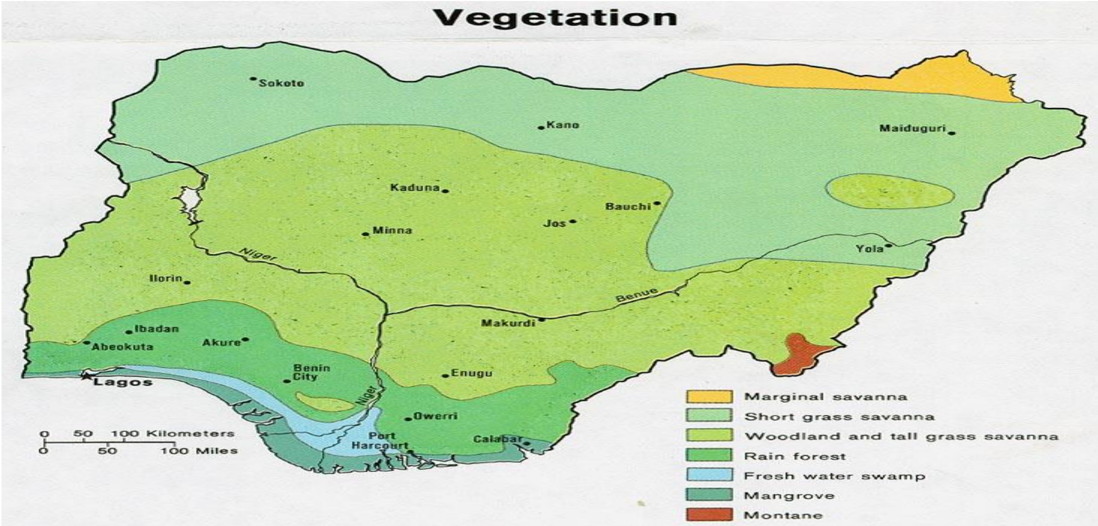


Figure 2.8 Vegetation Map of Nigeria **(Source: GAI, 2014)**

The implication of this variation in the overall climatic condition of Nigeria, is the differences in vegetative zones, shown in Figure 2.8, which are tied to a combination of rainfall and temperature. The ecology of the country varies from tropical forest in the south, to dry Savannah in the far North, showing a clear north- south zonation. In general mangrove swamp and rainforest are found in the south occupying about 20% of the area of the country, while grassland of various types occupies the rest.

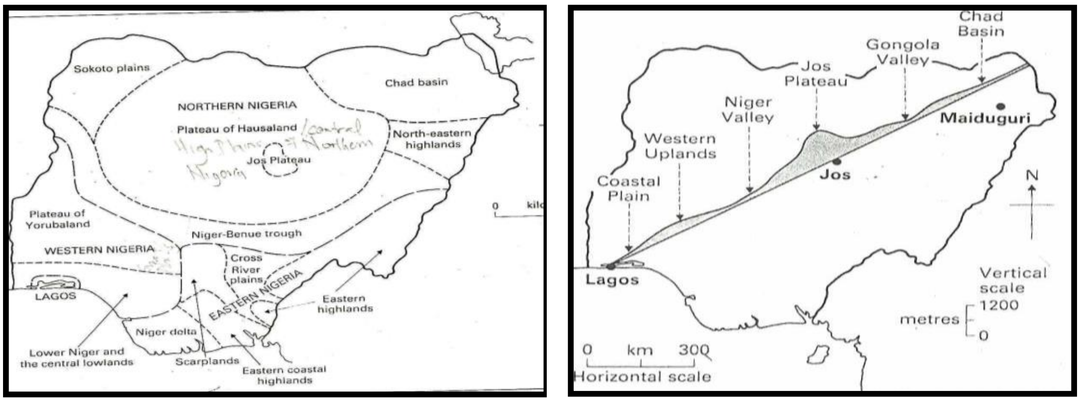


Figure 2.9: Map of Nigeria showing Land Form and Relief **(Source: Iloeje, 1982)**

As shown in Figure 2.9, the highest lands are along the north-eastern border of the country, which rise to a maximum of 240m above sea level at the high plains of Hausa land, and is characterized by a broad expanse of level sandy plains, interspersed by rocky outcrops. The land declines steadily from the Northern highlands southwards to the coastal lowlands at the Niger Delta, of less than 80m above sea level, stretching inland from the coast for over 250m.

Figure 2.10: Aerial photograph of the Niger Delta Lowlands, Southern Nigeria

Source: Niger Delta Home page (2015)

As shown in Figure 2.10, these lowlands are dissected by innumerable streams and rivers, which are tributaries of the River Niger, the 3rd longest River of Africa, originating in the Futa Djalon Mountains, north-east of Sierra Leone. The River Niger flows southwards from the higher plains, where it slows down to deposit its silt-clayey sediment load, and merges with numerous interlacing distributaries of the Delta, which discharge into the Atlantic Ocean. About two-thirds of Nigeria thus lies in the watershed of the River Niger, with the Niger Delta occupying over 60% of 800km Nigerian coastline.

Subsoil conditions in Nigeria thus display this physical variability in climatic conditions and geological structure, with the northern parts having good sub-soils and rocky grounds. The southern parts mostly have sedimentary soils which have moderately adequate stability, while the Niger Delta region towards the coast has the typical problematic fined grained deltaic marine deposits. The state of road infrastructure and level of highway development in the country is equally a reflection of this landscape variability, with a corresponding financial requirement for road development. Oguara (2002) described the state of road infrastructure in the Niger Delta, as being significantly worse than other regions of Nigeria. It was thus remarked that:

> "*The numerous meandering river systems and waterways, flood, erosion and other excess water related constraints constitute the major problems that hinder highway infrastructure development in the region"* (Oguara, 2002: 23).

Oguara (2002) listed the peculiar issues identifiable with infrastructural development in the region:

- Poor drainage;
- Swampy terrain;

- Heavy rainfall;
- High water table.

Chapter five of this thesis further outlines the geographic context of the region, providing a more in-depth background of the hydro-geological formation of the Niger Delta region of Nigeria, as it is currently known. This is to serve as a backdrop for highlighting the cost implication of the physical configuration of the Niger Delta, against which the historical antecedents to investment in highway development is predicated.

2.5 Geo-Political versus Geologic Definitions of the Niger Delta Region

The Niger Delta Environmental Survey (NDES, 1997:45), in its cartographic definition of the Niger Delta, limits the area on the basis of natural geological and geographical considerations (See Figure 2.11), to include from the:

- *"North {Apex} at the bifurcation of the River Niger into river Nun and Forcados;*
- *West from Benin River estuary;*
- *East: to the Imo River estuary and;*
- *Southern-most tip at the estuary of the River Nun".*

The total land area defined physically as being the Niger Delta area, based on the definition of its geographic limits by Niger Delta Environmental Survey (NDES, 1997), is approximately 25,900km^2, which is about 2.8% of the total land area of Nigeria. This is basically comprised of Rivers State and Bayelsa State, as shown in Figure 2.11.

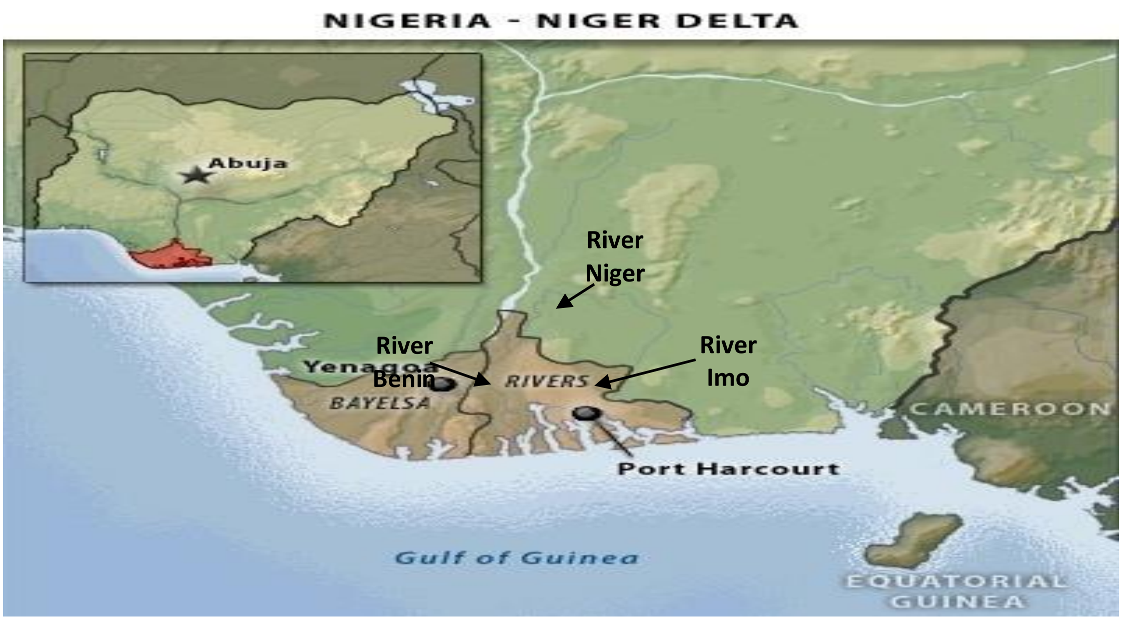


Figure 2.11: Geologic Definition of the Niger Delta (Niger Delta Home Page, 2015)

However, other definitions of the Niger Delta region are evident in the literature in geo-political premise, based on the Niger Delta Regional Development Master Plan (NRDMP, 2001). Teme (2002), a leading scholar on the Niger Delta geology, in alluding to this stated:

> *"Other definitions of the boundaries of the Niger Delta, for selfish reasons of reaping the abundant natural resources that are contained therein, have emerged over the years as 'sensu lato' definitions with rather poorly defined, incoherent and difficult-to-defend logic"* (Teme, 2002:11).

At present times, the definition of the Niger Delta region has become a political issue, due to proprietary rights over the oil wealth of the region, and so geo-political boundaries have emerged, extended beyond the geologic limits, to cover the 9 oil producing states of Rivers, Bayelsa, Delta, Edo, Ondo, Akwa-Ibom, Cross River, Imo, and Abia (NRDMP, 2001). Figure 2.12 shows the geopolitical definition extracted from documentary analysis of the NRDMP (2001), as used by the Federal Government in political premise.

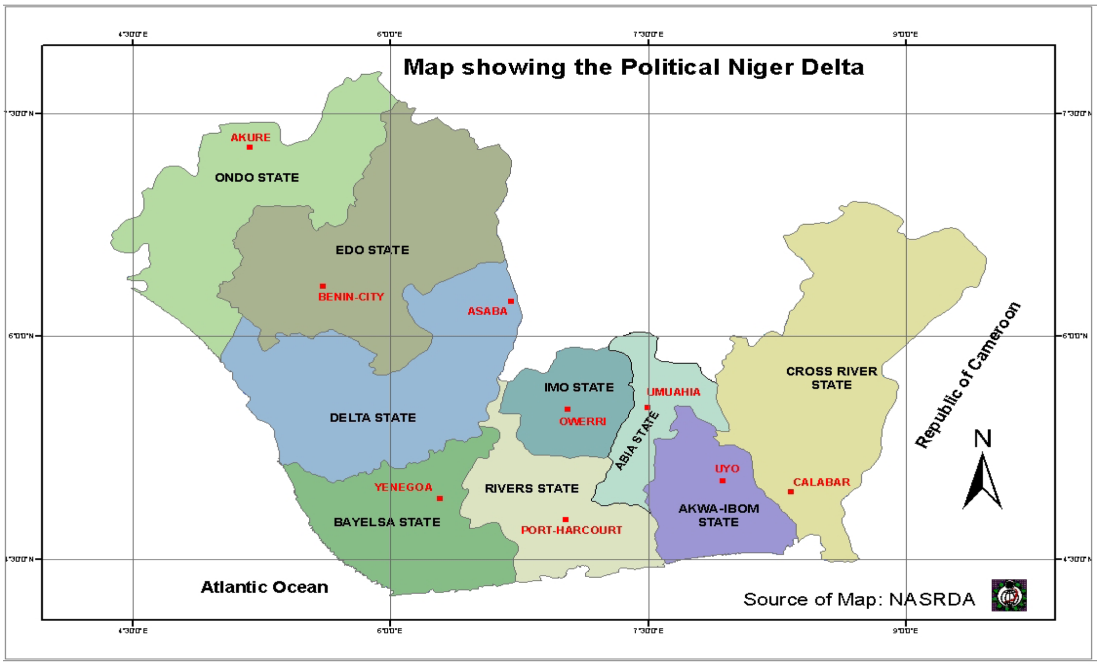


Figure 2.12: Political Definition of the Niger Delta (Source: NRDMP, 2001)

These states now constitute the Niger Delta Development Commission (NDDC), based on the geo-political definition of the NDRDMP (2001). Teme (2002), in describing the fan shaped geologic attribute of a typical delta, commented on this political definition, further asserting that:

> *"On this basis, the Niger Delta no longer has a bird foot configuration, and so is not supposed to be called a Delta"* (Teme, 2002:11).

Due to the inherently geotechnical and geologic perspective of the study, the researcher adopts the geologic definition of the Niger Delta region, which will serve as an analytical basis for delineating a geo-spatial classification for its sub-soils.

2.6 Past and Present Regional Highways Development Frameworks in the Niger Delta

Successive institutional frameworks have been setup to address infrastructural deficiencies in the Niger Delta, charged with the responsibility for the construction of roads in the Niger Delta region. Several authors and reports have chronicled past regional developmental efforts aimed at road infrastructural development in the region, whereby projects were mostly fraught with prolonged delays and abandonments, leaving in their wake a monumental backlog of uncompleted road projects (NDES, 1997; Oguara, 2002; Okon, 2009; Oviasuyi and Uwadiae 2010; Jacob, 2012). Typically, these include the Presidential Task Force (PTF) established under the 1979-83 military administration, whose set terms of reference to link the inland areas of the region, was not realised on account of funding shortfalls and poor planning (NDES, 1997; Okon, 2009). The Oil Mineral Producing Areas Development Commission (OMPADEC) was subsequently established in 1993, and inherited about 2000 abandoned projects from its predecessor, the PTF, initiated about 200 new schemes, and was defunct by 1999, leaving numerous unfinished projects (Okon, 2009).

Developmental programmes covering a wide range of project types in the region are however still currently ongoing in the Niger Delta. Presently there are three contract awarding bodies charged with the statutory responsibility for the construction of Trunk B state and inter regional roads in the region:

- Regional: The Niger Delta Development Commission (NDDC);
- Rivers State: Ministry of Works (RMW);
- Bayelsa State: Ministry of Works and Transport.

Despite the various developmental bodies, highway development in the region is still significantly lacking mainly due to technical rigours and astronomical cost associated with highway development on the flood prone soils. The requisite application of modem costly technologies by highway agencies, along with technical ingenuity by engineers, which should be based on an adequate understanding of the sub-soils in the area, have thus being speculated as lacking, and has hindered highway development in the Niger Delta region (Oguara, 2002). Chapter five of this thesis delves in-depth into describing the geologic configuration of the region, by analysing the technical rigours and financial implication of highway development, which has been a significant problem to successive state governments in the region. Further details on the organisational setup of the aforementioned highway agencies, and their approaches to highway project delivery are provided in chapter seven, based on the outcome of subsequent fieldwork.

2.7 Present State of Highway Development in the Niger Delta Region

Most parts of the Niger Delta region, particularly the coastal barrier islands, and mangrove swamp zones are yet to be linked up by roads, including fairly large settlements such as Bonny, Brass, Ogulagha and Escravos (Oguara, 2002; Ibaba, 2012). According to Ibaba (2012), there are no roads linking these areas to other zones, with communities in this zone linked to each other and to other zones through a network of waterways. Thus, the only available means of cargo and passenger transportation in some communities are by dugout canoes, motorized outboard and inboard engine boats, which are inadequate as shown in Figure 2.13.

Figure 2.13: Transportation in the Niger Delta (Source: Niger Delta Home Page, 2014)

In Port Harcourt and Yenegoa, the administrative headquarters of Rivers and Bayelsa states respectively, which are the largest settlements in the lowland rainforest zone, movement of people and goods is mainly by road transport, though in most parts of the zone, the road network is in a poor state of disrepair (Abam *et al.,* 2005). In the recent past, the only trans-regional road, the East-West road that passes through the region, has being described as a death trap due to the advanced level of failure of the road (Emujakporu, 2012). This has constituted a concern to all stakeholders in the usage.

Inter-settlement movements in the riverine areas of these states have also been severely restricted due to the near total absence of inter-town links. The few available roads are those within the towns and villages, a situation which has being frequently attributed to the terrain of these areas. Several authors have inferred that this is the fundamental factor which makes the development of land-based transportation difficult and which has also largely resulted in the several failed projects in the region. (Fashaye, 1992; Oguara, 2002; Ossai, 2012). According to Ossai (2012:87):

> *"The existence of roads which is taken for granted in some parts of the country is a luxury to the people of the predominantly riverine Niger Delta, which has the least kilometres of roads in the federation. A development blamed on the several abandoned government road projects in the state due to the developmental constraints posed by the difficult terrain"*.

This issue of road infrastructure backlog is at the forefront of the current violent agitations in the Niger Delta, which has been publicised in the local and international media (BBC, 2016). Attempts via road networking by the various state and regional highway agencies, are thus being concurrently executed in these zones. Plans have been reported to be currently underway for the construction of new inter-city and inter-state highways including access roads to link communities as well as the rehabilitation and upgrading of older roads (NDDC, 2016). Some of these abandoned road projects as earlier accounted for in the report by the NDES (1993), and which are currently being revived in the state include:

- The Ogbia-Nembe road project, which is now being undertaken in a collaborative effort between the Anglo-Dutch oil giant, Shell Petroleum Development Company SPDC and the Niger Delta Development Commission (NDDC);

- The Sagbama-Ekeremor-Agge road project, which was being handled by the NDDC but was later taken over by the Bayelsa State government following the abandonment by construction firm;

- The long abandoned Yenagoa- Oporoma road project passing through the vast mangrove stretch of Southern Ijaw council area is also another major road project which has being revived at the cost of N31 billion (NDDC, 2013).

Also, other new road networks designed to link communities in the hinterland by land are proposed to be initiated (NDDC, 2016). Yenagoa the capital of Bayelsa state has being recently described as '*a significant construction yard*', due to the flurry of ongoing construction works, as new layouts are being opened up, and wider roads being constructed. Some of the planned and yet to be constructed roads include the 46.20km Baen-Kpean-Ngo-Bonny Road in Rivers State and 65.3km Yenegwe-Kolo-Nembe-Brass road in Bayelsa State which had been delayed for a prolonged time. The Niger Delta Development Commission (NDDC) has commenced the construction of several road projects in the region. Rehabilitation and dualisation of the 337km East-West Road in currently on-going, with plans for the construction of a 731km Niger Delta Coastal road being proposed to link all the states in the NDRMP, by the Ministry of Niger Delta, as shown in Figure 2.14.

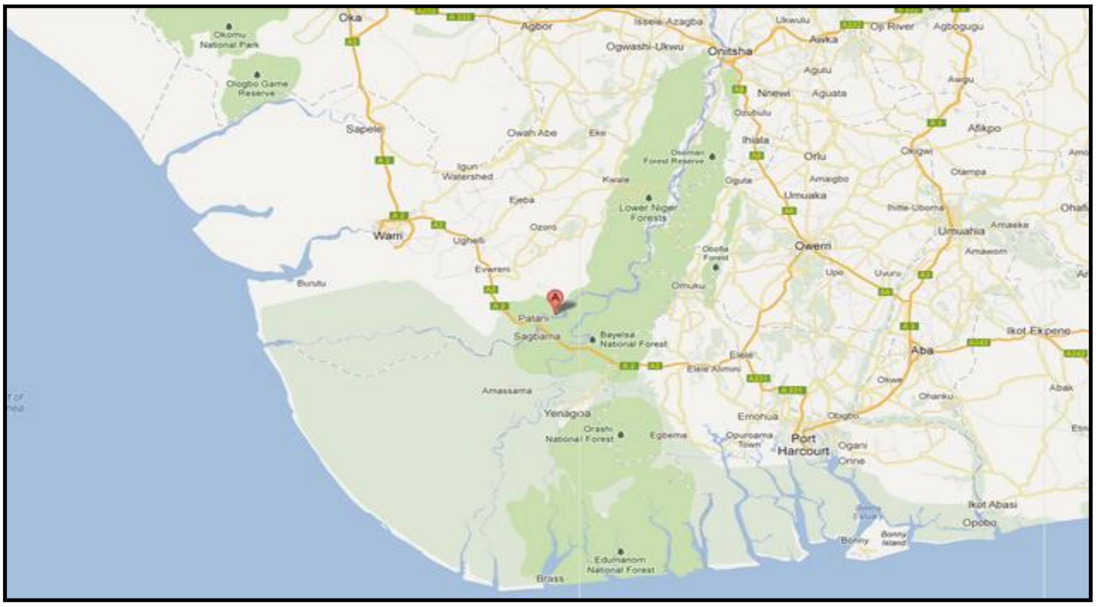


Figure 2.14: Proposed Intra-Regional Road Network in the Niger Delta

(Source: MND Homepage, 2015)

It is therefore evident from the local literature, that most of the communities in the Niger Delta region are yet to be linked up by roads, which reflects the significant investment capital which will be required to open up the Niger Delta region. The need to adequately and judiciously manage future investments on road development in the region is thus evident. Equally, the basic underlying factors responsible for the past trend, of rather alarming rate of project delays and abandonment, need to be identified, if history is not to repeat itself in this new epoch of developmental effort taking place in the region.

2.8 Highway Project Delivery in the Niger Delta: Delays and Abandonment

In recent times, increased investment figures in budgetary allocations projected for infrastructural development in the Niger Delta, has led to an increase in the volume of contracts for road construction, awarded to local contracting firms. A major concern amply portrayed in the literature due to the trend witnessed in past developmental efforts, revolves around: the mechanism of planning by government; project delivery and contractual management issues by the highway agencies; and project execution by indigenous construction firms (Mansfield *et al.*, 2004; Joseph, 2012; Ihuah and Benibo, 2014). This is due to the extensive delays and outright abandonment of road projects which has become endemic in the region (Ihuah and Benibo, 2014). Figure 2.15 shows the resumption of work on a major road, traversing the vast mangrove stretch of southern Ijaw local government area of Bayelsa State, in 2013, which had been previously abandoned by past government administrations for over 50 years.

Figure 2.15: Resumption of Construction Work after over Five Decades of Abandonment (Source: NDDC, 2013)

However, several other road projects scattered in other zones of the region, which had experienced similar fates, have till date remained un-resuscitated (NDDC, 2013). Some the well-publicised lengthily delayed and abandoned Trunk-B road projects executed in Rivers and Bayelsa States include:

- The Buguma-Edo-Abalama-Abonema road;
- The 10km Opume-Okoroba Road project;
- The Akpilai/Ogbia-Nembe road;
- The 22km Ogbia Nembe road.

Other than these well publicised major roads, innumerable delayed and abandoned lower-order trunk C roads are equally evident in the region, based on the findings of an independent report sponsored by the European Union, covering over 120 communities. Physical evidence discovered during the field work phase of this study shows that many of these abandoned community road projects have become flooded, and have also being overgrown by weeds, with the residents practically having to wade through the muddy waters to get to their various destinations. Drainages and ditches dug before the projects were abandoned, are most times left open with unsuspecting pedestrians and vehicles falling into them, particularly during the rainy season, when they are over-flown following very heavy downpour (Figure 2.16).

Figure 2.16: Flooded Abandoned Community Roads in the Niger Delta

Often times, pedestrians have to cross over strategically placed wooden boards at the risk of their safety to get to their destinations (Figure 2.16). The proximity of this abandoned open channels to the roadway, which vehicular traffic, often in jams, have to drive through, also puts passengers on board at great risk.

Figure 2.17: Community Protest over the Abandonment of Road Project

(Vanguard Home Page, 2014)

In recent times, as captured in Figure 2.17, public protestations and violence has erupted in parts of the Niger Delta region, over this issue of project abandonment by affected communities (Joseph, 2012; Ihuah and Benibo, 2014). The problem is so endemic that legislative action is presently being undertaken to address this issue. Currently, a bill for an act to amend the Public Procurement Act No. 14 of 2007, has being proposed by the house of representative in Nigeria. This legislative move was made to ensure that all '*dead'* projects were revived and new public projects are executed from inception to conclusion, within the stipulated contract award period. The bill is being proposed with a view to sanitise public sector project delivery in Nigeria.

This central issue, which has largely defined the developmental landscape of the region, has thus being viewed and discussed from varied perspectives in the literature. Several factors have been adduced for this regretful state of affairs, ranging from poor project appraisal to inadequate supervision and management. (Joseph, 2012; Sunjika and Jacob, 2013; Ihuah and Benibo, 2014). Commenting on this topical issue, Chukwu (2014:125) questioned whether:

> *"poor planning, haphazard procurement, and incompetent project management [were] the key causes [of failure] or is it financial mismanagement? [Ultimately] at the heart of this failure is the absence of effective institutions and mechanisms for planning, monitoring and evaluation ... The end user which is the people and the community are the ones that suffer the brunt and carelessness*".

Also issues emanating from the socio-cultural dynamics of political and unethical practices, such as lack of accountability, lack of political will, and corruption as speculated in government projects, have further constituted a source of public concern, frequently referred to and discussed in numerous international reports, media and scholarly literature.

2.9 Causes of Delays and Abandonment in Developing Countries: The Nigerian Context

Project delays have been described by Ubani and Ononuju (2013), as the non-achievement of planned project completion time, which consequently extends the stipulated duration of the project. Total abandonment is the permanent stoppage of works at the project site due mainly to difficulties surrounding the development (Ihuah and Benibo, 2014). The difficulties that cause project delay and abandonment in one setting, however may not be directly transferrable as applicable to others (Singh, 2010). It was argued that it is inappropriate for generalisation to be made on all developing countries, considering the diversity in geographic context, cultures and economy (Aiyetan, 2010; Singh 2010; Ihuah and Benibo, 2014). However, it is still necessary to explore the broader picture as obtainable in the wider context of Nigeria as a developing country, for similarities with other developing countries. From the literature several causes of project delays have been identified from the client's and contractor's perspective, some of which have been noted by various authors as particularly evident in developing countries. These are summarised in Table 2.2.

Table 2.2: Delay and Abandonment Causes in Developing Countries

Author	**Country**	**Causes of Delays**
Chan *et.al.(*2002)		Contractor ▪ Lack of contractor's competencies; ▪ Lack of understanding of risk and liability assessments; Client ▪ Lack of the client's competencies; ▪ Lack of community integration ▪ End users imposed restrictions on the project development.
Faridi and El-Sayegh (2006)	United Arab Emirates (UAE);	Client: ▪ Inadequate early planning, Contractor: ▪ Poor supervision and site management
Majid (2006) delays	Indonesia	Client: ▪ Inaccurate cost estimate ▪ Finance ▪ Change orders Contractor: ▪ Improper project planning, scheduling and site management
Toor and Ogunlana (2008) .	Thailand	▪ Design related ▪ Client's Finance related ▪ Contractor related
Sweis, *et al*. (2008)	Jordan	Contractors: ▪ Financial difficulties Client: ▪ Frequent change orders
Kaliba *et al. (*2008)	Zambia	Client ▪ political pressures from government ▪ political discontinuity ▪ complex administrative structures
Singh (2010)	India	Technical and Natural Factors: ▪ Terrain; ▪ Weather; ▪ Design and scope changes. Contractual Failures: ▪ Contract documentation; ▪ Contract implementation. Organisational / Institutional Failures: ▪ intra-organisational; ▪ Inter-organisational. Economic Factors: ▪ Inflationary; ▪ Financial. Geographic/location factors ▪ Urban/rural

The unceasing and rather alarming spate of public project delays and abandonment in Nigeria, has been reported to be seemingly higher than in most of the other developing countries, as Osemenan (1987:8), quipped: "*Nigeria has become the world's 'junk-yard of abandoned projects, worth billions of Naira*". This situation has however not seemed to have improved, with Nigeria still remaining perpetually known for it (Ayodele and Alabi, 2011). According to a press release in the Vanguard (2014: 4), by the lower arm of the legislature in Nigeria, the House of Representatives: "*Over 11,800 projects have been abandoned by successive governments with about N7.28 trillion required to finance the abandoned projects"*. These figures were quoted based on the findings of the Abandoned Projects Audit Commission, set up in 2011 by the Federal Government. Several authors in the scholarly literature have further carried out empirical questionnaire based studies to investigate the factors responsible for this situation, as summarised in Table 2.3.

Table 2.3: Delay and Abandonment Causes for Public Projects in Nigeria

Author	Causes of Delays
Mansfield *et al*. (1994)	▪ Political and institutional bureaucracy; ▪ lack of clarity during planning; ▪ Unethical practices; ▪ Poor project management on the part of clients and contractors; ▪ Cost overrun.
	▪ Inconsistency in government policies; ▪ Local currency devaluation; ▪ Unclear conditions of contract; ▪ Cost overrun ▪ inappropriate conceptual design and costing; ▪ Corruption and disregard for local law and customs.
Ayodele and Alabi (2011)	▪ Inadequate project planning and funding shortfall; ▪ Inflation; ▪ Bankruptcy of contractor; ▪ Variation of project scope ▪ Political factor; ▪ Incompetent project management; ▪ Wrong estimate; ▪ Inadequate cost control; ▪ Faulty design; ▪ Delayed payment.
Hanachor (2012)	▪ Improper financial analysis leading to cost overrun; ▪ Deliberate Under bidding of projects; ▪ Lack of technical analysis; ▪ Project site or Location factors; ▪ Lack of Social and needs analysis.
Ubani and Ononuju (2013)	▪ Ineffective project planning, and cost control; ▪ Corruption and communication gap among project personnel; ▪ Frequent changes in political power; ▪ Mode of financing for completed work; ▪ Degree of precision in this initial contract; ▪ Inadequate project formulation; ▪ Poor cost estimates; ▪ Militancy and youth restiveness; ▪ Land and legal disputes.
Ihuah and Benibo (2014)	▪ Payment remittance delay; ▪ lack of adequate fund allocation; ▪ leadership instability; ▪ Inconsistence in government policies; ▪ Unplanned urbanization; ▪ Project management Incompetence; ▪ Lack of stakeholders Involvement; ▪ Improper project budgeting;

	▪ Lack of proper need assessment; ▪ Bureaucratic bottleneck; ▪ Scope changes; ▪ Materials increasing costs and lack.

A central theme that has been consistently reported in all these studies, as responsible for the particularly dismal performance of public projects in Nigeria, is funding shortfalls, typically expressed as cost-overruns.

2.10 What Underlying Factors Specific to Highway Projects in the Niger Delta?

Cost overruns of significant proportions, much higher than in other parts of Nigeria have being reported by past development boards in the Niger Delta region, as the fundamental reason for the very high level of road project delays and abandonment, historically chronicled in the literature (NDES, 1997). Aiyetan (2010) listed geographic and environmental factors as one of the reasons why causes of delays and project abandonment differ. The highly variable and contrasting physical landscape of Nigeria, specifically the peculiarities in terms of geography and ecology has thus being asserted as further negatively influencing project delivery in the Niger Delta (Oguara, 2002; Ngerebara *et al*., 2014).

A survey of the local literature (NDES, 1997; Okon, 2009; Joseph, 2012; Sunjka and Jacob, 2013; Ihuah and Benebo, 2014) specifically focused on investigating the causes of project delays and abandonment in the Niger Delta, listed the following factors, which though evident in Nigerian projects are more peculiar to the Niger Delta: Typically issues due to lack of skilled personnel and technical experts; Gross underestimation of cost; Inadequate site and project information; Vulnerability to ravaging environmental (flood and erosion) related disaster; Colossal waste of resources due to late identification and resolution of design and specification errors; Adverse weather condition; Inaccessibility and geo-hazardous impassable terrain to the project site, were stated as distinctive features more peculiar to the Niger Delta. Andawei (2015) further developed a risk factor ranking, in order of their degree of impact, and concluded that inadequate design specification, a key technical responsibility of the client organization, had the highest impact in causing delays and abandonment in the Niger Delta.

It is noted that most factors enumerated, are closely aligned with the physical configuration of the region, as well as technical issues emanating from the highway agencies. It was thus provisionally assumed that these are the primary factors leading to the unusually high cost overruns, which have continued to plague highway project delivery in the Niger Delta region, and resulted in the immense waste of the significant financial resources, pumped into highway development by government. Oguara (2002:5), had also made a similar observation 14 years ago, and commented that: "*investments on roads in the Niger Delta region are not based on an understanding of the geotechnical problems which can arise during construction, considering its inherent typical deltaic soils of the humid tropics*". Furthermore, several recent engineering-geological research focused on the development of infrastructure in the Niger Delta, have consistently advocated for road construction to be scientifically rooted in an understanding of the terrain and its geotechnical intricacies, requisite for the management of funds currently being invested in highway development (Youdoewei 2013; Ngerebara *et al*., 2014; Otoko and Precious, 2014). The researcher thus hypothesised that: *Apart from other issues identifiable with public sector projects in Nigeria, more profound geotechnical issues, which are not adequately catered for by the highway agencies, makes highway delivery in the Niger Delta region prone to excessive cost overruns.*

2.11 Chapter Summary

This chapter has taken a chronological, holistic and analytic perspective to investment in highway development in Nigeria, with particular emphasis on past developmental efforts specific to the Niger Delta, in recognition of its physical environmental constraints. The key findings from the background literature analysis in this chapter are thus:

- The historical antecedents to investment in highway development in Nigeria, and specific to the Niger Delta, as a retrospective background to the current state of highway project delivery in the region;

- The prevalence of project delays and abandonment in the Niger Delta (past and present), and the severity of their impact, evident in the current state of infrastructural backlog in the region;

- The significant causes of project delays and abandonment in Nigeria, within the wider context of developing countries, and the peculiar technical factors notable in the Niger Delta region;

- The rationalisation that more profound practise based geotechnical issues, rooted in the geologic setting of the Niger Delta, beyond the generality of factors commonly reported in the literature as endemic in Nigeria’s public project delivery, may be fundamental to the prevailing menace of incessant delays and abandonment, leading to excessive cost overruns in highway projects executed in the region.

It is the researcher’s belief, that to understand why delays and project abandonments leading cost overruns, are amplified in the Niger Delta region, would require an in-depth understanding of the geotechnical practice based underpinnings of these negative manifestations, within the highway agencies responsible for project delivery. As such providing an insider perspective, within the distinct organisational dynamics of the three regional and state highway agencies, currently responsible for highway infrastructural development in the geologic setting of the Niger Delta region, constituted the over-arching theme of the fieldwork analysis in this study. The fieldwork thus centred on investigating whether the technical requirements and relevant geotechnical best practices, which should logically be adhered to, as strategies, requisite to manage the high level of financial risk inherent in the wetland terrain of the Niger Delta, are adhered to. However, before these practice based issues are investigated, the subsequent chapter, critically analyses the theoretical perspectives in the scholarly literature, which explains the variables which trigger the phenomenon of cost overruns in highway projects.

CHAPTER 3

Establishing the Explanatory Roots of Cost Overruns in Highway Projects: A Critical Theoretical Analysis

3.0 Introduction

Baccarani (2004) emphasises that the cost performance of construction projects is often identified as a fundamental measure of success for project sponsors. Yet against this, a large number of construction projects documented in the public domain, have been censured for notoriously running over their original budget estimate. A practical index used for the evaluation of the level of accuracy of estimates is cost overrun (Bordat *et al.*, 2004; Cantarelli *et al.,* 2010). Cost overrun is the excess amount of money expended at the conclusion of a project, in excess of the initial projected cost figure. As shown in Table 3.1, Tan and Makwasha (2010) stated that there are three possible scenarios, where '*ex ante'* (budgeted) cost figures either match or do not match '*ex post'* (actual) final accounts.

Table 3.1: Cost Estimation Scenarios

Ex ante = Ex post	Ideal
Ex ante < Ex post	Under-estimation of funds leading to fund shortage
Ex ante > Ex post	Over-estimation of funds leading to fund surplus

Source: (Tan and Makwasha, 2010)

The ideal scenario, stated by Tan and Makwasha (2010), is where there is equality of *ex-ante and ex-post,* this, Tan and Makwasha attest is what every project should strive to achieve. However, this is rarely achieved, as most construction projects tend to significantly overshoot their initial budgets leading to delays, contractual problems, and in the worst case scenario, abandonment. Overcoming cost overruns has remained a major challenge for highway agencies. The consequences of cost overruns in highway projects has led some to question the efficiency of public highway commissioners through the developed and developing world, leading to questions about the ability of such organisations to initiate and deliver highway infrastructure projects. Cost overruns in highway projects thus remain a topical issue, with the media, technical press, and scholarly literature, rife with publications analysing cost overrun trends, identifying their primary causes, and offering broader explanations for this pervasive trend. This chapter reviews the literature on the problem of cost overruns in construction projects, and specifically in relation to their explanations in public highway projects.

3.1 Cost Overruns Statistics in Construction Projects

Cost overrun trends in construction projects are evident in the literature, across national boundaries. On the UK construction industry, the Egan report (1998), one of the most widely referenced reports on the cost performance of the construction sector, showed that no less than 50% of projects ran over their initial budget. Within the same time frame in the United States, the General Accounting Office (1997) stated 77% of projects experience cost overruns, with some recording astronomically high levels of over 200%. According to the National Audit Office (2012), the cost profile of the London Olympic Stadium crept up from £2.4 billion in 2005, to £8.9 billion in 2010. Whilst Ahiagu Dugbai *et al.* (2014) presented some of the spectacular historic cases of excessive cost overruns recorded in building projects in the UK and Australia, as shown in Table 3.2.

Table 3.2: Historic Cases of Cost Overrun in Construction Projects

Project	Location	Estimated Cost (in millions)	Final Cost (in millions)	% Overrun
Sydney Opera House	Australia	A$7	A$102	1357
Nat West Tower	UK	£15	£115	667
Scottish Parliament	UK	£195	£414	112
British Library	UK	£142	£511	260

(**Source: Ahiagu Dugbai *et al.*, 2014**)

Yet, Ahiagu-Dugbai *et al.* (2014), further espoused that such unusually high levels of cost overruns were still being reported in recently completed construction projects. For instance, they cited the case of an Australian programme where 20 capital intensive projects, some of which were still ongoing, had exceeded their initial budgets, by a total of A$3.275 billion. Whilst the European Central Bank's new 45-storey glass and steel sky scraper headquarters in Frankfurt, Germany had by 2012, exceeded its estimated cost of £420m, by more than 100%, with a final account of £960m (BBC, 2012).

Several notable highway projects have been shown in the literature to have also experienced cost overruns of significant proportions (Flyvbjerg *et al.,* 2002; Odeck 2004; Creedy, 2006). Creedy (2006) reported that in the United States, a central artery tunnel project located in Boston, and popularly referred to as '*The Big Dig',* was revealed to have incurred a significantly high cost overrun of over 600%, and attracted negative media exposure, resulting in derision from both the press and general public. The initial estimated figure of US $2.6 billion in 1982, was shown to have escalated to above US $14 billion, by 2002. The Edinburgh Trams project in Scotland has also been reported to have already far exceeded its initial budget by £400 million, from the budgeted amount of £375 million (Ahiaga-Dagbui, 2014). Creedy (2006) reported that in Australia, under the Queensland government's Road Implementation Program, most projects estimated at more than one million dollars had significantly exceeded their initial estimates.

The Transport and Road Research Laboratory (TRRL, 1998) in investigating the phenomena of cost overruns in developing countries, revealed an equally large range of cost overruns above 50%, for six out of twenty-one projects carried out. Three projects experienced overruns ranging between 20 to 50%, whilst four projects experienced overruns in lower ranges of 10 to 20%. Two of these projects were however in an upper range of 100 to 500%. The African Infrastructural Country Diagnostic (AICD, 2008) studied the performance of road infrastructure investment budget focusing on twenty-four countries in Sub-Saharan Africa and found ranges of up to 700% evidenced in some of the analysed contracts. Morris (1990) reported that cost overruns recorded in India, for 189 out of 290 medium and large projects, ranged between 0 to 961%, with the majority averaging 80%, even after adjustment for increase due to high levels of inflation.

Cost overruns, evidently appear to be persistent in all public construction projects, in the developed and developing world, and has maintained a steady presence. Flyvbjerg (2002, 2004) as well as a host of other scholars have opined that the situation is worse in transportation projects, and that on the average highway agencies record significantly high levels of cost overrun compared to other clients of construction works (Baccarani, 2004; Tan and Wakmasha, 2010; Asmar *et al.,* 2011).

Several empirical studies in the literature show that time and costs are often exceeded by a significantly high margin for highway projects (Flyvbjerg *et al.,* 2002; Bordat *et al.,* 2004; Baccarini, 2004). Flyvbjerg *et al. (*2002) revealed that on a global scale, cost overruns remained consistently high, for major transportation infrastructure projects. Flyvbjerg *et al.* (2002) revealed that of 258 infrastructure project costs sampled worldwide worth $90 billion, with nine out of ten experiencing cost overruns. Cost overruns, were on average, 34% for tunnels and bridges, and 20% for road projects. Flyvbjerg *et al.* (2002:290), consequently asserted: "*Over the past 70 years no tangible improvement has been evidenced in the accuracy of cost estimates"*.

In contrast, Odeck (2004) analysed cost overruns for road construction projects in Norway, revealing an average of 7.9%, and a range of underruns and overruns from −59% to 183% for 420 road projects. Odeck 2004, further noted that the trend in cost overruns was relatively higher for smaller scale road projects than in large scale projects. This finding had earlier being upheld by Morrison (1990), from a study in India. Cantarelli *et al.* (2012), analysed several studies, highlighting the discrepancies in reported levels of cost overruns for different countries, which was attributed to the benchmark phase from where the cost overrun was being measured. It was stated: *"Different studies use different moments for the year of decision to build and the year of completion as the basis for the estimated and actual costs, and hence the extent of the cost overruns differs"* (Cantarelli *et al.,* 2012: 51). The authors further noted that:

> *"In the literature on cost overruns, hardly any attention is given to the project phases… literature has focused on identifying cost overruns but the moment when projects are most vulnerable to cost increases has not been studied. This is however of the utmost importance because it could improve our understanding of cost overruns considerably. … will help to distinguish between different explanations of cost overruns"* (Cantarelli *et al.,* 2012: 51).

In response to this identified gap in the literature, the subsequent section analyses the developmental phases of highway projects, in relation to the critical phase that primarily propagates cost overruns, prior to delving in-depth into various explanations of cost overruns proffered in academe.

3.2 Cost Overruns in Highway Projects: What Critical Reference Phase?

Cost overrun is measured as actual out-turn costs, minus estimated costs, as a percentage of estimated costs (Creedy, 2006). Actual costs are defined as: "*real, accounted construction costs, determined as being expended from the point of contract award, to the time of project completion* (Flyvbjerg *et al.*, 2002: 285). "*Estimated costs are defined as budgeted or forecasted construction costs determined at the time of the decision to build"* (Cantarelli *et al*., 2010). Cantarelli *et al*., (2010), equally affirmed, that the estimate designated by highway authority, based upon which the decision whether or not to implement the project, becomes increasingly changed, to the estimate based on which a formal contract is awarded, and up to point of project completion.

On this note, the literature shows a strong and still on-going debate on the basis to be used for estimating the level of cost overruns. Principally, project promoters are averse to the adoption of the initial phase of highway project development, which represents the '*time-of-decision-to-build'* as a benchmark, on the premise that it constitutes an unfair basis for such assessment (Simon, 1991). This is against the backdrop of the established fact that very early estimates exhibit the greatest amount of uncertainty (Oberlender, 1998; Schexnayder *et al*., 2003). Figure 3.1 shows the distribution pattern of estimated costs, in development phases around the final costs, as projected by Schexnayder *et al.* (2003).

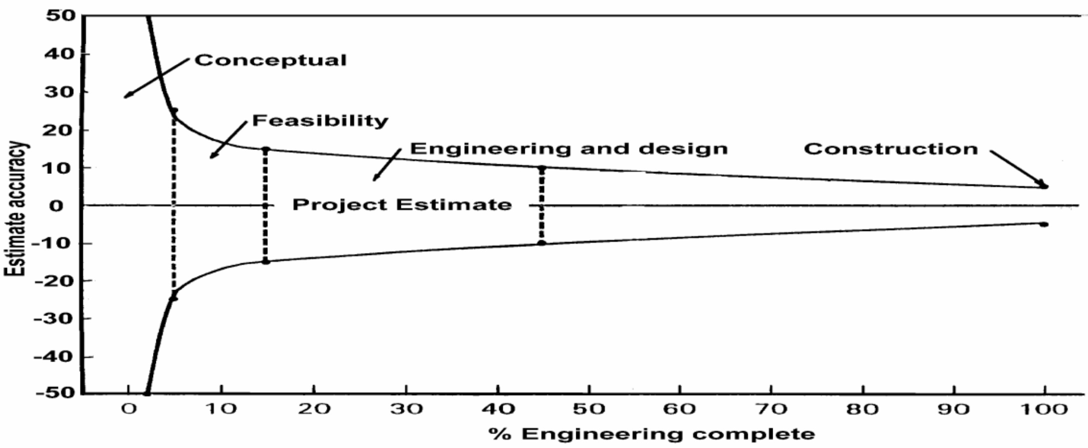


Figure. 3.1. Typical Bounds of Estimate Accuracy in Project Development Phases

(Source: Schexnayder *et al.*, 2003).

Schexnayder *et al.* (2003) stated the plus or minus 40 percent confidence range, typically dispersed monotonically around the mean, for estimates generated at the conceptual phase, reflects the lack of definite project information. Odeck (2004) was of a similar view, as Simon (1991), and supported this stance stating that the estimate generated at the detailed design and specification should be the basis on which planning approval and funding for projects ought to be sought. This argument was raised in view of the practice of parliament in the Norwegian context. Odeck (2004) recognized the highly challenging situation, often resulting from project cost underestimation at the planning stages and outline proposal phases, presented to the decision makers. Odeck (2004) asserted that decision makers in evaluating the viability of projects are misled, and will therefore base funding approval on this deceptive basis. Odeck's (2004) argument was thus that at the detailed design, the actual viability of a project will be known, and noted early enough by the decision makers who can then resolve to choose one of the following three alternatives:

- Not to implement the project at all;
- To implement the project in another form;
- To implement other project or projects.

Odeck (2004), thus concluded, the detailed design stage should in effect be considered as the critical estimate phase, to be logically used for assessing the level of cost overruns.

Several other authors have however argued otherwise, stating that the initial conceptual estimate is the most crucial estimate which should serve as a bench mark for assessing the level of cost overrun (Chou, 2005; Anderson *et al.*, 2006; Creedy, 2006; Cantarelli *et al.*, 2010; Asmar *et al.*, 2011; Tan and Wakmasha, 2010). Asmar *et al.* (2011), states that an estimate at this stage is ideally needed to provide information to highway agencies on which to base approval and funding decisions, as well as to establish a project baseline cost and budget. It was also noted by Sabol (2008), that the conceptual estimate represents the first point of effort made at assessing the potential cost of a project necessary to align decision-making. Along similar lines of argument, Flyvbjerg *et al.* (2002), in furtherance of the assertions of Wachs (1989:4) almost three decades ago, provided a strong justification for this stance, stating:

> *"When the focus is on decision making, and hence on the accuracy of the information available to decision makers, then it is exactly the cost estimate at the time of making the decision to build that is of primary interest. Estimates made after the decision to build are by definition irrelevant to this decision".*

The argument of these authors was rationalized on the following grounds:

- The impossibility of assessing how informed the basis for decisions are and the uncertainty associated with budgets;
- The deliberate concealment of project details and facts likely to reflect the true financial implications of a proposed project, termed as '*Salami tactics'*;
- The need to have a uniform platform for consistent comparisons of projects.

Flyvbjerg *et al.* (2002) noted that this preliminary phase was also used for computing cost overruns as the international standard. In line with these assertions, Evans and Peck (2008:18), further went on to state that:

> *"The cost estimate produced at the preliminary phase is the first cost estimate in the life of a project that should be able to be relied upon for program purposes and taken forward through future phases".*

This was stated against the background of the Australian context, whereby for government funded projects, budgetary allocation has to be voted out for a project after the identification of the proposed scheme from annual development budget. Schexnayder *et al*. (2003:8) also reiterated that:

> *"Initial cost estimates are more useful in determining funding levels needed for long-range capital programs. This quantification of cost is the initial figure that allows the project to proceed to the next phases for final design and construction".*

Turouchy *et al.* (2001), further stated that it is often thought of as the first estimate used for budgeting purposes and allocation of funds by highway agencies. Chou (2008), emphasized, the conceptual phase of cost estimation should be conceived as the most significant starting process, to influence the fate of a new transportation project.

Most of the studies in scholarly literature, as summarized in Table 3.3, adopt this initial estimate as the basis of cost overrun evaluation, convergently emphasizing the need for ensuring accuracy and supporting their stance with very sound and logical arguments.

Table 3.3: Perspectives on Critical Cost overrun phase

Authors	**Adopted Stance**	
	Conceptual Phase	**Design Phase**
Hall (1980)	#	
Simon (1991)		#
Turouchy *et al.* (2001)	#	
Flyvbjerg *et al.* (2002)	#	
Phaobunjong (2002)	#	
Schexnayder *et al* (2003)	#	
Odeck (2004)		#
Donnell (2005)	#	
Evans and Peck (2008)	#	
Tan and Wakmasha (2010)	#	
Asmar *et al* (2011)	#	

The multiplier impacts of inaccurate conceptual estimates, were further used as a case for supporting their arguments. It was asserted that on the flip side, very high conceptual estimates above the likely costs would mean insufficient funds for sponsoring other development schemes (Donnell, 2005**;** Tan and Wakmasha, 2010). This scenario, where budgeted figures are greater than the actual project costs, would imply an under-expenditure, resulting in fund carry-overs between financial years, and consequently funds not being efficiently utilized by the agencies. (Belli *et al.,* 2001). The Freiman curve in Figure 3.2, describes the scenario of over-estimation as self-fulfilling prophecies.

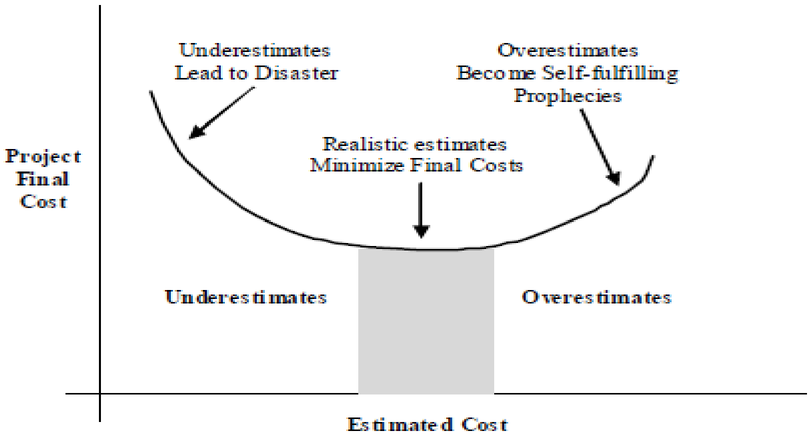


Figure 3.2: Freiman Curve Showing Estimating Scenarios (Source: Phaobunjong, 2002)

Conversely, very low estimates leading to the pervasive trend of cost overruns, would imply that adequate funds are not voted out for a scheme, and the progress of works would be stalled due this shortfall. Cusworth (1993) was of the opinion that the bureaucratic challenge associated with gaining further approval of funds, which is a consequence of the '*functional nature of public service institutions'* will therefore slow down the pace of project completion. Cusworth (1993), outlined the various phases that budgetary shortfalls, emanating from inaccurate conceptual estimates have to go through, before they can be accommodated in future budgets (Figure 3.3).

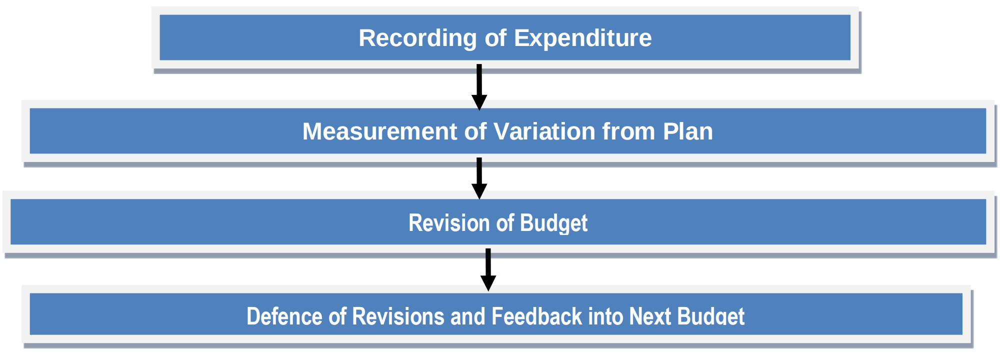


Figure 3.3: Budgetary Implementation Phases (Source: Cusworth, 1993)

As such, the bureaucracy associated with gaining further budgetary approval, requisite to accommodate such cost overruns, can lead to lengthy delays. One of the earlier authors in the literature, Hall (1980:34), in congruence with the Freiman curve, asserted that:

> *"Most of the planning disasters experienced in highway projects seem to be rooted with under-estimates at the preliminary phase".*

For a transportation agency, Alavi and Tavares (2009) thus posited that inaccurate conceptual estimates can lead to adverse consequences, including the:

- Disruption of plans, postponing, or cancelling scheduled projects to satisfy budgetary constraints;
- Reductions in project scope, resulting in projects that do not fully provide the service initially intended;
- Extensions in construction duration until additional funds become available.

Alavi and Tavares (2009), opined, an eventual misallocation of design resources, thus creating false expectations with the public and other stakeholders, is inevitable. This is because any upward increment in the budgeted figure set aside for a project, would mean a corresponding deduction from funds voted for other projects. It was reported that in 2002, the Virginia Department of Transportation (VDOT) had to postpone or cancel 166 projects due to lack of funding, occasioned by cost overruns incurred on other projects (Turouchy *et al*., 2001). The UK Treasury (2013) in recognition of this pervasive trend, issued supplementary guidance to the Green Book, which advocates increasing conceptual estimates for standard civil engineering projects by between 3% and 44%.

Considering the multiplier impact of cost overruns in public projects, and the significant waste of resources associated with this global phenomenon, this study identifies the need to provide an explanatory basis for cost overruns/underestimates experienced in highway projects, traced from the initial conceptual phase.

3.3 Explanations to Cost Overruns Rooted in the Conceptual Phase of Public Projects

Various events occurring from the initial phase, and along the subsequent phases of construction projects, provide explanations about a budget's dynamic history (Love *et al*. 2012; Ahiagu-Dugbai *et al.* 2014). An extensive range of articles have been written on this basis overtime, listing factors, and offering various technical and theoretical explanations for this dynamism (Hall 1980; Wachs, 1987; Morris 1990; Mansfield *et al*.,1994; Flyvbjerg *et al*., 2002, 2004; Baccarani, 2004; Bordat, 2004; Odeck, 2004; Kaliba *et al*; 2008; Akoa, 2011; Ahiaga-Dagbui *et al.,* 2014; Ubani, 2015). Some studies have attempted to generate a typology of explanations and domains for classifying cost overrun factors, and rightly labelled issues of inaccurate estimates, geotechnical factors, and errors under the umbrella term of 'Technical Explanations' (Cantarelli *et al*., 2010;

Allahahium and Liu, 2012). This is relative to 'Theoretical politico-economic and psychological explanations', which have proliferated in the literature, based on the pioneering works of both Kahneman and Tversky (1979), and Wachs (1989). Three interwoven theories: planning, decision-making and forecasting theories, have learnt credence to these technical and theoretical explanations (Cantarelli *et al.,* 2010). These theories are rooted in the cognitive dynamics of estimation, planning, decision and policy making by people in institutional setting under high levels of uncertainty, and how this leads to the various successes and failures of projects.

Technical explanations are founded in the fundamentals of best practice, which emphasize the need for adequate pre-contract preparation, via planning by clients before the execution of projects as a basis of reducing the impact of cost overruns in public projects (Brunes and Lind, 2015). Higher levels of initial preparation for projects have thus being logically inferred as inversely correlated with lower cost overrun values (Tan and Wakmasha, 2010). Technical explanations thus rely primarily on forecasting theories to explain cost overruns (Cantarelli *et al*., 2010). This is based on the need to project costs into the future as opposed to present values and occurrences. Slaughter (1995) commented that that there is nothing more certain than the unpredictability of the future. This paradox is descriptive of cost estimation particularly at the conceptual phase of project development, when only hazy and poorly defined details of project are available (Chou, 2005). Due to the fact that project attributes are often un-identical, experience and judgement will have to play a significant role in approximating future occurrences, attributed to the complex and ill-defined nature of construction process, leading to estimates often fraught with inaccuracy. Al-Tabtabai (1998:259) thus asserted the basic assumption underlying cost overruns is:

> "*The assumption that the future is indistinguishable from the past, except for the specific variables identified as affecting the likelihood of future outcome. Accordingly, a forecast should only rely on past performance predictions as long as the pattern of changes in the environment is steady*".

Forecasting related theories thus seek to better explain the build-up of errors unwittingly made due to inappropriate forecasting (Mackie and Preston, 1998; Cantarelli *et al*., 2010).

However, several other studies have argued that technical explanations are insufficient to account for the level of cost overruns often experienced in publicly funded projects. This has given rise to a plethora of theoretical explanations in the literature (Wachs, 1989; Bruzelius *et al*.

2002; Flyvbjerg *et al.*, 2002, 2004, 2008; Cantarelli *et al.,* 2010). Most of these explanations, as articulated and synthesised by Cantarelli *et al.* (2010), relate to non-technical factors, conceived as having a domineering influence on the occurrence of cost overruns in highway project estimates. Cantarelli *et al.* (2010), in examining the theoretical embeddedness of non-technical explanations, within existing theories of human behaviour and management, expounded that these class of explanations are derived from the theories of planning and decision making within organisations. Decision and planning theories often play out the dynamics of political and economic considerations, in the allocation of financial resources, as explanations of the outcome of a decision-making process. (Wachs, 1989; Cantarelli *et al.*2010). Cantarelli *et al*. (2010:793) cited such terms as "entrapment", "sunk-cost effect" the "knee-deep-in-the-big-muddy" effect and the "too-much-invested to-quit" effect, as used in previous research, which *refer to the "over-commitment of decision-makers to an ineffective course of action*". Path inefficiency and dependency, is thus induced due to deliberate or optimistic decision or policy making, implying the presence of an outcome that would have paid off better.

3.4 Technical Explanations

Several factors have been identified in the literature, as accounting for cost overruns in construction works (Chang 2002; Lo *et al*., 2006; Kaming *et al*., 1997; Memon *et al*., 2011). Typically, most studies have identified technical risk and uncertainty related issues in all forms of construction works, which lead to cost overruns:

- Design in terms of client related changes, incompleteness, or incorrectness of information;
- Estimating and financial risk containment methods;
- Managerial incompetency and team work related factors;
- Time constraints and delays;
- Unexpected ground conditions;
- Organisational;
- Skills related;
- Contractual and procurement related;
- Exogenous variables.

Scholars from developing countries, in Asia (Morris 1990; Long, *et al* 2004) and Africa (Aibinu and Odeyinka, 2006; Kaliba, *et al.,* 2008; Mansfield *et al*., 1994: Ubani, 2015), in addition to these commonly listed factors, have also listed issues with the sourcing of imported building materials;

payment inconsistency by highway agencies; high inflationary trend leading to the soaring of material prices, and lack of technical skills, as accounting for higher cost overruns. The average cost overrun found by Morris (1990) in a study of highway projects in India was 82%. Price escalation due to inflation over lengthy delays in the implementation of public sector projects in developing countries accounted for 20 - 25% of cost overruns, while the complementary 75 -80% were attributed to lack of planning foresight and technical factors.

However, Lundmark (2011), Tan and Wakmasha (2010) and Brunes and Lind (2014) have identified the pre-contract phase of project preparation, as having the dominant impact on the level of cost overruns in transportation projects. Tan and Wakmasha (2010) attributed the significantly higher levels of cost overruns experienced in highway projects to the complex nature of infrastructure projects, which often creates a propensity of projects to run over budget. They opined that the accuracy of estimates is affected by uncertainties and risks inherent in projects. Inaccuracies in the assumptions or technical data used as inputs to cost estimating at the pre-contract phase, was posited to be a major source of risk in projects, leading to cost overruns. Incompleteness of preliminary designs, engineering uncertainties and quantity surveys, inadequate site investigation of project locations, are some of the technical factors evident at the pre-contract phase, which trigger off post contractual issues leading to cost overruns.

Evans and Peck (2008) were of the opinion that the diverse range of project types in the engineering field, including highway projects, which require cost estimates, necessitated formal estimating skills apart from the technical knowledge, and the '*on the job training'* acquired by engineers in organisations. This was compared to the building sector, serviced by the quantity surveying profession, which subscribes to standards set out by the relevant professional bodies. As such the engineering background of, and the methodologies used by most estimators in highway agencies, which provided the technical know-how, were described as being insufficient to generate accurate estimates.

Some other authors (Ogunlaya, 1989; Baccarani, 2004 and Sodikov, 2007), have also emphasized on the deficiencies in the approaches used in estimate preparation by highway agencies. These authors were of the opinion that it is the estimating methodologies and technical details used in generating estimates, that basically influence the accuracy of construction estimates. Inaccuracies in the assumptions or technical data used as inputs, thus form a major source of risk in project cost estimation for highway projects. Turouchy *et al.* (2001), Evans and

Peck (2008), Romero and Stolz (2009), as well as Tan and Wakmasha (2010), reiterated that early estimates, were often based on judgment, expertise, and experience, and less on rigorous technical investigations. Thus, as the project is developed, inconsistencies in the estimating method often led to marked differences in subsequent estimates.

Young (1996), Chapman and Ward (1997), Creedy (2006) and Smith *et al*. (2006) views of cost overruns, emphasised the multiplicity of risk in projects, which they assert often lead to financial/economic loss, thus curtailing the realisation of project cost objective. Chapman and Ward (2006) extensively discussed the nature of the technical risks inherent in highway projects, and the need for adequate risk management and containment in project preparation, to subvert cost overruns. Whilst, Smith *et al*. (2006) stated, that in construction works, the output performance indices of time, cost and quality, are subject to risk and uncertainty, as the nature of highway construction works involves a high level of uncertainty, with a wide range of risk factors established as fundamentally affecting the accuracy of highway project cost estimates.

The views of both Chapman and Ward (1997) and Smith *et al*. (2006), are further corroborated from a predominantly engineering perspective by the technical press. The body of literature on geotechnical risks underscores that irrespective of projects details, ground condition is a factor that has to be contended with in highway projects, and accounts for higher levels of cost overruns, due to the more complex interfaces of transportation projects with the ground. (ICE, 1999, 2001; Whitman, 2000; Clayton, 2001; Venmans, 2006). The United States Department of Transport (USDOT, 2002: 23) in recognition of this, used the maxim: "*all transportation projects are carried on earth, with earth or in the earth*" to emphasize the importance of ground conditions in the construction of highway projects. Rao and Ranade (2013:58) thus stated that:

> "*In the early stages of large infrastructure projects, a significant proportion of the risk exposure comes from the unknown unknowns. These may derive from complex interfaces with the physical environment into which the infrastructure is to be built such as the route of the transport link*".

The Institution of Civil Engineers (ICE, 2001:12) equally underscored this, and further drew attention to the paradox that:

> "*Ground conditions constitute the highest element of risks in construction works, yet it is the element of construction work about which much remains to be known*".

The ICE (2001), further explained, that this is largely due to the fact that, unlike material requirements in construction which can be specified, ground conditions are predetermined and therefore beyond human control. Figure 3.4 represents the circle of concern on matters relating to ground conditions, showing the circle of influence for factors that can be controlled and exogenous ground related variables that can only be controlled within the limited decision interface.

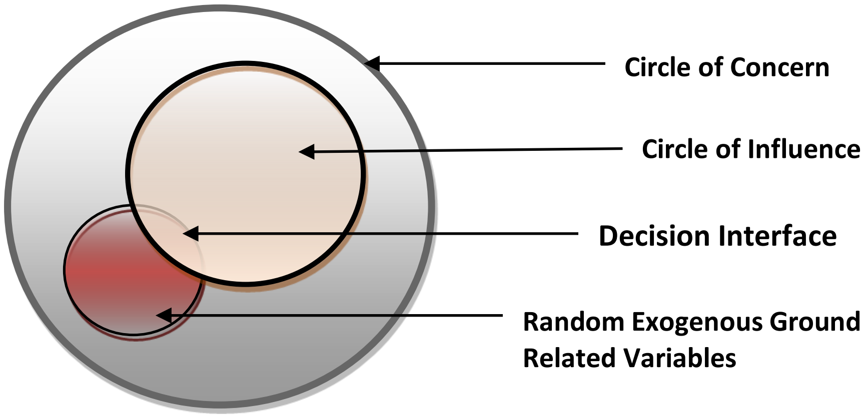


Figure 3.4: Circle of Concern for Ground conditions (Source: ICE, 2001)

Along similar lines, Clayton (2001) stated that issues relating to ground conditions therefore need to be clearly defined early on in the project, resolved at the pre-tender stage, and not allowed to spill into the contractual and construction phase, if significant cost overruns are to be avoided.

3.5 Theoretical Explanations

Various other perspectives on why cost overruns are so pervasive in highway projects have been expressed in the literature. This class of explanations seek primarily to disprove technical explanations, based on suspicions of unethical practices, deception, delusion and attitudinal issues of public officials in highway projects (Wachs, 1987; Flyvbjerg *et al*., 2002; Cantarelli *et al.,* 2010). The term theoretical explanations, is thus used in this study to tag the schools of thought, which mostly rely on applying existing theories on human behaviour (Optimism bias/delusion, psychological stereotyping, rationality of decision making with the goal of utility maximisation, and politics), to understanding why public projects run over budget (Cantarelli *et al.,* 2010). These perspectives however, are not clearly differentiated, often overlapping in the literature. Nonetheless, two distinct arguments can be discerned: psychological uncertainty/optimism bias and deliberate deception/strategic misrepresentation, which are argued from economic and political realms. Theoretical explanations which focus on the conscious manipulation of power and influence to foster self-interest, adopt the Machiavellian theory or agency theory of power and influence in decision making (Cantarelli *et al.,* 2010). Psychological explanations on the other hand build on the sub-conscious aspects of human behaviour, via the fundamentals of optimism bias and stereotyping of public projects (Hall, 1980; Kahneman, 1994; Mackie and Preston, 1998; Flyvbjerg *et al*., 2002; Cantarelli, *et al*., 2010, 2013).

3.5.1 Psychological Explanations

This school of thought espouses that psychological uncertainty and human decision making, relating to a reliance on heuristics and optimism bias are causing the problem, a finding strongly reinforced by the UK Treasury (2013) who issued supplementary guidance to the Green Book dealing specifically with optimism bias. Psychological explanations are upheld by a limited number of studies who resort to deploying theories of psychological stereotyping of public projects as being inherently poorly managed; planning fallacy and optimism bias. Planning fallacy was described by Cantarelli *et al.* (2010:15) as: "*the tendency to underestimate time, costs and risks of future actions, and at the same time overestimate the benefits of the same actions'*. Whereas optimism bias, was defined as: "*the systematic tendency to be overly optimistic*" Cantarelli *et al.,* 2010:10).

Explanations of inaccurate forecasts and estimates, in terms of optimism bias and appraisal optimism, have been largely developed by Kahneman and Tversky (1979a, 1979b), and later Kahneman (1994), based on experimental psychological research in the field of economics. Based on the outcome of the experiment, with students as participants, Kahneman and Tversky (1979a, 1979b) generated theories on the overly optimistic tendency of human judgment, wherein risk was subconsciously downplayed, while potential benefits were overblown. Such optimism was opined as constituting a hindrance to the need for thorough planning in project preparation. These results by Kahneman (1994) were theoretically applied by Flyvbjerg (2008:18) to explain cost overruns in transportation projects, by asserting that they were key issues in policy and planning: whereby promoters and planners make investment decisions based on highly inaccurate and biased judgements, leading to combination of underestimated costs and overblown demand forecasts. As such cost-benefit analyses, based on which investment decisions were made, were tagged: "*the consequence of inaccuracy to the second degree* "(Flyvbjerg, 2008:19).

Hall (1980) also articulated that the high element of uncertainty in public works, which are mostly large scale, and challenging to manage, as likely to account for significant disparity in the levels of cost overruns between public and private investments. Hall distinguished between three categories of uncertainties, relating to the planning phase of public projects, which significantly impact on investment outcomes: uncertainty in the planning environment; uncertainty in related decision areas and uncertainty about value judgments. Uncertainty in value judgements was contextualised from the viewpoint of how society perceives the delivery of the output of public and private goods, and how this relates to planning failures. Hall (1980), concluded that psychological reasons accounted for why public projects have often been undertaken on a faulty investment premise, which has typically threatened the viability of a notable number of public projects. This conclusion was drawn, solely based on an empirical study, which identified cost overrun ranges to be significantly higher in public works, as compared to private works.

Flyvbjerg *et al*. (2004) however questioned the validity of this physiological stereotyping, which perceives public proprietorship as inherently challenging, in direct contrast to the assumption of efficiency of private ownership, in curbing cost overruns. This was based on an analysis of variance between a sample of projects subdivided into public, private and state owned enterprises. The result showed that public projects as compared to private projects did not show any significant difference in cost overruns. However, state owned projects, which were subject to closer public scrutiny, regulatory statutes and accountability evidenced lower cost overruns. The authors thus concluded that the roots of cost overruns were more complex than the perceptions of public proprietorship asserted by Hall (1980), further questioning the ethics of public officials. Ganuza (2003) also noted this trend and tries to account for the perception of public agencies, considered as incompetent, from the perspective of the deliberate scant attention often given to design details before contract award, as a form of strategic behaviour calculated to stimulate cost overruns.

Along this continuum in the evolution of interesting psychological explanations, and theories based on the applied logic of optimism bias and planning phallacy, none of which have provided any form empirical evidence to validate their assertions about public infrastructure projects, thus emerged the theories of strategic misrepresentation, as depicted in Figure 3.5. This latter school of thought laid the blame for cost overruns in infrastructure projects on public officials, who were accused of deliberately misrepresenting facts when seeking for funding approval. According to

Flyvbjerg (2008, p 3), *"Optimism bias and strategic misrepresentation are both deception, but where the latter is intentional, the first is not, as optimism bias is self-deception".*

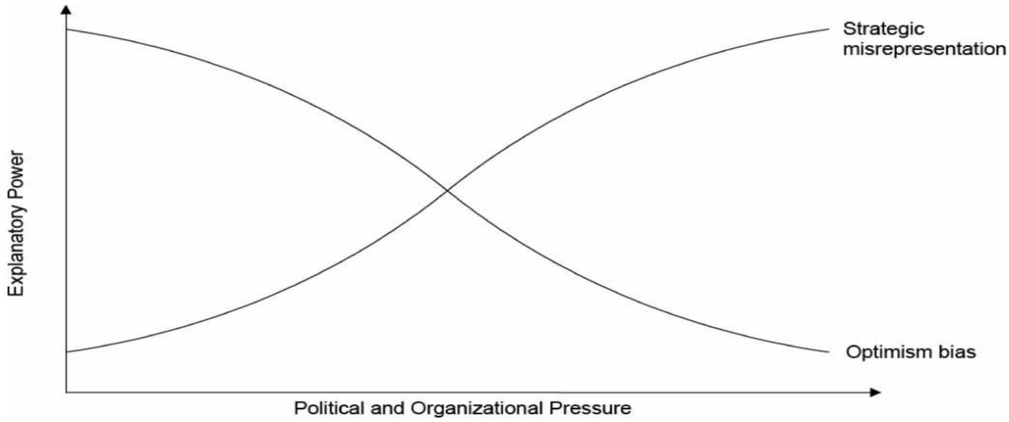


Figure 3.5: Explanatory Model of Cost overruns by Flyvbjerg (2008)

Mackie and Preston, (1998) also stated that appraisal optimism by overly optimistic promoters and forecasters, could be unintentional or deliberate. This was opined as accounting for cost overruns, and the authors further listed 21 sources of error and deliberate bias in highway projects, which often led to inaccurate forecasts and inflated benefit-cost ratios.

3.5.2 Strategic Misrepresentation

Wachs (1989), the earliest recognised author of theoretical cost overrun explanations, sought to attribute cost overruns to strategic misrepresentation. Indeed, Wachs opined that so called forecasting errors in the planning of transportation projects, were actually orchestrated and deliberate, in a publication titled "*When planners lie with numbers*". Wachs' (1989:67) argued*: 'the competitive, politically charged environment of transportation forecasting has resulted in the continuous adjustment of cost assumptions until they produce forecasts which support politically attractive outcomes'.*

Following the outcome of this earlier study, several authors principally Flyvbjerg set the trail in a line of publications, which sought to disprove technical explanations to cost overruns, on the premise of suspected strategic behaviour of the principal actors in public infrastructure projects. (Flyvbjerg *et al*., 2002 2003; Flyvbjerg, 2005, 2007, 2008; Flyvbjerg *et al*., 2010). In these publications Flyvbjerg and his colleagues built upon the earlier arguments offered by Wachs (1989) by similarly questioning the trend of consistent underestimation in public infrastructure projects, as to whether they were *'error or lies'*. Several other scholars, including Bruzelius *et al*. (2002), Altshuler and Luberoff (2003) and Ubani (2015) have also opined that the non-technical explanations for cost overruns, are more likely to account for the significant variance between budget estimates and the final project outturn value. Arguing from the perspective of strategic misrepresentation, these studies have emphasized the non-technical dimensions of explanation to cost overruns, principally bordering on deliberate deception on the part of planners and politicians. Bruzelius *et al*. (2002:146), attributed cost overruns to "*the rent seeking behaviour of special interest groups, and the tendency to underestimate tenders in order to get proposals accepted"*. Altshuler and Luberoff (2003:34) opined that: "*consistent underestimation is an example of the tragedy of the commons.... as it helps advance specific projects".*

From the perspective of Cantarelli *et al*. (2013), contractors and other parties to a contract may as well be entangled in the complex web of explanations based on deliberate actions, which lead to the build-up of cost overruns in highway projects. The complexity of the interaction was hypothetically explained by Cantarelli *et al*. (2013) by the use of the concepts of '*Game signalling theory*', to better theoretically explain the phenomena of cost overruns. The fundamental precepts of game theory are founded on the tenets of strategic behaviour, bounded in the interactive complexity of game signalling between the principal actors in public projects, namely the contractor and client, who are thus labelled '*Agent*' and '*Principal*' respectively (Cantarelli *et al.,* 2013). Cantarelli and colleagues, mapped out a hypothetical model of how both parties to a contract, anticipate each other's behaviour in setting price margins, during contractor selection and contract award phase of infrastructure projects, in an intricately psychological game of political and economic motives.

Ganuza (2003), had prior to the advancement of the theory of *Game signalling*, forwarded a hypothetical theory of '*Strategic ignorance under imperfect market conditions'* which also bordered on the dynamics of client-contractor relations, in setting pricing margins in the delivery of public projects. According to Ganuza (2003), changes in the designs and specifications during public procurement, accounts for most cases of cost overruns in public projects. This, led Ganuza (2003), to propose a model whereby most public agencies allocate a fixed amount to initial design, which are often altered and renegotiated after contract award, where imperfect conditions are stimulated, by deficiencies in the specifications. As such where contractors are horizontally differentiated, representing a perfect market supply condition, the sponsor feigns strategic ignorance by under-investing in initial design specification, to trigger homogeneity and intense competition. This reduces the comparative advantage of the more efficient contractors, and obtains lower bid values, which in the long run leads to inefficiency and significant cost overruns.

3.6 Critical Empirical Review of Studies Providing Cost Overrun Explanations

The literature in the previous sections, has taken a kaleidoscopic view of the myriad of competing explanations, seeking to understand and elucidate on the fundamental reasons why public projects consistently run over budgeted cost. It is thus probable, that cost overruns in highway projects, may have wider reaching underpinnings, rooted in a variety of technical and non-technical causes, as summarised in Table 3.4.

Table 3.4: Dichotomous Explanations of Cost Overruns in Highway Projects

Author	Technical Explanations	Theoretical Explanations
Kahneman (1979a,1979b)		Optimism bias
Hall (1980)		Poor value judgement
		Societal perception of the delivery of public projects
Wachs (1987)		Inherently and deliberately flawed nature of the forecasting techniques adopted
Hinze and Gregory (1991)	Larger size and complexity Simultaneous nature of execution translating to lower pre and post contract engineering	
Romero and Stolz 1993		
Kahneman, (1994)		Planning Phallacy: combination of Optimism bias and Appraisal optimism
Chapman and Ward (1997)	High level of risks and uncertainties	
Mackie & Preston, 1998	Errors	Appraisal optimism and bias
Clayton (2001)	Ground conditions	
Turouchy *et al* (2001)	Poor preliminary investigation and estimates	
Isakson (2002)	High level of ground related risk factors surrounding transportation projects	Pressure from conflicting interests, including politicians
		Misleading or underestimated time and cost projections used as a basis for attaining funding approval
Flyvbjerg (2002)		Deliberate Deception due to self-interest or political motives Physiological delusion due to economic motives
Altshuler and Luberoff (2003)		Strategic Misrepresentation
Ganuza (2003)		
Flyvbjerg (2004)	Length of project implementation, geographic location	
Baccarani (2004) and Sodikov (2007)	Poor estimating methodologies and technical details used in generating estimates	
Creedy (2006)	High level of risks and uncertainties	
Smith *et al* (2006).	High level of risks and uncertainties	
Sodikov (2007)	Inaccuracy of initial estimates due to:	

	Lack of comprehensive historic cost data base lack of adequate preliminary information; High level of uncertainties; Poor cost estimation methods based on judgment, expertise, and experience.	
Evans and Peck (2008)	Inaccurate quantity surveys Lack of formal estimating skills in the engineering field (only on- the-job training)	
Romero and Stolz (2009)	Inadequate preliminary investigations and estimates	
Tan and Wakmasha (2010)	Inadequate preliminary investigations and estimates	
Cantarelli *et al* (2010)		Physiological and Political explanations
Lundmark (2011)	Poor pre-contract preparation	
Cantarelli *et al* (2013)		Strategic behaviour of principal actors (clients and contractors): Game theory
Rao and Ranade (2013)	Uncertainty (the unknown unknowns) and risk exposure	
Brunes and Lind (2014)	Poor pre-contract preparation	
Ubani (2015)		Deliberate Deception

Different authors have thus adopted different underlying technical and theoretical narratives, as explanations to cost overruns. This subsection therefore, questions the veracity of the different types of explanations provided by seminal authors offering technical explanations, as well as those refuting technical explanations, with arguments from theoretical perspectives. This calls for a closer look at their methodological underpinnings. The questions thus posed in this study in critiquing these wide proliferations of explanations, are thus: *How well do these explanations hold up based on empirical data? What is the evidence? Are they based on primary sources of data or mere fiction and speculation?*

3.6.1 Empirical Review of Technical Explanations

Technical explanations as predominantly evident in the literature are mostly based on empirical studies, often using analysis of questionnaire surveys which sample the opinions of construction professionals or trends in cost overrun data (Mansfield *et al*., 1994; Aibinu and Odeyinka, 2006; Kaliba, *et al*., 2008; and Ubani, 2015). These studies often generate a long list of factors, which are sometimes subsequently ranked. Aibinu and Odeyinka, (2006) identified 44 factors, prioritising the 39 factors on a ranked profile, as a source of useful information for construction industry stakeholders, in curbing delays and cost overruns. Some authors including Cantarelli *et* *al.* (2010); Akoa, (2011); Allahahium and Lui (2011) and Brunes and Lind, (2014) have taken the evidence one step further, by seeking to categorize and classify the myriad of technical factors occurring over the lifespan of projects, into a typology of causes, on the grounds that generating a long list of factors, without tracing their fundamental defining characteristics, was insufficient. For example, Allahahium and Liu (2011), analysed 90 causes of cost overruns, identifying five major triggers for cost overruns including: (1) Market volatility principally due to micro and macro-economic variations; (2) novelty/unpredictable events such as unexpected ground conditions; (3) estimate distortion; (4) time pressures and (5) project complexity.

The methodology of listing factors, ranking, and categorizing causative variables on a typology basis, based on impersonal questionnaire surveys, which is the most rudimental and simplistic approach to explaining cost overruns, appears to have flooded the literature. Although this adds to the body of scholarly literature on cost overruns, and are methodologically valid, the researcher is of the opinion that these forms of empirical approach cannot be used as a basis of inferring specific cause-effect relationship on a project basis. This shortcoming of most technical explanations based on questionnaire survey, has also being noted by Ahiagu Dugbai *et al*. (2014:868), who described most of the studies on cost overruns, as replicative, stating:

> *"It is argued that questionnaires alone may not be suitable for investigating complex and systemic problems like cost overrun on construction projects… It is no surprise that the same factors seem to come top of the list most of the time ... It will take more thoughtful research design, perhaps research conducted within the context of a particular project, to be able to partly circumvent these default responses that have yet to help mitigate or contain cost overrun in construction".*

This characteristic feature of questionnaire based studies, limits the usefulness of the output of such research, in generating context specific explanations that can be relied on in practice.

However, the researcher notes that a few of these studies although based on questionnaire surveys, are methodologically more robust (Memon and Rahman, 2013; Sharma and Goyal, 2014), and have been used to develop explanatory relationships amongst costoverrun factors. For instance, Memon and Rahman (2013) investigated the effect of cost overrun factors based on survey responses of client, contractor, and consultant representative involved in handling small scale projects in Malaysia. A total of 54 survey responses were analysed using the Partial Least Square Structural Equation Modelling, a form of factor analysis, to model the relationship amongst various factors. The outcome of the analysis revealed latent factors which triggered the highest variance: contractor's site management related factors, had the most significant effect on small scale projects. Whereas Sharma and Goyal (2014) developed a fuzzy logic model for assessing cost overrun, based on a preliminary questionnaire survey, conducted to judge the level of importance of the identified factors. A fuzzy logic model was then developed, and used in mapping out decision trees on an input and output basis, complemented by graphical representation of the variation induced in cost overruns by different combination of cost overrun factors, to understand their combined effect. Sharma and Goyal (2014) fuzzy model showed that the largest hypothetical variation in cost overrun will be largely due to inadequate planning and scheduling, followed by variation due to short bid preparation time and contractors' experience.

A discernible shortcoming of the models developed by both Memon and Rahman (2013) and Sharma and Goyal (2014) is that the data used in their analysis was not sourced in relation to specific projects or based of any form of project information, instead it was generated through opinion surveys. As a result, the studies relied solely on the opinions of the respondents surveyed, to infer abstract statistical inferences about general factors that lead to cost overruns. It is thus probable that these models can explain the relationships amongst the cost overrun factors, but may have little explanatory power to account for recorded cost overruns on a project specific basis. This can be rationalised based on the fact that technically projects are unique, which is in stark contrast to the underlying assumptions of the findings of these studies. Furthermore, matters of sensitive dependence arise, in the generalisability of the study by Memon and Rahman (2013) with respect to small scale projects in Malaysia, as the study is based on the assumption that projects of a similar size will experience similar issues.

In addition to the aforementioned groups of technical studies, few others provide and analyse cost overrun data, to test specific project variables in accounting for the trend in the data, as explanations for the high level of cost overruns in publicly funded highway projects. Hinze and Gregory (1991), empirically tested for the effects of project size, location and complexity on the level of cost overruns experienced on projects executed by the Washington State Department of Transport. Flyvbjerg *et al.* (2002), conducted a similar study on a world-wide basis, from a sample of 254 projects. Akoa (2011) study based in Cameroun, did same. These studies concluded that the bigger sizes and complexity of infrastructure projects are correspondingly reflected in the increased levels of cost overrun.

Hinze and Gregory (1991), further explained, that the simultaneous nature of projects execution by highway agencies, invariably implied lesser amounts of pre and post-contract engineering hours available to each, thus accounting for the higher levels of cost overruns often induced in highway projects. Additional engineering, was thus stated as requisite, to overcome risks occasioned by the complex and simultaneous nature of highway project execution, which often creates a propensity for such projects to run over budget. Whereas, Flyvbjerg *et al.* (2004), asserted that the average length of implementation phase of transportation projects significantly impacted on the level of cost overruns recorded. This was inferred based on statistical analysis of 111 transportation projects: bridges tunnels; and roads, which showed that cost overruns varied in relation to project duration. Bridges and tunnels, with average duration of 6.6 years recorded higher cost overruns than rail and road projects with an average duration of 6.3 and 4.3 years. Flyvbjerg *et al.* (2004:15) thus concluded, sluggish planning and implementation of transportation projects had direct financial repercussions, stating: "*Sluggishness may, quite simply, be extremely expensive".*

However, other studies, such as those by Odeck (2004) in Norway, revealed that larger cost overruns were experienced in smaller projects. Morris (1990) also arrived at a similar conclusion, as Odeck (2004), for 290 projects analysed in India. Yet, contrary to the findings of these studies, both Love (2002) and Love *et al.* (2013) revealed that cost overruns do not vary by project type or size. The conflicting results, from various studies, further reinforces the need for more context based studies, and that studies aimed at developing generalizable theories on cost overruns, are not plausible, and will only be subject to rebuttal. A further discernible shortcoming of these studies is that conclusive inference is mostly drawn based on trend analysis and correlation analysis, which by virtue of reporting significant association between bivariate groups of variables, cannot be used to conclusively infer causality. The observations made by the researcher, had also being noted by Ahiagu- Dugbai *et al*. (2014:867), who stated that:

> *"Just because two things strongly correlate does not necessarily mean that one causes the other. This would seem readily obvious, but can be easily overlooked. A correlation provides circumstantial evidence implying a causal link, but the weight of the evidence depends greatly on the particular circumstances involved".*

3.6.2 Technical Studies Analysing of Cause-Effect Relationships Based on Project Data

Quantitative analytical techniques, which analyse cause-effect relationships, are generally grouped as Mathematical models (An *et al*., 2007). Models are reductions of reality replicating an intricate system using variables within those systems (Ahiagu Dugbai, *et al*., 2014). Mathematical models have however been scantly used in the literature to infer causality in relation to project cost overruns. The techniques which have being used to analyse cost overrun in a limited number of older and more contemporary studies include: Linear modelling techniques such as regression modelling, Networking and data mining techniques such as Artificial Neural Networks, Heuristics based models such as Case Based Reasoning /Reference Class Forecasting, Stochastic techniques such as Monte-Carlo simulations; and Logic based methods such as Binary Logistic modelling and Fuzzy Logic (Trost and Oberlender 2003; Attala and Hegazy 2003; Love *et al*., 2014; Ahiagu Dugbai *et al*., 2014; Lee and Kim 2015 and El-Kholy 2015):

3.6.2.1 Regression Models

Approaches to parametric cost estimation based on statistics using linear regression analysis have been developed since the 1970s (An *et al*., 2007). As such an empirical estimation of cost overrun based on cost drivers requires statistical functions (Hendrickson 1998). Cost overrun analysis using regression analysis generates the best fit parameter values for the cost overrun function based on which empirical cost inference can be made. Older studies such as Trost and Oberlender (2003) as well as Attala and Hegazy (2003) have used linear modelling techniques, based on regression analysis, to analyse cause-effect relationships in explaining recorded cost overruns in projects, and further tested the validity of these models with respect to their use in decision making for future projects, at specified levels of confidence. A more recent study by El-Kholy (2015) generated a regression based model, while comparing its predictive capacity to a Case Based Reasoning (CBR) model for similar data sets derived from 30 projects. The outcome of the study showed that the regression modelling had higher levels of accuracy to predict potential cost overrun in projects.

3.6.2.2 Case Based Reasoning Models

Case-based reasoning (CBR) models have high similarity to expert systems, being described as the foundations of artificial intelligence (An *et al.*, 2007). CBR derives its logic from a rule-based reasoning dependent on experience or memory with adaptations made for deviations from the rule (Chen and Burrell, 2001). Kim (2004) stated that the CBR approach is similar to expert judgments, that rely on the use of experience to solve problems, following the logical steps: outline of the key attributes describing the current problem; identification of similarity of attributes in previous past problems; and prediction within the interface of similarity with subjective correlative adjustment. A CBR system is thus heavily dependent on structure and content of the input case base, which have to be adequately indexed, organised and adapted for new cost estimating queries El-Kholy (2015).

Although the use of CBR systems have been reported as having lower predictive capacities, they are very useful in decision making and feasibility studies, as such models learn from both past project success and failures in solving new problems, by adopting/adapting solutions that were used to solve old problems (Kolodner, 1992). El-Kholy (2015) applied a CBR model to predict the likely cost overrun given the degree of similarity of the project characteristics to 20 past projects, using a similarity value of attribute, dichotomously assigned one or zero. El-Kholy (2015) used this method to analyse cost overrun factors, whose presence as part of a future project, is indicative of a potential to result in a similar degree of cost overrun, useful in reference class forecasting and decision making to minimise cost overruns for future projects.

3.6.2.3 Artificial Neural Networks

Artificial neural networks are expert non-parametric statistical estimators. The neural network model, rooted in artificial intelligence, has a "brain-like" structure, which can be used to make intuitive decisions similar to the human brain and find complex patterns within the data that often elude conventional analytical techniques (Turouchy *et al*., 2001). The potential for using artificial neural network relies on the development of genetic algorithms from project data sets, through a process of network training designed to learn and identify trends and relationships in the project input data (Al-Tabtabai *et al.*, 1999). More data input thus optimizes the accuracy of the network model, as outliers and erroneous data are identified and selectively filtered out (Al-Tabtabai *et al.,* 1999; Turouchy *et al*., 2001). The ability of the neural network to perform sensitivity analysis of a new input parameter to the computer database is an added advantage as it establishes the relative significance of each input parameter within the model, and how it affects the outcome variable (Turouchy *et al*., 2001).

Ahiagu Dugbai *et al*. (2014) used data mining techniques based on artificial neural networks, to analyse the complexity of non-linear interactions amongst quantitative project variables such as compensation events, project duration, as well as qualitative information on tendering method, location, project type, fluctuation measure and project's delivery partner. All analysed projects were completed at cost of between

£1,000 and £14 million, with a maximum duration of 22 months. Sensitivity analysis was further carried out to identify significant cost drivers in a selective elimination process, necessary to optimise the predictive capacity of the model. The least significant input factor identified was the location of the project, while the choice of the project's delivery partner, was inferred by Ahiagu Dugbai (2014), as majorly influencing the ultimate extent to which the projects ran over budget.

3.6.2.4 Probabilistic Based Methods: Monte Carlo Simulations and Analytic Methods

Monte Carlo simulations have also been carried out to analyse the probabilistic effect of specific cost drivers on cost overrun, based on the data distribution of the analysed projects. The core focus of probabilistic techniques is on the quantification of the variability of construction cost overrun based on inherent risks and uncertainties associated with a project (Zwaing, 2014). This is necessary to gain sufficient knowledge about the distribution of the cost parameter of interest. Typically, Lee and Kim (2015) analysed change orders issued during the construction period, due to changes in scope made by the client and changes made due to design errors, which lead to significant cost overruns. This study investigated 9028 change orders from 237 projects that were completed between 2005 and 2011 in South Korea. It was shown that an average of 4.57 of total project cost, was induced as cost overruns solely due to change orders. Love *et al.* (2014) developed a probabilistic Log-Logistic distribution of cost overruns for 49 road projects (new roads including upgrades and elevated highways) in relation to rework occasioned by errors and omissions in contract documentation, leading to cost overruns. This was used to develop best fit statistical distributions so that probabilities of occurrence of cost overruns was determined, and used to provide a basis to assess the adequacy of the construction cost contingency bench marked, as not less than 13.55%.

It is thus self-evident, that the findings from this class of technical studies on cost overruns which rely on modelling to understand cause-effect relationship, have a robust and methodologically valid underpinning, rooted in the specifics of project data, with a direct applicability useful in monitoring and reassessing future projects, prior to initiation, as a basis of subverting cost overruns. The use of modelling techniques, thus provide logical and repeatable relationships between independent cost overrun drivers and cost overrun, for practical purposes of risk analysis and management by clients.

3.6.3 Empirical Review of Theoretical Explanations

The preceding subsections, have taken a critical look at the methodological shortcomings of several groups of empirical technical studies, in explaining cause-effect relationships that lead to cost overruns. On the flip side of the argument, are the theorist, who make bold claims asserting why cost overruns are such a pervasive trend in public infrastructure projects. The researcher thus applies a similar critical analysis to spotlight the methodological validity of the studies driving this line of argument. An evaluation of several of these cost overrun studies based on theoretical explanations, indicate that political explanation, at the core of which is strategic misrepresentation, is the dominant discourse adopted by most studies in explaining cost overruns (Kain 1990; Pickerel 1992; Bruzelius *et al*. 2002; Altshuler and Luberoff, 2003).

However, based on the critical analysis, the researcher notes, that the studies by Kain (1990) and Pickerel (1992), although underlain by the theory of strategic misrepresentation, were focused mostly on explaining the inaccuracies in transportation benefit forecasts. Kain (1990) described in detail, the use of unrealistic land use forecasts and optimistic ridership forecasts, as a form of appraisal optimism that was used by the Dallas Area Rapid Transit (DART), to promote sponsorship for a 91-mile rail transit system. When alternative analyses indicated that the proposed $2.6-billion rail system would carry only slightly more riders than an unimproved bus system. Similarly, Pickerel (1992), made similar assertions as Kain (1990), for eight rail transit projects chosen over competing less capital-intensive options. However, Pickerel (1992) admitted that the accuracy of forecasts for the rejected alternatives could not be evaluated, to infer conclusively, that the errors in projected ridership and costs, led decision makers to make uniformed decisions. Although the interesting findings from these studies, support the notion of strategic misrepresentation, no form of research methodology or data sources deployed, were provided in the articles, for the researcher to access the validity and credibility of their findings.

The study by Bruzelius *et al.'s* (2002) was fundamentally presented as form of speculative commentary on the dynamics of decision making in mega projects, rather than based on any form of data analysis. The key theoretical assertions in the study by Bruzelius *et al. (2002)* were:

- The time frames typically involved in major project development and implementation, meant that different sets of political influences were often at work at the initial phase, when overly optimistic forecast are made, compared to the completion phase, when the full extent of cost overrun and unviability of the project is realised;

- Varied groups of project promoters can afford to advocate for the financing of projects, based on tax payers' money, because they do not bear the financial risk; except for contractors, who still bear minimum risk, but reap significant reward, even when over-optimistic tenders are forwarded;
- *"Real costs and real risks do not surface until construction is well under way" (p 145).*

Other studies revolving around this theme, are mostly text books, written on mega projects governance and investments, such as by Altshuler and Luberoff, (2003). It is thus, observed that the only empirical study out of the multiplicity of theoretical explanations evident in the literature, is the one by Flyvbjerg, *et al.* (2002), building on the arguments started by much earlier scholars (Hall 1980 and Wachs, 1989) and Bruzelius *et al.* (2002), promoting politically induced deception as a globally generalizable reason why public projects run over budget. The arguments from subsequent peer reviewed studies, after this time frame such as Cantarelli *et al.* (2010), although adopting the findings of Flyvbjerg *et al.* (2002), by emphasizing the systematic nature of cost underestimation, as a deliberate strategy used by government officials in getting funding approval, were expressed as opinions, and not drawn based on any form of valid statistical inference. The study by Flyvbjerg *et al.* (2002), is thus spotlighted.

The study by Flyvbjerg, *et al.* (2002:280) was based primarily on cost overrun data on 258 projects, which displayed a statistical pattern to the differences in initial and final cost, skewed in the direction of underestimates, over time and project location. It was stated:

> *"the pattern of cost underestimation … is of general import and is statistically significant … the pattern holds for different project types, different geographical regions, and different historical periods…the large-sample pattern of cost underestimation uncovered by us lends statistical support to the conclusions about lying and cost underestimation"***.**

The '*statistical support'* as referred to by Flyvbjerg, *et al.* (2002:285), in this analysis was:

> *"If misleading forecasts were truly caused by technical inadequacies, simple mistakes, and inherent problems with predicting the future, we would expect a less biased distribution of errors in cost estimates around zero. In fact, we have found with overwhelming statistical significance (p<0.001) that the distribution of such errors has a nonzero mean"*.

Solely based on this simplistic analysis, which lacked the merits of demonstrable causality, Flyvbjerg, *et al.* (2002:279), drew a generalised global conclusion that cost overruns in transportation projects were the deliberate outcome of political manipulation, and as such discounted all forms of technical explanations, primarily geologic factors, which became a trail blazer and empirical reference point for subsequent theoretical studies on cost overruns. It was stated:

> *"This article presents results from the first statistically significant study of cost escalation in transportation infrastructure projects … it is found with overwhelming statistical significance that the cost estimates used to decide whether important infrastructure should be built are highly and systematically misleading".*

Without any further inferential statistical test or supportive qualitative data, a visibly wild leap was made in drawing and generalising this theoretical conclusion, from an exploratory statistical trend analysis of project data, which reported that cost overruns were indeed a topical problem in transportation projects across the sampled locations, which had persisted over time. Several loopholes were thus spotted by the researcher, and other scholars in these premature conclusions.

Flyvbjerg, *et al.* (2002) study, carried out based on exploratory statistical measures, which provided an initial quantitative perspective of the project data, did not provide any form of qualitative data from inside the governmental client organization to support the study's assertions. Love (2015: 490) noted this, and commented thus:

> *"Despite the considerable amount of research within the field of transport and planning in the past thirty years, limited progress has been made to improving the performance of projects. We contend that this will continue to be an issue as long as research efforts focus on the 'outside view' with emphasis being placed upon strategic misrepresentation and optimism bias. Understanding 'why' and 'how' projects overrun, particularly from both 'outside' and 'inside' perspectives, is pivotal to reducing their impact and occurrence".*

The highly artificialised nature of Flyvbjerg *et al.'s* (2002) study, which solely relied on trends in the data, is a significant limitation in the methodological validity of the conclusion drawn. Ahiagu-Dugbai *et al.* (2014:41) noting this shortcoming equally stated:

> *"it is almost impossible to draw valid distinctions along a continuum of motivation when promoting a project from reasonable optimism, through over-enthusiasm, culpable error, to deliberate deceit using statistical analysis, as adopted in the Flyvbjerg's works*".

Ahiagu-Dugbai *et al.* (2014:41) further asserted:

> "*Adopting a positivist perspective to understand a complex issue like construction project governance, which usually involves a complex interplay of construction professionals, planners, business strategy, institutional framework and politics, would merely be superficial at best and never actually provide substantial evidence to support the kind of conclusions reached by Flyvbjerg et al".*

Flyvbjerg *et al.'s* (2002) conclusions are further challenged in the academic arena by several other authors including Osland and Strand (2010) and Love *et al.* (2012). Arguing against both the theoretical and methodological validity of Flyvbjerg *et al.'s* assertions, Osland and Strand

(2010:80) challenged Flyvbjerg *et al.'s* research design, espousing "*the research design did not support the general conclusion that the technical explanations can be ruled out*". It was argued that for the theory of deliberate underestimation, had little explanatory power, as its validation requires empirical data showing Cost Benefit Analysis for projects which should have been approved in place of the '*better under-represented projects*'. While Love *et al*. (2012) using a case study of Australian projects empirically showed that unintentionally overlooked technical factors inherent in projects dynamics can be triggered leading to cost overruns in public projects.

Further to this, Flyvbjerg's study is not adequate to provide the depth of understanding on the intrinsic contextual issues of cost overruns within the settings of highway development in specific countries and regions. Cantarelli *et al.* (2012) also argued against the global generalisability of Flyvbjerg's study, on the premise of the large differences in cost overruns revealed in various studies reported over time, which showed that cost overruns in country specific studies were either lower or higher than the statistics provided by Flyvbjerg. It was stated

> "*the abovementioned findings do not support this expectation; some country specific studies have smaller average cost overruns and others higher average cost overruns compared to the worldwide study by Flyvbjerg et al" (*Cantarelli *et al* 2012:50)

The global generalisability of Flyvbjerg's findings which though spanning 75 years, is mostly limited to developed countries in the Europe and North America. Developing countries, such as those on the African continent, which mostly do not have historical data spanning this time frame, were not included in the sample data. However, Flyvbjerg, *et al.* (2002) acknowledged that cost overruns appear to be more pronounced in developing nations. Following Flyvbjerg's argument, if this is the case, the theory of strategic misrepresentation cannot be said to provide a valid explanation for this disparity in the extent of cost overrun experienced in the developed and developing world. To overcome some of the shortcomings of the study by Flyvbjerg *et al.* (2002), in terms of geographical spread, Ubani (2015) attempted to replicate Flyvbjerg's study in the context of Nigeria. However, several shortcomings were also noted in this study, foremost of which, is the statistical validity of conclusions based on the quantitative analysis of cost overrun trends in a very small sample of eight public projects.

Extensive research also shows that private sector projects experience cost overruns, despite the lack of political motive, to strategically misrepresent cost. Classic examples such as the Channel Tunnel between France and the UK, as noted by Flyvbjerg *et al.* (2004), which should serve as the international model of private financing, however experienced a monumental cost overrun of 80%, double the average recorded cost overrun range on publicly funded tunnels and bridges.

Following this line of logic, Love (2009) also statistically showed that re-work leading to cost overruns, were evident in both public and privately owned infrastructure. This calls into question, the veracity of Flyvbjerg assertions regarding public officials.

3.7 Contextual Case Study Narratives Explaining Cost Overruns

Against the backdrop of notable shortcoming, in terms of the lack of in-depth qualitative analysis, that is discernible in most technical and theoretical studies, the researcher has isolated the few relatively distinctive and methodologically robust case studies in the literature, offering qualitative narratives to explain the propagation of cost overruns, from inception to completion. These are explored in detail in the forthcoming sections of the chapter.

3.7.1 Theory of Lock-in and Path Dependency by Cantarelli et al. (2010)

Cantarelli *et al.* (2010), studied the behavioural form of 'Lock-in', as used in managerial premise, which is the outcome of sub-optimal decisions made by institutions that sets the pace for path dependency, irrespective of the availability of optimal alternatives. Cantarelli *et al.* (2010:793) thus described Lock-in, as *"a form of psychological coping associated with the inability to withdraw from obligations made in the decision-making process".* Figure 3.6 represents the theoretical framework developed by Cantarelli *et al.* (2010), based on the literature, which was tested in the case studies.

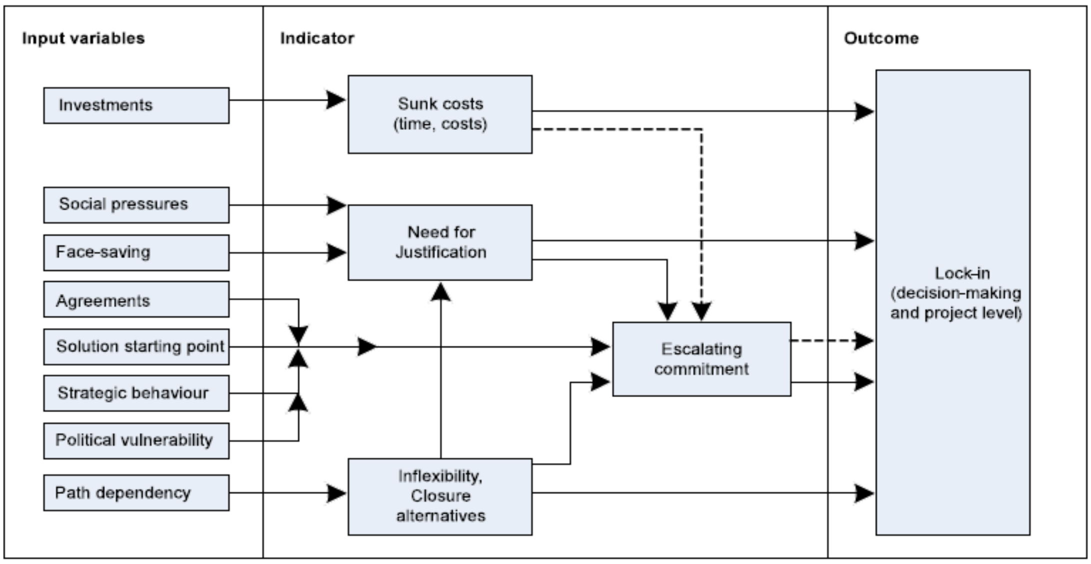


Figure 3.6: Theoretical Framework of Lock-in developed by Cantarelli *et al* (2010)

As Cantarelli *et al.* (2010) demonstrates, in Figure 3.6, the solid lines represent the influence of unconscious lock-in, whereby decision makers deliberately justify earlier project approval decisions made, without attempting to explore the option of reversing that decision, in the face of escalating cost. On the other hand, conscious lock-in emerges when the project proponents are trapped in their decisions, as there are no viable alternatives, and therefore irreversibly committed to seeing the project through to completion, even with evidence of escalating cost.

Two case-studies for large scale rail projects, HSL-South and Betuweroute, in the Netherlands were designed by the author to test the assertions that psychologically, lock-in often led to cost overruns in publicly funded projects. Several indicators of lock-in were thus developed as indicated in Figure 3.6, such as 'inflexibility and closure, 'sunk capital' in terms of time and cost, and the 'need for justification', for testing in the case studies. From the documentary analysis of several reports, principally those prepared by an investigative committee set up by the Dutch government, and annual progress reports in relation to the timeline and history of the projects, six of the test indicators were noted as evident in the case study projects. Typically for the Betuweroute project, the investigative reports contained statements such as "*the Betuweroute was put on the agenda before any research was carried out on the alternatives*" and *the solution was decided upon at a very early stage of the process*", an indicator of 'inflexibility and closure, at the initial planning phase. Cantarelli *et al.* (2010) research, further revealed that several other alternatives, that could have been implemented, were not considered or were proposed far too late.

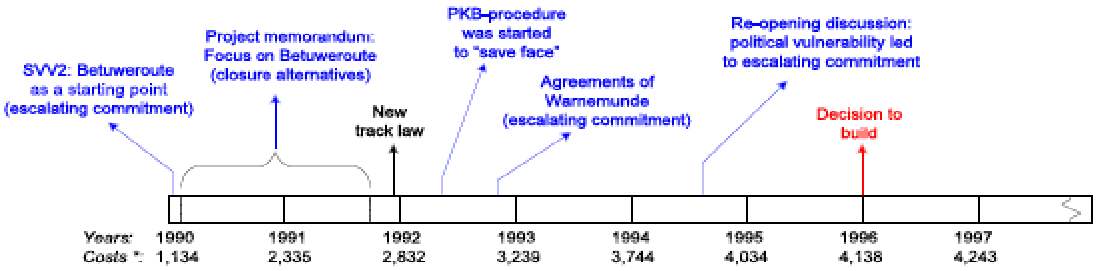


Figure 3.7: Decision level Time Line **Source: Cantarelli *et al* (2010)**

Content analysis of the various reports based on the indicators, was thus used to draw conclusive evidence on the role of lock-in in accounting for the over-commitment of the projects despite their escalating cost of the projects from inception to the decision to build (Figure 3.7).

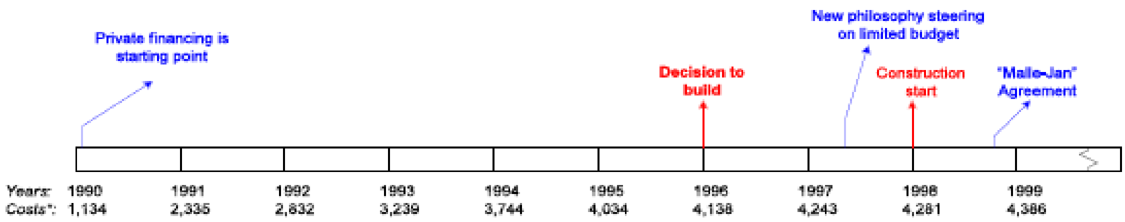


Figure 3.8: Project Level time line **Source: Cantarelli *et al.* (2010)**

Cantarelli *et al.* (2010), however concludes that conscious lock-in, as intentional strategic behaviour, did not necessarily disprove technical explanations, which were asserted as equally as important, as technical issues, explained the cost growth recorded on the analysed projects afterwards on the project timeline (See Figure 3.8).

Cantarelli *et al.'s* (2010) qualitative case study is a commendable context specific departure from other theoretical studies. However, a discernible shortcoming evident within the research design was the sole reliance on secondary information, from government reports and documents, which despite demonstrating cost growth in the projects, was inconclusive of practically demonstrating causality, with respect to the actual cost overrun recorded on completion. There was no form of primary data collection, such as interviews with the decision-makers or technical professionals in the institutions that executed the case study projects. The weakness and incorrect case study design, is thus evident, as Yin (2014), the seminal author of case studies, makes explicit the need for triangulating multiple strands of data within case study designs, to enhance internal and external validity This is considered methodologically relevant to draw more conclusive evidence of the effect of the identified factors on the levels of cost growth, amidst a possible array of other project specific incidentals.

3.7.2 Latent Pathogens Framework by Love et al. (2012)

Love *et al*. (2012) carried out a qualitative case study of cost overrun explanations in public building projects (Hospitals and schools), using a narrative, specific to the design of social infrastructure building projects.

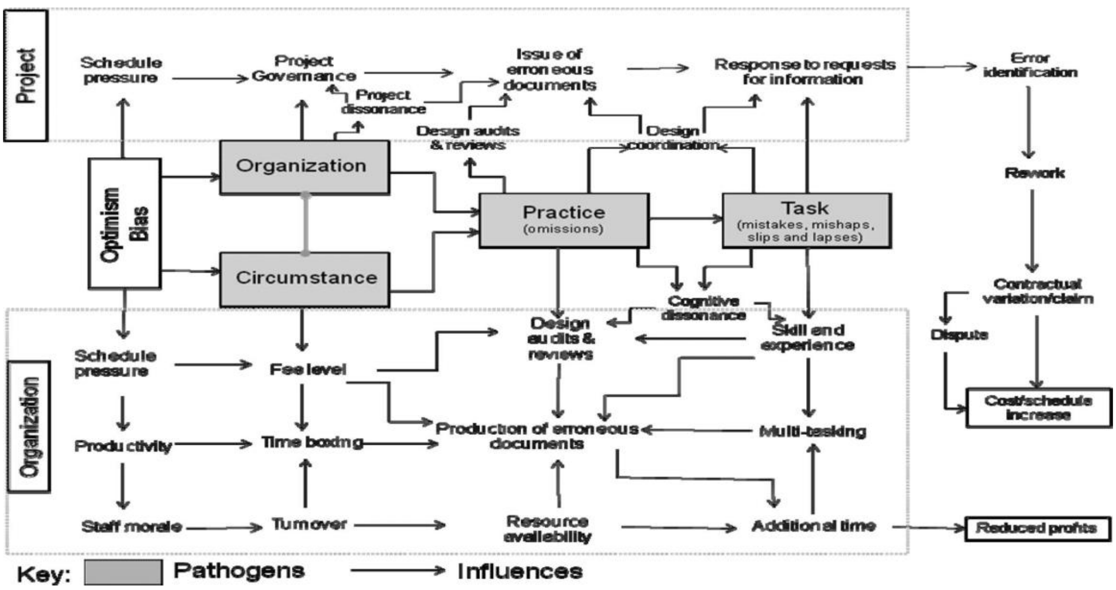


Figure 3.9: Latent Pathogens Leading to Cost Overruns by Love *et al*. (2012)

The objective of the study was to understand the chain of intermediary events and actions of project participants that culminated in cost overruns, and whether any form of strategic misrepresentation was evident. A narrative framework was conceptualized (See Figure 3.9), showing that when a project commences, design consultants often proceed with highly optimistic intent of producing error-free design documentation. However, revisions are frequently undertaken on the initial design documents produced. As such, most design organizations have adopted circumstantial market-driven strategies, that define the quality of consultancy service offered relative to fees, to stay afloat in the competitive environment. It was stated:

> "*Management within architectural firms focus on the administration of contracts and offices rather than the management of projects and practices"* (Love *et al*., 2012: 3).

Design quality offered in practice was thus conceptualized as a function of how fees are negotiated, with competitively procured services, yielding restricted consultancy services, in the face of the disproportionate and impracticable demands often imposed by the public sector. This latent condition, combined with the limited time frame available during the initial conceptual phases, activates trade-offs during the performance of tasks: design shortcuts against fee maximization, thereby setting off an additive chain of concomitant errors which creates significant 'error traps'. Such significant errors when discovered latter during the construction phase, may necessitate rework and variations, with the resultant resolution of conflicts and contractual disputes, leading to cost overruns.

Pathogens as represented in the framework thus represent "*the latent conditions that lay dormant within a system until an error comes to light"* (Love *et al.,* 2012: 3). Such pathogens may thus be considered part and parcel of the everyday functioning in an organization, which are considered normal practice, because they have been in existence over a considerable period of time. But in actuality, such practices negate or significantly deviate from best practice. Love *et al*.'s framework thus maps out the practices within design organizations, that constitute the latent issues, which combine with errors to result in active failures. Several forms of pathogens were identified by Love *et al*. (2012: 3) as leading to errors in design organizations:

> *"Practice: arising from people's deliberate practices; Task: arising from the nature of the task being performed; Circumstance: arising from the situation or environment the project was operating in; Organization: arising from organizational structure or operation; System: arising from an organizational system".*

Typical deliberate practices cited by Love *et al*. (2012: 3) as existing in design consultancy firms, was:

> "*the recycling of design details, specifications, and other contract documentation to reduce time and save money, without giving due consideration to the project's bespoke nature"*

As such, design errors in the original contract documentation prepared by consultants, termed '*Latent organisational and circumstantial Pathogens*', serves as the blue print which fosters dysfunctional contractual climate, where corner cutting measures in consultant's practices, and remedial tasks that ought to be taken, where stifled by their efforts at self-preservation. Using this narrative, twenty-four in-depth interviews with project participants who had been involved in the selected projects were conducted by Love and his co-authors. Allowing the researchers to gain an in-depth understanding of the contextual design based cost overrun triggers and errors, that each project experienced over its life span. From the data, Love and his colleagues developed the explanation for cost overruns within social infrastructure projects undertaken in Australian. This qualitative study by love *et al.* (2012) led to the following other principal findings traced as common to the projects studied:

- Value for Money was subconsciously downplayed as clients did not adequately plan for project risks, whilst being over optimistic, as a fixed budget had already been set for the projects;
- Initial project estimates were under-estimated by clients who did not account for potential hikes in material and local labour rates due to inflationary pressures;
- A series of design related errors occasioned by client's change related demands and pressures were placed on consultants, who were awarded contracts on the basis of lowest bid;
- A culture of risk avoidance by clients and consultants, compounded by the typical inclination to adopt the lowest bid system of contracting and poor project management provided, served as a catalyst for the consultancy firms to exploit unethical avenues to maximize their fees and profits.

Love *et al.* (2012) further emphasised that no evident form of strategic misrepresentation by clients were discerned, but a rather that of optimism bias, against the backdrop of political expediency and community pressures to satisfy user needs and to douse criticism by political opposition. It can further be inferred from the findings of Love *et al.* (2012), that in the Australian context, technical explanations as well as theories of game signalling advanced by Cantarelli *et al*. (2013), and efforts at risk avoidance, hypothetically conceptualised by Ganuza (2003), prevail, and not the assertions of strategic under-estimation by clients, asserted by Flyvbjerg *et al*. (2002).

Although the commendable empirical work of Love *et al.* (2012) generated a systematic qualitative framework of cost overrun explanations, emerging from primary data, it is lacking in the quantitative cost overrun data analysis, necessary to compliment the qualitative findings. As Yin (2014) prescribes, data from multiple sources strengthen the analytical generalisability and external validity of case studies, against the backdrop of its notable critique. This is also necessary, to overcome the several critiques which plague the output of purely qualitative research, resounded by advocates of methodological pluralism in construction management research (Dainty, 2007). These shortcomings may thus undermine the external validity of *Love et al*.'s study, as being no more than ideographic. Furthermore, *Love et al*.'s study uses a technical narrative contextualised in the development of building infrastructure in the Australian setting, which may limit the generalisability of the developed framework to developing countries or the specific context of highway projects.

3.7.3 Relay Race Project Governance Evolution Framework by Gil and Lundriganm (2012)

Gil and Lundriganm (2012) carried out comprehensive case studies on three mega projects that experienced massive cost growth in the UK, namely: London's Crossrail project, the London 2012 Olympic Games project, and BAA's Heathrow Terminal two. The study was based on 60 in-depth interviews with project leaders and all other key stakeholders, organised site visits, and archival project data. The cases were used as models of relay-races in mega projects, where the transitory phases of projects, represent points of handover of the baton of project leadership from the principal client to other key stakeholders (See Figure 3.10).

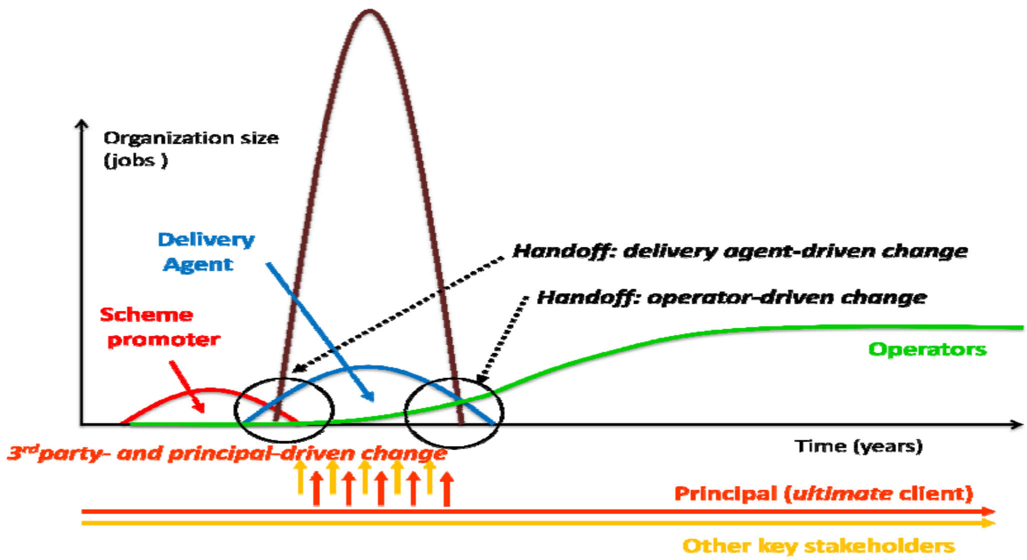


Figure 3.10: Relay Baton Handovers **Source: Gil and Lundriganm (2012)**

Gil and Lundriganm (2012) thus conceptualised a '*relay race'* framework for understanding cost growth, founded in the dynamics of project governance, amidst conflicting stakeholder interest and competitive strive for leadership in mega projects, which fosters design changes. This was explained as characteristic of mega projects, where '*the client is a multi-headed organization because the different clients may feel entitled to be in control'* (Gil and Lundriganm 2012:4). As such with differences in skills and competence of the race team (leaders), inconsistencies are generated, which pose a critical managerial challenge that often culminates in cost overruns, over the project phases, as shown in Figure 3.11.

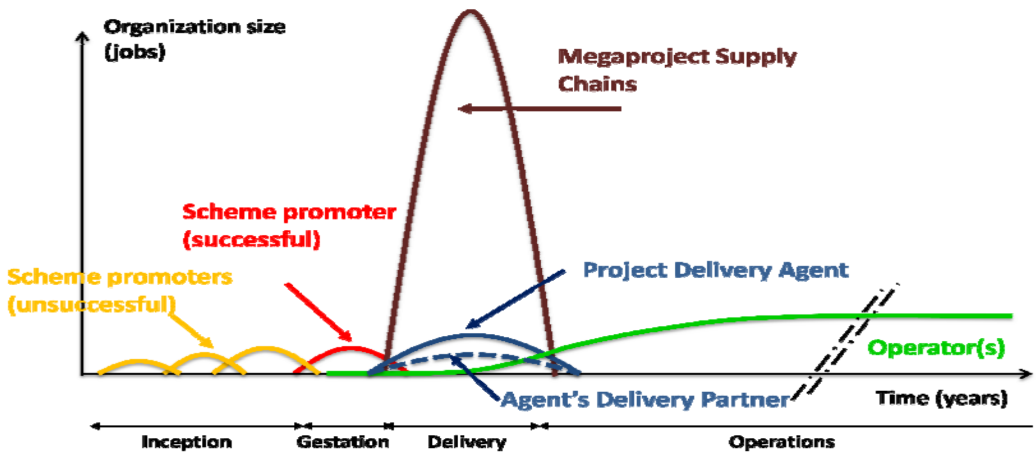


Figure 3.11: Contestants in Mega Project Leadership Source: Gil and Lundriganm (2012)

The concept of the relay race is such that at the initial inception phase of a project, the proposal tendered by a scheme promoter, may have been initially rejected (depicted in yellow lines as an idea bouncing off in Figure 3.11), but later gains acceptance (the idea gains momentum: red line) within a sponsoring public agency (referred to as the principal). The idea now has to be developed, and presented to decision makers for approval, who are conceptualised as having limited in-house technical abilities. This then implies that specialists with higher level of technical and managerial skills, have to be employed to put together a compelling case for the proposal to be approved. Aside from this technical requirement, the views of various stakeholders, future financial sponsors, and the general public, has to be incorporated, to facilitate the lobbying process. This shifts the emphasis from the more technical focus, and in the process, the project will significantly evolve, with changes in design and scope warranted by trade-offs and simultaneous negotiations necessary to gain political will. The time lag over which this takes place is the gestation period, during which generated controversies surrounding the proposed scheme will have been doused, with corresponding radical changes to the scheme made.

This thus sets the stage for elasticity in the project cost profile, as the project decision makers with lower levels of technical competence, invariably determine changes to the scope of projects and approve budget outlays. It was thus stated:

> *"Crucially, the promoter-led early negotiations at gestation with relevant stakeholders, and which are instrumental to gain political and financial endorsement for the scheme and support judgment calls, will frame the future institutional and organizational context under which the megaproject will be delivered, governed, and eventually operated"* (*Gil and Lundriganm (2012:7)*

Over the usually long gestation periods often associated with mega projects, inflation and other project and location specific incidentals may set in and further compound the issue. The project after approval falls back squarely under the managerial jurisdiction of the public agency, who now have to negotiate for technical competence with the project delivery agent (main contractor: blue line) to 'manage the fragmented supply chains (dark brown line) that will ultimately design and deliver the project. The design and delivery phase now marks a new era of negotiations and shift in technical competence, as the contractor often re-negotiates the initially approved outlay, from a position of technical expertise (supplied by the agent's delivery partner: dashed blue line), in the light of his perception of risks inherent in the project and new information which may have emerged over the period of gestation. Requisite changes to designs will now have to be made, and financial commitments renegotiated.

Gil and Lundriganm (2012), thus concluded that over this period of multiple re-negotiations and design evolution, the project will have experienced significant cost growth. This matched the empirical evidence gathered and analysed in the three case studies. The London's Crossrail, London 2012 Olympic Park, and BAA's, were shown by Gil and Lundriganm (2012) to have all experienced strikingly similar relay race narratives, accounting for the significant disparity between their final costs and initial approved budget figures.

3.7.4 Core and Periphery Hybrid Meta-Organisation Theory by Lundriganm and Gill (2013)

Lundriganm and Gill (2013), further argued that megaprojects are a hybrid form of meta-organization, with cost overruns intricately dependent on its hierarchical technical decision making *core,* enveloped in a permeable membrane, which allows for osmotic diffusion from *peripheral* actors to exert influence over designing and building activities. Lundriganm and Gill (2013: 1), thus described public agencies as open systems, where by the organisations have to adapt and align their product (projects) to the environment (stakeholders and political) they are designing for, and which they cannot control, stating:

> "*At the core, a flat collective shares control over the system-level goal and design requirements; its membership mirrors the organization…At the periphery, a transactional collective… that has no technical rights over the requirements… megaproject's designs are processed by a diffuse network of self-interested actors: land owners; planning authorities; private firms; funders, over whom no single entity has formal authority".*

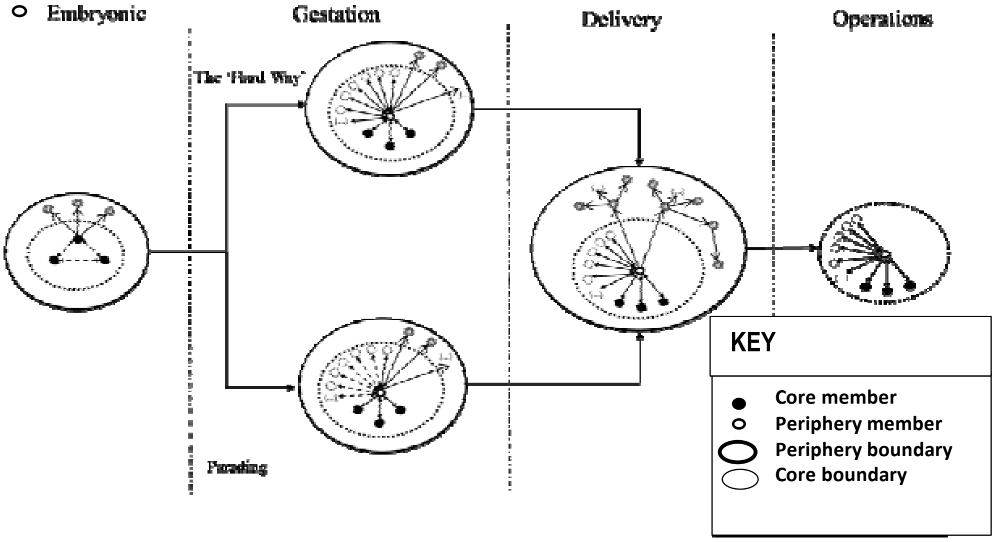


Figure 3.12: Core and Periphery Framework Source: Lundriganm and Gill (2013)

Using the same set of case study projects (London's Olympic, London's Crossrail, and Heathrow Airport's Terminal-2) as the relay race theory, the authors conceptualised two distinct developmental paths as shown in Figure 3.12. Either one of which mega public projects need to go through, which makes them distinctive, and thus account for the recorded levels of cost overruns. These were referred to as 'parading' and 'the hard way'. Lundriganm and Gill (2013: 1) thus stated that

> *"These developmental paths underlie the evolution of the megaproject organization towards a configuration to fit the environment"*

Through a longitudinal study of the development of the case study projects, it was shown that the Olympic project adopted the parading the route, in which lobbying and informal pledges between the core (technical actors) and the periphery (stakeholders), led to the speedy approval of the project, leaving it with renegotiated designs and escalated financial commitments. However, the hard way, which is sticking strictly to the initial technical proposal, was adopted by the other two projects, still had a similar effect on cost growth, due to the lengthier gestation period:

> *"Heathrow T2, a relatively 'small' megaproject took approximately the same time as the Olympics in gestation, whereas the Crossrail gestation took almost four times more after two decades of failed attempts….*" (Lundriganm and Gill, 2013:5).

It was thus concluded that:

> *"The environment will change and hence the core must adapt the requirements and its own configuration to stay fit*" (Lundriganm and Gill 2013:5).

Lundriganm and Gill (2013) thus stated that this important distinction between megaprojects core and the peripheral settings, often results in a '*meta-organization of managed ecosystems'*, even though temporary, can last decades from the embryonic stage, through gestation, to delivery, and lead to significant cost overruns.

3.7.5 Project Uncertainty Framework by Johansen (2015)

Johansen (2015) asserted that the 'concept of uncertainty' in projects largely accounted for underestimation leading to cost overruns. This was based on case studies of seven large projects in the energy sector and five projects in the public sector in Norway. Interviews and surveys regarding the uncertainty management of these projects were conducted, with questionnaires distributed to a representative selection of participants related to the projects. The questionnaires were distributed to 2701 persons, and overall there was a response rate of 29.7%. Johansen (2015) concluded that cost estimates normally increase over time due to organizational and project specific uncertainties.

The cost overruns experienced on the projects, Johansen (2015), revealed were not necessarily indicative of their successes or failure, but rather were representative of reflexive adaptions in response to uncontrollable uncertainties, that arose during project execution, necessary to fulfil the project objectives (as illustrated in Figure 3.13). His argument was however that there was undue emphasis in the literature on cost overruns in projects, from clients' perspective, which represented a narrow front-ended debate.

Uncertainty from the owner's, project manager's or contractors' view thus do not solely account for project underestimation/cost overruns. His assertion was thus that there are a multitude of controllable and uncontrollable contextual factors in projects which cannot be captured irrespective of the state of the art risk analysis tools deployed.

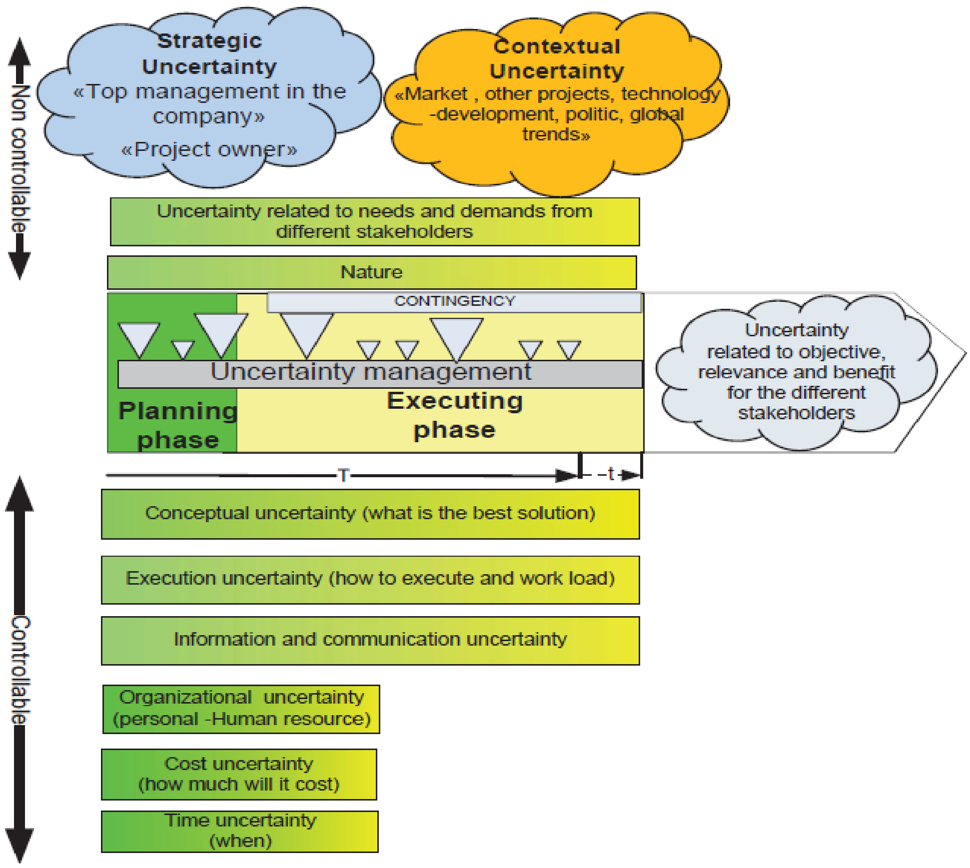


Figure 3.13: Project Uncertainty Framework **Source: Johansen (2015)**

Uncertainty in a single project can be due to the technical solution, the building process, the time needed to deliver activities and the objectives, the cost of the different components, which are controllable. However, different uncontrollable uncertainty factors played a part in the execution of the projects, such as strategic uncertainty and contextual uncertainty that happen because of changes in the organization and changes in the local and the global environment within which the project were executed, even when the projects were able to 'stick to the plan' for as long as possible.

Johansen (2015), thus concluded that managing uncertainty with small time, and cost buffers as well as handling a lot of foreseen and unforeseen uncertainties in a complex environment, with various stakeholders with different expectations and demands is a difficult task that led to cost overruns in the projects analysed. Johansen's (2015) uncertainty framework shares the characteristics of Gil and Lundrigann (2012; 2013) Relay Race versus Core and Periphery theories, which emphasize the multiplicity of risks and often competing/clashing interest groups in public projects, as accounting for cost overruns in public projects.

3.7.6 The 'Vicious Cycle of Short-Funding and Delays' Narrative by Morris (1990)

The preceding empirical narratives have all being conceptualised within the context of the developed world. The only case study found, which is contextualised in a developing country, and which provided a qualitative narrative explaining cost overruns in public projects, despite a comprehensive literature search by the researcher, is a relatively older study by Morris (1990) in India, carried out 26 years ago. Nonetheless, the findings from Morris (1990) less contemporary study, is considered by the researcher, to have significant implications for this study, by virtue of its setting in a developing nation.

Morris (1990) noted that for public sector projects in India, cost and time overruns were unusually very high. Cost overruns were on average 92% while time overruns were 192%. Morris (1990) carried out a case study of public projects, and analysing project cost overrun and time overrun data, as well as individual project reports on the cases, provided by the Committee on Public Undertakings (CPU) in India, to account for the wasted `capital in infrastructure projects. It was argued that a vicious cycle of events, accounted for project cost overruns in publicly funded infrastructure projects. This argument was raised in response to an on-going debate on economic stagnation in developing countries. It was queried:

> *"Are the delays and cost escalation due primarily to bureaucratic styles of functioning? How far are the individual enterprises responsible? Are there genuine problems arising out of technical difficulties, inadequate experience, of learning by doing, additional costs of technological self-reliance, additional costs arising from price preference for domestic contractors and suppliers which cannot be set right by administrative reform alone? It is important to have the answers to these questions before the appropriate policy initiatives are made to push the Public Sector in the direction of greater efficiency" (Morris, 1990: 155).*

The principal contentions and findings of the study by Morris (1990) were thus:

- Short funding of projects was the primary trigger for cost overruns. This was revealed from the analysis of sectorial pattern of capital outlay in annual budgets for different sectors, which provided evidence that the Indian Government was spreading thin, its financial resources, with the transportation sector accorded the lowest budget due to its priority status. The evidence showed that ratio of throw-forward, which is the equivalent of anticipated cost less accrued expenditure, was predominantly excessive. As such funds adequate for the full and timely completion of three to four projects were spread-out too thinly to accommodate up to six to seven projects. This practice thereby stretches project completion times for committed projects beyond the anticipated completion time, a period over which inflation would also creep in. Even with significant backlog of uncompleted projects, further projects were being initiated;

- Content analysis of 94 out of the 99 available project reports revealed such phrases alluding to *inadequate project preparation, planning and implementation*:

  "Project monitoring is absent'; '*Planning is non-existent/weak*'; '*Much divergence between the project report and the Project as it was actually implemented*', '*Project report not backed up by ground surveys'*; *'Estimates were based on inadequate data*"*(Morris, 1990: 158);*

- The trend analysis in the pattern of cost overruns, revealed that the high priority sectors, such as petroleum and natural gas, displayed half the national average cost overrun. Infra-structural investments like roads and railways on the other hand mostly experienced more than 100% cost overrun, with a capital (waste) factor' in excess of 250% due to delays. Morris (1990) although acknowledging other technical factors as major underlying factors accounting for cost overruns, thus stated the political expedient tendency of public authorities in developing countries to initiate a large number of projects, only to short fund them all, except for the ones accorded a high priority;

- It was further concluded that poor performance in the principal sectors of the economy like power, coal and steel, have also triggered a chain reaction effect which has led to loss of output and to higher costs leading to delays and cost overrun elsewhere in the economy, particularly infrastructure projects.

The interesting theoretical narrative offered by Morris (1990:154), as explanatory to cost overruns in public projects is thus quoted:

> *"Factors internal to the public sector system and Government largely account for the delays and cost overruns… Appraisal by the Government very often is devoid of meaning when the emphasis is only on the form of the project proposal rather than on its content- a tendency quite usual in bureaucracies. Since the public enterprises particularly those in the core sector have large dealings with each other, a vicious circle of delays has been built up. The politically expedient tendency to take up large numbers of projects and short fund them all, except those with the very highest priority, is perhaps the most important factor in delays. The Government's ad hoc approach in according high priority to certain sectors- oil and natural gas, and petroleum- while perhaps overcoming the problem in these sectors have compounded the problem elsewhere, particularly in the infra-structural areas".*

Mansfield *et al.* (1994) also made a similar assertion as Morris (1990) within the context of highway development in Nigeria, pointing major technical shortcomings in Nigerian highway delivery, based on questionnaire analysis. The authors described the typical scenario in Nigeria which often led to funding shortfalls: *"Projects are rushed at their commencement, with political sensitivities overriding the need for detailed preparation of project plans and estimates" (*Mansfield *et al*. 1994:256*)*. However, this was expressed as an opinion, and was not based on any form of qualitative data collection or analysis.

The narrative provided by Morrison (1990), is further noted, as contextually very distinctive from all the other empirical narratives analysed by the researcher, although no form of supplementary primary data collection was sourced, apart from documents/archival data, was evident in the study. The dynamics of under-development and shortcomings in the technical capabilities of public agencies, plays out a lot more in Morris (1990) study, which underscores the basis of the researcher's fundamental rationale for carrying out this research: that the institutional setting of public project delivery in the developed and developing world are very different. This study is thus framed within the lenses of the geotechnical difficulties, experienced by public highway agencies in the delivery of highway infrastructure, in view of the peculiar geologic setting of the Niger Delta region, which may trigger cost overruns, juxtaposed against the backdrop of the politico-economic setting of Nigeria as a developing nation.

3.8 Critical Literature Synthesis: Moving Beyond Abstract Postulations/Superficiality to Context Specific Studies, with In-depth Qualitative Narratives and Quantitative Outcomes

The varying explanations for cost overrun experienced on public highway projects, critically analysed in the literature review, can be broadly dichotomised into:

- Technical explanations which point out how projects fall short of the requirements of best practice, along with how unintentional errors in forecasting, coupled with uncertainties/unpredictable events, can invariably lead to cost growth.
- Theoretical explanations which attribute the prevalence of high levels of cost overruns to the inherent internal dynamics of public sector investments which tend to deliberately or subconsciously downplay technical requirements.

From the critical analysis of the literature, it can also be discerned that out of this lot, there are a plethora of methodologically simplistic empirical technical studies, which either list out factors, generate a typology of explanations, or carryout correlative studies on cost overrun trends and project. The researcher also notes that several of the quantitative empirical studies mostly deploy exploratory statistical tools to deduce conclusive inference. Typically, the use of correlation and factor analysis, which should be used as a preliminary exploratory tool to detect association, structure or collinearity amongst groups of variables, is often used as an inferential statistical tool to draw conclusions on cause-effect relationships.

On the other hand, in the bulk of theoretical research on cost overruns, the high level of abstract theorising without the merits of empirical evidence in the literature, as well as the lack of texture and context, required to understand project specific causes of cost overruns, and how these varying explanations complement and link to each other, in accounting for recorded project cost overruns, is a notable shortcoming. No project specific narrative account of events from empirical data, is tendered.

It would thus appear that most explanations for such a 'practical project information oriented concept' as cost overruns, which requires a clear narrative of the network of causal events (process) that led to the specific quantity of cost overrun (outcome), are in a state of lock-in. This shortcoming was noted by Love *et al*. (2012), as depicted in Figure 3.14, whereby each node represents an event or circumstance that triggers the next in the chain of events.

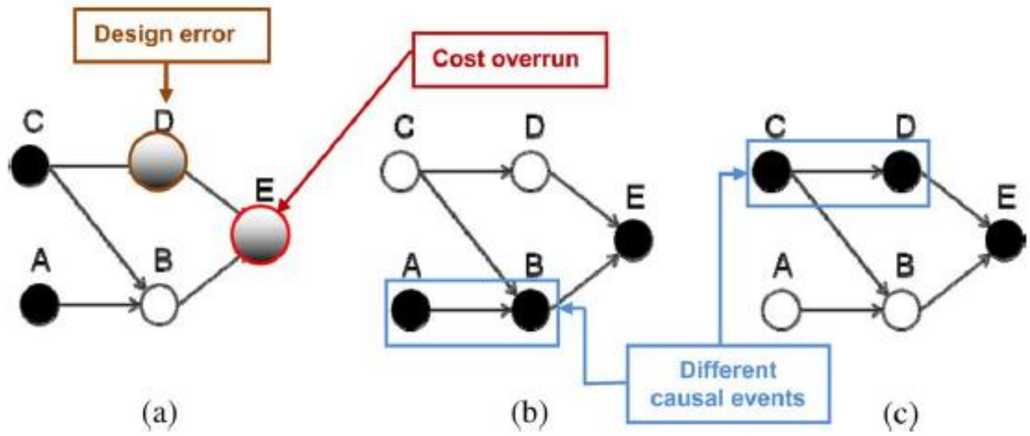


Figure 3.14: Counterfactual Causal Chains/Case Histories Leading to Cost Overruns

Source: Love *et al*. (2012)

Providing details of how events unfold in a counterfactual path dependent analysis, useful to provide a history to projects, is mostly lacking. Methodological inertia in artificialised opinion survey, lack of rigour, and imaginative theorising without concrete facts, are thus dominant in the bulk of the existing literature. The lack of demonstrable causality, context and outcomes by majority of technical and theoretical research on cost overruns, thus constitutes the argument of more contemporary scholars researching on cost overruns (Love *et al*. 2012; Ahiaga-Dagbui *et al*. 2014; 2015; Love, 2015).

Ahiaga-Dagbui *et al*. (2015), described the bulk of research centred on investigating the phenomena of cost overruns as '*superficial, replicative and stagnated'*, often more generating questions than answers. Ahiaga-Dagbui *et al*. (2015), further stated that the inferences drawn from most empirical studies were lacking in depth, based on simplistic correlative analysis which did not demonstrate cause and effect relationship with the recorded cost overruns in projects, and only just managed to scratch the surface of this complex phenomena plaguing construction projects. Ahiagu-Dugbai *et al.* (2014), argued that there needs to be more useful and robust research, targeted at understanding the propagation of cost overruns on a project specific basis, which could serve as platforms for Reference Class Forecasting (RFC) during decision making in future projects.

Ahiagu-Dugbai *et al*. (2014:40), thus underscored the need to fill in this evident gap in the literature on cost overruns, stating: "*More robust explanations of overruns need to factor-in process and product, as well as sources of changes to scope".*

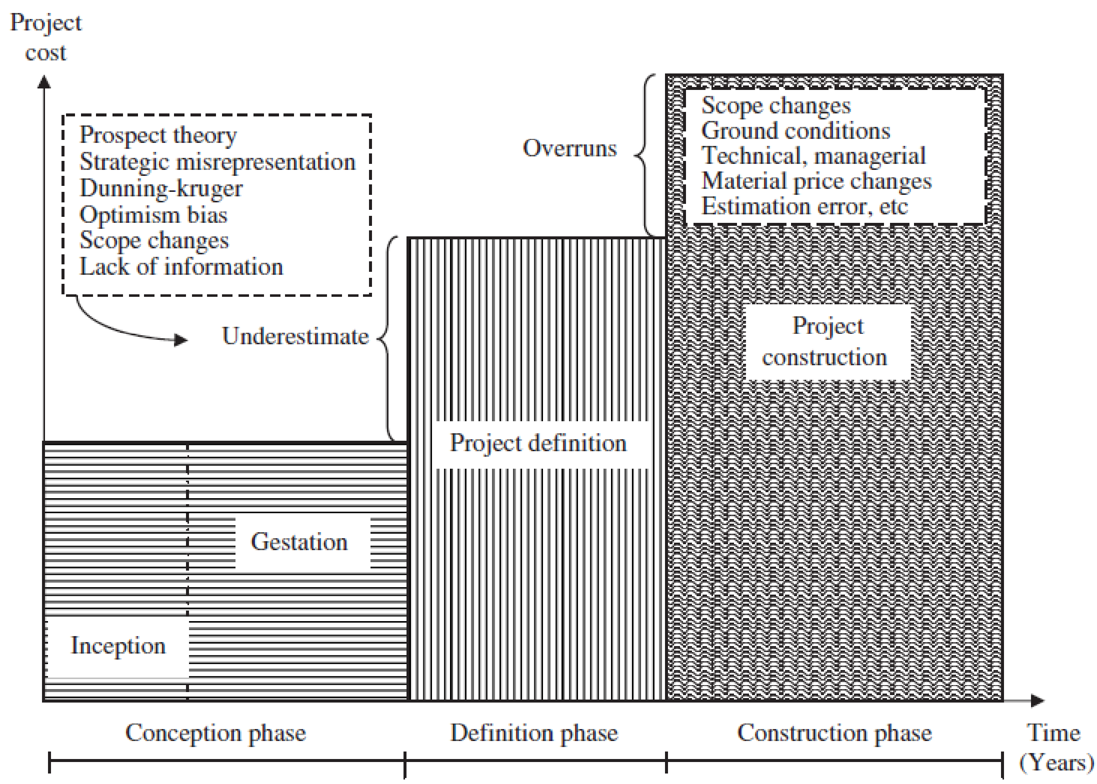


Figure 3.15: Generic Model of Explanation to Cost Overruns by Ahiagu-Dugbai *et al.* (2014)

Calling for further research to bridge the gap between theory of cost under estimation and cost overruns recorded in practice as shown in Figure 3.15, Ahiagu-Dugbai *et al*. (2014) identified the need to account for the network of interactions amongst factors and drivers accounting for cost growth, in other to provide less disjointed and holistic explanations to cost overruns. Love (2015), further reiterated this stance by advocating the need for studies which incorporate the insider perspectives (Practice) within highway organisations, to complement the outsider perspective (Theory).

A few distinctive empirical theoretical narratives as outlined in the literature review, have however used more comprehensive frameworks as context specific theories, explaining cost growth from the inception to the completion of public projects:

- Morris' (1990) Vicious short-funding and delays vicious cycle in India
- Cantarelli *et al's* (2010) Theory of lock-in and path dependency in the Netherlands;
- Love *et al's* (2012) Latent pathogens narrative of social infrastructure in Australia;
- Gil and Lundriganm (2012) "Relay Race" framework of project governance in the UK
- Lundriganm and Gil's (2013) Core and periphery framework in the UK
- Johansen's (2015) Uncertainty framework in Norway

Quantifying the contributory powers of the cost overrun factors identified in these theoretical frameworks, however, is also a necessary prelude to improving the accuracy of cost estimates, by isolating and catering for the identified cost overrun variables. This underscores the need for generating complementary quantitative explanatory cost overrun models. The trend in the literature reveals innovative approaches which have been sparsely used to investigate and model cost overrun relationships in projects. Typically: the use of probabilistic simulations to set contingency margins; data mining as a precursor to network modelling of non-linear cause-effect relationships accounting for project cost overruns; regression modelling to define the magnitude of cost overrun inducible by specific project variables; as well as the use of CBR models to aid in decision making for future projects, has been demonstrated by various studies.

These modelling techniques have however never been used in the literature to develop explanatory models of cost overrun trends in tandem with contextual narratives. It is thus observed that the few sparse, more methodologically robust studies, either mostly provide valid qualitative theoretical explanations (process) or quantitatively analyse project data and recorded cost overrun outcomes in projects (product). No study has been identified by the researcher as incorporating and linking both strands to the argument on cost overruns in highway projects, relevant to provide more comprehensive contextual explanations. This study in furtherance of the incisive observations of Love *et al.* (2012), as well as Ahiagu-Dugbai *et al*. (2014) identifies the need for more comprehensive and context based qualitative approach, complimented by the utilisation of project cost data modelling techniques. Further to these observations, Cantarelli *et al* (2012:50) emphasises the need for context based studies, specifically in relation to individual countries, stating:

> "*Without a general tendency in country specific studies towards lower or higher average cost overruns…, it remains difficult to make inferences about individual countries ... This therefore supports the need for further research into country specific cost performance of transport infrastructure projects".*

These evident shortcomings in the literature, sets the agenda for this research. This study attempts to fill the identified gap in the literature, by investigating geotechnical explanations to cost overruns, using a robust and thoughtfully designed mix of methods

3.9 Theoretical Framework

Considering the numerous studies in the local literature, identifying the potential limitations in Nigerian engineering practice, the researcher has adopted Love *et al*. (2012) latent pathogen theory, and the 'Vicious Cycle of Short-funding and Delays' Narrative by Morris (1990), as the theoretical framework for this study. It is thus hypothesized that: *Geotechnical pathogens will often lay dormant within the linear process configuration of design and cost estimating in highway organizations, but will be unintentionally triggered, culminating in significant cost overruns during the post-contract phase, as the project team deal with their delay effect and funding requirement.* Geotechnically induced latent pathogens, as plausible explanations for cost overruns are thus specifically investigated in this study. Therefore, although other triggers to cost overruns are acknowledged as present in highway projects, the study primarily sets off to investigate geologic/geotechnical factors that explains cost overruns. The researcher thus seeks to explore explanatory perspectives that are reflective of poor geotechnical input in pre-contract preparation, and how these account for increased cost overruns, using a technical narrative more applicable to highway projects, and contextualised within the geologic setting of the Niger Delta region.

3.10 Chapter Summary

Cost overruns in highway projects have been shown to be a topical issue, which has attracted a lot of negative public and media attention. A wide array of studies, have thus dwelt on, and analysed why cost overruns, seem to be an ever present feature of construction projects, particularly in those executed by public agencies. This chapter, has taken a comprehensive and critical outlook at the various approaches that have been used to explain the phenomena of cost overruns in public projects, with a view to establish the theoretical and methodical lenses through which past studies have been conducted. The outcome of the critical analysis, has revealed that several gaps in the literature exist in terms of: the lack of robust evidence to support the assertions that geotechnical risks impact on cost overrun levels in highway projects; the limited contextual specificity of studies; the paucity of methodologically robust explanatory approaches; and the exclusivity and cluster in the geographical spread of qualitative narratives, to the developed world, which is mostly not reflective of developing nations such as those on the African continent. In response to these identified gaps, this study is structured, as a distinctive and significant departure from previous studies on cost overruns. Chapter four provides a detailed outline of the research methodology, adopted in this study, necessary to provide explanations to the unusually high level of cost overruns recorded by highway agencies in the peculiar wetland terrain of the Niger Delta. This is against the backdrop of the techno-economic and Institutional setting of Nigeria as a developing country.

CHAPTER FOUR

The Research Methodology

4.0 Introduction

This chapter sets out the research methodology, which is the overall framework that served as a guide on all aspects of conducting this study. A distinction is however made between the terms *Method* and *Methodology*, which are often used interchangeably. Research method refers to *"a more or less consistent and coherent way of thinking about and making [collecting] data, way of interpreting and analysing data, and way of judging the resulting theoretical outcome"* (Morse and Richards, 2002:10). Whereas Creswell (2003: 5), defines research methodology as: "*A strategy or plan of action that links methods to outcomes and governs our choice and use of methods*. A proposition reinforced by Farrell (2011), who described methodology as the design of research at a strategic level.

Others, such as Saunders *et al.* (2009:34) definition of research methodology, however, emphasises less on the practicalities of conducting a research, and more on its underlying theoretical underpinning, referring to it as: "*The theory of how research should be undertaken*". With Holden and Lynch, (2004:397) contending that that: "Research *should not be methodologically led, rather that methodological choice should be consequential to the researcher's philosophical stance".*

This implies that the logic and philosophical underpinnings of a study should be encompassed in the research methodology, and should therefore inform the specification of the research methods that are practically deployed in the investigation of a problem (Dainty, 2008). Creswell (2003) thus recommends that the research methodology should serve as a basic guide on all aspects of a study, from shaping the broader philosophical ideas that are brought to a study, down to the specifics of data collection and analysis.

Conceptualisation of the research methodology of this study, therefore, was projected in multiple and interactive layers, as an interwoven synthesis, of informed decisions made at the philosophical, strategic and practical levels. (Gajendran, 2011). As Farrell (2011:23) underscores, "*there is need for a detailed description of each step of the research process"*, the components of the research methodology adopted in this study, are presented and explicitly defined exhaustively, in a hierarchical order, visualised in Figure 4.1.

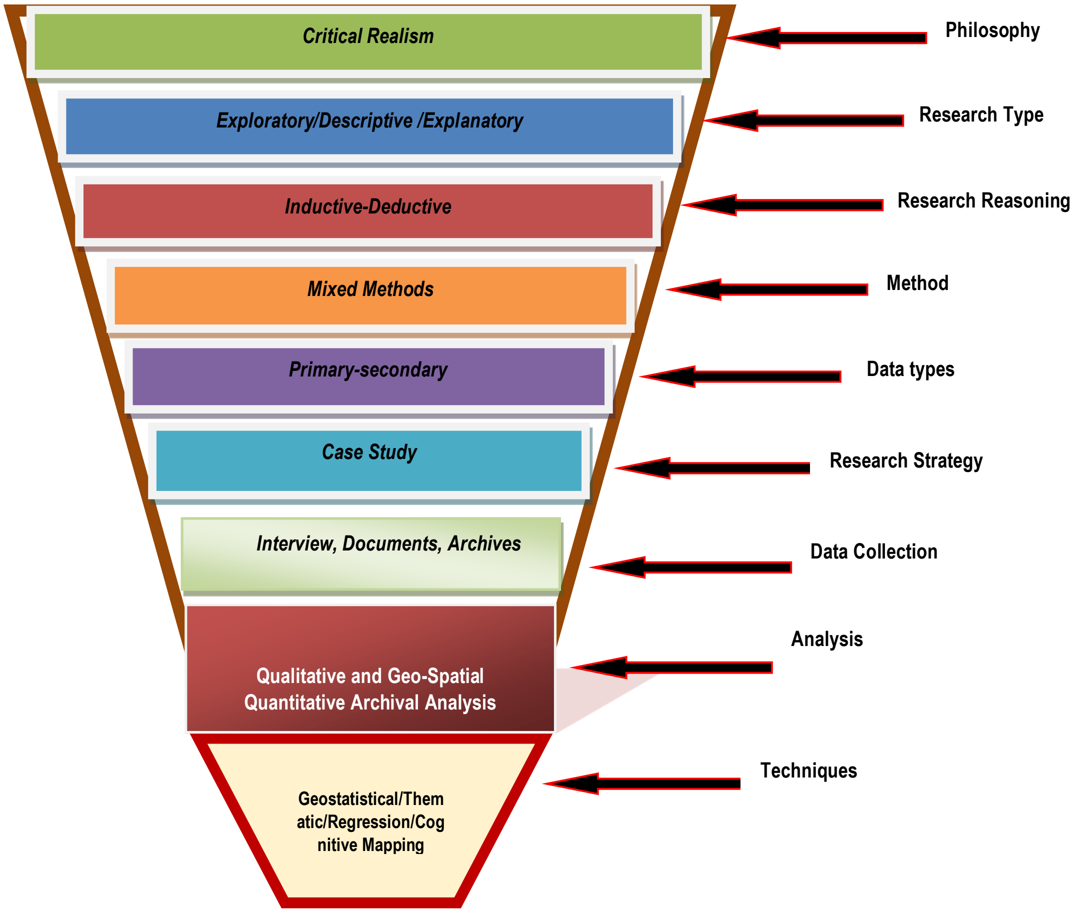


Figure 4.1: Research Methodology of this Study

It therefore followed that in the discussion of the research methodology of this study, these multi-layered interactive constituents had to be clarified, and a logical justification provided, to support the choices made at each layer. The elements of the research methodology adopted in the conduct of this study, are thus presented in a coherent flow of well-articulated philosophical arguments and theoretical positioning, grounded in an existing and widely recognised body of knowledge, covering all aspects of academic enquiry at doctoral level.

4.1 Research Philosophy

The term 'Philosophy', as used in general premise, refers to a '*system of beliefs and assumption about the fundamental nature of knowledge, reality, and existences'* (Oxford Dictionary, 2014). Philosophy in the domain of academic enquiry, provide the framework for how a research project is conducted, based on the researcher's beliefs and assumptions, concerning what is valid as knowledge, and what process should be used to attain that knowledge (Guba and Lincoln, 2005; Saunders *et al*., 2009). For instance, Saunders *et al.,* (2009:107) espouse:

> "*Our values can have an important impact on the research we decide to pursue and the way in which we pursue it. This may not lead to any form of discord, but it may mean that some observers accuse us of untoward bias*.

As such, the philosophy of a research, though mostly an abstract entity, emanates in the way the work is written (Holden and Lynch, 2004). A vast array of terminologies has been used by different authors in the scholarly literature, to describe and explain the philosophy of research: Knowledge claims; Philosophical assumptions; Epistemologies and ontologies; Paradigms; Knowledge claims; World views (Crotty, 1998; Mertens, 1998; Lincoln and Guba, 2000; Creswell, 2003; Creswell and Clark, 2011).

Typically, within the context of social enquiry, Blake (2005) described research paradigms, as the broader philosophical and theoretical traditions, which have served to provide a platform for addressing and understanding social issues. Blake (2005), consequently asserted that, research paradigms provide a platform for the application of logic, in the linkage of people's experiences and perceptions, within the wider context of the social world in which they inhabit. In this context, Blake (2005) used the term 'research paradigms', to describe the theoretical underpinnings of enquiry, which is shaped by particular ways of viewing the social world, and the comprehension that stems from such views. Creswell and Clark (2011), however, described the terms *World view* and *Paradigm* as being synonymous with the term research philosophy. Creswell and Clark (2011), traced the terms back to their origin in the 1970's, when Kuhn defined paradigm as a set of generalizations and beliefs common to a specialised discipline. Creswell and Clark (2011), further, distinguished it from current usage, by describing research philosophy as the commonality in the shared beliefs and values of researchers, and how this affects the way research is conducted.

It is therefore necessary that the philosophical stance taken, and assumptions made, about how and what will be learnt, in the process of conducting this research, is explicitly elucidated, as it informed the overall structure of the study, reporting, as well as the manner in which data was collected, analysed and interpreted.

4.2 Elements of the Research Philosophy

There are four major dimensions of research philosophy, about which core assumptions concerning the conduct of this research, were made: ontology, epistemology, axiology and rhetoric (Creswell, 2003; Grey, 2009; Saunders *et al*., 2009). These ontological, epistemological, axiological and rhetorical strands, thus shaped the reasoning about how this research was conducted. They are thus defined apriori, as the basis on which the subsequent critical evaluation of the research philosophies was made in section 4.3, necessary to select and adopt the most suitable orientation for the study, in providing a robust explanation, for the phenomenon of cost overruns experienced in highway projects.

4.2.1 Ontology

Grey (2009) explains ontology as an understanding of what reality is, i.e. the perception of what exists out there in the world (Hughes, 1990). It is thus a reflection of what the researcher views as being reality. At the ontological level of research philosophy, Saunders *et al.*, (2009) mapped out two extremes of this scale; Objectivism and subjectivism, which frame the lenses with which researchers look at social phenomena (Grey, 2014). The objective school of thought isolates reality from social external influences, as opposed to the subjective, which emphasizes that reality is shaped by social forces. Hughes, (1990) therefore summarised the question of ontology, as hinging on the nature and significance of empirical inquiry, as to whether or not the world is factual.

With this outlook, an ontological stance of either to: adopt a singular (*A world exists out there independent of our knowledge*); or multiple (*There are several ways of viewing the world*), perception of reality, was taken. This decision was however made, in tandem with the intrinsic nature of the phenomenon being investigated: '*Cost overruns in highway projects'*, with a view to provide a comprehensive and in-depth understanding of it.

4.2.2 Epistemology

This relates to the fundamental belief of a researcher concerning what constitutes knowledge. Epistemology is focused on how people identify knowledge and the standards that determine what can be said to be knowledge. Hughes (1990) used the phrases: "*What counts as fact?*", and "*What is the character of our knowledge of the world?"* to describe epistemology. Epistemology of research thus hinges primarily on what is considered acceptable knowledge for a particular field or a particular study (Saunders *et al.*, 2009).

In this vain, the researcher's perception of the nature of knowledge, and what is considered valid as constituting knowledge, dictated the approach to this study. Therefore, the legitimacy of knowledge as adopted in this study, was established at the epistemological level (Grey, 2014).

This inherently manifested in terms of the level of bias introduced in this study i.e. whether the researcher maintained an objective distance from the facts, or infused a subjective presence (researcher's/participants') into the research, as later elucidated.

4.2.3 Axiology

The axiological strand of the research philosophy revolves around what values go into conducting the research (Heron, 1996; Creswell, 2003; Saunders *et al.* 2009). Axiology emphasizes the role of values on the conduct of a research and its effect on the credibility of research outcomes, as either being value laden or value free (Saunders *et al.,* 2009). Researchers thus clearly recognize and acknowledge the impact of their values on study outcomes, if value laden.

The axiology of the study, thus defined how the values of the researcher were either been expressed in the study or conducted independent of the researcher's values (Grey, 2009). As subsequently elaborated, it informed the choices made by the researcher in collecting evidence, and the mode of reporting the study findings. The axiology of the research therefore, was articulated explicitly in all facets of the research.

Axiology as such, covers issues of rhetoric in terms of reporting findings, and how validity was ensured within the context of this study. Brinberg and McGrath (1985:19) described rhetorical issues within the process of research as:

> "*The identification, selection, combination and use of elements and relations from the conceptual, methodological and substantive domains of a research study to ensure validity of research findings*".

Brinberg and McGrath (1985) explained that rhetoric can be inferred, from the way a research is conceptualized and articulated. As it is dependent on the value or worth attached by the researcher, as to what is considered important in the subject domain, it determined which measures were logically taken to ensure generalisability, or a lack thereof, in this study. Typically claims to generalisability are not made in reporting findings, if the philosophical basis of the research assumes multiple realities and acknowledges subjectivity as to what constitutes knowledge (Blake, 2005). In this vain, such study outcome may be considered ideographic, and analytic generalizations, nested within the confines of the specific setting, which adds to the knowledge domain may be made (Yin, 2014).

4.3 Research Philosophies

There are major philosophical positions or knowledge claims adopted by researchers in the conduct of research. Various authors (Creswell, 2003; Grey, 2009; Saunders *et al.,* 2009) have categorised these philosophical positions using varying terminology, often with some level of fuzziness, lacking in explicit distinction. For instance, Creswell (2003) outlined four distinct philosophical stances or theoretical perspectives in research, namely: Post-Positivism; Constructivism; Advocacy/participatory and Pragmatism. Whilst Grey (2009) suggested the main philosophical positions include: Positivism; Interpretivism (Phenomenology, Symbolic Interactionism, Hermeneutics and Naturalistic Enquiry); Critical Enquiry; Feminism and Post-Modernism. Finally, both authors views are challenged by Saunders *et al.* (2009) who discussed these philosophical views on the basis of four categories: Positivism; Realism; Interpretivism and Pragmatism, defining the relativity of epistemological and ontological stances, as an onion bulb.

Despite these different world views discussed, Positivism and Interpretivism, are consistently discussed in the literature, in relation to their contrasting ontological, epistemological and axiological stances, with a third world view, Pragmatism, presented as a combination of both approaches in the more recent literature (Saunders *et al*., 2009; Creswell and Clark, 2011). The debate in the literature, thus appears to be centred on the two extremes of positivism and interpretivism, as to what is reality, and what therefore should constitute knowledge. Positivism is repeatedly cited in the array of research philosophies, owing to the fact that it is the foremost research approach, while Interpretivism and pragmatism have emerged as distinct classes of post-positivists philosophies. On this basis therefore, the discussion of the literature on the multiplicity of philosophical stances, has been delineated and synthesized along these three broader divisions of the Positivist, Interpretivist and Pragmatist perspectives.

4.3.1 Positivist/ Post-Positivist Philosophical Stance

Grey (2009) reported that positivism was the dominant philosophical stance in the 1930's, through to the 1960's. This philosophical stance is based on the epistemological view that, the world exists externally and independent of the researcher, and that knowledge comes from observing the world around us (Creswell, 2003; Blake, 2007). It has been described as a theoretical stance analogous to working with observable facts, similar to the research tradition of the natural scientist or the physical sciences (Sanders *et al.*, 2009).

A term used by Blake (2007) to describe positivism was '*Empiricism'*. Blake (2007) described positivism as being based on the key assumption, that knowledge can only be produced by the objective usage of the human senses, and that this is the only sure and reliable basis on which research can be conducted. Saunders *et al.* (2009) suggested that following the positivist tradition, the trained researcher should carry out a study scientifically, using and applying standard established procedures. Blake (2007) described the positivist philosophical stance as "*Having an undistorted contact with reality*". Additionally, Blake (2007) further stated, this ultimately depicts value neutrality, necessary to yield an accurate representation of reality. In this way the researcher is seen as a '*subject'* trying to study an '*object'*.

In the 1980's the core principle of the positivist school of thought was broadened to reflect post-positivist views. This was based on an intellectual movement, which defied the absolute finality of the positivist tradition. This post-positivist stance challenged the traditional notion of absolute truth of knowledge, based on the reasoning that the positivist tradition was not applicable particularly when studying the behavior of humans. Saunders *et al.* (2009) description of *Realism* appears synonymous with this post-positivist stance. The proponents of this school of thought, asserted that knowledge is conjectural, and that absolute truth can never be found, as it continuously changes in the light of new findings emanating from social reality.

The key attributes of the post-positivists philosophical stance are summarised by Creswell (2003):

- That knowledge is imperfect and therefore refutable;
- That research is a process of continuous refinement of knowledge in the light of stronger evidence;
- Rationality, data and evidence are the defining basis of what constitutes knowledge;
- The reduction of ideas into discrete numeric measures of observation is pivotal;
- The generation of generalizable causal statements is the central focus of inquiry;
- Objectivity is central to ensuring reliability and validity.

4.3.2 Interpretivism

This is the major philosophical stance that has been identified in the literature as critical, and starkly opposing the positivist stance. Hammersley, (1993) historically traced the evolution of interpretivism, as being the outcome of a long history of criticism of the hypo-deductive logic of the positivist tradition. This was based on the disparity between the laws of science and social reality, which therefore warranted different methodological approaches (Grey, 2014). The central argument proffered by the Interpretivist group was:

> *"Rich insights into this complex world are lost if such complexity is reduced entirely to a series of law-like generalisations" (Saunders et al., 2009:116).*

On this premise, Crotty (1998) emphasized the focus of the interpretivist on the qualitative uniqueness of individuals' perspectives, as opposed to the positivist perspective, which seeks to establish consistencies in data as a basis of generating laws. Interpretivism therefore, relies on the subjective meaning given to reality by the participants in a study. As such reality is conceived as being multi-faceted, from the view points of the human beings, regarded as the key social actors that define reality (Descombe, 2007). Creswell (2003), described the researcher in this vain, as striving to derive meaning from the complexity of views, as opposed to narrowing down to a few categories of ideas.

The terms '*social construction of reality'*, '*constructivism*' and '*constructionism*' all refer to interpretivist philosophical stance, which emphasize that reality is socially constructed or interpreted (Creswell, 2003; Blake, 2007; Saunders *et al.*, 2009). Grey (2009:21) used the phrase "*Culturally derived and historically situated*" to describe the Interpretivist philosophical perspective to research. As Creswell (2003) reiterates, meaning and interpretation of subjects in such studies, are culturally and historically negotiated, through the process of interaction, and not simply imprinted on individuals.

It would however appear that, there is a diverse range of classifications in the literature on philosophical approaches, that by implication should be inclusive in the interpretivist world view. Some authors have categorised all anti-positivist philosophical stances as being Interpretivist (Saunders *et al.*, 2009). Yet some have isolated and listed interpretivism as one of the numerous world views, alongside others such as feminism, critical theory and realism (Blake, 2007; Grey, 2009). Creswell (2003) however, grouped philosophical approaches that advocate for specific social and marginalised causes under as participatory/emancipatory world views, as distinct from those of the Interpretivist. This was rationalised, in view of the shortcomings of the interpretative approach, in addressing specific social issues about marginalised groups of people in society.

In the researcher's view however, all the other philosophical perspectives which rely on the need to emphasize the values of the researcher and the participants can be grouped under the broader perspective of interpretivism. This, in the opinion of the researcher, is because the key distinctions noted amongst these philosophical groups, are the differences in the levels of involvement of the researcher and the participants, as well as the specifics of the subject matter being investigated. Along similar line of logic, Blake (2007) analysed the differing stances adopted by researchers within the context of socially constructed knowledge. The author described the researcher in this scenario as being an '*insider*' and a 'l*earner*', while noting the distinction in terms of the researcher's stance as to *'being for*', '*being with*' and '*partnering with or conscientizing with*' the participants. Creswell (2003), also explained the researcher's stance as being either '*collaborative'* or '*understanding'* and geared towards change or theory generation. The descriptive views of the more commonly listed non-positivist philosophical stances in literature are briefly outlined:

4.3.2.1 Phenomenology

The philosophical stance of phenomenology, according to Grey (2014), is that the comprehension of social reality can only be gained through the richness of the experiences of participants in a study. Grey (2014:67) further stated that, a fundamental requirement of phenomenology, "*is the laying aside of preconceptions and common-sense believes"* in order for new meanings to evolve, unadulterated. Descombe (2007) used the phrase "*adopting the stance of a stranger*" to describe the approach of the phenomenologist. Saunders *et al.* (2009) also alluded to the researcher's position as being required to figuratively "*enter the world of our research subjects and seeing reality from their viewpoints*" (Saunders *et al.* 2009:116).

Thus emphasis is placed on obtaining authentic reflections of the phenomena being studied (Descombe, 2007). This is done to a sufficient depth, relevant to capture even the slightest nuances in the phenomena. The need to explore the individual construction of personal experiences in-depth, is underscored as a key feature of phenomenology. With Descombe (2007) emphasizing the central focus, to be exploring multiple realties. Phenomenologists, according to Descombe tends "*to live with and even celebrate the possibility of multiple realities* (Descombe, 2007:79). Therefore, to the phenomenologist, the world exists only in the way it is experienced and interpreted from the differing perspectives of participants.

4.3.2.2 Symbolic Interactionism

Grey (2009) traced the emergence of symbolic interactionism in the 1930's, to the discontentment of some philosophers in the conceptualization of human behaviour. It was considered necessary for research to explore the reality of human practices and lived experience.

This approach emphasises the continuous interpretation of social reality. To the symbolic interactionist, human interaction is not induced by cause-effect relationships, but is largely set in a symbolic linguistic world. Different symbols thus hold different meanings, dependent of the value system inherent in the socially contrived setting. This is in the light of human interaction which leads to a corresponding re-adjustment in the human perception of the social world around us (Saunders *et al.*, 2009). A central theme in this philosophical approach is the derivation of meaning (Grey, 2009; Saunders *et al.*, 2009). Meaning is seen as being regularly revised, based on experience, and is therefore not stable (Grey, 2009). As such Grey (2009) stated that the meaning of making in the process of interpretation, is the core of human interaction. Close observation of subjects in the field setting, is typically a necessary approach to achieving this because a symbolic interactionist explains the actions of individuals as an outward manifestation of the meanings that are attached to social reality (Grey, 2009).

4.3.2.3 Feminism

The feminist approach to research is one of the philosophical schools, that Creswell (2003) discussed as being of an advocacy/participatory based stance. This approach is used to explore the wide range of issues surrounding women, policy and institutional frameworks, within the context of the oppression, which women are seen as being subjected to (Creswell, 2009). The central debate of the feminist, is that of dominance and complimentary oppression, on the parts of men and women respectively, which has shaped their knowledge of the world (Grey, 2009).

Creswell (2009) summarised the generic characteristics of the feminist philosophical research, typical of most forms of advocacy research:

- Change oriented;
- Liberation from the shackles of unjust societal imposed constraints;
- The objective of empowerment;
- Collaborative relationship between the researcher and the participants.

The underlying assumption of the feminist school of thought is that: the feeling of superiority amongst men is regarded as having to a significant degree, distorted their view of the world (Grey, 2009). This is opposed to women who are operating from the level of being dominated, and thus have a relatively undistorted and objective perception of reality. On this basis therefore, Grey (2009) stated that the feminist group have challenged what ideally ought to constitute knowledge, claiming that objectivity and rationality are constructed around a predominantly male vantage point. The feminists thus advocate for a shift in this approach, to embody the deeper experience of reality enabled by the oppressed feelings and emotions of women.

4.3.2.4 Critical Theory

The philosophical stance of the critical theorist is similar to the feminist, with the core difference being the specificity of the subject of debate. Creswell, (2003) classified this research approach as one of the advocacy based philosophical positions. Grey (2009) however discussed critical philosophy as being quite distinct from other research stances. The author described it as a meta-physical process of investigation, which calls on both the researcher and participants to question their basic value system. The author described this as "false consciousness" with a requisite need for its discarding to generate a neutral mentality. According to Guba and Lincoln (1994:) critical theory is a "*Virtual" reality shaped by social, economic, ethnic, political, cultural, and gender values, crystallised over time".* The critical theorist thus challenges conventional social structures and advocates for individuals in society to transcend these boundaries (Creswell, 2003). It is principally empowerment driven and focuses on revisiting currently held values and assumptions in relation to power structures in society (Grey, 2009).

4.3.3 Pragmatism/Critical Realism

Creswell and Clark, (2003) referred to pragmatism as "the third major philosophical movement". Pragmatism as the name implies, is a philosophical position which is practical in nature. It thus relegates the philosophical debate of singular or multiple realities, in terms of epistemology and ontological arguments, to the background. John Dewey is considered the pioneer author of this philosophical movement, which criticised traditional epistemologies on the basis of *the "too stark a distinction between thought, the domain of knowledge, and the world of fact to which thought purportedly referred"* (in Thayer, 1952). Dewey (1890) thus queried "*Is Logic a Dualistic Science*?" and coined the phrases "*theory of inquiry*" or "*experimental logic*" as more amenable to the practicalities of carrying out research (in Hickman and Alexander, 1998). To the pragmatist therefore issues emanating from the dialectical epistemological, ontological debates should take a backseat to the more cogent issue of the research problem and how best to provide an understanding of it. (Creswell, 2003; Saunders *et al.*, 2009; Grey, 2014). Creswell and Clark, (2011) stressed that the focus of pragmatism is on the research questions and the consequences of the research, which should ideally be of primary importance. Whereas, Grey, (2009), stated that, the practicality of the need to provide answers to different research questions, may warrant different philosophical approaches. This is on the grounds that a philosophical approach adopted for one research question, may be inappropriate if applied to another. The use of pragmatism as a world view therefore accommodates the use of both subjective and objective knowledge.

Tashakari and Teddlie (2003), noted thirteen different authors who clearly stated the need for a philosophical stance that was all encompassing, without the need to engage in philosophical arguments. This was rationalised on the premise that pragmatism has a trajectory that is rooted in practice and thus devoid of the divergence implicit in other philosophical perspectives. Hughes and Sharrock (1997) asserted that, most modern-day realism and empiricism have adopted variants of the pragmatist philosophy, by relegating philosophical arguments to the background, rather focusing on the specifics of the problem being investigated and the relevant methods to tackle them. It was thus stated that: "*There is certainly no reason to feel bound by stipulations about a unified method or a unified ontology for science, for on these arguments no such creature exists"* (Hughes and Sharrock, 1997:94).

There are however authors who have expressed the need for caution in adopting pragmatism as an all embracing world view, without explicitly defining the underlying ontological and epistemological stance of the researcher, describing it as more akin to intellectual laziness. Typically, Holden and Lynch (2004:401) stated that. "*if a researcher perceives ontology and epistemology to be irrelevant, then how can they ensure that their methods are really appropriate to the problem in hand? Conceivably the problem could be better investigated with a method from an alternative philosophical stance".* Moore (1905), in the wake of the rising acceptance of pragmatism inspired by John Dewey works, reviewed a compilation of studies by critics who challenged the philosophical position of pragmatism. The major issues cited were: looseness in the use of the term '*practical purpose'*; the implied subjectivity/relativity of the position; and the lack of a unifying prescriptive principle (Moore, 1905).

The theoretical application of the pragmatic world view, is thus still subject to debate in the literature. In more recent works, Greene and Caracelli (1997) argued that the use of multiple world views gives rise to irreconcilable differences in research, and rather emphasized the need for a differentiation of world views with respect to specific parts of a study. Similarly, Creswell and Clark (2011) advocated that the multiple philosophical stances used within a particular study needs to be explicitly defined within the research.

Critical realism has been argued to be a variant of the pragmatist philosophy, albeit one with a clearly defined ontological and epistemological positioning: *that social reality exists not only in the mind, but in the objective world and can thus also be objectively studied* (Huberman and Miles, 1985;1995). Typically, Lipscomb, (2011:1) expounds**: "***Pragmatism has been advanced as one means by which the Gordian knot of theoretical dispute can be cut and critical realists have, in recent years, also asserted same"*. The critical realist philosophical positioning also termed '*transcendental realism'* by Huberman and Miles, (1985), albeit controversial, is however backed by a rigorously argued intellectual justification by its proponents. The justification of the pragmatic-like philosophical positioning of the critical realist, as reinforced by its proponents: Huberman and Miles (1985); Frazer and Lacey, (1993); and Campbell (2002), is thus rationalised beyond the pragmatist mantra, '*practicality of the research'*, which has evoked major criticism from both the positivist and constructivist traditions.

Critical realism evolved from the post-positivism movement of realism, which views 'reality' as "*whatever it is in the universe that causes the phenomena we perceive with our senses*" (Frazer and Lacey, 1997:133). It was further stated that there is no objective or certain knowledge of the world, admitting to the possibility of alternative valid accounts of any phenomenon. Saunders *et al.* (2009) described realism as a predominantly objective positivist stance, but one which is conditioned by social reality. The authors distinguished between direct and critical realism on the basis of how the human senses perceives reality. Thus from the critical realist's position, human knowledge of reality is a result of social conditioning, and cannot be understood independently of the social actors involved in the knowledge derivation process (Dobson, 2002). Other authors such as Groff (2004: 23) concur with this description of critical realism, but emphasise more on its empirically inclined post-positivist nature typical of all forms of realism, espousing: *critical realism offers a "point of entry into epistemology and metaphysics for practicing social scientists*". Whilst Carter (2000:1) is of the view that "*critical realism attempts to reconcile the threatened divorce between social theory and empirical research*". Critical realism, which is thus more common in the social sciences, entails the concomitant retention of both an empiricist ontological view and a constructivist epistemological relativism (Campbell, 2002). It recognises that diverse valid perceptions and understanding of a research phenomenon is tenable.

4.4 Positioning Construction Management Research within the Philosophical Debate

Construction management research, as a form of social research is confronted with the fundamental issue of determining a core philosophical orientation, to be considered as adequate and best suited to enquiry about construction phenomena (Dainty, 2008; Fellows and Lui, 2015). Dainty (2008) stated that construction management, as an emergent field of research, is yet to have a recognised methodological orientation, characteristic of other more established domains, and therefore builds on the traditional philosophical assumptions of related natural and social science research. The term "*Methodological pluralism*", was thus used to describe the use of multiplicity of philosophies and methods, compatible with the study of construction phenomena (Dainty, 2008). This subsection analyses the extensive scholarly debates, advancing and advocating the competing philosophical positions, that inherently lend themselves as potential lenses useful to view and understand construction phenomena. The underpinning argument being that, the differences in world views, will yield marked differences in the type of knowledge generated. Bryman (1988:34) in the context of organizational research, typical of the construction industry, thus espouses "*different research paradigms will inevitably result in the generation of different kinds of knowledge about the industry and its organizations*".

Fellows and Liu (1997), traced the historical antecedent and dominance of the reductionist approach to carrying out positivist quantitative studies in construction research, as aligning itself more to the natural sciences. Typically, Panas and Pantouvakis (2010, investigated the various forms of positivist approach typically deployed in construction productivity studies. These were noted as mostly, the development of experimental frameworks, such as field experiments or laboratory tests, controlled experiments, comparative evaluations, based on statistical or probabilistic analysis. Data collection techniques utilized were mostly from archival sources for quantitative project data and questionnaires aimed at eliciting quantifiable data, useful for verifying hypotheses, often formulated on the basis of a literature review.

However, promoters of interpretivism view construction management research as a social science research, and advocate for studying construction phenomena as being socially contrived (Hartmann and Dorée, 2010; Gajendran, 2011). Their stance was thus: gaining rich insights into human behavior, is necessary to understand the actions of key professional players in the construction industry, which lends itself to multiple world views. Dorée (2010), opined that Construction Management as a discipline should strive to solve sociotechnical problems by proactive engagement with its socially driven knowledge base. In line with this constructivist view, Dorée (2010), asserted that social construction of knowledge, which is relative and non-objective, offers a rich, epistemological basis for carrying out construction research. A distinction, was further made between cognitive and social constructivism, with the former alluding to understanding gained through the dynamics of personal experience via social engagement, and the latter, being knowledge shaped by cultural influences.

Seymour and Rooke (1995), as well Seymour *et al. (*1997), further questioned the predominant philosophical leaning of the construction industry to quantitative studies, with their underlying positivist viewpoints, which signifies that the role of interpretivism was largely unexplored and downplayed. Gajendran (2011) investigated the potential philosophical orientations amenable to study the informal settings of the construction projects and organisations. Typically, it was revealed that such anti-positivist world views as Constructivism, Critical Theory, Hermeneutics-Emancipation, Critical Realism and Pragmatism presented viable alternative paradigms, to study the complex interrelationships commonly enacted, as a consequence of a project team's formal and informal activity. In view of this, Gajendran (2011) emphasized the consequence of the stiff philosophical positions, often taken by most researchers in the construction industry, as rich insights into the complexity of social forces in organisations and projects are not captured, severely limiting the depth of understanding provided. Gajendran (2011:90) thus concluded:

> *"Multiple philosophical points of departure, matched to a range of alternative methodologies, is indicative of the desirability of blending to reflect the peculiarities of each context under investigation… presents opportunities to conduct rigorous in-situ investigations, leading to authentic and deep insights that would otherwise remain unseen".*

Several derivative forms of interpretative philosophy, have however been applied to study the complexity of construction phenomena in a scant number of studies. Some studies capture the characteristic inter-connectivity of the construction industry, by conceptualizing complexity and systems frameworks, as a theoretical basis for applying interpretivism (Bresnen 1986; Baccarini 1996; Bresnen, *et al* 2005; Marrewijk *et al*. 2008; Remington, *et al* 2009). Typically, Bresnen *et al*. (1986) used an ethnographic approach to study the complexity of internal administrative arrangement, uncertainty, and the interrelationship between organisations in a contractual setting, noting the dual motivational drivers underlying such interaction. It was thus explained that the duality in the orientation of the construction industry stems primarily from: the client's need for an integrated trajectory of the project organisation; and the contractor's firm's need to meet up, in the fast paced and rapidly evolving technological setting of the construction industry. Others, such as Gorse and Emmitt (2007, 2009), Baarts (2009) as well as Pink *et al*. (2010) delve in-depth into the socially contrived behavioral and linguistic underpinnings of the actors in projects, such as those relating to safety practices on construction sites or understanding of invisible routes of communication by migrant workers, which is more akin to phenomenology or symbolic interactionism. Yet O 'Leary (2004:47) tows the philosophical logic of the critical theorist, stating *"without an appreciation of how attributes, positions of power and privilege, and worldviews conspire to create subjectivities, researchers in the construction industry, can easily fall into the trap of judging the reality of others in relation to their own reality*".

The use of such interpretative methods, is however not without flaws and criticism. The criticism of these methods, stemming primarily from its high dependence on the articulate skills of the participants, who provide the information, and the interpretative value laden posture of the researcher; as well as issues of generalisability. Dainty (2008) reported that 19 of 107 sampled research papers in 'construction management and economics', used single and focus group interviews, three of which used observation/visual data, while another three deployed textual analysis of documents. Hammersley and Gomm (2005) critiqued the sole adoption of singular methods, particularly interviews, with its limited methodological validity, due to the likelihood of eliciting responses geared towards promoting self-preservation, rather than the objectivity of facts being sought. Criticism thus surrounds the sole use of interpretative philosophies in construction industry research, with some authors dismissing it as inappropriate for scientific enquiry, by being '*too subjective'*, '*journalistic*', '*more akin to consultancy'* and '*not rigorous*' (Runeson, 1997; Harriss, 1998, Raftery *et al.,*1997). Others however, accept that it's the only feasible and practical means to access contextual meaning and form to social processes, within projects and organisational settings in the construction industry (Seymour and Rooke, 1995; Seymour *et al.,* 1997; Hartmann and Dorée, 2010; Gajendran, 2011).

These criticisms, and the aftermath of the incisive publications by Seymour and co-authors, propagated a need to amalgamate these dichotomous methodological orientations, beyond the isolated positivist versus interpretative philosophical realms, to straddle both methods of research. Dainty (2008), however, noted the still slow awakening in the consciousness of construction management researchers, in the direction of mixed method studies, unlike research in the management sciences. Only 12, out of 107 sampled published papers, using mixed methods. Within the 76 purely quantitative papers, limited reference was made to using exploratory interviews (Dainty 2008). Only a scant number of studies were noted as "*drawing upon a greater diversity of methods to enrich their understanding of the actuality of practice from the perspectives of those who work in the sector*" (Dainty 2008:7) These figures therefore indicate that, construction industry researchers still mostly tow the logic of the positivist, to understand to the complexity of socially derived organizational issues, leading Dainty (2008:9) to query their ability to provide '*a rich and nuanced understanding of industry practice'*.

Dainty (2008) thus recommended the use of triangulation of multi-method inferences, that incorporate multiple philosophical orientations as the only valid alternative, to escape such methodological dilemmas. This philosophical movement, typically pragmatism, was reinforced by Mingers (1997:9), using a practical analogy:

> *"Adopting a particular paradigm is like viewing the world through a particular instrument such as a telescope, an X-ray machine, or an electron microscope. Each reveals certain aspects but is completely blind to other... Thus, in adopting only one paradigm one is inevitably gaining only a limited view of a particular intervention or research situation … it is always wise to utilize a variety of approaches"*.

However, Barrett and Sutrisna (2009) advocate for critical realism, which equally affords the use of multi-methodologies, for instance within the context of a case study, with grounded theory incorporated as a further strategy, to maintain both objective and subjective realities of the constructs associated with a study.

4.5 Adopted Research Philosophical Stance in this Study: Critical Realism

It is often argued that the selection of a research philosophy by the research community is mostly an intuitive decision, often in line with the researcher's ontological and epistemological stance and preference, which may not necessarily ensure the rigor and robustness of the research effort (Holden and Lynch, 2004). Some other researchers, for example Panas and Pantouvakis (2010:77), have predicated the selection of an appropriate methodology, by identifying those typically deployed in similar studies, with the ultimate objective of "*Preserving research validity and establishing of a seamless methodology that could be repeatedly applied*". The researcher however, is of the opinion that stereotyping or basing methodological and philosophical decisions, on the existing philosophical traditions or predominant trend in previous studies, would amount to methodological stagnation, which will stifle innovation and creativity in the long run.

Various opinions have been expressed on the criteria for choosing a research philosophy (Grix, (2001; Holden and Lynch, 2004; Rooke and Kaguoglo; 2007; Gajendran, 2011). According to Holden and Lynch (2004): *It is our contention that research should not be methodologically led, rather that methodological choice should be consequential to the research philosophical stance and the social science phenomenon to be investigated*. However, Grix (2001:23) asserts *"methods themselves should be seen as free from ontological and epistemological assumptions, and the choice of which to use should be guided by the research questions"*. In line with the suggestions of Holden and Lynch (2004), and Gajendran (2011), the researcher is of the view that the most appropriate philosophical orientation should be objectively defined, devoid of personal or discipline based paradigmic preferences, in relation to their merits for achieving the research aims and objectives. Rooke and Kagioglou (2007), although in predominantly interpretative premise, further reinforces the researcher's stance by asserting that a fundamental requirement in research is its *'Unique Adequacy'*. Unique Adequacy, a criterion for adjudging reliability and validity in qualitative research, means that: "*the methods of analysis used to report, should be derived from that setting*. The implication of this logic for this research and academic enquiry in the construction industry is that the method of analysis should not necessarily be determined *a priori*, being '*transplanted in-situ'* from similar studies in the knowledge domain, but should rather emerge from the peculiarities of the problem and context under investigation. The challenge for the doctoral researcher is thus making critical and informed decisions on the appropriate research methodology, and the underlying epistemological, ontological and axiological assumptions, which gives credence to the research output, while ensuring its original contribution to an existing body of knowledge (Grix, 2001).

The choice of an appropriate research paradigm is therefore critical to producing meaningful outcomes. Gajendran (2011:90) alluded to several other considerations in choosing a philosophical/methodological stance, stating that:

- *The subtlety of the paradigm variations demands deep engagement with the literature to perceive the differences…*
- *Researchers need to carefully evaluate and respond to critiques of the chosen worldview and why it will deliver meaningful outcomes.*
- *The need to accommodate the practicality of the research design, as aligning the conceptual research design to the operational research design is a frequent challenge faced by researchers.*

Taking into consideration, the guidance offered by Gajendran (2011), and having analysed the different philosophical stances evident in the literature, the researcher makes an informed choice in the selection of a research philosophy, in tune with what is considered most appropriate to achieve its objectives, while factoring in the practicality of the methods implicit in the choice. The researcher adopts the philosophical stance of the critical realist, via the amalgamation of ontological positivism, which rejects the view of multiple realities, with epistemological constructivism, in acknowledging the role that values and societal ideology play in the derivation of empirical knowledge.

However, in adopting the critical realist philosophical stance, the researcher is not unaware of its criticism, mostly accused of being 'logically contradictory' (Nune, 2013). From the physical and social sciences, proponents and advocates of the critical realist philosophy have erected categorical philosophical defences in readiness for such criticism, (Frazer and Lacey, 1993; Campbell, 2002). To the constructivists, such justification was provided by Frazer and Lacey (1993:182) "*Even if one is a realist at the ontological level, one could be an epistemological interpretivist . . . our knowledge of the real world is inevitably interpretive and provisional rather than straightforwardly representational*". Critical realism was thus further conceived by Lawson (2003) as a methodologically valid lens for the social sciences, on the issues of ontology and in relation to the nature of the study phenomena (sensory abstractions or real/tangible?). To the positivist, it was contended by Campbell (2002:29) that "*all scientists are epistemological constructivists and relativists* in the construction of scientific knowledge". More specifically in the engineering sciences, Panas, and Pantouvakis (2010) noted that in the construction of quantitative experimental frameworks and models during productivity studies, scientific data needs to be primarily sought through human subject, who are inherently subjective in their representations.

In the selection of a research philosophy therefore, Saunders *et al.* (2009) described the relationship between the different research philosophies or world views as a continuum rather than them being parallel and distinct. The author represented this in an onion form and explained that any research by its nature will locate its approximate location on the relative scale of philosophical stances. Realism was thus located as at midpoint between the extremist positions of the positivist and the interpretivist.

The researcher towed the preceding line of logic of the critical realist, as the appropriate philosophical lenses through which the aim of this research and its objectives was achieved. The need to capture the peculiarities of the wetland conditions in the Niger Delta (a physical entity), the techno-economic dynamics of the developing world (A techno-socially constructed entity) coupled with the geotechnical drivers (Technical) embedded within organisational practices (Socially driven), dictated that the altercation between the empiricist and subjective philosophies be squashed. This choice was further informed by the necessity of incorporating multiple perspectives from project participants in highway organisations, inherently manifest in their accounts, which had to be sourced and interpreted by the researcher to understand the complexity of the phenomena of cost growth leading to cost overrun in highway projects.

The researcher thus does not take any rigid philosophical stance but rather focused on providing answers to the research questions. Philosophical flexibility was thus warranted. Ontologically the reality of the concept of construction cost overruns is project specific, and can be measured precisely. However, epistemologically, inaccuracy of cost estimates leading to cost growth, has a wide range of differing explanatory perspectives, and has being established in the literature to be closely linked to subjectivity inherent in the organisational context of highway agencies. The philosophical basis of this research, thus has a predominant leaning towards an interpretivist epistemology as shown in Figure 4.2, to understand the phenomena of cost growth, while retaining the singular ontology of the reality of cost overruns in highway projects, typical of critical realism.

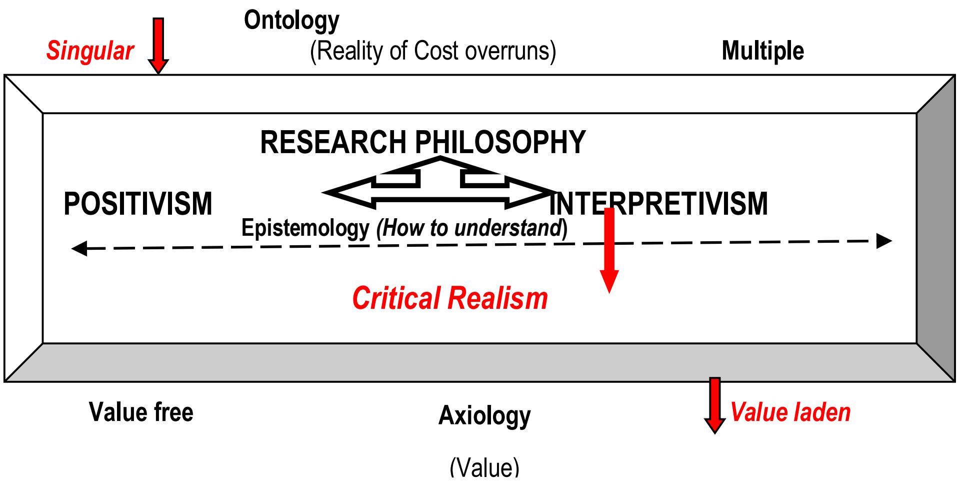


Figure 4.2: Research Philosophical Position

The theoretical appropriateness of relying more heavily on the interpretative world view as opposed to the positivist view at an epistemological level, is defined by the need to gain knowledge on the propagation of cost overruns through human subjects, who are the executors of projects, as well as the need to factor in the organisational dynamics surrounding highway projects. As Saunders, *et al.* (2009:115) asserts: "*Focusing on practical applied research,* *integrating different perspectives to help interpret the data*", thus making the adoption of a purely positivist approach to cost overrun research impractical.

Axiologically, the values of the researcher were therefore manifest in the research as the researcher sought to interpret and derive meaning from the varying participant's descriptive explanations of their organisations' approach to the management of ground related risk. The potential for subjectivity as the respondents describe the design and costing approaches in the highway agencies, further underscores the role that values play in the knowledge derivation process of this research. This defining characteristic of the study, further made knowledge derivation on the pure empiricist basis of positivist philosophy, inappropriate. Subjectivity that may be attached to the interpretation of results by the researcher on this basis is therefore acknowledged.

Grey (2009) summarised the applicability of positivist and interpretivist approaches, as being in line with truth seeking and perspective seeking methods, respectively. The latter is the fundamental ideology of the study, and not the basic underlying axiom of the former: '*The impersonal development of theory for generalizations*. Claims to generalizability of findings from this study are thus not made on this premise. Unlike positivism, in which scientific knowledge is statistically generalised to a population, the critical realist perspective adopted in this study strives for theoretical generalisability of the socially derived knowledge, that is how the analytical outcomes of this empirical study can fit in or 'nestle' with or within existing theories (Yin, 2014). The position of the critical realist stance of this study is thus also distinct from pure constructivism, which asserts that reality is socially constructed, and thus as individualistic perceptions, cannot be generalised.

The ability of the critical realist to infer causality within a predominantly interpretative epistemology, further defined its appropriateness to understand the context specific explanations for the propagation of cost overruns in highway projects, which is fundamentally driven by actions/inactions of the human actors in highway organisations. According to Huberman and Miles (1985:21), critical realism is an "*an approach designed to yield verifiable knowledge of human group life and human conduct*". This is predicated on the critical realist assumption that there are '*reasonably stable law-like links of causality*' amongst social constructs, whereby human actors in social and historical setting have always exhibited '*sequences and regularities that link phenomena together*' (Huberman and Miles 1994:429). Objectivity straddling a multi-perspective interpretative understanding of the human factors in organisational practice, that drive the more technical concerns about ground related risks, is thus a core requirement, necessary to infer causality in this cost overrun research. On this basis therefore, in the adoption a critical realist philosophical stance, to provide a multi-methodologically robust explanation for cost overruns experienced in highway projects executed in the Niger Delta region of Nigeria, the researcher pre-supposed and acknowledged the:

- Differences of opinions on the ongoing geotechnical practice in highway organisations and their contractual affiliates;
- Role that the geology of project location, particularly in wetland terrain, has to play;
- Contextual geo-political institutional dynamics of highway development in the Niger Delta;
- Underlying technological constraints in the developing world;
- Value laden role of the researcher in interpreting and reporting findings, which underscores the need for triangulation of findings from various sources.

Having established the broader philosophical stance, which guided knowledge acquisition in this study, subsequent sections evaluate and justify the choices made in relation to the other more logic based and practical elements of academic inquiry, further down the conceptual hierarchy of the research methodology.

4.6 Research Type

Yin (1994), relates the nature of the research questions in terms of 'how', 'why', 'when', 'what' and 'where' to the type of research: exploratory; explanatory; or descriptive, being conducted. 'What' questions are predominantly exploratory which seeks to explore a phenomenon in more detail, 'How' and 'why' questions are mostly linked to explanatory studies while 'when' and 'where' research questions are more descriptive. This study was thus concerned with not only the what's, but the how's and why. This research was exploratory, as it sought to understand the specific nature (What) and extent to which (How much) geotechnical risk impacts on cost; was descriptive in identifying the critical phases (when) in highway projects where the susceptibility for cost overruns due to ground related risk occurs; and was explanatory in inferring causal links between the identified factors and cost overruns. This was necessary to establish causality, in lieu of the study aim, further defined by its critical realist positioning.

Although it may be argued that the phenomenon of cost overruns in highway projects is not a novel concept that should warrant an exploration, this study explored the peculiar heterogeneous and predominantly wetland geologic setting of the Niger Delta as a test bed for understanding financial risks due to the ground. In tandem, it provided an in-depth descriptive account of how lack of geotechnical best practices can further exacerbate the propensity of highway projects to run over budget. The exploratory phase of the study is thus implicit in the identification of geotechnical pathogens, through a practiced based technical literature review, and statistical exploratory analysis of the spatial geotechnical field data on Niger Delta soils.

The descriptive element of the study described the design and costing practices currently being deployed by the highway agencies in the study area. According to Hendrick *et al.* (1993) a descriptive study provides a picture of a situation as it occurs. Grey (2009), equally opined that descriptive research is relevant to give a snapshot of a situation, person, or event or to show relationship within a defined structure. The descriptive phase of this study thus began with an extensive background literature review on the prevailing geographic and geologic setting of highway development in the study area, to serve as a background to field work findings. The fieldwork results further described the details of design practices of highway agencies in the Niger Delta, processes, and functions inherent within their respective organisational structures for ensuring geotechnical input.

The explanatory perspective of the study centred on the study's aim of explaining the high level of cost overruns incurred in highway projects, and the prevalence of lengthy delays and abandonments in the Niger Delta region. Such explanations were sought from the local literature, the scholarly literature, and the literature on geotechnical best practice. Ketokivi (2010) posited that an explanatory perspective to research underscores the role that theoretical explanations play in scientific inference. Grey (2009) points out that typical explanatory studies ask the "why" type of questions. Explanatory studies seek to provide factors or reasons accounting for a descriptive study (Huberman and Miles, 1994; Ketokivi, 2010). As Huberman and Miles (1994:429) asserts: There is need, not only for an explanatory structure, but also for a careful descriptive account of each particular configuration. On this basis therefore this research is considered a normative study, designed to evaluate what happens in practice, in relation to what ideally ought to be in theory, from a geotechnical perspective, in order to provide an explanation for the current trend of unusually high cost overruns in highway projects. The research thus ultimately investigated how applicable current theory emerging from academe, the intricacies of the wetland geology of the Niger Delta, and the technical requirements of geotechnical best practice, explained cost overruns in highway projects.

4.7 Research Reasoning/ Approach to Theory Generation

The process of knowledge acquisition in research is defined, and categorised based on the logical manner of reasoning behind an inquisition (Huberman and Miles, 1995; Yin, 2014). Saunders *et al.* (2009) explained deductive reasoning as the development of theory in a research, which is subsequently subjected to rigorous testing, analogous of experimental types typically deployed by physical scientist. In this way of reasoning, there is a search for causal relationship which defines the basis of subsequent testing (Creswell, 2003). Ketokivi (2010) used the terms '*Logical coherence'* to describe deductive reasoning in research, in explaining that deductive reasoning follows logical analytic steps from the general, down to the specifics in a coherent manner.

Inductive research on the other hand, explores a phenomena and allows the trends and theories to emerge from the data. Ketokivi (2010) thus explained that inductive reasoning runs in direct opposition to deductive based reasoning emanating from the specifics and leading to wider generalisations. On this premise, Ketokivi (2010) further described inductive reasoning as an '*ampliative form of reasoning*', stating that conclusions arrived at from the process of induction serve to amplify knowledge claims without established analytical foundations in the knowledge domain.

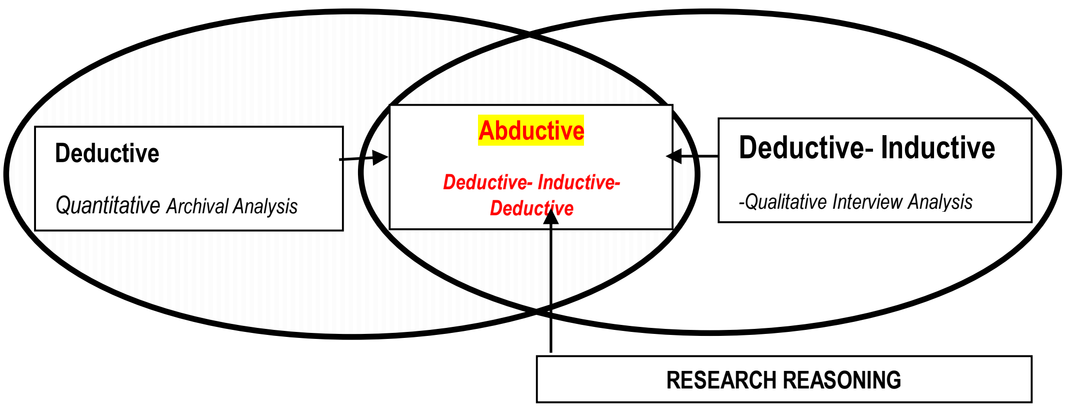


Figure 4.3: Deductive/Inductive Based Research Reasoning in this Study

This research was both deductive and inductive in approach as shown in Figure 4.3, necessitated by its critical realist philosophical underpinning. Critical realism according to Huberman and Miles

(1994) calls for both deductive and inductive reasoning to establish causal connections in credible ways, by providing descriptive accounts as evidence to back up the plausibility of such explanation.

This research was commenced from a principally deductive based approach using a geo-statistical exploratory analysis of data on the engineering properties of subsoils approximated for project locations. This served as a basis for inductively identifying geotechnical pathogens from the technical literature as well as noting unresolved arguments, which constituted the basis of drafting the interview guide, used to elicit related information in the subsequent field work, and in further qualitative analysis of the collated textual data.

The researcher used a deductive/inductive approach to interpret data revealed from interview sessions carried out with participants. This is because although this research is not structured on the basis of established predefined theories, the deductive reasoning deployed in the interpretation of the interview data is structured along established standards of best practice, deduced from the exploratory analysis of the geotechnical best practices in the literature. This is in line with the suggestion of Yin (2003: 56):

> *"Since established theory is often the basis for formulation of initial research questions and objectives, the same theoretical perspectives can be deployed to direct the research reasoning of the study*".

However, the purely inductive element of this research, is more evident as the researcher sought to gain knowledge based on previously un-anticipated themes and trends which emerged from the qualitative interview data. The findings from the deductive-inductive interview analysis, were then further analysed deductively, by quantitatively transforming and modelling the qualitative outcome of the interview analysis. Regression analysis is used to explain how much variation in the cost overrun experienced in the sampled highway projects, was induced by the deduced geotechnical themes, while content analysis was used to relatively assess and rank the weightiness of the emergent themes. The researcher's conceptualised flow of logic linking the evidence sourced from multiple sources, is depicted in Figure 4.4.

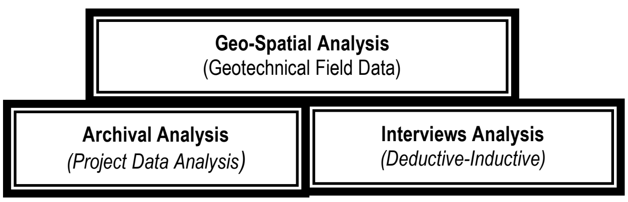


Figure 4.4: Multiple Sources of Evidence in this Case Study

This requisite higher level of abstraction, concretised within the context of this research is captured in Figure 4.5, which portrays the complex but holistic interaction between the multiple sources used, to elicit qualitative and quantitative information as a basis of triangulation. This is considered relevant to adequately capture the intricate complexity of the issues driving the phenomena of unusually high cost overruns in highway projects executed in the Niger Delta.

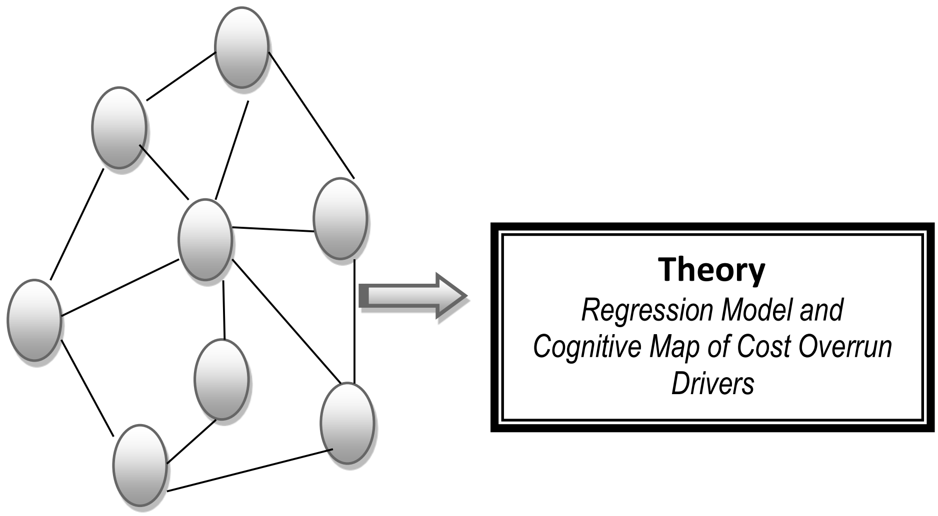


Figure 4.5: Approach to Theory Generation in this Research

Triangulation of the analytical findings thus serves as the basis of theory generation, directed at explicitly defining the financial impact of geotechnical risk, predicated on ground conditions in the Niger Delta, while factoring in the socio-political dynamics inherent within the highway agencies in the region.

4.8 Research Method

Research methods are dichotomised on the basis of being either qualitative or quantitative in approach. In tandem with making philosophical choices, is the decision on methods to deploy in other to achieve the research objectives (Walker, 1996). Birley and Moreland, (1998) asserted that methods are predicated on the background philosophical underpinnings or paradigms which frame the study. Thus methods relying on the positivist world view typically adopt quantitative methods, while those relying on an interpretative stance tend to favour the use of qualitative methods. Other authors such as Guba and Lincoln (1985), have also made a distinction between research methods, by highlighting fundamental axioms of research at the philosophical level which serve to distinguish between quantitative and qualitative research methods. These are summarily presented in table 4.3.

Table 4.3: Five Axioms of Quantitative vs. Qualitative Research Methods

AXIOM	QUANTITATIVE	QUALITATIVE
Ontology	Singular reality	Multiple realities
Epistemology	Objective view	Subjective view
Axiology	Value laden	Value free
Causal connection	Applicable	Not applicable (*Entities exist in a state of simultaneous mutual dependency)*
Generalisation	Necessary	Not necessary (*Ideographic Knowledge: Claims to generalisation are not made)*

Source: Guba and Lincoln (1985)

Guba and Lincoln (1985) used the term '*Naturalistic inquiry'* to describe qualitative research, asserting that qualitative research, unlike quantitative research have more complex interaction amongst the variables of the study. This is further explained by the hermeneutic circle which emphasises that qualitative research in its natural setting relies on understanding the whole and that the smaller bits of the enquiry are part of a whole and therefore do not operate in isolation (Bontekoe, 1996; Schwandt, 2001). Guba and Lincoln (1985) also listed major distinctive defining analytic characteristics indicative of qualitative research, some of which have also been identified within the context of this study by the researcher. This is presented in Table 4.4.

Table 4.4: Typical Characteristic of Qualitative Research identified in this Study

Typical Characteristic noted by Guba and Lincoln (1985)	As Identified Within the Context of This Research
Natural Setting	*Organisational Research context of this study provides the natural setting in investigating design and estimating practices of the highway agencies.*
Human Instrument	*Data obtained from multiple informants and perspectives. is filtered through the researcher's interpretation*
Utilisation of Tactic Knowledge -	*Researcher's Intuition guides the data acquisition process in the interviews.*
Multiple Realities-	*Not Applicable. The researcher adopts the stance of a critical realist, and thus posits that the drivers to the phenomena of cost overrun in highway projects are not abstract entities, that can only be subjectively conceptualised, but are project specific technical and social variables in organisations, which exhibit cause-effect relationships that can be objectively studied, and inferred from the different participant accounts and narratives of the project actors.*
Purposive Sampling	*Researcher purposively sample respondents that can provide the requisite technical insider information on the prevailing design and costing practices of highway agencies in the Niger Delta*
Inductive Data Analysis	*Researcher starts from data analysis deductively, but reflexively reverts to an inductive mode, to uncover emerging subtleties evident in the practices of highway agencies in the Niger delta, which have broader implication in theory and audience of practitioners and policy makers.*

Emergent Flexible Designs -	*Recurring unanticipated social constructs emerge as themes from the data with researcher's increasing familiarity with the data, which are reflexively infused into the analysis.*
Ideographic Interpretation -	*Researcher acknowledges the role of personal values in the interpretation of the data from the participants.*
Focus Determined Boundaries	*The analytic boundaries of the qualitative data generated from interviews are explicitly defined and constrained in relation to the study objective of explaining the propagation of cost overruns in highway projects, relative to ground conditions in the Niger Delta, and thus does not transcend outside this analytic realm.*

Adapted from Guba and Lincoln (1985)

At a less generic and more practical level, attributes which are typically descriptive of qualitative research methods, were noted by Descombe (2009), who also distinguished qualitative from quantitative research on the following basis, as shown in Table 4.5.

Table 4.5: Attributes of Qualitative and Quantitative Research Methods

Quantitative	Qualitative
Numeric unit of analysis	Textual unit of analysis
Statistical analysis	Descriptive analysis
Large scale studies	Small scale studies
Specific focus	Holistic focus
Researcher detachment	Researcher involvement
Predetermined research design	Emergent research design

Adapted from Descombe (2007)

Descombe (2009), thus described qualitative studies on the basis of the type of data analysed which is typically textual or graphical. As such documents, images, reports, observations and voice recordings transcribed into text are the basis of detailed descriptive analysis of study phenomena and theory generation. Descombe (2007) also noted that qualitative research, by virtue of its level of in-depth analysis of a phenomenon, is usually associated with small scale studies which are relatively more focused in terms of scope. This enables the researcher to be more actively involved in the field and to use subjective judgement to generate theories in line with emerging trends in the data collected.

Quantitative methods on the other hand entail analysis of numeric data generated from a sampling procedure representative of study populations, using statistical tests to enable generalisation of theories generated (Descombe 2007; Saunders *et al*., 2009; Creswell and Clark, 2013). The numerical nature of quantitative studies makes them amenable to statistical analysis, with reliability further enhanced by larger sample sizes (Saunders *et al*., 2009). The objective of such statistical analysis is to isolate the effect of specific factors in relation to other factors of interest, often by isolating factors from their contextual background. Quantitative studies thus entail the need for researchers' detachment in the inquiry process, to isolate subjective influences from interfering with the research process (Descombe 2007). This can be contrasted with qualitative studies which strive to enhance and relay as much background information as possible (Huberman and Miles, 1994). Quantitative studies thus rely on the objectivity underlying the instruments of data collection as a basis to verify predetermined theories.

Table 4.6 is an outline of the attributes of this research following the scales defined by Descombe (2007), which also shows that this research exhibits several characteristics of a qualitative study, further justifying the researcher's adoption of a predominantly interpretative stance at an epistemological level, but with a mixed method analytical approach.

Table 4.6: Characteristics of this Research

Characteristics	Study Attributes
Unit of analysis	Numeric and Textual *(Mixed)*
Analysis	Descriptive and Quantitative *(Mixed)*
Scale of study	Small *(Qualitative)*
Focus	Holistic focus *(Qualitative)*
Researcher position	Involvement *(Qualitative)*

The need to analyse both textual data from participants' accounts and documents, quantitative data on cost overrun from project archives, as well as numerical geotechnical index data on Niger Delta soils, in this research, is indicative that this research is a mixed method study, requisite to provide methodologically robust explanations for cost overruns. Mixed-method approach in cost overrun research is however a rarity, as previously noted in the review of the methods used in the empirical literature on cost overruns. As Dainty (2009:10) noted:

> *"The apparent lack of methodological diversity, coupled to a lack of adventure towards interpretative research designs, suggests a research community rooted in methodological conservatism and disconnected from the debates going on in many of the fields from which it draws".*

However, in a related subject domain, such as construction productivity studies, mix method studies are more common. Several construction productivity studies deploy mixed-methods based on empirical qualitative work, and archival productivity data which are quantitatively modeled (Panas and Pantouvakis, 2010). For example, Al-Sudairi (2007) used qualitative data, from observation data in the form of timed video recordings with in-depth interviews with construction operatives, to simulate data models linking contextual human factors to lean construction on sites. Cottrel (2006) also analyzed both qualitative data on technical as well as human project management factors such as experience vision, commitment to explain quantitative site productivity data, via the use of multiple regression analysis.

The bulk of current applications of methods in empirical cost overrun studies, substantially deviate from the principles of methodological pluralism advocated by Dainty (2009) for the construction management research community. It had been noted by the researcher that data elicitation techniques in most cost overrun studies relied primarily on either the use of questionnaires or document analysis, with no form of qualitative narrative. Dainty (2009:7) also noted this in the broader orientation of construction management research, stating that:

> *"An enduring adherence to the positivist paradigm will do little to enable construction management researchers to grasp the meaning of social action from the perspective of the actors involved".*

It is thus the researcher's conviction that methodological pluralism, applied to cost overrun research, would yield less artificialized and more methodologically valid explanations for cost overruns, which describe context and show causality. Dainty (2009:6) assertions further reinforces the researcher's stance:

> *"Researchers use the real-world context of the construction industry as sites for developing research questions ... It could be reasonably expected that their methodological positions and the methods adopted may have broadened and diversified to reflect the multiple traditions from which it draws upon".*

Mixing of methods is however, not without challenges, as quantitative and qualitative research are dialectically underpinned by divergent, almost incompatible, paradigmic assumptions. Descombe (2007) recognising the challenges of mixing methods, suggests that a more practical approach to defining the qualitative and qualitative aspects of research in a mixed method study would be in terms of the types of data and how it is treated analytically. For this study, the mix of methods deployed is shown in Figure 4.6.

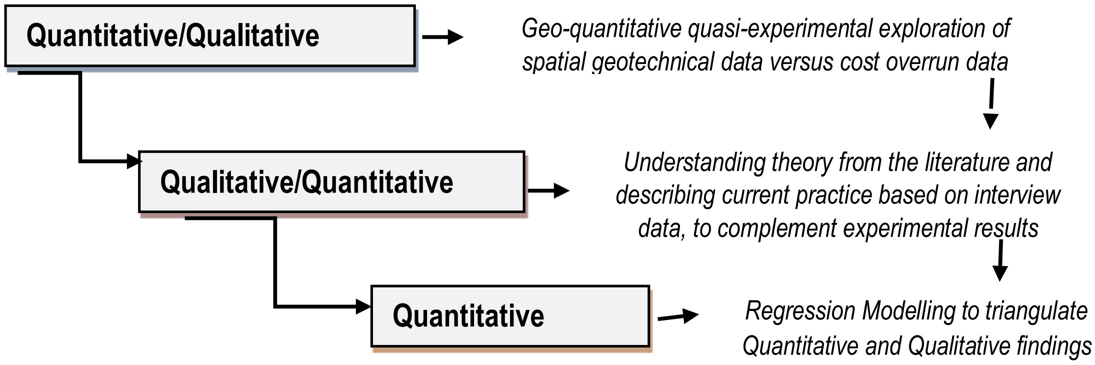


Figure 4.6: Methods of the Study in this Research

It is thus obvious that this research cannot be clearly categorised on the basis of the dichotomy often used in research. The study by virtue of its design displays dual characteristics typical of both a qualitative and quantitative study. Commenting on the propensity of most practical applied research to demonstrate such attributes, Descombe (2007) further went on to clarify that in practice these methods are not mutually exclusive, and the dichotomy is therefore not completely distinctive, but rather a question of relativity in terms of the extent to which the research adopts one method relative to the other. On this basis, mixed methods, which is a hybrid of both qualitative and quantitative methods is adopted to suit the practicalities of this research.

The rising popularity of mixed methods is due to the inherent limitations of the individual quantitative and qualitative research methods (Dainty, 2007). Several other authors (Yin, 1994; Creswell, 2003; Creswell and Clark, 2013) have posited that mixed methods have the advantage of overcoming the shortcomings of both qualitative and quantitative research methods. Creswell (2003) stated that the mixing of methods neutralizes the biases of each individual method. The adoption of mixed methods in this research thus gives the researcher the requisite flexibility to utilise all available research tools to achieve the study objectives.

4.9 Research Strategies

Research strategy can be defined as the means of designing an enquiry, in order to turn research questions into projects. This essentially frames the overall study approach (Robson, 1993). This crucial element of scholarly enquiry, Robson (1993) further stressed, should be addressed with adequate consideration given to the plethora of issues and possibilities from the wide range of available research strategies. As listed in Table 4.7, these strategies are typically associated with qualitative or quantitative research, with the notable exception of case studies, whose applicability traverses both types of research method.

Table 4.7: Research Strategies in Qualitative and Quantitative Methods

Quantitative	Qualitative
Experiments	Ethnography
Surveys	Phenomenology
Case Studies	Grounded Theory
	Case Studies

Strategies utilised in quantitative methods, adopt a positivist philosophical perspective of objectivity. As such quantitative researches are mostly associated with experimental type studies: true experiments and less rigorous quasi-experiments, and surveys which require the generation of theory to enable generalisations (Creswell, 2003).

Qualitative research strategies, characterised by an interpretative stance, are more closely associated with attitudinal studies of individuals or in organisational research, often requiring the researcher to be closely linked to the study site and the participants (Bryman, 1989). They are therefore humanistic and interactive with the researcher being highly participatory (Creswell, 2003). Qualitative research is predominantly associated with strategies such as ethnography, grounded theory, phenomenological research and even case studies, which have been shown to be adaptable to both quantitative and qualitative studies (Yin, 2014).

The researcher in this study, in view of this variety of options makes a conscientious choice as to which strategy can best serve to achieve the aim and specific objectives of the study. The basis of this decision however stems from the applicability of each type, in relation to the research questions or study objectives (Saunders *et al.,* 2009). It was thus stated that:

> "*The general principle is that the research strategy or strategies, and the methods or techniques employed, must be appropriate for the questions you want to answer*" (Robson, 1993: 23).

This is because for any choice made there are basic underlying set of assumptions, advantages and disadvantages which must be evaluated (Saunders *et al.,* 2009). The noticeable overlap in applicability between these various research strategies has been noted by both Yin (2003) and Saunders *et al*. (2009), leading the authors to espouse that in the selection of an appropriate research strategy, the question is more about relativity: How well can it lead to achieving the research objectives? Consequently, the following section of the methodology will be devoted to evaluating the range of possible research strategies that are potentially amenable for studying the generality of research questions that this study seeks to answer.

The evaluation begins with the purely quantitative strategies before appraising the qualitative approaches. Ethnography and phenomenology listed amongst the purely qualitative research strategies are however excluded from the detailed evaluation, based on their abstract nature and emphasis on cultures and peoples' lived experiences, which is beyond the scope of this research and due to their philosophical incompatibility with the empirical nature of the critical realist stance adopted in this study. The evaluation of the purely qualitative strategies herein is thus limited to grounded theory, due to its fundamental applicability to all qualitative research. Case study research which straddles both methods of research concludes the evaluation.

4.9.1 Experiments

The deployment of an experimental strategy is often associated with the empirical approach of conducting research (Robson, 1993). Experiments have been defined as an empirical investigation which is conducted under simulated conditions, as a means of eliciting defining properties or relationships existing between identified variables (Descombe, 2007). Descombe (2007) identifies three fundamental criteria for the use of experiments**,** these include**:**

- The underlying assumption of causality in the variables;
- The deployment of controls as a mechanism for exclusion;
- Empirical observation of a phenomena and detailed measurement.

It is therefore clear that the basic rationale for undertaking experiments is to establish cause-effect relationships amongst variables, which will form a platform for the formulation of generalizable theories. The repeatability, precision and credibility which are requisite of experiments, however cannot be feasible in a research of this nature. This is because of the impracticality of being able to manipulate the variables under study: Ground conditions in the Niger Delta region and the geotechnical practices in highway agencies, to suit an experiment type research. Within the context of this research, experiments therefore, do not provide an adequate strategy for investigating the phenomena of cost overruns in highway projects.

Also the highly objective nature of experiments does not make it amenable to carrying out this research, which recognises the subjective influence of human beings as the key medium through which information would be gathered. The artificial and intensively structured nature of experiments therefore cannot serve to achieve the study objective of understanding the practices of highway agencies in terms of the level of adherence to geotechnical best practices. This study is not artificially contrived, but is carried out in a real life scenario, which is set in the social context of the highway organisations.

4.9.2 Surveys

The word survey can assume different meanings depending on the context of its usage. Descombe (2007) highlighted a definition of survey, from the geographical perspective of surveyors, as the need to obtain data, which can be applied to mapping out the social world. Surveys in a research context however have been generally used to refer to the collection of standardised information from a population or sample most commonly with the aid of questionnaires or structured interviews (Robson, 1993). Carrying out surveys is a principal strategy that provides quantitative measures of trends, attitudes or opinions based on samples derived from a wider population (Creswell, 2003). Surveys do not incorporate any specific methods of data collection but rather can be carried out using different tools (Descombe, 2007). Types of surveys include postal and internet questionnaire surveys; face-to-face surveys (interviews), observations and documents. Each of these types of surveys have basic advantages and disadvantages, and it therefore falls to the researcher to weigh the options in the light of the kind of information sought (Robson, 1993; Descombe, 2007).

Surveys can be conducted as cross-sectional or longitudinal studies. Surveys often conducted on the spot within a specified time frame with the general intent of bringing things up to date are cross-sectional in nature (Yin, 2014). They thus provide a structured and instantaneous snapshot of a specific event at a specific point in time. This is as opposed to longitudinal studies where research spans a longer time span. The choice of conducting longitudinal survey research is usually with the intent of tracing the development of changes in phenomena over time, typically required for time series analysis (Yin, 2014).

The representativeness and size of samples in a survey research are critical issues that define the level of generalizability of research findings (Creswell, 2003). Descombe (2007) thus emphasized that one key characteristics of a survey research is "*Wide and inclusive coverage*". This inherent advantage of the survey research strategy makes it a potential strategy for most research in terms of its wider coverage. However, although the comprehensiveness of a survey may cover a wider range of participants due to larger sample size, the depth of information obtainable from surveys is often limited (Yin, 1994).

The data to be potentially gained through the use of survey is allowed to '*speak for itself*' leaving out the finer details (Descombe, 2007). Implications of using survey as the strategy for this study, would thus be that context would be lost, a major shortcoming spotted by the researcher, as a significant gap in the bulk of the previous research on cost overruns. Characteristic features in organisations, such as how the hierarchy of authority impacts on design and estimating practice, facts which can only be relayed via the richness of data from descriptive narratives, will be missed out. As such holistic background information on the complex inter-related design and costing processes, functions and job designations within the organisational structure of the highway agencies, which can affect the understanding of the study phenomena, may not be elicited from surveys which produce structured responses.

In the context of this study, the empirical nature of survey research, which lends itself more to objectivism on an axiological scale, leaves out the interpretative element which is the driving philosophical root of this enquiry. This lack of 'texture' and 'feel' by virtue of the highly structured and objective format of survey questions, will thus prove to be a major shortcoming for this study. A more in-depth approach is therefore deemed appropriate, to achieve this study's objective, of assessing the geotechnical adherence evident in highway projects executed in the Niger Delta region of Nigeria.

4.9.3 Grounded Theory

The origins of grounded theory can be traced back to the work of Glaser and Strauss (1967). Their development of the grounded theory approach was in direct opposition of the logico-deductive methods of science which entailed the testing of preconceived theories based on empirical field work (Glaser and Strauss, 1967). Their criticism of the scientific method was on the premise that such theories often do not fit in with real life scenarios and therefore remain ungrounded. The authors thus advocated the development of theories that were firmly rooted in the practical reality of a phenomena, particularly in the study of people and their interactions.

Grounded theory as a research strategy is closely linked with the symbolic interactionism philosophical reasoning (Graham and Thomas, 2008). On this basis grounded theory advocates for a continuous adjustment in the perception of reality on the basis of new meanings derived from human interaction. According to the original version of grounded theory advanced by Glaser and Strauss (1967), the researcher is expected to approach the study with an open mind, without relying on any preconceived notions. The accumulated bulk of existing theories are therefore not relevant at the onset of the research. This has however been a point of considerable debate in the literature, on the grounds of the practicality of any researcher being able to achieve this state of 'blankness' (Descombe, 2007).

Strong views were expressed by other researchers in opposition to the notion of blankness, as being philosophically impossible because to a large extent, it is these preconceived notions that would have led the researcher to conduct the research (Descombe, 2007). This initial extremist position of 'blankness' was thus later modified by Strauss and Corbin (1990) who acknowledged that prior experiences and theories should have a role. According to Strauss and Corbin (1990), this was due to the acknowledged fact that any research must have a 'beginning focus' from which to start. However, it was stressed that such theories should be viewed as 'provisional' in relation to the study being conducted, pending the outcome of the research. Thus it was stated that:

> *"The initial questions and areas of observation are based on concepts derived from literature and experience. Since these concepts do not have proven theoretical significance to the research, they must be considered provisional" (Strauss and Corbin, 1990:180)*.

Although the need for empirical fieldwork is emphasized in the deployment of grounded theory, it is necessary that theories be allowed to emanate from the field and not to be generated at a high level of abstraction and then tagged on to present situations (Glaser and Strauss, 1967). The emphasis is thus that theory should be systematically generated, and gradually developed based on emerging trends which can then be generalised. The collection of data should therefore be systematic and not just amassed with expectation that the data would speak for itself (Descombe, 2007). This systematic nature of data collection is carried out at the first instance on a broader platform. Subsequent data collection become increasingly directional and focused, in line with the flow of conceptual categories that is seen to be emerging from the data (Strauss and Corbin, 1990). The selection of instances that would be included in a grounded theory research is thus dictated by the patterns of concepts that can lead to theory development (Strauss and Corbin, 1990).

On the basis of these fundamental requirements outlined above, the potential applicability of grounded theory to the purely qualitative element of in-depth interviews used in eliciting information describing current practices is still limited by the inherently theory driven nature of grounded theorising. Another challenge posed through the adoption of a grounded theorist approach to qualitative data analysis, is that grounded theorists carry out continuous theoretical sampling based emerging theoretical categories. This is carried out up to the point of theoretical saturation, a stage in the research at which the addition of further instances does not add any new perspective to the research (Graham and Thomas, 2008). This requirement to systematically reduce the scope and number of instances studied in grounded theory researches, in effect practically constrains in its applicability by the limited instances in the context of this study. This is because the analytic boundaries of the qualitative analysis, in this study is confined to understanding and explaining how ground related risk, due to the deltaic terrain, in highway projects are managed. An inference that will be made from the interpretative analysis of practices prevailing in the existing three highway agencies in the study site (The Niger Delta terrain). This will in effect directly impact on the availability of cases to utilise as a basis of achieving theoretical saturation.

Another shortcoming identified in the potential adoption of grounded theory for use in this research is its limitation to purely qualitative researches. This research by virtue of its design, as dictated by the study objectives, is fundamentally a mixed methods study and therefore grounded theory as an overall research strategy will not be all encompassing enough, to adequately address the quantitative strands of the study. The need to evaluate numerical as well as textual data from the field work, thus refutes the fundamental purely qualitative premise of grounded theorising.

4.9.4 Case Study

A case study is the study of a specific phenomenon using singular or multiple settings to describe and provide an account of the events, experiences and processes occurring within each setting (Descombe, 2007). The applicability of using case studies as a research strategy has being linked to diverse settings. Yin (2014) illustrated the use of case studies in political, individual, group and organisational settings. Its wide applicability equally transcends various subject domains including sociology, planning, psychology, construction, business and economic studies. Yin (1994) attributed the wide spread usage of case studies to the distinctive need to unravel and understand complex social phenomena.

Yin (2003) also stated that case studies can be used as a pilot, preliminary or main study, pointing out the most common characteristics typical of case study research irrespective of its intended usage:

- Real life context;
- Multiple sources;
- In-depth study;
- Theoretical propositions to guide data collection and analysis;
- Empirical enquiry.

An attribute of the case study, as a research strategy, is thus its ability to retain the wholesomeness of the real life contextual background of research, which is necessary to give research its meaning. This focus of case studies, on relationships and processes within the context of a social setting, makes it very applicable to the organisational context of this research.

In emphasizing another major attribute of case study research, Robson (1993) contrasted survey methods with case studies in terms of the level of information obtained from participants. Surveys typically require a limited amount of information from respondents due to their highly structured format, while case studies depend on collecting extensive information from identified informants. In research where depth of information rather than breath is emphasised, Robson opined that case studies offer a distinct advantage. This distinguishing quality of depth afforded by the use of case study, is noted by Descombe (2007), as being due to its central focus on the instance being investigated. The aim of a case study is thus skilfully worded by Descombe (2007:36) as being "*To illuminate the general by looking at the particular".* The in-depth study afforded by the use of case study is based on the fact that research efforts are all directed to the 'case', which can lead to the discovery of more details. Robson (1993) defines the 'case' to be the situation, individual, group, organisation or the prevailing phenomena that has warranted the study.

The underlying logic of *'replication*' typical of empirical enquiry in case studies, concomitantly means that the case may be extended to cover multiple instances. The rationale behind using one case or a few selected cases arises out of the need to focus attention on typical instances as opposed to mass studies, is to uncover useful insights which may simply have been glossed over. The generalisability of theories generated from case study research are thus directly correlated with the number of cases studied. Multiple case studies are thus deemed to have higher levels of generalizability than single case studies, as they enable cross-case comparisons. Cases selected on this premise must therefore be comparable.

Yin (2003b:5) also stipulated three fundamental conditions that must be used in deciding the applicability of case study as a research strategy: *"Nature of research questions ('How' and 'Why'); The extent of control the researcher has over actual behavioural events; The degree of focus on contemporary issues"*. Typically, the case study approach is logically deemed appropriate to provide answers to '*How are estimates for road projects in the Niger Delta region prepared at the pre-contract phases of highway projects*?' The case study approach thus has the potential to provide holistic answer to this research question posed to satisfy the study objective of eliciting information on the level of geotechnical input in evident in the existing estimating practice of highway agencies in the Niger Delta region. With respect to the degree of control the researcher has over actual behavioural events, the researcher has no influence directly or remotely on the costing and design practices prevailing in highway agencies in the Niger Delta. The information sought are practices that are ongoing, and thus cannot be manipulated by an external observer (the researcher) outside the case. The '*degree of focus in a research: on contemporary or historical events'*, posited as the third criterion by Yin (2003) has however been argued by other authors, who noted that although case study research is predominantly associated with contemporary phenomenon they can also be historical (Eisenhardt and Graebner, 2007). Irrespective of this argument, this central issue of cost overruns in highway projects is a very topical one, which has attracted, and is still receiving attention from scholars, construction professionals, stakeholders as well as continuous local and international media exposure.

Yin (1994) stresses that the most outstanding characteristic of a 'case' or 'cases' in a case study research must be its significance, and further outlining the criteria for such significance: The unusual nature of the case or one which is of public interest; the theoretically or practically significant underlying issues; or the technically distinctiveness of the situation. On this critical point, the peculiar nature of the Niger Delta terrain as well as its practical significance for the financial risk management of highway projects, justifies the selection of the case study site. The geo-spatial analysis of the geology of the Niger Delta, in chapter five of this thesis underscores this.

4.9.5 Selected Research Strategy: Case Study

Experiments and surveys are deemed inapplicable to the context of this research in lieu of their purely positivist philosophical under-pinning, which is devoid of context, and restrictive of the depth of evidence that can be sourced. As such the restrictive, artificialized and highly structured nature of positivists methods, with their implied logico-deductive approach negates the wholesomeness which the researcher considers pivotal to investigating and understanding the interrelated processes and functions in cost estimating, designs and contracting for highway projects. This is because in the context of this study, the distinction between the study phenomena and its context is highly blurred and thus cannot be divorced from one another to suit the structured format of experiments and surveys.

From a philosophical perspective, the interpretivist philosophical root of grounded theory aligns more closely to the philosophical underpinning of this research, than the positivist underpinning of experiments and surveys evaluated. However, the purely 'theory building from qualitative data' objective of grounded theorising, which Corbin and Strauss (1990) explained as '*seeking to develop a well-integrated set of concepts from the data, that provide a thorough theoretical explanation of phenomena under study'*, is a limitation in this research. This is because, although the study seeks '*to provide explanations for cost overruns'*, the relevant application of the existing body of theoretical propositions in cost estimating, highway designs and geotechnical engineering to the data is implied. Furthermore, although grounded theory might have presented a possible alternative on the basis of its philosophical compatibility with the interpretative strand of the study, its applicability is restricted in the quantitative strand of the pragmatist critical realist philosophical underpinning of this research.

The need for a more encompassing research strategy, that is compatible with the critical realist philosophical stance adopted in this study, therefore made the adoption of experiments, surveys or grounded theory, as an overall research strategy for this study, inappropriate. Based on the overall assessment of the applicability of all the research strategies, the case study approach was deemed the most philosophically, technically and practically compatible with achieving the objectives of this study. The specific attributes of the case study strategy, which served as the criteria for its selection are thus its: Appropriateness and wholesomeness in investigating the study phenomena; Ability to incorporate requisite multiple sources and research techniques; and compatibility with adopted pragmatist philosophical critical realist viewpoint of this study. These are discussed in further detail:

4.9.5.1 Appropriateness/Wholesomeness in investigating the Study Phenomena

In the context of this study, the depth of information needed to achieve the objective of the study, lends itself to using a case study research strategy, as depth rather than breadth of information is emphasised. Yin (1994:13) provided a technical definition of a case study as: "*An empirical enquiry that investigates a contemporary phenomenon within its real life context*". Yin (1994) compared this distinguishing feature of a case study to those of experiments, where there is a clear cut purpose of stripping off the context. As such although surveys to a certain extent can investigate a phenomenon and its context, its ability to investigate the context is extremely limited. Adopting a case study approach was thus considered the most logical choice for the purpose of providing a robust and in-depth explanation of cost overruns experienced in highway projects, executed in the Niger Delta region, against the backdrop of its peculiar geologic configuration. It is thus considered as being the most suitable holistic approach, necessary to demonstrate the far reaching impact of geotechnical pathogens on the current state of highway project delivery in the study area.

4.9.5.2 Capacity to Incorporate Multiple Data Sources and Research Techniques

One tangibly discernible characteristic of case study strategy, considered requisite in this study, apart from its ability to explore in-depth a single phenomenon while retaining its natural setting, is its ability to incorporate a variety of methods (Yin, 2003b). This distinguishing quality of case study research, to accommodate different qualitative and quantitative data and techniques, yielded the richness of evidence which the researcher considered pivotal to achieve the study aim. This salient feature of a case study research enabled the researcher to source data from multiple sources. This study deployed a systematic quantitative analysis of project cost data, as well as geotechnical data, prior to a detailed qualitative evaluation of textual data. Adopting the case study strategy thus provided a platform for incorporating these diverse data types.

The methodological pluralism implied by this mix of data types (Numerical and textual) represents a shift away from the conventional positivist viewpoint of most construction industry research. Dainty (2008) recommended a paradigm shift in the ideology of construction industry research, which should materialise in an increase in the use of qualitative methods beyond the predominance of quantitative empiricism evident in most scholarly text.

4.9.5.3 Compatibility with the Adopted Critical Realist Philosophy of this Study

Based on the study's critical realist underpinning philosophical positioning, the epistemological, ontological and axiological implications of this stance as earlier clarified, is more of relativity in positioning, between the extremities on the continuum of philosophical spectrums. On this basis therefore, purely positivism based (Experiments and Surveys) or wholly interpretivism based (Grounded theory) research strategies are rendered incompatible with the philosophical stance of this study. The critical realist philosophical viewpoint, which is the guiding principle shaping the design of this research, can only be justifiably operationalised in this study by the adoption of the case study research strategy.

Further establishing the compatibility of the case study research strategy, is the fact that although it acknowledges the social construction of knowledge, it is guided by theoretical propositions, which retains the element of empiricism necessary from the critical realist lenses, to infer causality in relation to cost overruns in highway projects. It is therefore logical and apt to adopt the philosophically hybrid orientation of the case study research strategy, on the grounds of its compatibility with the critical realist philosophical positioning of this research.

4.10 Adopting the Case Study Research Strategy: Measures of Reliability and Validity

From the preceding kaleidoscopic evaluation of the various research strategies, in terms of their potential suitabilities, the case study approach has been selected. This is on the basis of its comprehensive applicability to investigating the organisational settings of highway agencies, as a necessary medium for conveying the complexity of the interactive processes and functions driving cost overruns in highway projects. In operationalising the case study, to achieve the aim of the study therefore, it becomes essential that the validity and reliability of the study output produced from its adoption is not undermined by issues of validity and reliability. (Bryman, 1989:54) recommended that:

> *"When a measure is devised, it should not be presumed to be appropriate and adequate; rather it is necessary to establish that it meets the researcher's aims and that it has adequate measurement properties*"

Reliability and validity basically define the appropriateness and consistency of a measure over time, which is its replicability as accurate and true reflections of the concept being measured. As such measures should be taken to address issues of:

- Construct validity;
- Internal validity;
- External validity;
- Reliability.

Qualitative research, however emphasizes the relevance of social conditioning to the reasoning process and its role in our understanding of a phenomena. Raoke and Kaguoglo (2007) thus recommended that qualitative data and output should be justified and validated using some other supplementary methods following the three fundamental tenets of qualitative research:

- Postulate of Adequacy;
- Postulate of Consistency;
- Postulate of Subjective Interpretation.

Ketoviki and Mantere (2010:316) in attempting to resolve this philosophical argument, in the context of organisational research, stated that '*incompleteness of inductive reasoning*' is a dilemma often faced by researchers in attempting to draw theoretical conclusions from empirical data with a requisite level of credibility. He attributed this dilemma to several factors, including:

- Theoretical and pragmatic proliferations;
- Difficulties in placing the research argument in the context of the broader theoretical debates relevant to demonstrate study contributions;
- Lack of standards particularly in qualitative premise;
- Sheer complexity of social interaction in the interpretation of results.

These arguments and issues which have been going on throughout the history of western philosophy have remained unresolved till date in contemporary epistemology (Ketokivi and Mantere, 2010). The central contention in the literature, to which criticism of the mode of theory construction from qualitative data analysis is hinged, arises from the "*Postulate of Subjective Interpretation*" which limits the generalisability of theory constructed from the analysis of qualitative data to noting more than an ideographic interpretation. Ketokivi and Mantere, (2010) concluded that irrespective of this argument, all knowledge claims that are rooted in empirical data are derived as variants of forms of inductive reasoning typical of qualitative researches. It was thus recommended that rather than dwelling on this dichotomy, '*a cooperative attempt* *should be used in illuminating the argument*' as a justification of research contribution (Ketokivi and Mantere, 2010:332).

Yin (2003b), recognising the need for ensuring reliability and validity of findings, thus stated that irrespective of the numerous advantages of case study research, it has also attracted similar negative criticism as most forms of qualitative research, which often times portrays it as an unreliable. The issue of construct validity was noted by Yin (2014) as especially challenging, as researchers may not have adequately defined the specific concepts being studied in the case study, as they relate to the study objectives. Further to this, researchers may not adequately operationalise the concepts where adequate parameters (*Postulate of adequacy*) in the evidence are not measured. Yin (2014) also highlighted that issues of internal validity of inferences (*Postulate of subjective interpretation*) made from data subjectively analysed also constitute a concern, which may undermine the adequacy of the case study findings in providing explanation for the phenomena being studied. External validity of findings, beyond the specific domain in which the case study is conducted, is also an issue often associated with case studies (Yin, 2014). The replicability of the case study findings, which shows how credibly the case study was conducted (Postulate of consistency) is a concern that needs to be adequately addressed to ensure reliability (Yin, 2014). Lack of rigor, bias and low generalizability, are the major challenges of the case study approach commonly referred to in the literature. Yin (2014), thus underscored the need for adequate measures to address these key issues, to ensure reliability and validity of data and research output, from the point of conceptualising the research design, down to the specifics of data collection and analysis.

Following the hybrid interpretative-positivist tradition typical of a critical realist philosophical positioning, Yin (2014) identified the following measures that can be taken to ensure validity and reliability of a case study research. This is summarised in Table 4.8:

Table 4.8: Measures of Reliability and Validity in Case Study Research

Measures recommended	Case Study Tactic	
Construct validity (***Postulate of Subjective Interpretation)***	▪ *Use of multiple sources of evidence* ▪ *Establishing the chain of evidence from data* ▪ *Use of multiple key informants*	**Data Collection**
Internal validity (***Postulate of Adequacy***)	▪ *Do pattern matching* ▪ *Do Explanation Building* ▪ *Address Rival Explanations* ▪ *Use Logic models*	**Data Analysis**
External validity (Research Design)	▪ *Use theory in single case study design* ▪ *Use replication logic in multiple case-study design*	**Research Design**
Reliability ***(Postulate of Consistency)***	▪ *Use case study protocol* ▪ *Develop case study data base*	**Data Collection**

(Source: Yin, 2014)

Following this line of logic, the measures of validity and reliability posited by Yin (2014) are ensured in this case study research, to establish the credibility of the study's contribution (in Table 4.9).

Table 4.9: Measures of Validity and Reliability adopted in this Case Study

Measures Recommended	As applied to this Research
Construct validity	▪ *Definition of concept, case and context being studied;* ▪ *Identifying units of analysis and acquiring data to measure them.* ▪ *Use is made of multiple sources of evidence from interviews, documents and archives;* ▪ *Use of multiple key informants with multi-disciplinary perspectives;* ▪ *The chain of evidence is increasingly established from the data, from the exploratory statistical analysis of archival data to the descriptive qualitative analysis of interview data;*
Internal validity ***(postulate of adequacy)***	▪ *Pattern matching via thematic analysis of qualitative data;* ▪ *Use of step-wise regression modelling in explanation building;* ▪ *Use of cognitive mapping to visually converge all sources of evidence;* ▪ *Addressing key rival and complementary explanations to cost overruns.*
External validity ***(Postulate of Consistency)***	▪ *Use of theoretical framework derived from the literature as proposition in the singular distinctive case study of the Niger Delta region*
Reliability	▪ *Preparation of pre-designed interview templates, ethical consent and introduction letters as part of case study protocol* ▪ *Detailed outline of data collection methods*

4.10.1 Construct Validity: Research Variables, Design and Approach to Theory Construction

Yin (2014) emphasized that theory development is central to conducting case studies. The researcher's impetus for the study, was based on the perception of a strong link between the phenomena of significant cost overruns and the deltaic terrain of the study area, as depicted in Figure 4.7.

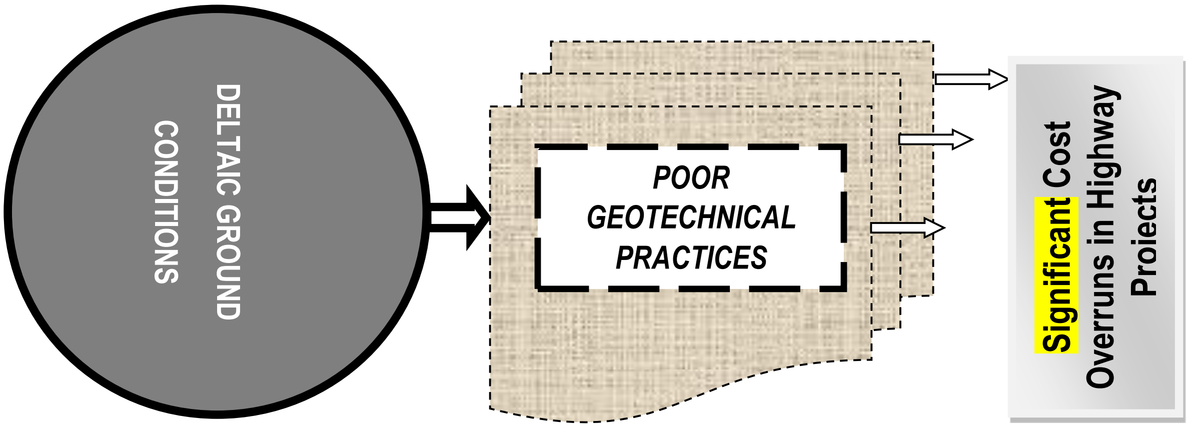


Figure 4.7: Researcher's Conceptualisation of Study Phenomena

This study researches the phenomenon of '*unusually high cost overruns*' typical of highway projects in the Niger Delta, a region which is geographically known for its extremely poor terrain and variability in subsoil types. As earlier clarified, case studies are typically useful to research theoretically or technically distinctive cases, where there is a deliberate emphasis on the contextual conditions. Yin (2014) emphasised that the completeness of a case study is further enhanced by an explicit distinction between a "case" and its context, and that the spatial boundaries of the context or case should be defined. Highway project development in Niger Delta region, is studied as a single case study, due to its geologic distinctiveness and extremity in documented cost overrun levels, perceived as being predominantly tied to the shortcomings in the geotechnical practice of the three highway agencies operating in the region.

This study thus places particular emphasis on the '*contextual geologic conditions of the case'*, which the researcher considers a major impact factor in accounting for cost overruns. The '*context*' of the '*case*', is however purposively limited to the spatial boundaries of present day Rivers and Bayelsa States, due to their embodiment of the definitive geologic characteristics of a delta, clarified in the literature, and which is of particular importance in the study.

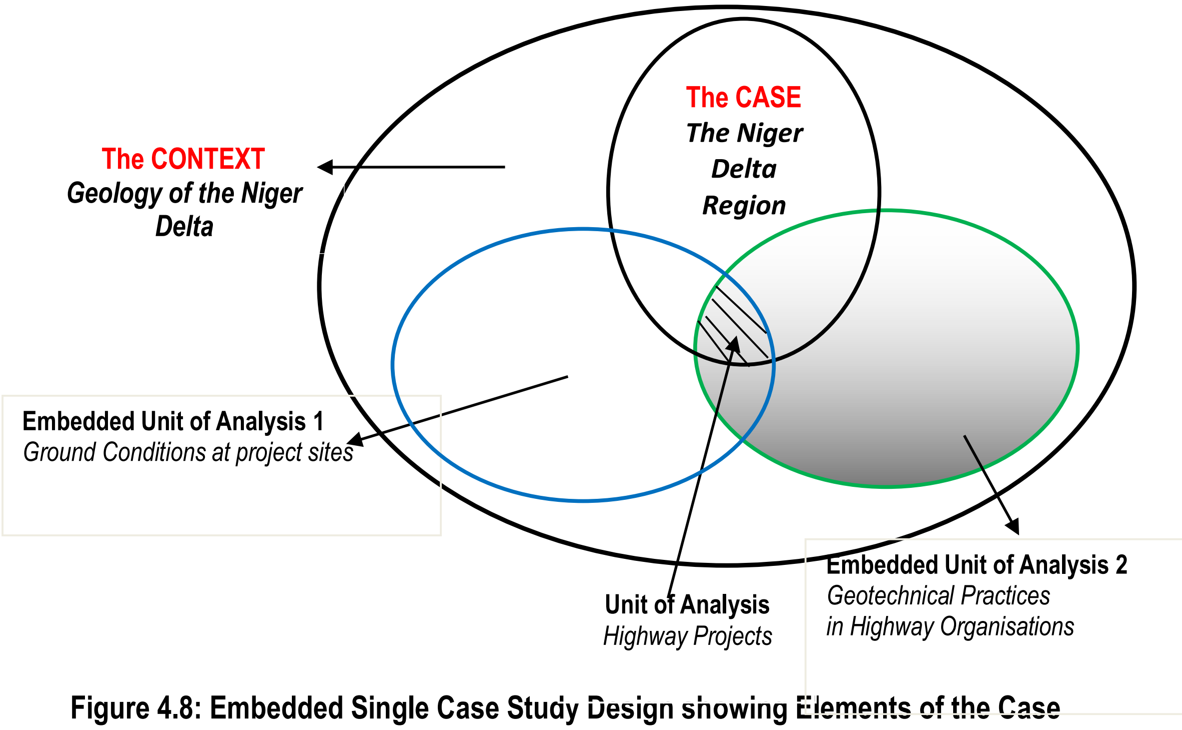


Figure 4.8: Embedded Single Case Study Design showing Elements of the Case

The unit of analysis, towards which all data collection effort is targeted, is thus *'Highway projects in the geologic setting of the Niger Delta',* with embedded units as shown in Figure 4.8. The singular distinctive case of the 'Niger Delta region, is thus selected and used to understand the propagation of high cost overruns in highway projects, triggered by latent geotechnical pathogens inherent in the '*ground conditions'* (Embedded unit of analysis 1) as well as due to prevailing *'geotechnical practices'* (Embedded unit of analysis 2). The specific case selected for investigation, *'Highway development in the Niger Delta Region',* embodies the extremities of geology and cost overruns, around which the core arguments (study and counter) in this study revolves*:*

- The study argument*: Pathogens may be unintentionally triggered due to lack of geotechnical best practices by highway organisations, which will be further exacerbated by poor subsoil conditions at project sites, leading to significant cost overruns.*

- The counter argument*: Deliberate deception by project proponents and planners, not geology or geotechnical risk, is the only statistically valid explanation for cost overruns.*

This study argument has thus guided all aspects of the components of the design of this case study, as Yin (2014) prescribes, from the: initial propositions conceptualised from the literature on geotechnical best practices; research logic, unit of analysis, as well as setting the criteria for interpreting finding from the fieldwork. As such with this underlying motivation, the researcher sought to understand the extent to which the highway organisations accommodate ground conditions, implied by the peculiar terrain of the region in highway designs and estimates. This in essence forms the basis of generating theory which ties the loosely argued logic of the pathogenic effect of geotechnical drivers on cost overruns, evident in the literature, as well as refuting the counter argument.

4.10.2 Internal and External Validity: Operationalising the Case Study from Data to Theory

Having clarified the concepts and variables under investigation in this case study research, it becomes necessary to explore the practical issues of validity associated with the mixed method approach taken as a route, to operationalise the case study from data to theory. This is because case study research can be associated with both quantitative and qualitative researches (Bryman, 1989). Typically, case studies in most organisational settings are carried out from an interpretivist or positivist viewpoint on the philosophical spectrum (Sexton, 2007). In the context of organisational research, Bryman (1989:25) distinguished qualitative case studies from quantitative case studies in terms of the "*level of emphasis on interpretations of individuals working in the organisations*". Bryman (1989:26) stated that for qualitative case studies:

> *"The research process often starts with a set of loose concepts, ideas and relationships between issues perceived as relevant and important in relation to the knowledge domain based on the investigators preoccupation ... with theoretical reflections filling in the gaps during data collection".*

Quantitative case studies however, model the research process to closely mimic a scientific approach in which data on organisational attributes is collected and analysed with researcher's impersonal detachment typical of experimental or survey research to establish verifiable facts (Bryman, 1989). Typical of a positivist approach, hypotheses are formulated, based on which statistical tests are carried out on numerical measures of the organisation. A positivist approach to theory construction in organisational studies, according to Bryman (1989) thus requires that all efforts are usually directed towards:

- Generating quantifiable attributes (Variables) to test the hypothesis;
- Establishing and demonstrating causality (Theoretical explanations/ Internal validity);
- Ensuring generalization beyond the specific confines of the specific context (External validity);
- Achieving replication/reliability (minimising the impact of researcher's biases/values on credibility of research outcome).

Following this line of logic, and in tune with the critical realist philosophical underpinning of this research, the case study approach used to generate theory in this study, is a hybrid merger of the requirements of both qualitative and quantitative research. Theory in this case study, which assumes a critical realist orientation, is therefore generated qualitatively and quantitatively. Theory on Embedded Unit of Analysis 1 *(how deltaic ground conditions induces cost overruns*) is generated quantitatively, while theory on Embedded Unit of Analysis 2 (*linking geotechnical practices in organisations to the high level of recorded cost overruns*) is generated qualitatively. Figure 4.9 shows the researchers approach to data generation and triangulation of sources leading to theory construction.

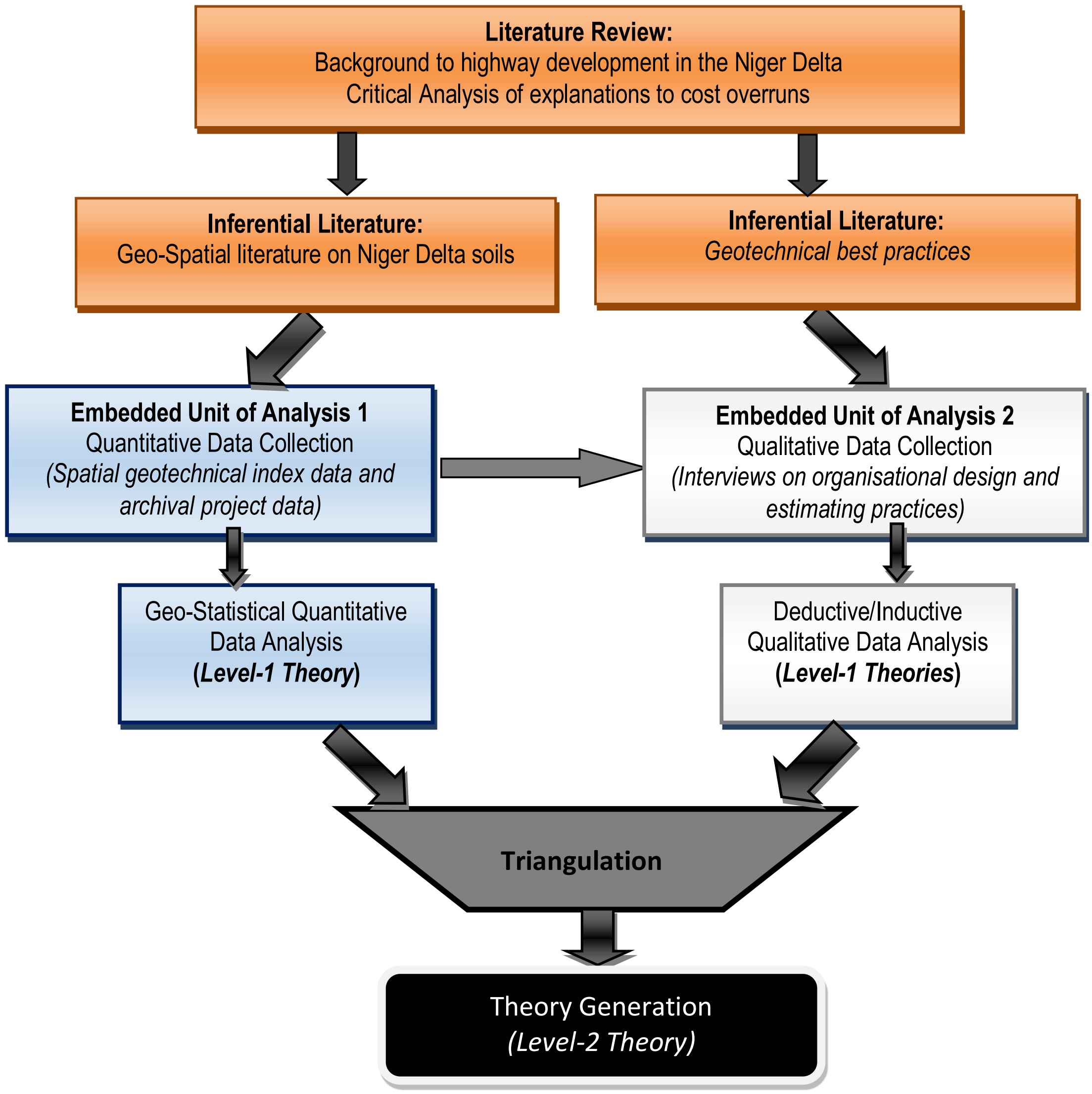


Figure 4.9: Practical Approach to Theory Construction in this Study

This research starts from a prior set of concerns derived from the theoretical issues in the literature. Quantitative and textual data are then collected using semi-structured interviews and documentary/archival sources. The incorporation of data from multiple sources is designed to improve the internal validity of the case study design, in terms of ensuring that premature conclusions are not drawn from circumstantial evidence, and the external validity of the study output. Dainty *et al.* (1997) advocated for triangulation of data to give different but convergent perspectives to the theoretical explanation of the phenomena under investigation. Dainty *et al.* (1997) explicitly rationalised this need on the following grounds:

- The systematic combination of different methods and data types reduces the possibility of the researcher drawing erroneous premature conclusion through an over-reliance on a single data set or technique;
- Increased generalisability of theories generated from social negotiation to having a wider resonance in the body of knowledge;
- Not being bounded by the empirical parameters of a study;
- Enhanced understanding of the study phenomena based on the holistic consideration of the various strands linking the evidence from various levels of enquiry.

The researcher's approach to theory building follows the prescription of Yin (2014), whereby level-1 inferences, which are lower order theories generated from the different multiple sources, corroborate each other to yield a level-2 inference, which is an analytically generalizable theory, at a conceptual level higher than the case studied. This study in achieving triangulation, therefore:

- Generates a first Level-1 theory, by collecting numerical data on the spatially dispersed geotechnical index variables on subgrade soils at project locations, and cost overrun trends from archives. These are analysed geo-statistically in a quasi-experimental fashion, as an exploratory step to understand the inherent propensity for the deltaic ground conditions at project sites to induce cost overruns in highway projects. the findings from this phase builds up and links to further understanding what latent triggers exists in practice;

- Generates a second Level-1 theory, by collecting textual data on the geotechnical practices of the highway agencies during design and costing processes, with respect to managing risks due to the deltaic ground conditions at project sites. The qualitative data is deductively analysed, relative to standards of geotechnical best practice, to gain a further in-depth understanding of the underlying issues accounting for the inference made from the preliminary geo-statistical analysis;

- Generates a third level-2 theory, in reflexive adaptation to unanticipated social constructs emerging from the qualitative data. Theory in this regard is thus further generated from the qualitative data using a purely inductive approach, similar to the approach of grounded theorising.

- Triangulates all the level-1 theories from the quantitative and qualitative strands of the case study to yield two *'level-2* theories: A Regression Model explicitly accounting for the variance in cost overruns induced by geotechnical pathogens; and a Cognitive map visualising the complexity of the interplay between geotechnical pathogens and emergent social constructs, represented as an array of barriers to geotechnical best practice in highway project development in the Niger Delta region.

The case study findings are subsequently analytically generalised back to serve as a '*working hypothesis'*, useful in studying the impact of geotechnical pathogens in triggering cost overruns, typical of similar heterogeneous wetland geology and socio-cultural setting. This empirically corroborates and advances the validity of geotechnical explanations, amidst the strong dialectical debate in the literature, which features other rival as well as complementary explanations, in accounting for cost overruns in highway projects. The implications of the case study findings in refuting the chief rival explanation to cost overruns is addressed, and the wider policy implications of the research are discussed. The unanticipated theoretical concepts which emerge from the study, as reflexively analysed and cognitively mapped out with the initial geotechnical themes, are infused as part of the study findings, forming a basis of recommendations for further studies.

4.10.3 Reliability of Data used as Evidence in this Case Study

Specific details on the approach to data management in ensuring reliability of evidence tendered in this case study research, is further provided in the subsequent more practical aspects of the overall research design, in terms of the:

- Data types;
- Methods of data collection;
- Structure of interviews;
- Sample size of interviews;

- Mode of participant recruitment;
- Mode of conduct of interviews;
- Analytical techniques

4.11 Data Types

Sanders *et al.* (2009) stated that the answers to most research questions are usually derived from a concurrent analysis of both secondary and primary data. However, with limited levels of available secondary data, reliance is placed on fundamentally generating primary data. Within the context of this research, use will be made of both primary and secondary data sources based on the nature of the research questions relevant to achieve the objectives of the study.

Primary data is defined by Nachmais and Nachmais (1992:291) as *"Data collected in a contrived or natural setting in which the participants are aware of being studied, or data that is collected personally by the researcher"*. As such primary data produces a contemporary; unpublished; unique and first-hand account of events. Primary data for this study was obtained from interview sessions conducted with participants linked to the highway agencies. This constituted the principal source of data deployed for the qualitative strand of this case study, which provided a first-hand description of the design and costing processes within the highway organisations, and thus the level of geotechnical input in projects.

Secondary data refers to data collected by others for purposes, which differ from the original research objective (Descombe, 2007). Secondary data includes both raw data without any attempt made at processing the data: letters; dairies; manuscript; notes; records; field work reports, as well as published summaries compiled in a systematic format (Saunders *et al.*, 2007). Secondary data could be recent or historical which serves as the basic distinction between documentary and archival sources. Documentary and archival sources, which are sources of secondary data, are unobtrusive.

4.12 Reliability of Secondary Data Sources in this Case Study

Alternative documentary sources exist that can be availed for research purposes. They can be visual, audio or written sources, although the written sources are relatively more commonly used. Descombe, (2007) listed a wide range of written documentary sources such as: Government publication and official statistics; Newspapers and magazines; Records of meetings; Letters and memos; Diaries, as well as web pages and internet. A note of caution is however sounded by Descombe (2007) when using secondary sources to ensure a high standard of reliability. Researchers are therefore advised to cross check for the authenticity, credibility, representativeness and unambiguity of documentary sources before using them as reliable sources of evidence in research.

However, Yin (2009) indicated the strength of documentary analysis as being unobtrusive and therefore, devoid of manipulation to align with the case being studied. Yin (2009) stated that most organisations collect and store a variety of data to support their operations: However, issues of confidentiality and access are typical with organisational documents. Descombe (2007) who although expresses the need for caution in the deployment of secondary data, stated that documents and archives are a useful and reliable source of information in research, which can be used as an independent source of evidence in parallel with questionnaires, interviews or observation or as supportive sources of evidence.

Documentary and archival data for this case study were obtained from: the project records of the three highway agencies being investigated; a research institute which sources geotechnical information on the engineering properties of sub-grade soils at various locations in Nigeria, although in limited amounts; and privately sourced geotechnical investigation reports from consultancy firms located in the Niger Delta region, to supplement the data obtained from the research institute. This was further complimented by a literature survey of geo-spatial studies on the geology of the Niger Delta, available from the extensive work already carried out on local soils.

Information obtained from these sources principally constituted the bulk of the secondary data which to a large extent shaped the quantitative dimension of the case study. The collated geotechnical data was filtered to correspond with project locations and analysed with project information and cost overrun data from archives of the three highway agencies in the study area for completed highway projects, to establish the chain of evidence.

4.13 Primary Data Collection

The tool for the collection of primary qualitative data in this study is the use of interviews. The research by virtue of its design, relies on the need to collect qualitative data principally from human participants. Saunders *et al.* (2009) defined an interview as a purposeful discussion between two or more people. Descombe (2007) however opined that an interview is much more than a conversation and involves much more technicalities than an ordinary conversation. Descombe (2007) distinguished interviews from conversations on the following basis:

- The ethical necessity of consent on the part of the interviewee;
- Interviewee's words are treated as records;
- The topic of discussion is defined by the interviewer.

Descombe (2007) advocated that interviews were particularly suited for use in the exploitation of complex and subtle phenomena, as opposed to straight forward factual information in which questionnaires can prove to be efficient. The qualitative aspect of the research sought to describe and understand in detail, the approach to designing and costing highway projects, by the highway agencies.

4.13.1 Structure of Interviews

Interviews may be: in-depth; semi-structured; structured as shown in Figure 4.10, based on the level of formality and structure used in conducting the interviews (Saunders *et al.*, 2009). Each of these interview formats may be warranted by different situations and with underlying issues.

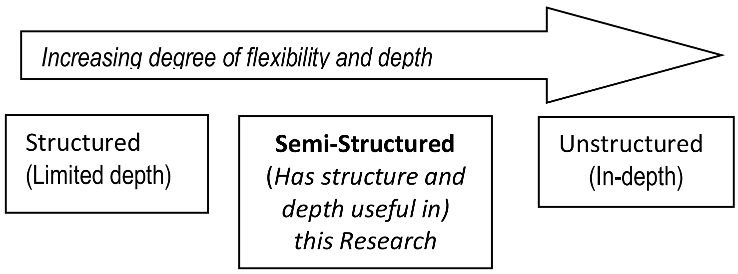


Figure 4.10: Interview Structure used for Collecting Primary Data

Structured interviews are usually conducted using a pre-coded set of questions which are read out to the respondent on the basis of which options for structured responses to the questions are provided (Saunders *et al.,* 2009). The structured nature of these interviews demands that the questions and any preliminary explanations of the interview questions be presented in an identical format to each respondent to avoid bias. Structured interviews are also referred to as '*interviewer administered questionnaires'*, and are deployed mainly for the collection of quantitative data (Descombe, 2007). Structured interviews are useful as a tool of data collection in survey research. Within the context of this case study therefore they offer limited opportunity for eliciting the kind of in-depth qualitative information the researcher considers necessary to understand the practices of the highway agencies.

At the other extreme on the scale of formality and structure, are the un-structured interviews which are conducted as completely open discussions. Saunders *et al.* (2009) explained that the interviewer in using this format opens the interview with a broad outline of the topic of the interview, and from then onwards the conversation is allowed to flow freely to cover any related issues. Although there is no pre-structured list of questions to administer, the interviewer has to have a clear vision of the issues to be covered in relation to a topic. The interviewee in this circumstance is referred to as the '*informant*' and as such will dictate the pace and directional flow of the interview. This type of interview provides a platform for exploring the beliefs, behaviour and attitude of the respondent in relation to a specific topic and is thus considered less useful for the purpose of this study which focuses on the organisational processes and not the people. The researcher was thus of the opinion that since the research is not focused on attitudes or believes of individuals but rather on their professional evaluation of the current technical organisational processes, the use of unstructured interviews would not best serve the research objectives.

Semi-structured interviews are only partly structured research interviews, but with a high degree of flexibility in format. On this basis of its flexibility and usefulness with respect to providing answers to the research questions, this form of structure was used to draft the questions in the interview guide used in this study (Appendix A). This thus defined the structure of the interviews conducted in this study. The researcher set out to interview the respondents with a general outline of questions on the themes that that the study covered, as deduced from the literature review. However, there was a degree of flexibility in the nature of the questions asked. The primary purpose of the interviews was thus reflected in their semi-structured format, which was principally targeted at eliciting information relevant to assess the prevailing level of geotechnical input in the progressive phases of highway development.

The flexibility of a semi-structured form of interviewing presented its apparent advantages in this study. As such depending on the on the respondent or the specific organisational context, certain questions were asked which were omitted in other contexts. Additional questions not originally part of the interview protocol were also introduced to probe unanticipated issues that occurred in the course of the interview and which the researcher considered crucial to the study. This discretionary method of interviewing was thus tailored to suit the prevailing context of the individual interviews to gain a better understanding of the phenomenon of the geotechnical issues driving the phenomena of cost overruns in highway projects. The flow of conversation was directed along specific paths that the researcher was interested in, but the respondents has more room to freely express their opinions on issues discussed. This led to a better understanding of current practice and enabled the researcher to induce inferences on the prevailing level of adherence to geotechnical best practices. The usefulness of this flexibility was further evident as a plethora of unanticipated themes, discernible from repeated trend and patterns in the interview conversations, emerged. The structure, flexibility and in-depth nature of semi- structured interviews were therefore significant advantages in this research.

4.13.2 Conditions of Entry: Ethical Conduct and Mode of Participant Recruitment

Prior to the field work, the researcher had prepared a synthesised draft of the data requirements of the research, as part of the university requirement of obtaining ethical approval. On this basis participant information sheets, consent letters, risk assessment and a draft of the interview protocol were submitted and ethical approval gained. The ethical approval given by the research board of the University of Salford is contained in the Appendix E. The interview sessions were thus conducted in consonance with the ethical requirements of the University of Salford.

To recruit participants from the highway organisations introductory information letters (AA-OMC1-Nov'14, in Appendix) explaining the nature and purpose of the research were sent to the respective highway organisations. This was complimented by personal contacts and insiders within the targeted highway agencies, necessary to facilitate the approval process. Winkler (1987), who spent nearly one year of a three-year project negotiating access, advocated the use of early planning and arrangements, friends and contacts within target organizations as tools for overcoming the problem of access. Early planning by the researcher was thus key to ensuring that the necessary permission was obtained from the organisations.

On gaining approval, the research project information was provided and consent sought from the delegated personnel within the relevant units of each organisation (AA-PCF1- Nov'14 and AA-PIS1-Nov'14, in Appendix). The delegates which were chosen in relation to their job description and within the highway agencies, were thus relied on as the primary source of information on the design and estimating practices in their organisations. It was also necessary to eliminate other subjective influences, such as the hierarchical ranking of the staff, to ensure that subjective influences by virtue of their ranking did not bias the information gained.

The information provided from interviews conducted within the organisational settings of the highway agencies, was further complimented by information provided by external registered consultants and contractors, employed by the agencies but outside the organisational settings of the highway agencies. Participants interviewed outside the confines of the organisational structure of the highway agencies were recruited on the basis of their: Professional links to the highway agencies (Consultants); and the contractual relationship with the Highway agencies (Contractors). Another principal criterion used in selecting respondents, external to the highway organisations investigated in this study, was their level of experience and qualifications necessary to provide the required technical information on the designs and costing practices of highway projects executed within the Niger Delta. Individuals assessed as possessing the requisite level of professional experience and academic qualifications in relation to the outlined criteria were recruited on the basis of their consent (AA-PCF1- Nov'14, in Appendix). The perspectives and views of the consultants and contractors outside the organisational structure of the highway agencies, were thus incorporated as a further measure to ascertain the reliability of data gained from within the highway organisations.

Information letters outlining the nature of the research and the relevance of their professional opinions to the study were thus forwarded (AA-PIS1-Nov'14, in Appendix). Recourse however had to be made to the use of the LinkedIn professional network, where the profiles of four (4Nr) of the respondents were assessed, to gain online access to them. This was achieved through live chatting, after the interview protocol had been made available to them for viewing.

4.13.3 Proposed Sample Size

On the preceding outlined basis therefore the designated number of respondents 12(Nr) from the three highway agencies was constituted to comprise:

- Quantity surveyors – Two (A management level and an operational level staff) from each of the three highway agencies (6Nr);
- Civil engineers - Two (A management level and an operational level staff) from each of the three highway agencies (6Nr).

Respondents were also sampled external to the highway thus:

- Consultants: Three respondents, one each randomly selected from the list of registered consultancy firms provided by the highway agencies constituted the three (3Nr) sample size of interviews carried for the consultants group.

- Contractors**:** Three road contracting firms, one each were selected from the list of registered contractors provided by the three highway agencies, and constituted the sample size for the contractors group. The firms were also selected based on the information provided by respondents from the highway agencies as to the volume of road contracts executed by these firms and which established their relationship with the highway agencies.

Descombe (2007) appraises the appropriateness of this method of sampling to where the researcher possesses prior knowledge of the people, events or organisations. On this basis it is recommended to “hand pick” respondents who are likely to provide the most valuable information. As such within and outside the organisational structure of the agencies, the participants in the interviews were purposively recruited on the criteria of their professional demographics, to elicit information on the ‘*unit of analysis 2*’ of this case study (costing and design of highway projects executed in the Niger Delta).

4.13.4 Mode of Interview Conduct

The interview sessions, which lasted for an approximate duration of 45 minutes, were conducted over the telephone and online through life chatting on the LinkedIn professional network for as opposed to face-to-face interviews. However, some of the interviews conducted over the telephone lasted over one hour, in the light of unanticipated information that emerged in the conversation, and which the researcher considered vital to explaining why cost overruns were so unusually high for highway projects executed in the Niger Delta.

Telephone and internet based interviews can be distinguished from face-to-face interviews in terms of the distance between the interviewer and participants which according to (Bryman, 1989). can be conceptualised on two levels:

- *Physically in terms of literal distance which be as much as thousands of miles;*
- *Figuratively, in terms of the lesser personal effects of interviewer’s social characteristics on the interaction and respondent’s replies*” (Bryman, 1989: 44-45).

The choice of the telephone interviews, supplemented by internet based interviews, was based on this apparent advantages over personal face-to-face interviews, in addition to other advantages which were noted by Bryman (1989). These included the:

- Relatively less expensive nature
- Enhanced speed of execution
- Considerably more coverage afforded
- Relative ease with which they can be scheduled and supervised.

These advantages were particularly evident in this study, based on the fact that the researcher on establishing initial contact with the respondents, noted that a higher percentage of them were more accessible online, and via the telephone. This may be attributable to the relative ease of telephone and internet access in modern times. Recourse to the use of other online video conferencing tools was however limited by technological constraints posed by the low level of advancement in Information Technology (IT) based communication in the study area. The combination of these two relatively accessible media of communication used in the study, afforded the researcher far more coverage. This is demonstrated by the total sample size of 18, with 16 of the interviews conducted representing a high response rate of 89%. This statistic further broken down represents 83.3% 10 of 12Nr response rate within the highway organisations and a 100% (6 of 6Nr) response rate from outside the highway agencies. This high response rate is attributed to the fact that access to the respondents was easily managed. This was due to the fact most of the respondents 10 out of the 14Nr interviewees via the telephone, preferred to be interviewed after work hours in the evenings between 17:00 to 20:00 Hours. This demonstrated ease of scheduling the interviews to suit the respondents' preferences, would not have been absent with face to face interviews, which would have presented practical difficulties for the researcher due to the geographical dispersion of the interview sites. This is apparent, based on the fact that the respondents were situated in different locations in the difficult predominantly wetland terrain of the Niger Delta with the implied transportation issues. The interview locations are also distributed amongst several organisational settings, (Three Highway agencies; three Contracting firms; three Consultancy firms), each of which would have protocols and formalities in accommodating and scheduling face-to-face interviews. The use of face- to-face interviews would thus have constituted a hindrance to speed and ease with which the interviews were conducted and supervised.

It has been opined that people are as honest over the telephone as they are in face-to-face contact (Descombe, 2007). This was also noted by the researcher, in that the four interviews conducted during working hours of the organisations, typical of face to face interviews, were much more restrained compared to those carried out after work hours. As such the acclaimed superiority of face to face interviews over telephone interviews is put to question (Bryman, 1989; Descombe, 2007). The telephone and internet based interviews thus still retained some of the personal element of face to face interviews, despite the fact that the visual element is foregone. The researcher is also of the opinion that that the visual element is not of particular importance, but rather is more prone to the established effect of visual social interactions in interviews (Bryman, 1989). This opinion is further reinforced by the fact that the primary purpose of the interviews was to elicit information relating to technical details of designs and estimating, and not the behavioural or attitudinal characteristics of the respondents.

4.14 Reliability of Qualitative Data from Interviews

All necessary measures, relevant to improve and ascertain the reliability and accuracy of qualitative data collected during the field work, were thus taken via the: Piloting of Draft Interview Questions; Use of Multiple Informants; Appropriate Distribution of Professional Demographics. The practical details of these measures as applied in the field work are thus described in detail below.

4.14.1 Piloting of Draft Interview Questions

Preliminary piloting of initially drafted interview was carried out to ensure that the questions were structured in clear, simple and unambiguous language, using appropriate technical terminology (Bryman, 1989). This was considered imperative to ensure that respondents could readily comprehend questions and did not attach more than one interpretation to the questions asked. Piloting of the interview questions was also useful in ensuring that the structure of questions would elicit responses necessary to gain the required information. As such questions that were initially poorly presented were restructured, based on the comments raised in the pilot study. A copy of the initial draft interview questions is attached as part of the appendix. The justification for the revision is attached also in the appendix, with the final interview template.

4.14.2 Use of Multiple Informants

Within the organisational structure of the highway agencies, reliability of data was achieved by a cross comparison of information provided by the different cadre of respondents: (Management and operational professional staff) from within a particular agency, with subtle discrepancies duly noted. This method is an adaptation of the use of '*Key Informant Research'* which is common with organisational studies, used to retrieve factual data rather than attitudinal data. Multiple informants from each highway organisation were thus used to elicit relevant information, as opposed to using one key informant, selected to speak on behalf of the organisation. The rationale for adopting this approach is based on findings from a number of older organisational research studies in the literature (Philips 1981; Hickson *et al.*, 1986; Bryman, 1989) that have pointed out the limitations of using a single informant. Typically, several issues were raised, such as:

- Whether it is possible for a single informant to provide accurate information on the organisation as a whole?
- The possibility of variability of status of the informant affecting the reliability of information provided, which may have implications for the comparability of data.
- The potential for error, ignorance bias or deliberate distortion of facts from a single informant.

However, it is recognised by the researcher that although aggregated accounts from the multiple participants may not completely eliminate this identified shortcomings, it greatly minimises them.

4.14.3 Appropriateness of Professional Demographics

The adequacy of the respondents' demographic information, with respect their professional/ academic backgrounds and experience, was ensured in the selection of potential participants as measures of reliability and validity. As such the years of experience and professional qualifications of respondents, was elicited as part of the demographic information. This was considered necessary to demonstrate the specificity of the experience in relation to the information being sought. As such, it established the reliability of information provided by respondents from the consultancy and contracting firms.

4.15 Data Protection

The audio taped interview conversations were handled with the utmost level of discretion. Audio tapes were locked up for the duration of their use and will be destroyed along with all back-up copies made, at the conclusion of the research. Data collected online were equally handled with discretion. Only the researcher and the supervisor had access to the raw data collected. Personal computers were also pass-word protected, with controlled access to data files as a further measure to ensure security of transcribed data from interviews. Prior to transmitting the transcribed data, personal information and all forms of respondent identity were removed and replaced with codes before further encryption.

4.16 Data Analysis

Data analysis in this study was carried out in several distinct but linked phases, with previous phases progressively leading to latter phases, as a strategy of explanation building advocated by Yin (2015), to ensure internal validity in explanatory case studies. The multiple analytical techniques deployed for this purpose are briefly outlined, although further detailed breakdown of the approach deployed at each phase is provided in the subsequent chapters of this thesis.

4.16.1 Exploratory Geo- Statistical Analysis

The researcher began the analysis from the exploratory phase of the study, by developing a geotechnical classification of subsoils in the Niger Delta, as a form of quasi experimentation. Broad conceptual geomorphic categorisations of Niger Delta soils, as used in engineering geologic application, were synthesized from the local literature, to highlight its geologic heterogeneity. Based on the synthesized geotechnical classifications, cost overrun data for the geologic zones identified as having similar subsoil characteristics, are analysed using a quasi-experimental design approach, for significant differences in the level of project cost overrun incurred on highway projects. Analysis of Variance of cost overruns incurred on a sample of sixty-one completed highway projects, spatially distributed amongst the synthesised zones, was thus carried out to infer whether the differences in the geology of project locations has any bearing on the level of cost overruns recorded in the highway projects, executed by the 3 highway agencies operating in the region.

Further to this, the various engineering parameters, which represent the suitability of sub-grade soils in the Niger Delta, as bearing media in highway construction, are inferred as the factors which are latent in the geologic setting. Geotechnical data on sub-grade soils referred to as 'Index properties', which provide quantitative parameters that reflect the properties of soils, as applicable to highway designs, are used to extrapolate the basic engineering suitability of the sub-grade soils at the spatially dispersed project locations in the Niger Delta region. This explorative geotechnical phase was useful to show the inherent capacity of the geologic configuration of the Niger Delta terrain, to compound the cost overrun propensity of highway projects. This served as a backdrop to understanding the level of geotechnical risk the terrain possesses, and which should ideally be catered for by adequate geotechnical practices.

On this basis, a descriptive spatial geotechnical analysis of Niger Delta soils was carried out, using standard engineering classification of sub-grade soil types, and their financial implications as bearing media in highway construction analysed. A set of hypotheses to statistically test for association between these geotechnical index variables, relating to the stability and expansivity of soils, and cost overruns are tested using correlation analysis, which subsequently forms an integral part of the stepwise regression modelling used latter in explanation building. This constituted the preliminary geospatial exploratory phase, upon which the descriptive qualitative phase, targeted at eliciting information on the prevailing geotechnical practices of the highway agencies, was built.

4.16.2 Descriptive Qualitative Analysis (Deductive)

Further to the initial exploratory analysis, the researcher identified geotechnical best practices from the literature, to account for the deduced disparity in cost overruns levels, revealed from the geo-spatially distributed pattern of the cost overrun data. A conceptual framework of geotechnical pathogens, identified from the literature on geotechnical best practices, was developed and served as a basis for drafting the interview template. The interviews were used to elicit information on the prevailing level of adherence to geotechnical best practice by the highway agencies, during the design and estimate phases of project development. The elicited data was thematically analysed, relative to the standards of geotechnical best practices. This were inferred as the primary triggers to cost overruns, as they exhibited a pathogenic latent effect, which exacerbated the inherent propensity of the wetland terrain of the Niger Delta. The analysis was carried out using the NVIVO-10, qualitative data analysis software, after transcribing the interview notes.

4.16.3 Descriptive Qualitative Analysis (Inductive)

Other non-geotechnical social constructs which were unanticipated, however emerged from the interview data, and were reflexively infused into the qualitative analysis. The inductive interview analysis was carried as a second stage of qualitative data analysis, whereby the researcher re-read the interview transcripts and matched patterns repeated occurring across the data. The analysis in this regard was thus carried out without a prior literature base similar to grounded theorising. A multiplicity of social constructs was inductively inferred as the barriers to geotechnical best practice, and by extension contextual drivers to cost overruns.

4.16.4 Explanatory Regression Modelling and Cognitive Mapping

This phase was further structured to build on findings emanating from the results of the previous sets of analysis. This entailed the triangulation of output from: the geospatial factors deduced from the quantitative archival project data on cost overrun and subsoils variables; together with the qualitative findings on the geotechnical themes inferred from the interview analysis, using regression modelling. A multiple log regression model was generated, by a step-wise introduction of categorical dummy variables to represent the assessed levels of geotechnical practice, which varied depending on the class of project and the executing highway agency. This was further juxtaposed on ground conditions at the respective projects locations, as indicated by the quantitative spatial geotechnical data on sub-grade soils.

Regression modelling was thus used to infer causality, explicitly quantifying the proportion of variance in the cost overrun data, accounted for by the inherent geotechnical properties of subsoil at project locations, and the variance induced due to lack of geotechnical best practice. Some of the variation in the recoded cost overruns however remained unexplained. The unexplained variation in the regression analysis, was attributed to the emergent social constructs. This served to tie up the multiple stands of analysis, and establish the chain of evidence pointing to how the levels of geotechnical input account for cost overruns in estimates. The triangulated findings were thus presented as a quantitative model, which explicitly showed how poor geotechnical practices and the geology of project location in the Niger Delta, accounted for a greater percentage of the variance in cost overruns recorded on highway projects.

Cognitive Mapping was subsequently used to map out the interplay between the geotechnical pathogens and emergent themes, which are represented as the barriers to geotechnical input, in accounting for the unusually high levels of recorded cost overruns in the Niger Delta. The emergent barriers to geotechnical are however relatively weighted and ranked using content analysis, based on the number of coding references made to each emergent node. The result of the cognitive mapping is a visual projection of the intricate complexity of the interplay, and the counter factual phase dependent relationship between the core geotechnical factors and the corresponding emergent barriers, with nodes relatively sized to reflect their ranking.

4.17 Chapter Summary

This chapter has articulated all the elements of the research methodology of this study, from the higher order philosophical underpinnings of the study, down to the more practical issues of data collection and analysis. Critical arguments and justification of the choices made at each level of the hierarchy of the research elements has also been provided. The case study approach has been adopted as the research strategy in this study. In more practical terms, broken down into the specific processes and phases as applied to this study, the research methodology translates into the following case study research design represented as a flow chart in Figure 4.11.

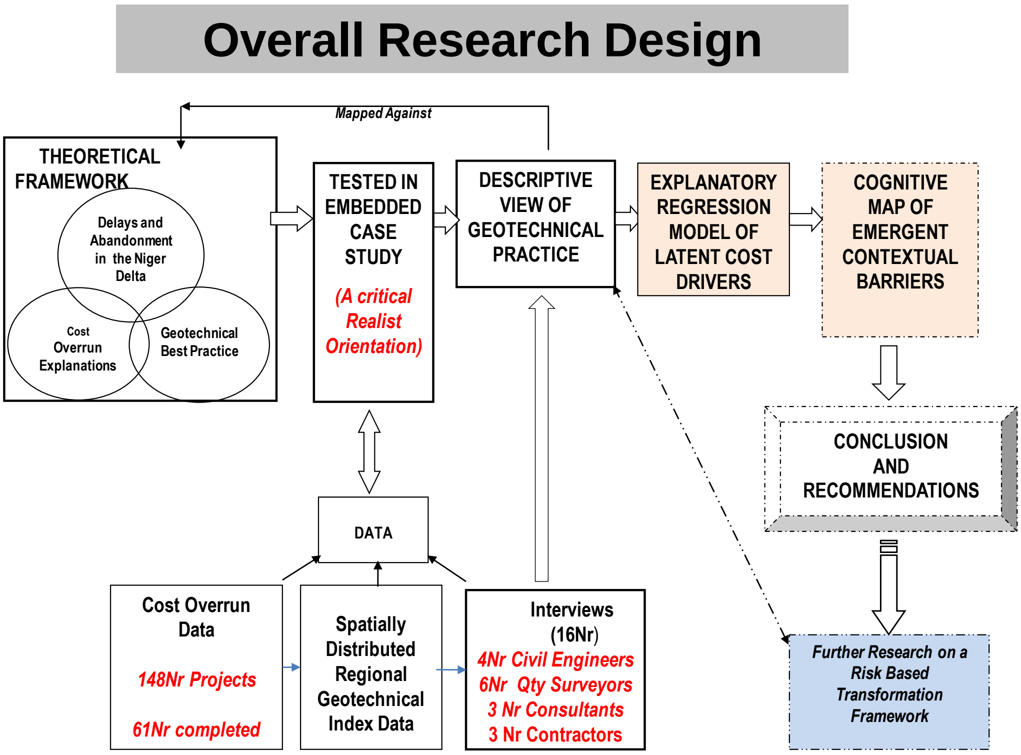


Figure 4.11: Overall Case Study Research Design

Figure 4.11 thus shows an outline of the various practical phases of the case study, and the systematic stages used in developing an explanatory model of latent geotechnical pathogens and contextual drivers to highway project cost overruns, predicated on the geologic context of the study area. The subsequent chapter is a detailed geo-spatial quantitative analysis of the geologic configuration of the Niger Delta region of Nigeria, as an exploratory phase of the study, highlighting the magnitude of ground induced financial risk to highway project delivery.

CHAPTER 5

Exploratory Geo-Statistical Analysis of Latent Geologic Cost Overrun Drivers

5.0 Introduction

This chapter of the research is focused on exploring the geologic peculiarities of the Niger Delta region (Unit of Analysis 1), which has made it a significant geographic area of scholarly interest in this research. This chapter describes the difficult terrain of the Niger Delta region, in relation to the poor engineering index properties of subsoils, and statistically explores this geotechnical undertone as a potential trigger which creates a propensity for cost overruns in highway projects. The heterogeneous geologic configuration of the area, in terms of its geomorphology is thus descriptively analysed based on available local literature, supplemented by the researcher's geotechnical field work data. Exploratory statistical tests of significant difference and correlation analysis, are further used to analyse recorded cost overrun data for 61 completed highway projects. The ultimate goal of the geo-statistical analysis was to establish spatial cause and effect relationships, between the heterogeneous geologic setting of the Niger Delta and cost overrun trends evident in highway projects.

5.1 Geomorphology: Heterogeneous Geologic Configuration

The Niger Delta is the 9th largest Delta in the world with an area of 19,135 square kilometres. It is one of the largest wetlands in Africa. The whole basin is dissected by numerous creeks, streams, marshes and lagoons. The terrain of most parts of the Niger Delta is characteristically poorly drained, from the inundation of the adjoining lowlands forming swamps and coastal islands as shown in Figure 5.1.


Figure 5.1: Mangrove/Freshwater Swamps in the Niger Delta (Source: NDRDMP, 2006)

However, the upper northern limit of the Niger Delta, is characterized by tropical rainforest woodland as shown in Figure 5.2. This is the zone with the most extensive dry land, and the population distribution is denser, with far larger settlements than other wetland zones. This heterogeneous configuration of the terrain thus has correspondingly varying geotechnical implications for highway development.

Figure 5.2: Tropical Rainforest in the Niger Delta (Source: NDRDMP, 2006)

The silted and marshy grounds of the swamps are representative of the difficulties of undertaking any major construction in the area. Most of the soils encountered are soft and present sub-grade problems due to high water tables (Oguara 2002). Several scholars researching on the geology of the Niger Delta: (Akpokodje, 1987,1989; Oguara, 2002; Teme, 2002; Youdoewei, 2013; Ngerebara *et al.,* 2014), have consequently underscored that most parts of this variable geological setting, runs in the negative as regards construction works, with the technical and financial undertones tremendous.

5.2 Highway Projects Cost Overrun Levels in the Niger Delta: Project Data

Cost and locational data from a total of 315 Infrastructure projects (buildings, canalisation, shore protection, and road projects) awarded from 2002 till date, were obtained from the available archival records of the three highway agencies responsible for highway development in the region, represented as HA1. HA2 and HA3. 148 of these infrastructure projects were road projects executed at various locations in the Niger Delta (Rivers and Bayelsa States), 61 of which were completed, while 87 were a mix of currently ongoing, delayed and abandoned projects.

Figure 5.3: Data Filtration Criteria for Analysis

The project data was filtered down on the basis of the study scope to only road projects. Furthermore, only the completed road projects were analysed, for their levels of cost overruns, necessary to test the study hypothesis. No other form of selective sampling was adopted. Table 5.1 shows details of project data for the completed highway projects in the Niger Delta, awarded from 2002, while Table 5.2 shows the descriptive summary statistics for the cost overrun data on the 61 completed road projects.

Table 5.1: Project Cost Overrun Data for Completed Highway Projects

S/No	Location (LGA)	Agency	Date of award	Budget Estimate (N in Millions)	Final Cost (N in Millions)	Percentage cost overrun
1	Ahoada west	HA1	5-Nov-09	800.00	1,300.57	62.59
2	Eleme	HA1	15-Dec-04	15.47	29.27	89.25
3	Obio-Akpor	HA1	10-Dec-04	355.68	1,923.34	440.74
4	Ikwerre	HA1	10-Dec-04	1,102.35	3,739.86	239.26
5	Khana	HA1	2-Jul-07	2,861.83	3,198.63	11.76
6	Asari-Toru	HA2	10-Jun-02	11,204.16	19,287.24	72.14
7	Degema	HA3	30-May-10	2,063.00	3,397.01	64.66
8	Ekeremor	HA3	10-Dec-04	508.47	780.86	53.57
9	Akukutoru	HA3	20-Dec-06	1,847.34	6,428.21	247.97
10	Sagbama	HA3	26-Sep-06	45.57	108.34	143.78
11	Ogbia	HA3	10-Dec-04	791.72	1,974.40	149.37
12	Ekeremor	HA2	10-Dec-04	1 45.56	228.34	56.86
13	Southern-Ijaw	HA1	2-Jan-02	27.35	65.04	137.78
14	Brass	HA2	10-Dec-04	51.08	96.52	88.95
15	akassa – brass	HA2	10-Dec-04	18.14	31.89	75.75
16	Andoni	HA2	10-Dec-04	13.00	25.75	98.07
17	Gokana	HA1	10-Dec-04	1,016.98	1,417.50	39.38
18	Ahoda East	HA1	1-Feb-02	38.36	87.56	128.24
19	Oyigbo	HA1	10-Dec-04	295.89	1,050.58	255.05
20	Port Harcourt	HA1	4-Nov-02	332.88	923.71	177.48
21	Port Harcourt	HA1	10-Dec-04	966.00	1,913.09	98.041
22	Etche	HA2	17-Aug-06	5,203.57	7,820.99	50.30
23	Abua	HA2	10-Dec-04	943.09	1,972.99	109.20
24	Gokana	HA2	12-Dec-08	23.14	32.55	40.67
25	Ikwerre	HA2	11-Jul-07	18.47	27.98	51.53
26	Emuoha	HA2	10-Dec-04	24.65	34.17	38.60
27	Ikwerre	HA2	10-Dec-04	37.90	50.52	33.29
28	Port Harcourt	HA2	10-Dec-04	600.00	842.42	40.40
29	Omuma	HA2	2-Jan-02	245.14	533.02	117.43
30	Obio-Akpor	HA3	10-Dec-04	761.23	1,612.34	111.80
31	Obio-Akpor	HA3	1-Jan-03	816.50	2,210.94	170.78
32	Obio-Akpor	HA3	10-Dec-04	2,625.00	6,261.46	138.53
33	Etche	HA3	10-Dec-04	427.00	793.23	85.768
34	Port-Harcourt	HA3	10-Dec-04	427.00	1,230.72	188.22
35	Asari-Toru	HA3	10-Dec-04	427.00	786.88	84.28
36	Ndoni	HA1	10-Dec-04	836.93	3,235.61	286.60

37	Yenegoa	HA1	10-Dec-04	464.19	4,879.96	951.26
38	Yengoa	HA1	10-Dec-04	2,500.00	4,319.86	72.79
39	Sagbama	HA1	10-Dec-04	3,479.90	4,479.91	28.73
40	Nembe	HA1	28-May-12	9,667.78	29.42	204.32
41	Okrika	HA1	10-Dec-04	2,069.07	5,763.29	178.54
42	Asari-toru	HA2	6-Sep-01	3,396.21	12,133.83	257.27
43	Sagbama	HA2	6-Sep-01	15.18	1 61.66	978.57
44	Kolokuma	HA3	10-Dec-04	56.29	96.28	71.06
45	Ogbia	HA3	10-Dec-04	3,062.38	12,930.41	322.23
46	Bonny	HA1	30-Dec-05	14.37	19.49	35.64
47	Brass	HA1	25-Jan-07	14.50	29.48	103.34
48	Southern Ijaw	HA1	10-Dec-04	2.32	16.51	613.21
49	Egbema	HA3	5-Nov-09	586.13	11,871.55	1925.40
50	Sagbama	HA3	20-Dec-06	1,200.26	1,200.26	0
51	Kolokuma	HA3	1-Jan-03	275.60	729.65	164.74
52	Ogbia	HA2	7-May-02	780.46	12,941.74	1558.20
53	Akuku-Toru	HA1	10-Dec-04	3,359.74	6,713.02	99.80
54	Bonny	HA1	5-Nov-09	9,668.00	26,421.86	173.29
55	Okrika	HA1	2-Jan-02	1,735.10	3,989.53	129.93
56	Andoni	HA1	10-Dec-04	4,175.68	8,675.68	107.76
57	Opobo=Nkoro	HA1	10-Dec-04	3,546.65	5,585.02	57.47
58	Yenegoa	HA3	13-Jun-07	427.00	1,283.18	200.51
59	Ndoni	HA3	2-Jan-02	427.00	1,401.77	228.27
60	Kolokuma	HA3	10-Dec-04	427.00	1,464.47	242.96
61	Ogbia	HA3	23-feb-06	427.00	1,369.66	220.76

Table 5.2: Descriptive Summary Measures

			Statistic	Std. Error
Cost Overrun	Mean Percentage Cost Overrun		216.4657	43.29592
	95% Confidence Interval for Mean	Lower Bound	129.8610	
		Upper Bound	303.0704	
	5% Trimmed Mean		157.6045	
	Median		111.8076	
	Variance		114346.732	
	Std. Deviation		338.15194	
	Minimum		.00	
	Maximum		1925.40	
	Range		1925.40	
	Interquartile Range		148.92	
	Skewness		3.653	.306
	Kurtosis		14.378	.604

Table 5.2 shows that the mean cost overrun for the projects executed at various locations in the Niger Delta is 216.47% over initial estimates which shows the unusually high cost overrun levels recorded on the sample of 61 highway projects executed in the Niger Delta. The standard error of the mean however is 43.30%, which represents the likely variability around the mean value of the cost overrun recorded across various locations, taking into consideration differing samples of 61 previously executed highway projects. However, the analysis shows that at a 95% confidence level, the mean value of cost overrun will likely still fall between130% to 303% The minimum value of this range of cost overruns, estimated under this level of probability, is still

remarkably high compared to the levels of cost overruns evident for highway projects reported in the literature.

Based on the analyzed data set, the standard deviation of 338.15%, shows a considerable level of dispersion of cost overruns at various locations around the mean, which is not reflected in the interquartile range of 148.92 around the median. This indicates that the dispersion is not evenly distributed, but is heavily skewed (3.65), as the median of cost overrun percentage, 111.81 is much lower than the mean value (216.47) of cost overrun. The negatively skewed shape of the data is shown in the frequency histogram (Figure 5.4), with percentage cost overrun values at the project locations predominantly clustering around values much lower than the mean.

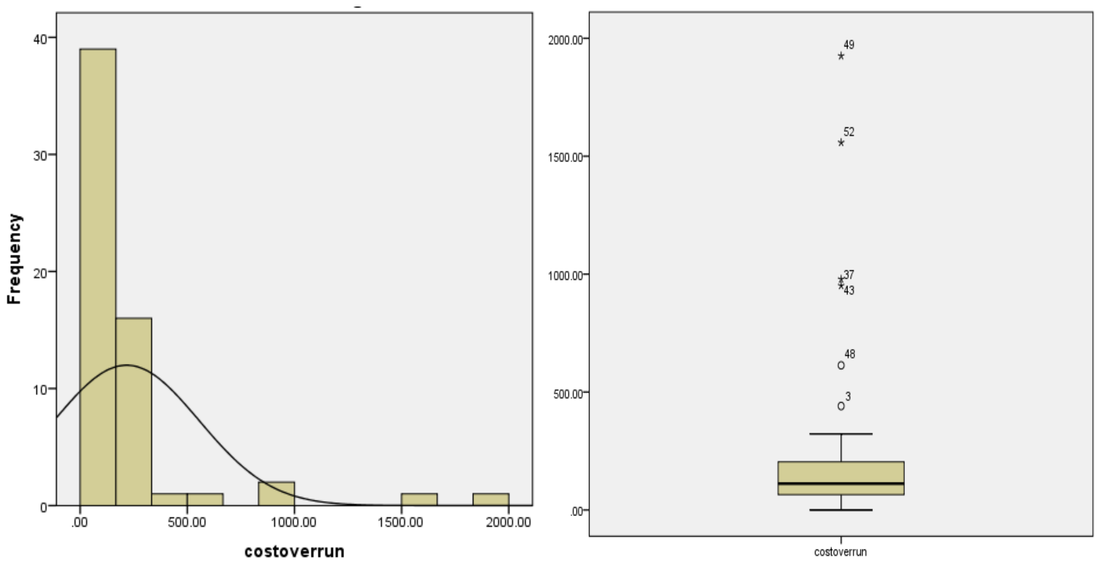


Figure 5.4: Frequency Distribution and Box-plot of Cost Overrun Data

The box plot in Figure 5.4, shows a five-number summary: the median, the 25th and 75th percentiles, and the minimum and maximum observed values of cost overrun. that are not statistically outlying. Outliers and extreme values outside this range are thus noted. The skewness of the data thus may be due to the very conspicuous outliers noted, in order of increasing magnitude for project No: 3; 48; 43; 37; 52; and 49, located at Obio-Akpor, southern Ijaw, Sagbama, Yenegoa, Ogbia and Egbema, which has dragged the mean value to be much higher than the median. It is however noted the by the researcher that 5 out of the 6 outliers occur for projects in riverine areas. It is also noted that there is a wide variability in the cost overruns values with an approximate difference of 1925% in cost overruns values between the minimum of 0.00 occurring in Sagbama, an upland location, and the maximum of 1925.40 % occurring in Egbema, a riverine location. These observations made from the descriptive phase of the analysis served to reinforce the researcher's predisposition, based on which further inferential geo-statistical tests were carried out on the sample project data.

5.3 Heterogeneity of the Niger Delta Terrain: *Any Cost-Overrun Implications?*

The environmental condition of most parts of the Niger Delta makes the use of conventional pavement designs, materials and construction methods particularly in the riverine locations, inappropriate. This may imply that highway design and construction in these zones as compared to the uplands would ideally require expensive specification for works, ultimately increasing the cost of construction projects so many folds. The subsequent analysis thus seeks to explore if there is statistical association between subsoil factors and cost overruns. The researcher's approach thus, is to statistically analyse the more quantitative descriptive properties of sub-grade soils in the region, with the level of cost overrun incurred at project locations. This is rationalised against the logic that the key financial inputs of material, labour and plant costs requisite for the construction of roads in the Niger Delta are reflective of the implied design and construction costs requisite at project locations, as illustrated in Figure 5.5.

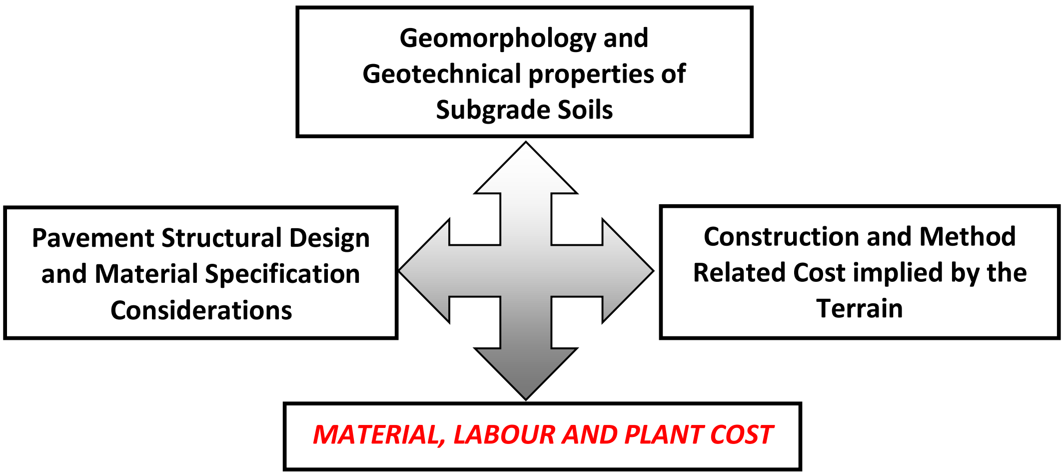


Figure 5.5: Cost Implication of Road Construction in the Niger Delta

By implication, the variable geomorphology and the geotechnical characteristics/indices of subsoil will form the primary set of predictive variables shaping the cost profile of the financial inputs of material, labour and equipment necessary for the construction of roads at various locations. Therefore, any design and cost estimating assumptions in highway procurement, made on a homogenous basis will not reflect the final costs of projects, and will consequently induce a corresponding level of cost overrun or under-run. The logical cost-overrun implications of the heterogeneous geologic setting of the Niger Delta soils for road construction can thus be viewed from:

- The point of relatively higher design and specification requirements necessary to adapt the subsoil conditions in the swampy and coastal zones, than in the uplands;
- The point of additional cost/expenditure that may likely be incurred during the construction phase for projects situated in the riverine meander and coastal belts as opposed to the upland areas of the region.

The subsequent subsections thus explore and analyse the cost overrun implications of the geologic variability of the terrain, as it relates to the geotechnical practicalities of road construction in the Niger Delta. This is with a view to test if the potential impact of the heterogeneous geomorphology of the region, can explain the significant level of cost overruns in the sample of completed highway projects.

5.4 Difficult Expansive Soils of the Niger Delta (The 'Chikoko' Clay)

The general geology of the Niger Delta consists of various types of sub soils. Sub-soils in the riverine areas of the Niger Delta, predominantly consists of extremely soft deltaic marine clay locally referred to as '*Chikoko'*, with a dark grey, dark brown to black coloration (Otoko and Pedro, 2014). Fatokun and Bolarinwa (2009:3), in identifying the major problem soils of Nigeria, described those existing in the sub-soils of the Niger Delta as: "*Composed of 'Peat, Organic silts and Clays characterized by dark colours and strong odour which are highly compressible with low strength*".

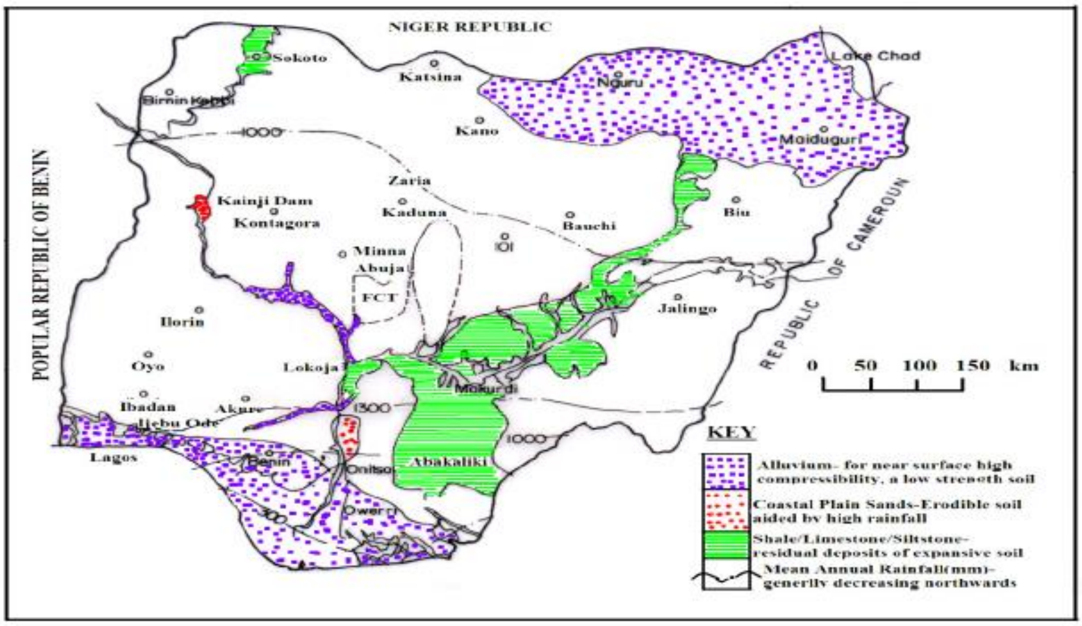


Figure 5.6: Geographic Distribution of Expansive Problem Soils in Nigeria

Source: Fatokun and Bolarinwa (2009)

Figure 5.6 shows the distribution of problematic expansive alluvium soils in Nigeria, and its prevalence southwards in the Niger Delta region. These chikoko soils have been shown to be highly undesirable in their natural forms for road construction, as shown in Figure 5.7.

Figure 5.7: Highway Construction in the Niger Delta Mangrove Swamp Forest

(Source: NDRDMP, 2006)

This is due to their characteristic swelling and shrinkage potential, with corresponding changes in water content, as seasons change from rainy to dry. Thus any structure, including a road pavement, constructed with or placed on such soils, exist to grapple with typical geotechnical problems, in the absence of adequate ground engineering.

Several scholars (Omotosho and Ogboin, 2009; Youdoewei and Nwankwala 2010, 2013; Otoko, 2013; Youdeowei, 2013 and Ngerebara *et al.,* 2014) have attempted to map out and study specific areas in the region. Notable works have being published on the developmental needs of the Niger Delta terrain, from a geotechnical and geological perpectives. Whilst related studies evaluating the suitability of sub-soils for road infrastructure development include technical reports by George and Atuboyedia (2007), Fatokun and Bolarinwa (2009) and the Nigerian Building and Road Research Institute (NBRRI, 1998)

These field work based studies have collectively stressed that the geotechnical difficulties inherent in the Niger Delta, due to the wide spread occurrence of 'chikoko' soils, calls for adequate geotechnical measures in designs and during construction to ensure an adequate margin against the behaviour of these naturally weak soils. The effort and methods requisite to improve the geotechnical properties of soils, and to attain the standard minimum level of compaction and engineering requirements of the underlying soils, has cost implications which varies with the occurrence of these highly expansive soils. These assertions were thus tested based on cost overrun data.

5.5 Inferential Analytic Procedure

The Inferential data analysis was carried out on the basis of the researcher's hypotheses structured in relation to the preceding logic, using the statistical tests outlined in Table 5.3.

Table 5.3: Hypotheses and Statistical Tests used in the inferential Quantitative Analysis

S/No	Hypothesis	Statistical Test
1	There are significant differences in the levels of cost overruns incurred for highway construction in the differing geologic settings of the Niger Delta $\mu_{z1} \neq \mu_{z2} \neq \mu_{z3}$	One-Way ANOVA
2	There is a significantly higher cost overrun impact of the lack of geotechnical input for projects executed in the coastal and swampy geologic setting of the Niger Delta (Zones 2 and3) compared to the Uplands (Zone 1). $\mu_{Z2} > \mu_{Z1}$ $\mu_{Z3} > \mu_{Z1}$	Turkey-Kramer Multiple comparisons
3	Percentage cost overruns are significantly associated with geotechnical properties of subsoil at project locations in the Niger Delta region.	Correlation Analysis

These statistical tests were thus carried out with a view to exploring if latent geologic drivers inherent in the heterogeneous geomorphology of the region, accounted for the unusually high cost overruns recorded in highway projects. The analysis was however underpinned by a preliminary local literature synthesis on the spatial classifications and nature of the Niger Delta geology, which was supplemented by secondary geotechnical fieldwork data, obtained from detailed ground investigations carried out by geotechnical firms and from institutional sources.

5.5.1 Hypothesis 1 and 2: ANOVA Test and Turkey-Kramer Multiple Comparisons

The ultimate goal of the analysis for Hypothesis 1 was to capture whether the variable terrain of the Niger Delta, was reflected in the levels of cost overruns currently experienced in highway projects, using a quasi-experimental approach.

- H_o: There is no significant difference in the percentage cost overruns between road projects executed in the various geographic zones of the Niger Delta
- H_1: There is a significant difference in percentage cost overrun between road projects executed in the various geographic zones of the Niger Delta

The treatment variable for hypothesis 1 was thus 'Ground Condition at project location'. It was thus an underlying assumption that all projects executed in a particular geo-zone have similar geotechnical challenges. For the purpose of testing this hypothesis, the population was subdivided into smaller stratums on the basis of the geomorphic divisions of the Niger Delta physical territory, as synthesized in the subsequent subsection, to replicate the average zonal subsoil conditions, which correlate with the regional geotechnical characteristics of the Niger Delta. This is because there are several ways in which specific zones of the Niger Delta region can be delineated spatially from a geographic perspective, depending on the purpose of the classification. The purpose of the classification used in this study, was to analyse for significant differences in cost overrun levels that can be attributed to the geologic variability of the terrain. It was therefore assumed that the prevalence of expansive chikoko clays in significant proportions in any zone, may be reflective of the cost-overrun propensity of subsoils at specific project locations.

The classification scheme adopted by the researcher, utilized the physiography of the region, as a basis for the analysing the cost overrun implication of the distinct geologic environments. The physiographic zones as referred to in this analysis adopted the definition of the United States Department of Transportation (2006: 5)

> "*A region, all parts of which are similar in geologic structure and climate, and which has consequently had a unified geomorphic history with a pattern of soils, relief features or landforms differing significantly from that of adjacent regions*.

The one-way Analysis of Variance (ANOVA) test was considered most appropriate, for the purpose of comparing the mean percentage cost overruns incurred by highway agencies for completed highway projects in the physiographic zones of the Niger Delta, so as to isolate the effect of subsoil geology. The probability distribution used in this test, was the F-Distribution, suitable to test several population means simultaneously. The ANOVA test was thus used to determine whether the sample means came from a single population or populations with different means. The underlying strategy of this test was to estimate the sample variations and then to find the ratio of this estimates. If the ratio is one, then logically the two estimates are same and therefore come from a single population. On the other hand, as the ratio differed from one, then it was concluded that the samples are not the same. The F distribution therefore, revealed that the ratio was much too large to have occurred by chance, on the basis of which it was attributed to the treatment source (Ground conditions). This ultimately led to the inference that the variation in cost overrun levels, occurred due to the inherent differences in ground conditions, and by implication the differing levels of geotechnical risks latent in the geologic zones. The format for the computation of the F value is summarized in the Table 5.4.

Table 5.4: ANOVA Table

Source of variation	Sum of squares	Degrees of freedom	Mean square	F
Treatment (*Differences in ground conditions between geo-zones*)	SSE	k-1	SST/k – 1=MST	MST/MSE
Error	SST	n– k	SSE/n – k= MSE	
Total	SS_{total}	n- 1		

Where:

- SS_{total} is the sum of squares total =$\sum X^2 - (\sum X^2)/n$
- SST is the sum of squares treatment = $\sum (t_c^2/n_c) - (\sum X)^2/n$
- SSE is the sum of squares error = SS_{total} – SST
- k is number of treatments
- n is sample size
- MST is mean square treatment
- MSE is mean square error
- n_c is no of observations per treatment (The number of observations for each zone is determined by the number of completed projects located in the LGA's, as delineated following the geo-classification criteria synthesized in the subsequent section).
- t_c is treatment total

The decision rule was based on the critical value as determined by the F statistic at the 0.05 level of significance. The criteria being that; if the null hypothesis is not rejected, it is concluded that there is no difference in cost overrun, and if the null hypothesis is rejected, then we conclude that there is a significant difference in cost overrun between the projects executed in the various zones.

At this point, it was not known which of the geo-zones had a higher level of cost overrun or by how much. The approach deployed for this detecting this was the '*Turkey Kramer Multiple Comparison Procedure'*, useful to determine which pair of zones significantly differ in the levels of cost overruns. This test enabled simultaneous comparative examination between the sub-groups in the ANOVA test, as all pairs of geo-zones, were relatively tested in pairs, for the most significant disparity in cost overrun. The underlying computational strategy was based on the differences between all pairs of mean costs within the zones. A "*critical Range"* was then computed using Equation 5.1.

$$Q_u = \sqrt[2]{\frac{MSE}{2} * \{\frac{1}{nj} + \frac{1}{nj1}\}} \quad \text{.......... } \textit{Equation 5.1}$$

- Where Qu = Upper Tail Critical Value from a Studentized Range Distribution
- MSE= Mean square error
- n_J and n_{j1} = Number of sample units in Pairs of mean building cost

The pairs of means were then compared against the corresponding critical range. A specific pair was thus declared significantly different, whereby the absolute difference in the sample means, was greater than the critical range.

The following sub-sections provide a detailed breakdown of these analysis procedures followed, which were predicated on a literature analysis of geologic mapping based spatial studies, that was used to disaggregate the Niger Delta soils into the subzones used in the ANOVA test. This form of quasi-experimentation was thus deployed by the researcher, as a basis of devising a spatial quantitative concept, delineating distinct geologic settings which would likely have differing cost implications for highway projects.

5.5.2 Geo-Classifications of the Niger Delta Region in the Literature

Based on earlier studies carried out on geography of Nigeria by several scholars (Ayaode, 1973; Okoye, 1975; iloeje, 1982; Durotoye, 1983; Udo, 1985; Ganier, 1989), and taking all the relevant aspects of the geography of the Niger Delta region into consideration, physiographic regions can be delineated. On this basis, divergent views and classifications have been proposed and adopted for developmental and academic purposes. Physiographically, the Niger Delta has been subdivided into climatic, vegetation as well as ecological regions, each having its own geographic personality. This is because, the Niger Delta is a heterogeneous region, and its geography can be analysed from various viewpoints.

Early scholarly works, typically by Iloeje, (1982), attempted to develop a physiographic classification for the coastal margin areas of Nigeria, and defined the region to include swamps, alluvium, lagoons and estuaries. Attempts have also been made by planning bodies in the region to incorporate these perspectives for development purposes. The Niger Delta Regional Development Master Plan (2002) facilitated by The Niger Delta Development Commission (NDDC), in partnership with the state governments, local government areas, oil companies, and communities in the region, classified the Niger Delta region into the following five distinct ecological/vegetation zones:

- Barrier island/Mangrove forest and coastal vegetation;
- Fresh water swamp forest;
- Lowland rain forest;
- Derived savannah;
- Montane region.

It is however of useful note from the study view point that the spatial and geographic definitions used to define the physical boundaries of the Niger Delta region to arrive at the above classification is politically driven and cannot be used as a true definition of the physical attributes of what should ideally constitute a 'Delta' (Teme, 2002; Oguara, 2002). Consequently, Oguara, (2002) recognised only four of the ecological zones that have being established in the Niger Delta region by planners on the basis that the montane region, which lies to south-east, falls outside the boundaries of the geologic Niger Delta as earlier defined:

- Coastal barrier islands;
- Mangrove swamp forest;
- Freshwater swamp forest;
- Lowland rainforest swamp.

This classification however, still cannot serve to bear out the underlying objective of the study, which seeks to highlight the geotechnical disparities amongst the various regions for design and construction cost purposes. Geological or geo-morphological regions, as proposed in the scholarly literature on Niger Delta geology, are thus considered more appropriate (IGST, 1996; NDES, 1997; NDDC, 2001; Oguara, 2002; Teme, 2002; Ngah and Youdoewei, 2013).

One of the earliest published geologic classifications of the Niger Delta soils was by Allen (1965). Numerous geomorphologic units were noted by this pioneer author as shown in Figure 5.8.

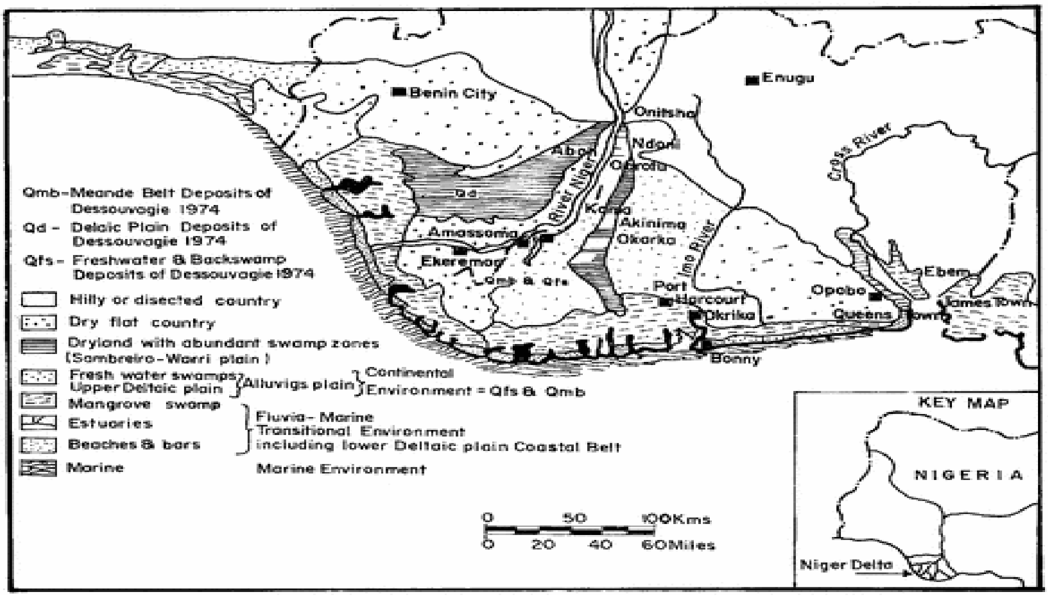


Figure 5.8: Geologic Classification of the Niger Delta (Allen, 1965)

Short and Stauble (1967), however classified the Niger Delta soils into 5 major units, which have been more frequently cited in latter and more recent scholarly literature, by several authors including: Akpokodije (1987); Ngah and Youdeowei (2013); Ngerebara *et al.* (2014).

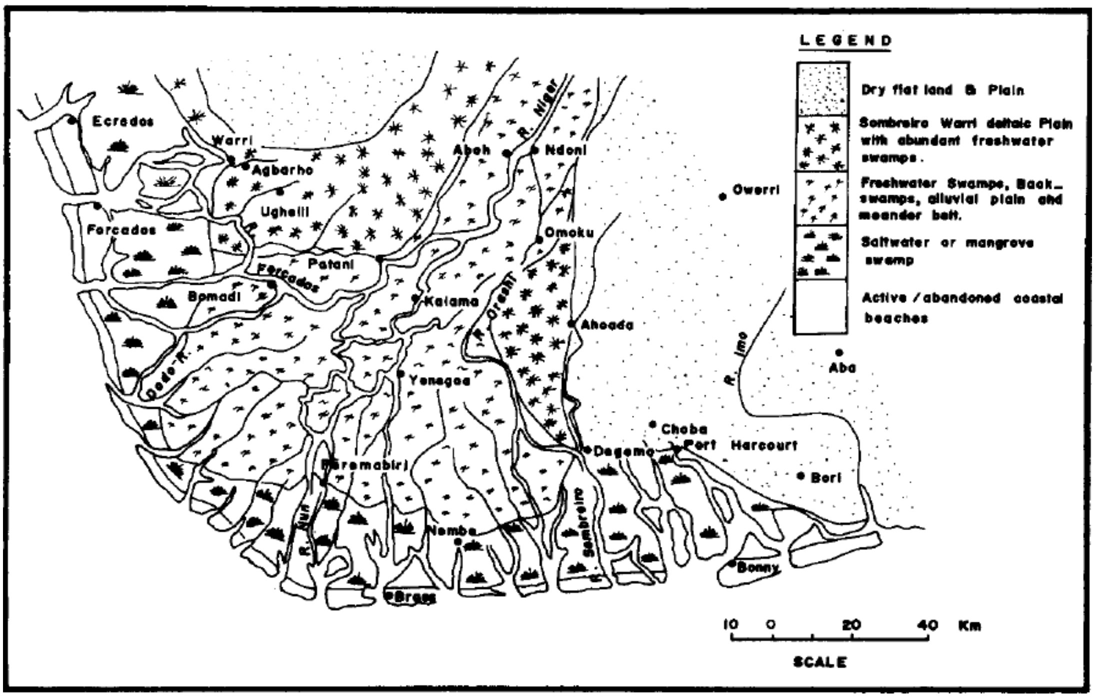


Figure 5.9: Geologic Classification of the Niger Delta (Short and Stauble, 1967)

Short and Stauble (1967) noted five distinct geomorphic units in the Niger Delta, within the three broader main environments: continental; transitional and marine environments, as shown in Figure 5.9. The five geomorphic units include:

- Beaches and bars;
- Freshwater swamps/Alluvial plains;
- Mangrove swamps;
- Dry land with abundant swamp zones;
- Dry flat land.

Durutoye (1983), defined the Niger in his characterisation of the geomorphology of the coastal margin region of the Niger Delta, as consisting of three geomorphic units:

- The upper flood plain: This being the first unit of the Niger Delta, is a fresh water flood plain in which sandy river channels are flanked by levees which descend laterally into forested back-swamps, with cut-off meanders or ox-bow lakes, and point bar ridges marked by dense bush.

- The lower flood plain: This second unit has tidal flats which are colonised by brackish mangrove swamps, and marked by a reticulate drainage pattern, resulting from the network of branching distributaries. The level of the back-swamps lies between high and low tides, and are thus regularly inundated.
- Barrier Island: This forms the third unit and lines the coastal area of the Niger Delta and is separated by tidal channels of the numerous discharging distributaries of the River Niger. These islands consist of a series of low beach ridges, two to three meters high, aligned parallel to the coast.

Akpokodije, (1987), one of the pioneer local researchers on Niger Delta soils, was amongst the foremost group of scholars who attempted to classify the Niger Delta soils for engineering purposes. The author divided the Niger Delta into four different zones, each with quite dissimilar stratigraphic and geotechnical characteristics. His classification was derived for the superficial soils of the region useful for road construction purposes, taking into account geomorphology and the geotechnical variations:

- Reddish brown sandy clay loam (RBSCL-1);
- Brown sandy Clay loam soil (BSC-2);
- Light grey fine sand and silty clay (LGFSC-3);
- Dark Organic/peaty clay (DOPC-4).

The approximate distribution of these soil types is shown below in Figure 5.10.

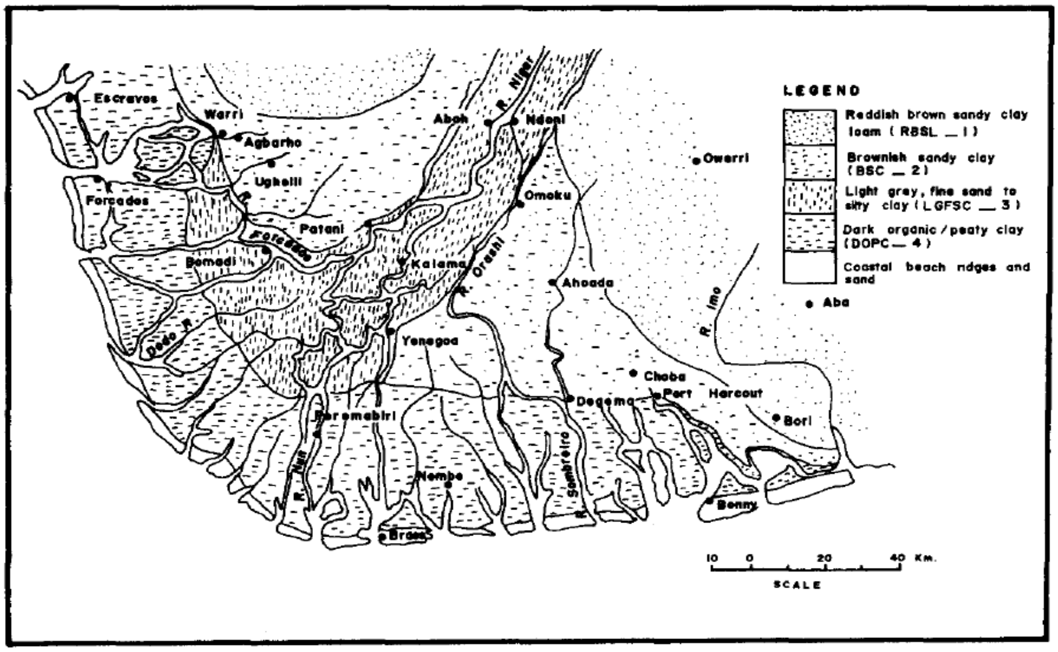


Figure 5.10: Geotechnical Zones of the Niger Delta after Akpokodje (1987).

Akpokodije, (1987) described the foundation suitability of soil type 3 and 4 as being relatively low, and in addition stated that:

> "These soil profiles *vary significantly within short lateral distances as a result of the frequent, erratic and lenticular occurrences of highly compressible organic clay and/or peat-clay mixtures [Chikoko soils]*" (Akpokodje, 1987:121).

This classification was developed, in recognition of the need for a detailed and more comprehensive study of the region, as a strategy to incoporate resilence in dealing with the recurrent twin harzards of flood and erosion in the region. In his study, Akpokodije, (1987) advocated for the development of a comprehensive engineering geological mapping of the Niger Delta region to outline the major problem soils in the region.

The Institute of Geosciences and Space Technology (IGST), Port Harcourt (1996) later developed a classification of Niger Delta soils in their research on flood and erosion in the region. IGST (1996) identified the following six geomorphic units of the Niger Delta as shown in Figure 5.11.

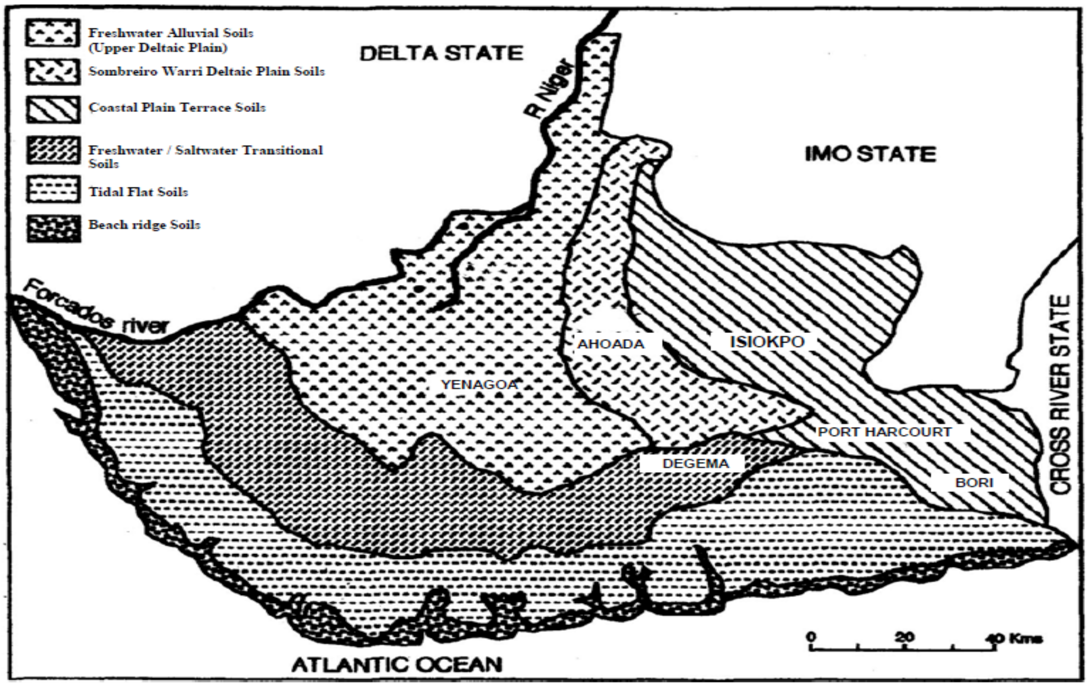


Figure 5.11: Geomorphic Units of the Niger Delta after IGST (1996)

Teme, (2002) divided the Niger Delta into 3 hydro-meteorological zones:

- Upper Delta zone (fresh water);
- Middle delta zone (transition or mangrove);
- Lower delta zone (Barrier ridge islands).

This classification was developed in an attempt to highlight the impact of water on the behaviour of rocks and soils in the region in portrayal of the major foundation types commonly used for building construction in these zones.

A more recent study by Ngah and Youdeowei (2013) identified five major geomorphologic units (in Figure 5.12). The coastal plain sands were described as the dry flatland and plain, as compared to the purely marshy terrain of the swamps which are either fresh or salt water swamps. The salt water swamp zone contains the largest stretches of mangrove forest. The 'Warri-Sombrero deltaic plains is a mix of relatively drier land interspersed with numerous swamps. While the coastal beaches refer to the existing stretch of sandy beaches adjoining the coastal front, some of which are no longer active.

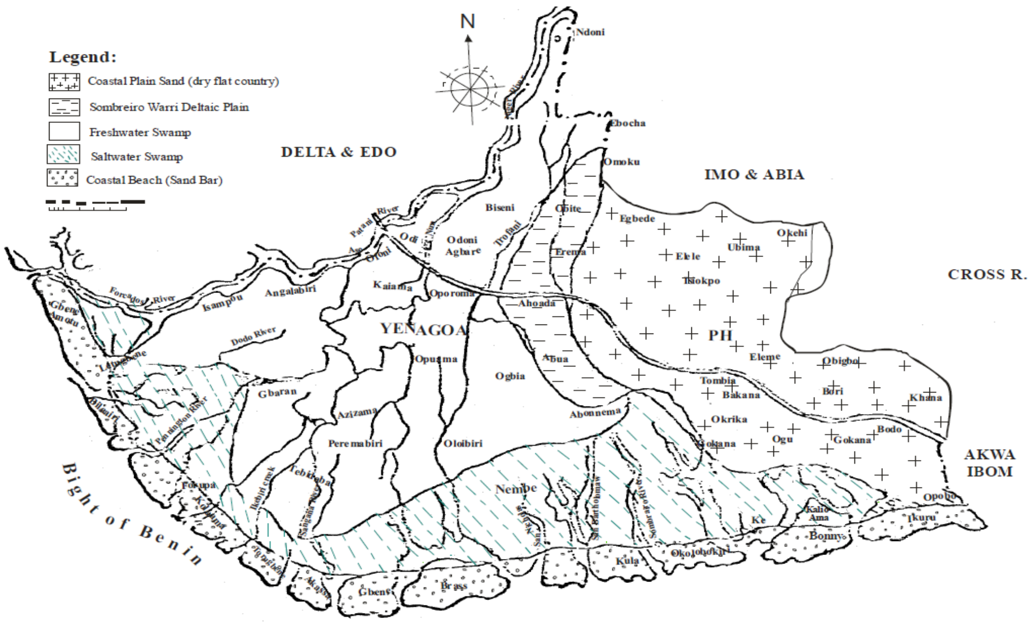


Figure 5.12: Geomorphic Units of the Niger Delta after Ngah and Youdeowei (2013)

This classification aligns closely with the earlier classifications by Short and Stauble (1967) and IGST (1996) in terms of similarity of its configuration on a broader scale. The only notable difference in this classification discerned by the researcher, is the merging of the 'fresh water alluvial soils' and the 'Fresh/salt water transitional' under the 'Fresh water swamp'. The fresh water swamp zone which consists mainly of marshy back swamps, alluvial plain soils and meander belts predominantly falls within Bayelsa State. As can be deduced from this classification, the largest stretch of dry land in the Niger Delta falls within Rivers State i.e. the coastal plain soils in the with large patches of fresh water swamp soils. These constitute the riverine areas of the state. Salt water swamps and beach soils are prevalent in coastal communities for both states with progression towards the Atlantic coast.

5.5.3 ANOVA Groupings: Synthesized Geo-classification of the Niger Delta

It can thus be seen that greater difficulties emerge in the classification of the Niger Delta sub-soils, and opinions differ on the types of zones that can potentially be used to delineate geotechnical regions applicable to highway projects, as summarily captured in Table 5.5.

Table 5.5: Classifications of the Niger Delta Soils

Authors	▪ **Classification**
Short and Stauble (1967)	▪ Beaches and bars ▪ Freshwater swamps/Alluvial plains ▪ Mangrove swamps ▪ Dry land with abundant swamp zones ▪ Dry flat land.
Durutoye (1983)	▪ The upper flood plain; ▪ Lower flood plain; ▪ Barrier Islands.
Akpokodije (1987)	▪ Reddish brown sandy clay loam (RBSCL-1) ▪ Brown sandy Clay loam soil (BSC-2) ▪ Light grey fine sand and silty clay (LGFSC-3) ▪ Dark Organic/peaty clay (DOPC-4)
IGST (1996)	▪ Freshwater Alluvial Soils (Upper Deltaic Plain); ▪ Sombreiro Warri Deltaic Plain Soils; ▪ Coastal Plain Terrace Soils; ▪ Freshwater/Saltwater Transitional Soils; ▪ Tidal Flat Soils; ▪ Beach Ridge Soils.
Teme (2002)	▪ Upper Delta zone (fresh water); ▪ Middle delta zone (transition or mangrove); ▪ Lower delta zone.
Oguara (2002)	▪ Coastal barrier islands; ▪ Mangrove swamp forest; ▪ Freshwater swamp forest; ▪ Lowland rainforest swamp.
Ngah and Youdeowei (2013)	▪ The coastal plain sands; ▪ The Sombreiro-Warri Deltaic plain; ▪ The freshwater swamps; ▪ The saltwater or mangrove swamps; ▪ The coastal beaches.

This study therefore attempted this exercise here, in choosing a basis for the geotechnical classification of the Niger Delta sub-soils, while being fully aware of its implications, from these scholarly articles that have tried to analyse and classify them. The regions so adopted, based on the geomorphology of the region, sought to achieve spatial distribution as well as reflect geotechnical variations within the study area. To achieve this aim, the researcher adopted Teme

(2002) broader three subdivisions of the region as correlated with IGST (1996) six more distinctive geomorphic units in the study, from the perspective of geomorphology. The researcher also noted that the geotechnical characteristics of the subgrade soils are better descriptively analysed by Akpokodje's (1987) classification, which was specifically derived for the purpose of engineering designs. However, this classification and soil groupings so derived by Akpokodje's (1987), transcends beyond the spatial limits of the Niger Delta region as defined by the NDES (1997), whose geologic interpretation of the region is adopted in this study to cover only Rivers and Bayelsa State (shown in Figure 5.13).

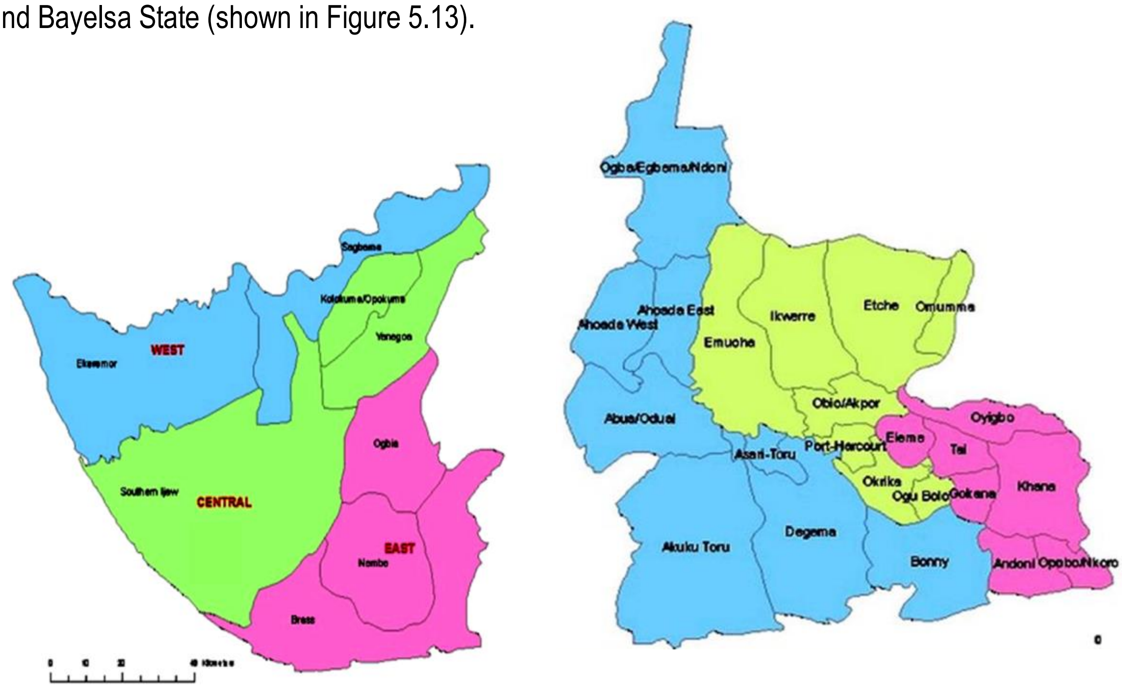


Figure 5.13: Map of Disaggregated Niger Delta Showing Rivers and Bayelsa State

The reddish brown sandy clay loam (RBSCL-1) falls outside this spatial boundary and describes the typical lateritic soils found in neighbouring states that compose the political Niger Delta. This soil group is therefore not recognised in this study. On this basis only 3 major soil groupings from Akpokodje's (1987) classification are applicable to defining the zones of the Niger Delta in this study.

- Zone 1(BSC): Sand-clayey subsoil strata of the dry, flat plains;
- Zone 2 (DOPC) Organic peaty Two-layer clay sand sequence of the fresh water back swamps;
- Zone 3: (LGFSC) Three-layer slightly organic sand-clay-sand sequence of the Tidal Flat/saltwater swamp and coastal beaches/ridges.

Akpokodje's (1987), geotechnical description of the soil types in each zone is further corroborated by the trend in information obtained on field geotechnical data, as mapped out, based on the Unified Soil Classification System (USCS). Figure 5.14, based on the available field work information, geotechnically characterises up to 70% of the sub-grade soils of the Niger Delta, using the USC system, and superimposes the three applicable zones from Akpokodje's (1987) and Teme (2002) classification. As can be discerned, most of the sample points of the upper delta are low plastic clays (CL) which have moderate geotechnical implication for road construction. Towards the middle and lower delta however, the soils become predominantly highly plastic clays and silts, which grades into highly plastic silts and organic silts, with very high geotechnical implications for highway construction.

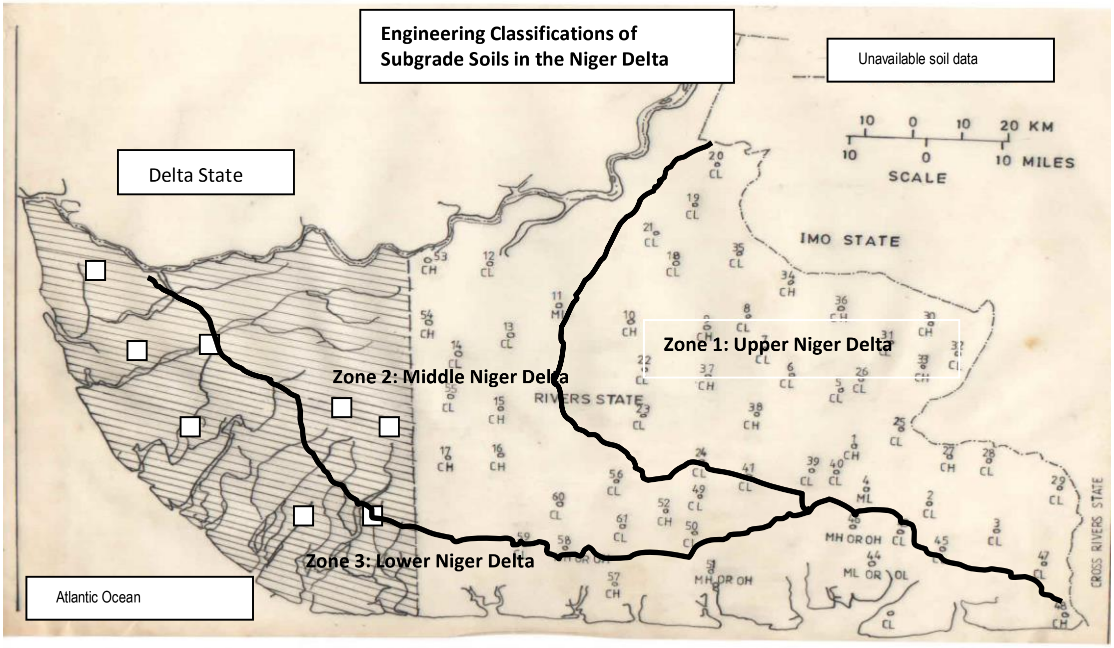


Figure 5.14: Engineering Classification of Niger Delta Sub-Grade Soils

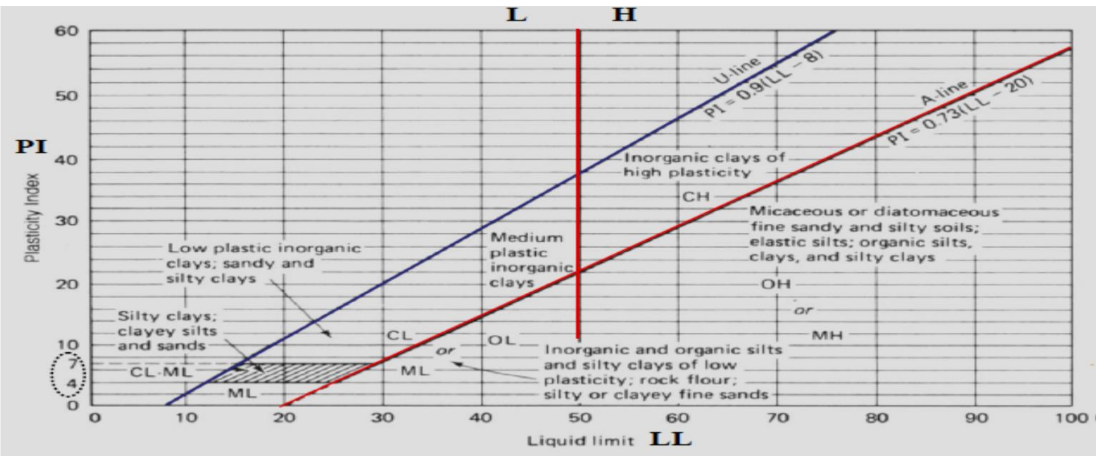


Figure 5.15: Casangrade's Plasticity Chart **Source: Coduto (2007)**

The geotechnical description of the soil types shown in Figure 5.14, is derived using the Casangrade's Plasticity Chart (Figure 5.15), an international engineering standard for describing soils. From the point of view of highway design and costing, three broad conceptual geomorphic categorisations of Niger Delta soils in engineering geologic cost application were therefore discerned, as synthesized in Table 5.6.

Table 5.6: Geotechnical Regions of the Niger Delta as adopted in the Study

Geo-Zones	Sub-Soil types	Stratigraphic Sequence/ Description
Upper Deltaic (Zone 1) *(Dry land interwoven patches of fresh water soils)*	Coastal Plain Terrace Soils Deltaic Plain Soils	Dry plain sandy/clayey subsoil strata *(Brown Sandy Clays)*
Middle Delta (Zone 2) *(Fresh/Salt Water Back swamps)*	Freshwater Alluvial Soils Fresh water Transitional Soils	Two-layer clay sand sequence *(Dark organic peaty clays)*
Lower Delta (Zone 3) *(Salt water swamp and sandy coastal soils)*	Tidal Flat/saltwater swamp Beach Ridge Soils	Three-layer, sand-clay-sand *(Light grey slightly organic sands and clays)*

There is of course a certain amount of overlap, and the broad divisions here as adapted from the literature and diagrammatically approximated in Figure 5.16, are aimed at highlighting the likely geotechnical implications for road pavement designs and costing in the different local government areas (LGA) listed in Table 5.7.

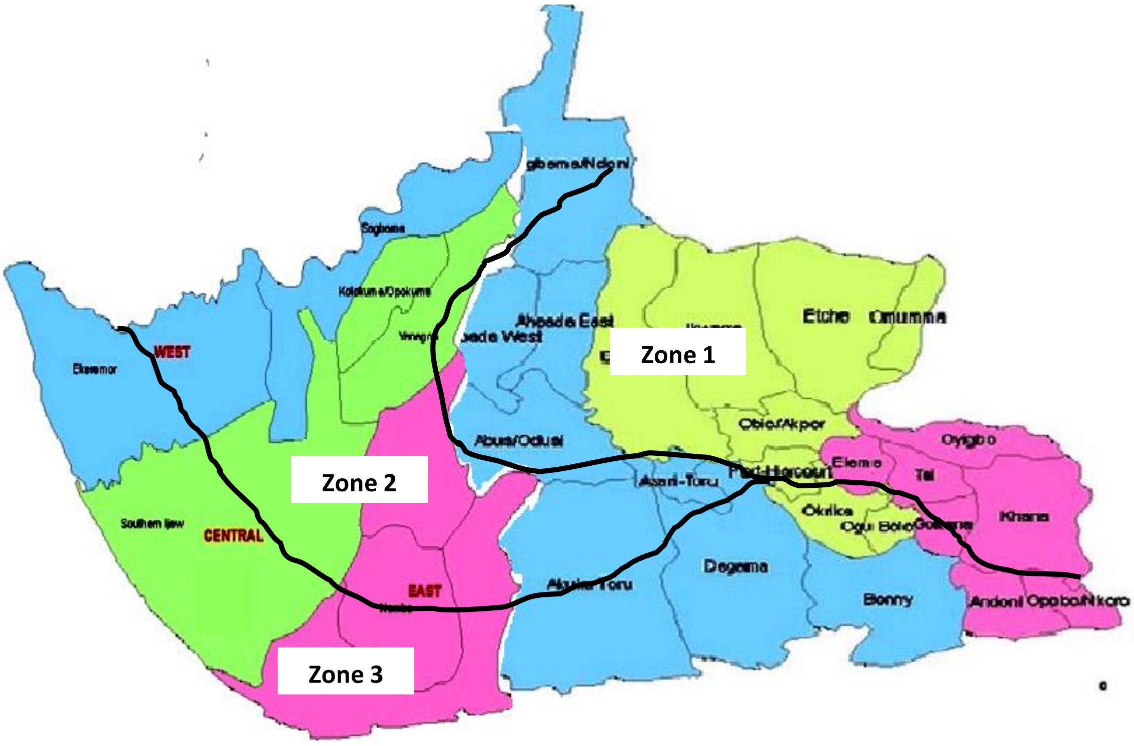


Figure 5.16: Niger Delta Showing LGA's in the Adopted Basis of Geo-Classification

Table 5.7: Geo-Classification of LGA's in the Niger Delta

Zone 1: *Dry land interwoven with patches of fresh water soils*	Zone 2: *Fresh/Salt Water Back-swamp peaty soils*	Zone 3: *Coastal Salt water swamp and sandy beach soils*
1.Port Harcourt 2.Obio-Akpor 3. Etche 4. Ikwerre 5. Omuma 6. Oyigbo 7. Eleme 8. Tai 9. Khana 11. Ahoada east 12. Ahoada West 13. Abua 14. Gokana	15.Ogba-Egbema-Ndoni 16. Okrika 17. Ogu-Bolo 18.Asari toru 19. Ogbia 20.Sagbama 21. Kolokuma-opokuma 22. Yenegoa 23. Nembe	24. Ekeremor 25. Brass 26. Southern Ijaw 27. Degema 28. Bonny 29. Andoni- 30. Opobo Nkoro 31. Akuku-toru

This geo-zoning, used to analyse for the disparity in the geo-technical characteristics of the sub-grade soils, is further used to analyse the cost-overrun implications of the inherently differing levels of geotechnical risks, posed to highway project execution in these zones.

5.5.4 The One-way ANOVA Testing for Significant Differences in Cost Overruns between the Geo-Zones

H_0: $\mu_1 = \mu_2 = \mu_3$

H_1: $\mu_1 \neq \mu_2 \neq \mu_3$

This hypothesis is tested on the grouped sample data (Table 5.8), based on the F distribution at the selected 5% level of significance, as a basis of making inferences about the impact of ground conditions.

Table 5.8: Cost Overruns in the Geo-Zones

Upper Delta: Zone 1-Uplands	**Middle Delta: Zone 2- Back-swamps**	**Lower Delta Coastal: Zone 3**
% Cost Overrun	*% Cost Overrun*	*% Cost Overrun*
62.60	286.60	99.81
89.25	951.26	173.29
440.74	72.79	129.93
239.26	28.74	107.77
11.77	204.33	57.47
39.38	178.54	35.64
128.25	257.28	103.35
255.05	1925.40	613.21
177.49	1,558.20	137.78
98.04	322.23	88.96
50.30	1,925.40	75.75
109.20	0.00	98.08
40.67	164.74	72.14
51.54	71.07	64.66
38.61	200.51	53.58
33.29	228.27	247.97
40.40	242.97	
117.44	220.76	
111.81	149.38	
170.78	1650.32	
138.53		
85.77		
188.23		
84.28		
85.77		
Mean: 117.35	Mean: 393.80	Mean: 132.39

5.5.5 Testing of Statistical Assumptions

The deployment of these analytical measures, however, was subject to satisfying the basic underlying assumptions of parametric statistical tests of significant differences: Homogeneity of Variance and Normality. These key assumptions which are critical to assess the appropriateness and use of the statistical tests for analysing the sample cost data, are evaluated. This is because significant deviations of the sample data from these assumptions can impact the accuracy of analysis output.

The assumption of homogeneity of variance was tested for using the 'Modified Levene's test' (NIST, 2012). Levene's approach is a potent tool useful for checking the homogeneity of variances in statistical tests which require that grouped data have unequal variances, which has been modified in present use. (Gastwirth *et al*., 2009). The modified Levene's test for homogeneity of variance, tests the equality of the variances in the cost overruns between the geo-classification. It is based on the idea that if the variation in the cost overruns in each zone does not differ, an analysis of variance of the absolute differences in cost overrun from the median value in each zone, can be used to test the null hypothesis of equal variances (NIST, 2012). The modified Levene's test of homogeneity of variance, was carried out on the grouped cost overrun data, graphically represented in Figure 5.17, and reported in Table 5.9.

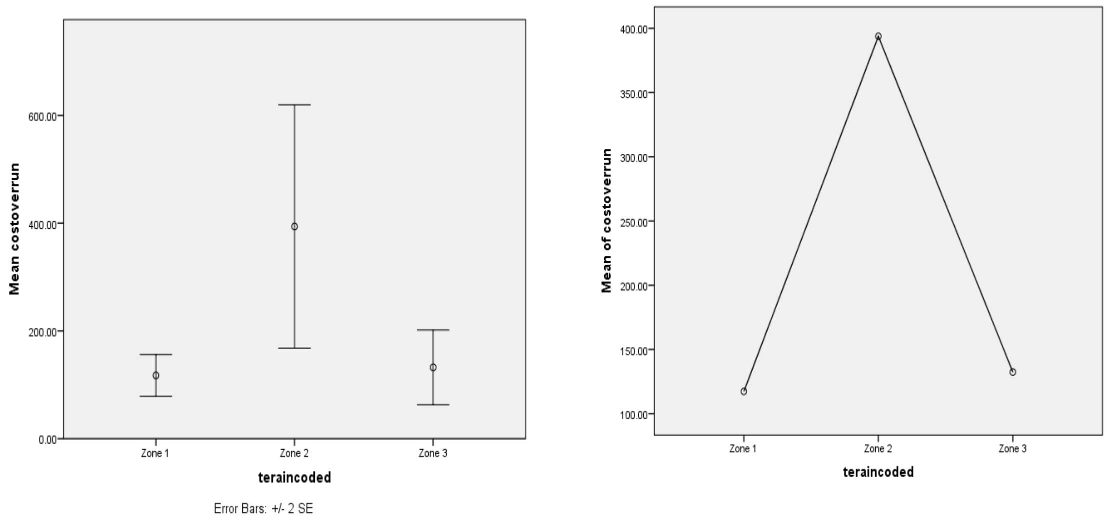


Figure 5.17: Error Bar Chart and Mean Plot of Group Samples

Table 5.9: Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
12.145	2	58	.000

The Levene's statistic rejected the null hypothesis that the group variances are equal, implying that the mean and level of variation in cost overrun clearly differed for the three geo-zones. Therefore, the violation of the ANOVA assumption, of equality of variance across groups, does not hold for the data. The one-way ANOVA is still fairly robust to the violation of this assumption if the samples are of equal or near equal sizes. As shown in Table 5.10, the sample sizes for each zone are not equal, which reinforces the need for the equality of the variances.

Table 5.10: Descriptives for Cost Overruns in Geo-Zones

	N	Mean % Cost Overrun	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Zone 1	24	117.3535	94.91760	19.37497	77.2734	157.4337	11.77	440.74
Zone 2	21	393.7971	517.46407	112.91992	158.2503	629.3439	.00	1925.40
Zone 3	16	132.3865	138.79635	34.69909	58.4271	206.3458	35.64	613.21
Total	61	216.4657	338.15194	43.29592	129.8610	303.0704	.00	1925.40

The assumption of normality was tested using descriptive measures and visual analysis. Figure 5.18 provides a quick, visual summary of the data and factor-groups. The Normality Q-Q plots and box plots provide some evidence about the shape of the distribution (NIST, 2012).

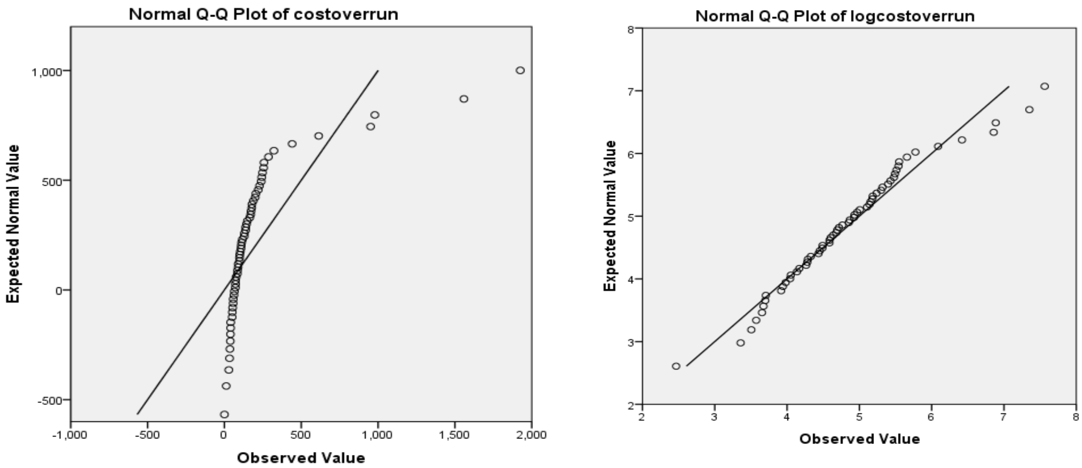


Figure 5.18 (a and b): Normality Plots of Project Data before and after Transformation

As shown in Figure 5.18a, the sample data violated the assumption of normality. The implication of this outcome was two-fold: either a transformation of the data is carried to induce normality; or a non-parametric test for significant differences such as the Kruskal Wallis one-way ANOVA is used (Gregory and Dale, 2009). The former was carried out as a first option, since the non-parametric equivalent is not as powerful as the ANOVA test. A logarithmic transformation of the cost overrun data was thus computed to bring the distribution of values closer to normal. The log transformation, in Figure 5.18b, visually appears to have made the sampling distribution to better approximate a normal distribution.

Table 5.11: Descriptive Summary Measures before and after Log Transformation

Cost overrun				
			Statistic	Std. Error
Cost overrun	Mean		216.4657	43.29592
	95% Confidence Interval for Mean	Lower Bound	129.8610	
		Upper Bound	303.0704	
	5% Trimmed Mean		157.6045	
	Median		111.8076	
	Variance		114346.732	
	Std. Deviation		338.15194	
	Minimum		.00	
	Maximum		1925.40	
	Range		1925.40	
	Interquartile Range		148.92	
	Skewness		3.653	.306
	Kurtosis		14.378	.604

Log-cost Overrun				
			Statistic	Std. Error
Log cost overrun	Mean		4.8390	.12455
	95% Confidence Interval for Mean	Lower Bound	4.5898	
		Upper Bound	5.0882	
	5% Trimmed Mean		4.8002	
	Median		4.7413	
	Variance		.931	
	Std. Deviation		.96477	
	Minimum		2.47	
	Maximum		7.56	
	Range		5.10	
	Interquartile Range		1.18	
	Skewness		.597	.309
	Kurtosis		1.031	.608

The descriptive summary output in Table 5.11 as well as Figure 5.19 also showed that the skewness and kurtosis were greatly reduced, and the mean and median were much closer together, as outliers and extreme values have been pulled in.

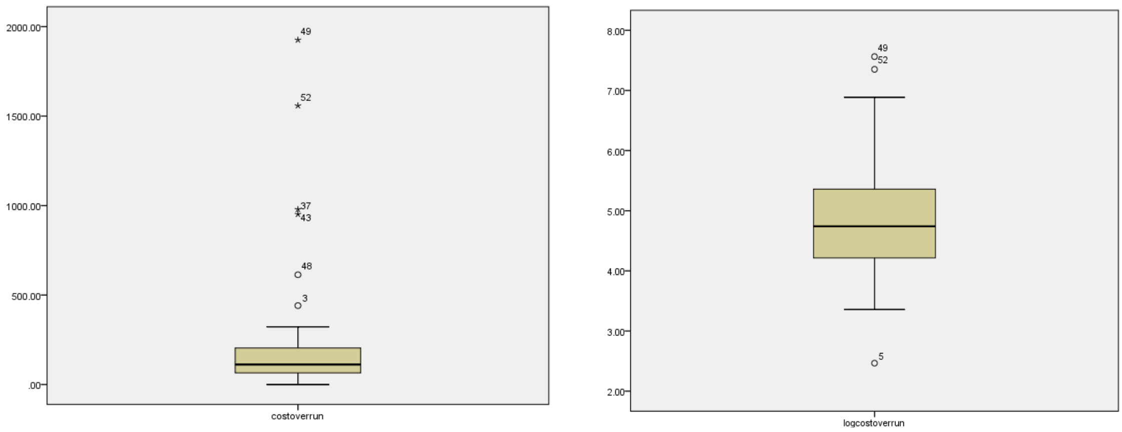


Figure 5.19: Box-plots showing Cost Overrun and Log-transformed Cost Overrun Values

The log-transformed cost overrun values were thus used for further analysis in the computation of the F-statistics. However, all other diagrammatic descriptive representations of the data and interpretation of results afterwards were presented using the back-transformed cost overrun values. The ANOVA analysis, showing the analysis output for the data as transformed, is presented in Table 5.12.

Table 5.12: ANOVA Analysis Output for Log Cost overrun

	Sum of Squares Actual vs Log	Df	Mean Square	F	Sig.
Between Groups	(1009241.097) 11.714	2	5.857	7.728> 3.23	.001< 0.05
Within Groups	(5851562.808) 43.202	57	.758		
Total	(6860803.905) 54.917	59			

5.5.6 Inference

The significance value of 0.001 in Table 5.12 is less than 0.05, and the F-Value of 7.728 is greater than the critical value of 3.23. Thus, the null hypothesis of equality of means across the geo-zones is rejected, and the alternate hypothesis was accepted: It was thus inferred that:

> *There are significant differences in percentage cost overrun between highway projects executed in the various geo-zones of the Niger Delta.*

The ANOVA results thus established that cost-overruns experienced on highway projects execution, differ amongst the three geo-zones of the Niger Delta, likely due to the differences in the level of geotechnical risks inherent in these distinctive zones. However, at this point in the analysis, the zonal pairs where the most significant difference lies, was not yet known.

5.5.7 Tukey Krammer-Multiple Comparison

The structure and nature of the differences in cost overrun level, is explored using the Turkey Kramer multiple comparison procedure. The post-hoc analysis output of the Tukey Honestly Significant Difference (HSD) test output is shown in Table 5.13.

Table 5.13: Multiple Comparisons of Log-Cost Overrun Using Tukey HSD

(I) teraincoded	(J) teraincoded	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Zone 1	Zone 2	-.98291*	.26359	.001	-1.6172	-.3486
	Zone 3	-.83033*	.28098	.018	-.8065	.5458
Zone 2	Zone 1	.98291*	.26359	.001	.3486	1.6172
	Zone 3	.15257	.29201	.064	.1499	1.5553
Zone 3	Zone 1	.83033*	.28098	.018	-.5458	.8065
	Zone 2	-.15257	.29201	.064	-1.5553	-.1499
*. The mean difference is significant at the 0.05 level.						

The result of the HSD analysis equally tallies with the contrast test run concurrently for the log-cost overrun data under the assumption of equal variances as shown in Table 5.14.

Table 5.14: Contrast Coefficients for Pair-wise Comparisons

Contrast	Teraincoded							
	Zone 1	Zone 2	Zone 3	Value of Contrast	Std. Error	T	Df	Sig. (2-tailed)
1	1	-1	0	-.9829	.26359	-3.729	57	.000
2	0	1	-1	.1526	.29201	2.920	57	.065
3	1	0	-1	-.8303	.28098	-.464	57	.001

Both the post-hoc and contrast tests are significant at the designated 0.05 level for the pair-wise comparison of:

- Zone-1(Uplands) versus Zone-2 (Back swamps);
- Zone-1(Uplands) versus Zone-3 (Coastal).

This indicated that percentage cost overruns between these pairs varied significantly. However, for zones 2 and 3 i.e. the back-swamps versus the coastal zones, percentage cost overruns did not vary significantly. This was equally displayed in the range test of homogenous subsets analysis output returned simultaneously with the post-hoc test shown in Table 5.15.

Table 5.15: Homogenous Subsets

Homogenous subsets			
Teraincoded	N	Subset for alpha = 0.05	
		1	2
Zone 3	16	4.6069	
Zone 2	20		5.4595
Sig.		.887	1.000

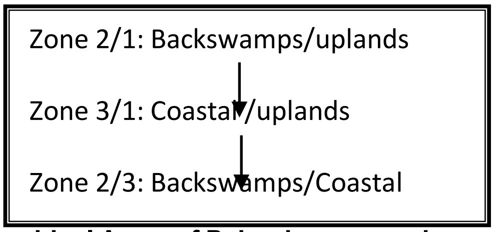


Figure 5.20: Hierarchical Array of Pair-wise comparisons

These differences as deduced from the magnitude of the mean differences or absolute values of the contrast, are captured in hierarchical order in Figure 5.20. Projects located in the back-swamps and coastal areas, evidently experienced significantly higher levels of cost overruns than the uplands. This analysis output directly reflects the trend in cost-overruns induced due to the heterogeneous terrain of the Niger Delta.

5.6 What Latent Geotechnical Variables Account for the Significant Differences in Cost Overruns Experienced Between the Geo-zones?

Various engineering parameters are used to assess the suitability of sub soils as bearing media for construction works (Coduto, 2007). For road construction, the engineering properties of the superficial sub-grade soils are the determinant design variables that influence the cost of construction (USDOT, 2002), and can thus be inferred as the factors which are latent in any geologic setting. The Nigerian standard of road designs, the Transportation and Road Research laboratory (TRRL, 1993) stipulated by the Federal Ministry of Works, as a guide, principally requires that the CBR, which is a reliable composite geotechnical index of sub-grade strength, be tested under simulated dry and wet conditions (Ngerebara, 2014). High CBR values indicate good strength of any given soil type material. Very low CBR values of less than two are typical of highly plastic clays with volume instability. Six CBR classes; S1 to S6, are specified in this guide. The poorest soil class being S1 having a CBR value of 2% typical of the swamps, with the best soils having values above 30%. The structural catalogue of the TRRL (1993) defines six CBR classes (S1 to S6) as follows:

- CBR, 2.0 % (S1) .... Very soft ground;
- CBR, 3.0 – 4.0% (S2) .... Soft ground;
- CBR, 5.0 - 7.0 % (S3) .... Medium hard ground;
- CBR, 8.0 - 14.0% (S4) ....Hard ground;
- CBR 15- 29% (S5) ....Hard ground;
- CBR 30 (S6) ....Hard ground;

The combined thickness of the pavement structural layers, from sub-grade to surfacing, based on these subsoil designations stipulated by the guide, increases from 200 to 300mm for S6 (Hard ground) soils, up to 650-1000mm for S2 (Soft ground) soils. The implication of this variation in design requirement, is its influence on the volume of construction materials needed. The CBR index, thus gives an indication of the financial sensitivity of highway designs in response to changing subsoil profiles.

This directly reflects the cost overrun implication of using homogenous designs without ground investigations, irrespective of changing soil profiles, typical of the heterogeneous terrain of the Niger Delta, characterised by extreme variation in soil types. As such, if the problematic marine clays/peat (Chikoko) soils, rated as very poor, with its characteristic shrinkage and swelling potential, abound to varying degrees in the geo-zones, are not properly investigated, the remedial re-engineering measures, as noted by several authors including Oguara (2002), Youdoewei (2013) and Otoko (2014) would imply additional costs of either:

- Excavation to remove such poor soils to the extent of prevalence, and replacement with adequate fill materials;
- Compaction and preloading with locally available free draining material;
- Stabilisation in place with chemical additives to achieve the required minimum strength characteristic for the sub-grade.

Typically, the first alternative will basically entail importing good quality laterites with high CBR values from burrow pits located in more stable terrain. Importing the laterites required to replace the poor soils in marshy areas, will thus be subject to the availability of source sheds, and the haulage distance from these source locations, which are often situated in the coastal plain soils of the upper delta, transported to construction sites in the swamps and along the coast.

The CBR is an aggregate index for rating the strength of sub-grade soils. It however correlates very well with other more specific descriptive and quantitative geotechnical properties of expansive soils, which differ more conspicuously in values dependent upon the local geology (Coduto, 2007). The values of these engineering parameters can thus be inferred as typically representative of the level of constraint posed by the physical characteristics of sub-soils in the Niger Delta. These other parameters, useful for gauging the suitability of expansive soils in engineering geological application, have thus being sourced by the researcher, as part of the secondary data gathered during the fieldwork. They are therefore statistically analysed in subsequent subsections, as latent geotechnical cost overrun drivers in the geologic setting of the Niger Delta, which may be triggered by poor levels of ground investigations, leading to the evidenced disparity in cost overrun levels between the geo-zones.

5.6.1 Descriptive Geotechnical Parameters of Sub-grade soils: Grain Size Distribution

Grain size analysis is used in geotechnical practice to identify the sizes of the various particles which make up a soil sample. Grain size analysis thus produces a grain size distribution of soil particles (Coduto, 2007). Uniform graded soils are referred to as poorly graded or gap-graded, on the basis that the ideal mix of the various size range of particles is not present in a soil sample, but rather the distribution of particle sizes is skewed. Such poorly graded soils predominantly contain one particle size all (mostly small or mostly large). Soils consisting mostly of gravel (particle sizes >2 mm) and sand (particle sizes between 0.1 –2 mm) are referred to as coarse grained while silt (0.01 –0.1 mm), and clay (< 0.01 mm), which are the typical grain size of Niger Delta soils, are fined grained soils. Youdoewei (2013) explained that poorly graded soils will have relatively low densities and low strength, since the number of particles per unit area and interlocking frictional forces is small, and therefore reduces their structural stability for road construction. In such soils, it was thus explained that modifications of the natural properties of the sub-grade soils may be required.

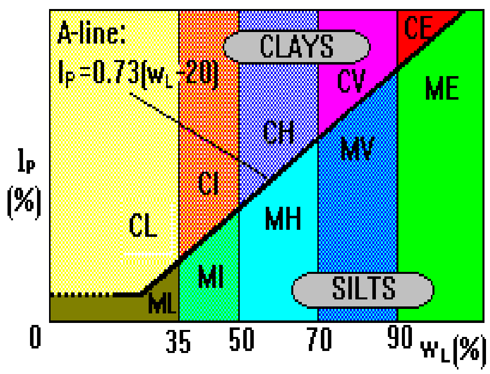
To identify such poor soils in engineering application, two common classification systems, developed by the American Association of State Highway and Transportation Officials (AASHTO) and the Unified Soil Classification System (USCS), are used. They are thus utilised for the purpose of geotechnically classifying soils and describing the approximate properties of sub-grade soils at the locations of the completed highway projects, using standard designations, representing different soil particle size mixes.

Table 5.16: The AASHTO Classification System

Group	AASHTO Symbol	Typical Symbol
Group A-1	Group A-1-a	Stone or gravel fragments
	Group A-1-b	Gravel and sand mixtures
Group A-3	Group A-3	Fine sand that is non plastic
Group A-2	Group A-2-4	Silty gravel and sand
	Group A-2-5	Silty gravel and clay
	Group A-2-6	Clayey gravel and sand
	Group A-2-7	Clayey gravel and silt
Group A-4	Group A-4	Silty soils - Low plasticity
Group A-5	Group A-5	Silty soils- High plasticity
Group A-6	Group A-6	Clayey soils -Low plasticity
Group A-7	Group A-7-5	Clayey soils - Medium plasticity
	Group A-7-6	Clayey soils -High plasticity
Group A-8	Group A-8	Peat and other highly organic soils

(Source: Coduto, 2007)

The ASSHTO classification system as shown in Table 5.16 has 8 major groups: A1~ A7 (with several subgroups) and organic peaty soils A-8, with a corresponding progressive decrease in the suitability of the sub-grade soils from A1 to A8. A1-to A3 soils are generally rated as excellent to good sub-grade material, as they contain mostly coarse grained soil particle sizes such as sand, while A4 to A7 soils are silts/clays and are rated as fair to poor, while the A-8s are less of soils, being mostly plant and animal remains.



•**Symbols:**
•G: Gravel
•S: Sand
•M: Silt
•C: Clay
•O: Organic
•Pt: Peat

•**Liquid limit symbols:**
•H: High LL (LL>50)
•L: Low LL (LL<50)

•**Gradation symbols:**
•W: Well-graded
•P: Poorly-graded

Figure 5.21: The USCS Soil Classification Designation Symbols (Source: Coduto, 2007)

However, based on the USC classification system, coarse grained soils, defined as having less than 12% fines are classified using sieve analysis, while soils having more than 12% fines are classified using the plasticity chart as shown in Figure 5.21. This form of engineering classification of soils, utilises relevant parameters as obtained from a grain size sieve analysis and plasticity (Fluidity of soils in response to added moisture) of soil samples plotted on a plasticity chart to derive the appropriate designation for the soil types. The A-line of the plasticity chart differentiates silty soils from clayey soils, as well as organic peats from inorganic soils, based on the percentage of fine gained soils. The rating of soil types using this classification for excellent to good subgrade soil rating, ranges from well graded gravelly soils (GW) to poorly graded sandy soils (SP) to sandy clays (SC) on the coarser upper rating. The fined grained soils which are rated as poor subgrade materials range from low plasticity silty soils (ML) to highly plastic clays(CH) and low plasticity organics and to peat at the lowest extreme as shown in Figure 5.21.

Extracts from geotechnical field data obtained, have thus been used in Table 5.17 to approximate the average descriptive rating of the suitability of sub-grade soils for the sample project locations as geographically dispersed in the Niger Delta. The distributive mix of subsoils at the project locations have been described using the AASHTO and USC classification system.

Table 5.17: AASHTO and USC Description of Subgrade Soils at Project Locations

Project No	Per cent Passing B.S. Sieve			AASHTO CF/N	USC Soil Description	General Rating as Sub-Grade Material
	2 mm (No 10)	425 Micron (No 40)	75 Micron (No 200)			
1	99.0	74.4	46.0	A-2-4	Inorganic clay silt	Excellent to Good
2	99.8	79.0	04.1	A-3	Inorganic silt, fine sands, rock flour with slight plasticity	Excellent to Good
3	100.0	79.1	37.5	A-2-4	Inorganic clay silt	"
4	95.7	58.5	5.1	A-3	Inorganic silts rock flour, silty fine sands with slight plasticity	"
5	99.5	87.6	10.0	A-3	Inorganic clayey silt	"
6	100.0	0.02	49.0	A-7-6	Inorganic clayey of high plasticity	Fair to poor
7	100.0	75.5	48.6	A-7-6	Inorganic clayey silt	Fair to poor
8	99.9	90.8	43.9	A-8	Inorganic clayey silt	Poor
9	99.9	71.9	36.4	A-7-6	Inorganic clayey of high plasticity	Fair to poor
10	99.9	99.9	70.7	A-8	High plasticity clay with organic matter	Poor
11	100.0	00.9	5.5	A-3	Inorganic silts, rock flour, silty fine sands with slight plasticity	Excellent to Good
12	00.6	98.0	93.0	A-8	High plasticity organic clays and silt	Poor
13	99.9	99.1	95.6	A-7-6	Inorganic clayey silt	"
14	99.8	99.4	74.0	A-6	"	"
15	99.9	98.4	95.4	A-7-6	Inorganic clayey of high plasticity	"
16	99.9	00.5	96.1	A-8	"High plasticity organic clays and silt	Poor
17	90.0	95.3	79.8	A-7-6	"	Fair to Poor
18	09.8	79.8	19.4	A-3	Inorganic clayey silt	Excellent to Good
19	00.0	81.4	15.1	A-2-4	"	"
20	09.4	70.0	41.8	A-2-4	"	"
21	100.0	83.9	25.3	A-2-4	"	"
22	09.5	91.0	58.9	A-3	"	"
23	00.0	81.7	33.9	A-3	Inorganic silts rock flour, silty fine sands with slight plasticity	"
24	100.0	96.2	50.5	A-3	"	"
25	99.0	74.3	21.5	A-3	"	"
26	90.8	54.8	20.3	A-3	"	"
27	100.0	*88.7*	47.7	A-7-6	Inorganic clayey of high plasticity	Fair to Poor
28	100.0	75.4	29.1	A-7-6	Inorganic clayey silt	"
29	90.9	66.0	22.7	A-7-6	Inorganic clayey silt	"
30	100.0	75.0	40.8	A-7-6	Inorganic silts	"
31	99.8	67.7	29.0	A-7-6	"	"
32	100.0	80.0	39.6	A-2-4	Inorganic clayey silt	Excellent to Good
33	99.9	81.2	43.0	A-2-4	Inorganic clayey of high plasticity	"

34	100.0	3.5	39.4	A-2-4	"	"
35	98.8	50.7	19.6	A-2-6	Inorganic clayey silt	
36	100.0	71.7	33.7	A-7-6	Inorganic clayey of high plasticity	Fair to Poor
37	100.0	84.5	51.1	A-2-6	"	Excellent to Good
38	99.8	81.8	54.1	A-7-6	"	Fair to Poor
39	99.8	86.5	45.6	A-6	Inorganic clayey silt	"
40	100.0	80.6	42.4	A-6	"	"
41	99.9	58.4	24.9	A-2-6	"	Good to Fair
42	100.0	99.9	7.4	A-2-6	"	"
43	100.0	99.4	64.1	A-7-6	"	Fair to poor
44	98.7	90.1	53.9	A-2-7	"	Good to fair
45	100.0	99.3	56.2	A-2-7	Inorganic clayey silt	Good to fair
46	99.6	95.4	967	A-7-6	"	Fair to poor
47	99.9	85.8	43.5	A-7-6	Inorganic clayey silt	"
48	993	79.7	58.3	A-7-6	Inorganic clayey of high plasticity	"
49	99.5	70.3	46.9	A-7-6	Inorganic clayey silt	"
50	100.0	79.7	31.5	A-7-6	"	"
51	99.9	99.3	96.4	A-2-6	"	"
52	99.7	97.2	96.4	A-7-6	Inorganic clay silts of high plasticity	"
53	99.9	95.6	67.1	A-7-6	"	"
54	99.9	98.9	92.0	A-7-6	"	"
55	99.7	99.1	59.5	A-7-6	Inorganic clayey silt	"
56	100.0	89.5	30.0	A-7-6	"	"
57	93.6	64.9	42.5	A-7-5	Inorganic clayey of high plasticity	"
58	100.0	100.0	95.5	A-6	"	"
59	99.9	85.5	27.4	A-7-6	Inorganic clayey silt	"
60	99.4	77.4	46.5	A-7-6	"	"
61	99.9	72.7	32.7	A-7-6	"	"

From Table 5. 17, it can be discerned that almost two thirds (39 sample points) of the soil types at project locations fall within the lowest range of soils (A-6, A-7 and A-8), which are mostly highly plastic silty-clays, classified as fair to poor sub-grade soils in engineering application, due to the high percentage of very fine grained soil particles. The prevalence of fine grained particles in the Niger Delta soils, which limits the applicability of the soils at project locations, inferred as inducing cost overruns during the construction phase, is further statistically explored, based on more quantitative index parameters of subgrade soils.

5.6.2 Quantitative Parameters: Index Properties

Although the particle size distribution and classification of the soils are useful in providing a broader picture of the engineering applicability of the soil types in the region, they are more descriptive, and thus not amenable to statistical manipulation. Other more quantitative geotechnical parameters, such as Atterberg limits, free swell, maximum dry density and optimum moisture content give more specific quantifiable geotechnical attributes of sub-soils. These engineering index properties of the sub-soils, approximated for the sampled project locations, which may account for the cost overrun disparity between the geo-zones, are presented in Table 5.18. The definitions of these quantitative parameters are also provided.

Table 5.18: Geotechnical Index Properties of Soils at Project Locations

S/No.	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Free Swell (%)	Maximum Dry Density (x 10^3 Kg/m^3)	Optimum Moisture Content (%)
1	48.5	26.3	22.0	30	1.89	13.0
2	45.5	18.5	27.0	40	2.00	12.5
3	49.6	20.5	29.0	50	1.99	13.8
4	0	0	0	15	2.10	12.0
5	35.5	17.0	18.5	45	1.91	13.8
6	48.0	20.0	28.0	4S	1.86	16.3
7	49.0	24.0	25.5	55	1.95	15 1
8	49.0	26.5	22.5	50	1.93	15.6
9	52.0	25.5	26.5	60	2.00	11.8
10	59.5	20.5	39.0	80	1.78	18.0
11	0	0	0	0	1.73	14.1
12	37.0	17.0	20.0	25	1.84	12.2
13	47.0	21.5	25.5	60	1.72	20.0
14	35.0	20.5	14.5	30	1.89	15.4
15	62.4	25.5	37.0	80	1.66	19.0
16	64.0	26.0	38.0	40	1.71	18.0
17	52.5	20.0	32.5	70	1.77	15.5
18	24.5	16.5	8.0	35	2.09	9.0
19	32.0	16.0	16.0	40	2.13	8.2
20	48.5	17.5	31.0	50	2.02	12.3
21	33.5	17.0	16.5	40	2.06	10.0
22	45.5	18.5	27.0	70	1.93	14.0
23	39.0	31.0	18.0	50	2.05	11.2
24	32.0	17.0	15.0	55	2.40	13.4
25	37.0	16.0	21.0	45	2.13	9.0
26	34.5	15.5	19.0	50	2.02	10.0
27	53.0	21.5	33.5	45	1.92	15.3
28	44.5	20.0	24.5	50	2.04	12.5
29	41.0	20.0	21.0	40	2.04	12.0
30	52.0	21.0	31.0	50	1.95	15.0
31	41.0	18.5	22.5	40	1.97	12.6
32	47.5	20,0	27.5	60	1.98	13.1
33	50.5	19.5	31.0	50	1.92	13.8
34	57.0	22.0	35.0	55	1.90	14.0
35	36 0	17.5	18.5	40	2.00	10.0
36	52.5	23.5	29.0	50	1.95	13.6
37	56.5	25.5	31.0	60	1.87	16.0
38	63.5	27.0	36.5	60	1.86	17.2
39	48.0	21.5	36.5	50	1.91	15.3
40	45.5	18.5	27.0	50	1.92	15.5
41	34.5	15.6	19.2	45	2.16	8.8
42	22.2	0	22.2	20	1.75	14.3
43	36.2	20.5	15.7	10	1.69	16.8
44	35.2	26.2	9.0	50	1.69	18.5
45	26.7	21.9	4.8	30	1.63	17.2
46	65.6	37.4	23.2	60	1.43	22.8
47	31.7	12.3	19.4	45	2.13	9.4
48	56.0	27.3	28.7	80	1.65	17.8
49	49.0	22.0	27.0	40	2.00	12.3
50	32.0	14.9	17.1	35	2.03	11.4
51	70.5	33.5	37.0	80	1.64	21.8
52	70.5	19.5	37.7	75	1.94	15.0
53	55.6	18.9	36.7	75	1.89	16.6
54	533	28.5	25.0	40	1.63	19.2
55	28.0	16.5	11.5	20	1.91	15.0
56	24.7	12.2	12.5	30	2.11	9.7
57	50.1	19.7	30.4	50	1.97	12.2
58	67.5	34.8	32.7	80	1.63	21.5
59	27.1	15.8	11.3	75	2.30	10.4
60	41.0	16.7	24.3	70	2.01	11.6
61	32.8	15.8	17.0	30	2.06	8.5

5.6.2.1 Expansivity Parameters

For finer grained expansive soils which are predominant in the Niger Delta region, the Atterberg limits (Plastic Limit and Liquid limit) is used in engineering application to define soil behaviour with increasing water content, are shown in Figure 5.22.

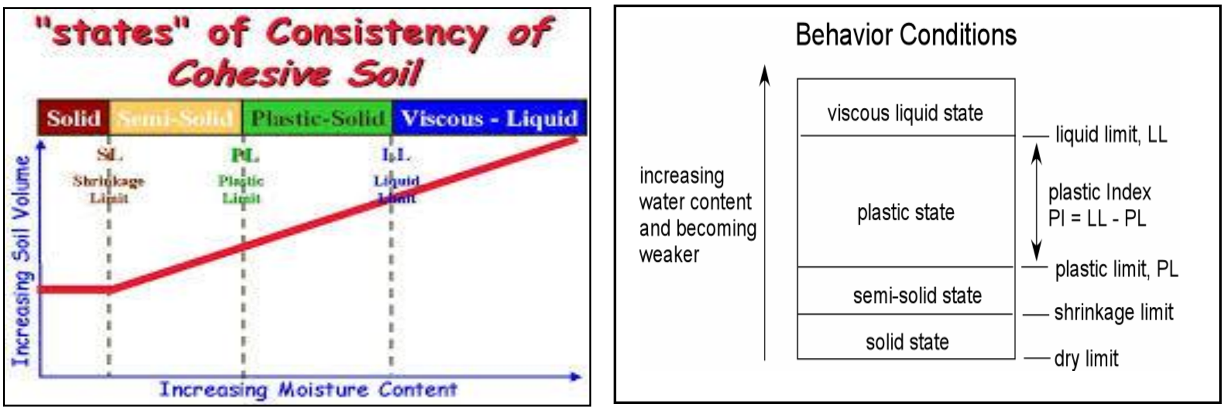


Figure 5.22: Engineering Behaviour of Fine Grained Soils with Increasing Water Content (Source: Coduto, 2007)

The parameters of expansivity are thus defined:

- Plastic limit (PL): The lowest water content at which the soil remains plastic (Semi-solid).
- Liquid limit (LL): The moisture content at which soil begins to behave as a liquid material and flows.
- Plasticity Index (PI): Represents the range of percentage water content that induces a change from the semisolid phase to the liquid phase, in which the soil begins to behave as a liquid. During this range of water content, the soils are described as being in the plastic state. Plasticity Index is calculated as the difference between the liquid limit and plastic limit.
- Free Swell (FS): is the geotechnical index descriptive of the swelling potential of unconfined soil when submerged in water. The swell potential of a soil is the percentage volume change that occurs in the soil with increased water content during the phases of transitioning.

5.6.2.2 Compaction Parameters

- Maximum Dry Density (MDD): This is a measure of the degree of compaction on a soil mass. The implication of this index property of soil for sub-grade soils in road construction is the level of compaction that would be required per unit volume of the soil. Further consolidation of the sub-grade under imposed traffic is prevented if the compaction is carried out to a sufficient depth that naturally attains this maximum dry unit weight. The maximum dry density of soils tends to decreases with an increase in percentage of fine particles. A-1 materials typically display the highest maximum densities while the A-7 materials will tend to have relatively lower density.

- Optimum Moisture Content (OMC*):* The moisture content at which the density of a soil reaches a climax point referred to the maximum dry unit weight. The optimum water content is thus necessary to improve compaction, above which the dry density begins to reduce (Coduto, 2007).

5.7 Hypothesis 3: Correlation Analysis of Geotechnical versus Project Cost overrun Data

Correlation analysis of the paired sample cost overrun and geotechnical data is carried to test if there is any significant statistical association between the geotechnical properties of sub-grade soils in the Niger Delta as represented by their geotechnical index values, and the level of cost overruns experienced on the highway projects.

Table 5.19: Correlation Analysis of Geotechnical Variables versus Cost Overrun

		Cost overrun
Plasticity Index (PI)	Pearson Correlation	.630
	Sig. (2-tailed)	.002
Free Swell (FS)	Pearson Correlation	.630
	Sig. (2-tailed)	.002
Liquid Limit (LL)	Pearson Correlation	.625
	Sig. (2-tailed)	.00
Plastic Limit (PL)	Pearson Correlation	-.716
	Sig. (2-tailed)	.000
Max Dry Density (MDD)	Pearson Correlation	-.447
	Sig. (2-tailed)	.418
Optimum Moisture Content (OMC)	Pearson Correlation	.462
	Sig. (2-tailed)	.008

From the output of the correlation analysis in Table 5.19, only the parameters of expansivity (PI, FS, LL and PL) display, relatively high correlations with cost overruns. Compaction parameters such as the Maximum Dry density and Optimum Moisture Content, however display weaker correlations with cost overruns. The predominantly high Plasticity Indices, Swell Potentials and Liquid Limits of the soils are indicative of very poor and weak subsoils at project locations, due to their tendency to rapidly undergo volume changes.

These expansive characteristics of soils are highly undesirable for road construction, as they portend high shrinkage and expansion potential for road pavements constructed on them, associated with significant volume increment such soils experience, with changes from dry season to wet season. The occurrence of such soils have thus been noted as problem soils in the region by several scholars, which imply significant financial post contract connotations for highway projects, if they are not adequately investigated prior to the contracting and construction phases (Chukweze, 1991; Youdeowei and Nwankwala, 2010; Otoko and Pedro, 2014).

These assertions are consistent with the positive correlation coefficient of these parameters with cost overruns, returned from the correlation analysis. However, the Plastic Limit (PL) displays a negative correlation with cost overruns, implying that higher plastic limit of soils would connote lower cost overruns. This can be explained by the fact that soils which have high plasticity ranges, are stable even with the introduction of water, without rapidly undergoing changes into a semi-solid phase.

The Atterberg Limits and Swell Potential of the Niger Delta soils can thus be inferred as an indication of the how much financial constraint is posed by ground conditions to highway construction, which would translate into significant cost overruns if not adequately catered for in pre-contract preparation. The plasticity and swelling index characteristics ultimately determine the geologic potential for projects to run over budget, underscoring the need to accommodate these geotechnical requirements in highway designs, and the implied cost in client's and contractor's estimate preparation.

These geotechnical variables are thus inferred as the latent geologic variables inherent in the heterogeneous wetland terrain of the Niger Delta, which inherently induce cost overruns in highway projects, in the absence of adequate ground investigations. They are further incorporated in chapter nine, as a part of the variables included in the regression modelling of latent geotechnical cost overrun drivers in the geologic setting of the Niger Delta region.

5.7 Chapter Summary

The exploratory geo-statistical analysis carried out in this chapter, has provided an empirical view of the geologic variability of the terrain of the Niger Delta, and how this creates a potential for highway projects to run over budgeted cost estimates. The significant cost overrun disparities, between the various synthesized geo-zones of the Niger Delta, inferred from the analysis, has reinforced the researcher's pre-conceived assertions, that the unusually high level of cost overruns recorded in highway projects, is strongly correlated with the peculiar geologic setting of the region. It has thus provided an empirical justification of the need for further investigation into what latent geotechnical pathogens in the practice of the highway agencies, were responsible for triggering these geologic cost overrun drivers inherent in the wetland terrain of the Niger Delta region, to actively manifest in the excessive level of cost overruns.

Figure 5.23, inspired by ICE (2001), represents the researcher's conceptualised circle of concern on matters relating to ground conditions, showing the circle of influence of the geologic setting of the Niger Delta, with exogenous geotechnical variables that can only be controlled within the limited decision interface via adequate ground investigations and ground risk containment in practice.

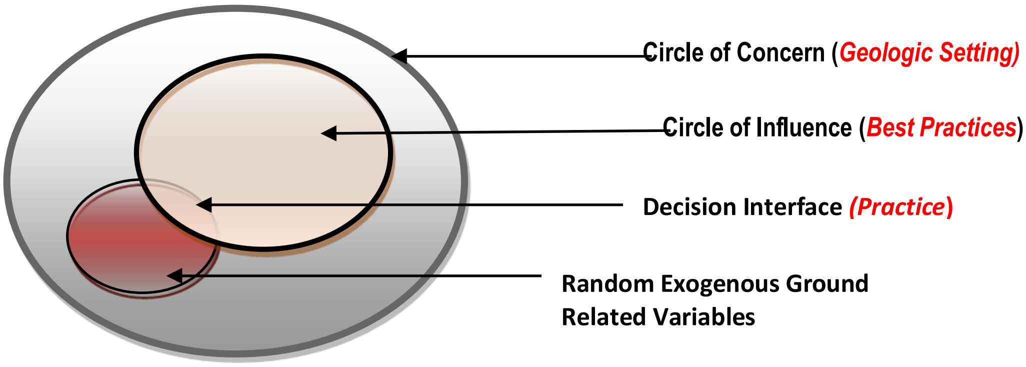


Figure 5.23: Conceptual Approach to managing Ground conditions

(Adapted after ICE, 2001)

It was thus the researcher's interim proposition at this phase of the study, based on the geo-statistical analysis results, that: *The trend in cost overruns are primarily triggered by issues relating to the management of geotechnical risks, inherent in the ground conditions of the Niger Delta, which ideally ought to be clearly defined and tackled, but were not resolved early on in the project at the pre-tender stage, thereby allowed to spill into the contractual and construction phase, leading to significant cost overruns*.

Identifying the geotechnical shortcomings/deviations from the dictates of best practice, was thus considered a necessary starting point for subsequent qualitative analysis. Chapter six of this thesis, thus explores best practices in the technical literature requisite to accommodate ground conditions in designs and estimates, a lack of which therefore, may account for the unusually high cost overruns in the sampled highway projects.

Chapter 6

Geotechnical Best Practices: Exploratory Literature Review of Geotechnical Triggers to Cost Overruns in Highway Project Estimates

6.0 Conceptual Approach to the Literature

This chapter reviews the relevant literature related to the key concepts/themes which define the practical basis of the study. Figure 6.1 diagrammatically captures the major thrusts of the literature which discusses the prevalence of cost overruns in highway projects due to ground risks, as a background to the core emphasis of deducing latent pathogens that can potentially exists in practice.

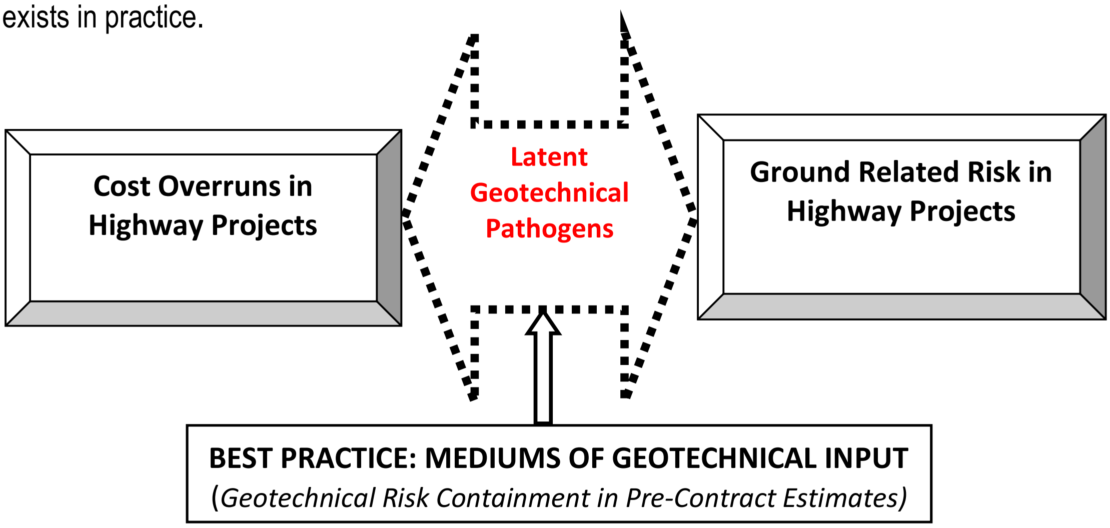


Figure 6.1: Conceptual Approach to the Literature

The significance of ground risks for triggering cost overruns, latent in the pre-construction phases of highway projects, is reviewed as the theoretical basis of the need for geotechnical input. The exploratory literature analysis explicitly illuminates best practices which represents the various progressive mediums of risk containment in highway projects via adequate geotechnical input at the: Conceptual costing phase of budget estimate computation; Engineering designs/detailed estimate preparation phase; Contractual phase during bidding, tender documentation, and contractor selection. The above conceptual background sets the structure of the literature review, which leads the researcher to deduce gaps in knowledge, suspected as prevailing in the professional practices of highway agencies. Due to the practice based nature of this aspect of the research, related articles from the technical press evident in publications by international professional bodies, recognised standards of best practice, research institutes and highway agencies are thus used to support the bulk of scholarly literature.

6.1 Ground Related Risk in Highway Projects: The Need for Geotechnical Input

Ground conditions have been repeatedly asserted to account for a significant percentage of the technical risk posed to highway development, due to its complex interfaces with the design and construction of transportation projects (Alhalaby and Whyte, 1994; Venmans, 2006;2013). The literature reveals that irrespective of projects details, ground condition is a factor that has to be contended with in highway projects (ICE, 1999, 2001; Whitman, 2000; Clayton, 2001; Venmans, 2006; 2013). The United States Department of Transport (USDOT, 2002) in recognition of this, used the maxim "*all transportation projects are carried on earth, with earth or in the earth*" to emphasize the importance of ground conditions in the construction of highway projects. Rao and Ranade (2013:58) thus stated that:

> "*In the early stages of large infrastructure projects, a significant proportion of the risk exposure comes from the unknown unknowns. These may derive from complex interfaces with the physical environment into which the infrastructure is to be built such as the route of the transport link*"

The Institution of Civil Engineers (2001:12) equally acknowledged this, but however drew attention to the paradox that:

> "*Ground conditions constitute the highest element of risks in construction works, yet it is the element of construction work about which much remains to be known*".

The Institution of Civil Engineers (2001) further explained that this is largely due to the fact that, unlike material requirements in construction which can be specified, ground conditions are predetermined and therefore beyond human control. Ground related risk according to the Institution of Civil Engineers (2001) have adverse consequences for project cost; completion times; environment; health and safety; and quality of design, as illustrated in Figure 6.2.

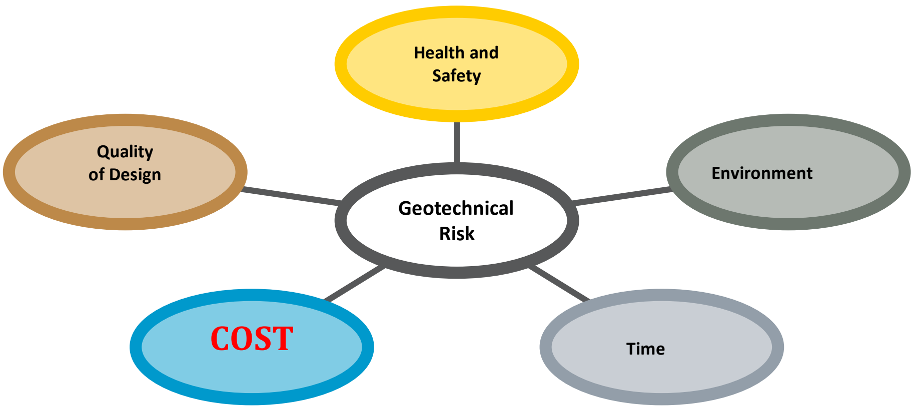


Figure 6.2: Ground Related Risk and its Impact on Construction (Source: ICE, 2001)

This study's definition and focus, on ground related risks, emphasizes its cost implication, and is placed in the context of the need for geotechnical input as a medium of financial risk containment in the pre-contract phases of highway project estimate development.

Several publications (Peacock, and Whyte, 1992; Alhalaby and Whyte, 1994; Whitman, 2000; Clayton, 2001; Venmans, 2006) have thus identified ground conditions, and the relatively high level of uncertainty associated with it, as one of the most fundamental technical explanation of cost overruns in highway projects. However, as noted in the literature review earlier, there appears to be a central debate, between the technical and theoretical studies from refereed peer reviewed journals, on this key theme. Yet, the literature reviewed in subsequent sections (from both the scholarly and technical press), which stems from the former, continues to report the need for geotechnical input, as being fundamental to subverting cost overruns and ensuring a project's successful delivery. As a result of this contradiction within the existing literature, this chapter is focused on exploring what specific geotechnical pathogens have been reported to trigger cost overruns in highway projects, as a prelude to testing the statistical validity of geotechnical risk factors in explaining cost overruns.

6.2 Empirical Literature on Cost Overruns Identifying Ground Related Risk Factors

Alhalaby and Whyte (1994) asserted that the highest percentage of technical risk leading to cost overruns in highway projects are linked to design and engineering issues related to ground conditions. According to Paul *et al.* (2002), unanticipated ground conditions can escalate project costs by as high as 10% or more while site investigation costs only account for 0.20 to 1.55 percent of the capital cost of projects. Albatal *et al.* (2010) studied the levels of financial risks associated with varying scopes of the site investigation for highways projects. The authors carried out cost analysis of the cost of initial geotechnical investigation against the post contract cost associated with failure to carryout adequate site investigation. It was concluded from detailed cost analysis, that the post contract cost was 10.2 times the minimum ideal expenditure on site investigation.

In view of the very high impact of ground related risk in transportation projects, several empirical studies in the literature have identified it as one of the most fundamental factors to which delays and cost overruns in highway projects can be attributed (Mansfield *et al.*, 1994; Ashton and Gidado, 2001; Bordat *et al.,* 2004; Kaliba *et al*., 2008). The literature synthesis (Table 6.1) highlights several issues related to inadequate geotechnical input identifiable from factors such as poor preliminary engineering; changes in site conditions; design errors and changes in specifications; and deficient specification in contract preparation; all of which have underlying geotechnical drivers. These are dominant in the array of technical factors causing high levels of cost overruns in highway projects.

Table 6.1: Empirical Studies Identifying Ground Related Cost Overrun Factors

Author(s)/Year	Country	Major Factors Identified
Merewitz (1973)	USA.	Price level increases Scope changes *Unforeseen conditions and structural modifications*
(Mansfield *et al*., 1994)	Nigeria	Poor contract management *Changes in site conditions* Financing and payment of completed work
Ashton and Gidado (2001)	UK	*Design and re-engineering due to ground conditions*
Abd El-Razek *et al*. (2008)	Egypt	Financing by contractor during construction Delays in contractor's payment by owner *Design changes due to unexpected ground conditions during construction*
Kaliba *et al. (*2008)	Zambia	*incompleteness of preliminary engineering* *technical challenges* *changes in design drawings and specifications* Improper planning
(Tumi *et al*., 2009)	Libya	Improper planning Lack of effective communication *Design errors*
(Creedy *et al*., 2010)	Australia	*Design change* Scope change *Insufficient investigations and ground conditions* *Deficient documentation (specification and design)*
Mahamid and Bruland (2012)		*Unforeseen ground conditions*

Ashton and Gidado (2001) asserted that the financial impact of lack of ground investigation on highway construction cost will become evident in inaccurate designs which will translate to increased cost overruns. This was based on findings revealed from an analysis of a large sample of 474 questionnaires responses received from construction practitioners in the UK, and supported by content analysis of 41 project documents. The sample demographics included project managers, engineers, and other construction professionals. Contractors for the case study projects emphasized financial losses incurred due to difficulties experienced in the execution of substructure works as a direct consequence of uncertain ground conditions. The content analysis of documents based on detailed project cost estimates, schedules and site progress programmes, equally revealed high cost overruns and delays.

In developing countries, typically, the study by Mansfield *et al.* (1994) considered the causes of cost overruns in Nigerian highway projects. An array of factors which were responsible for the significant level of cost overruns evidenced in highway projects, were listed and ranked based on severity rankings, accorded them from data, obtained using questionnaire survey among key stakeholders (contractor, consultant and client organisations) in Nigeria. Changes in site conditions, was ranked 5th in the survey, with a mean severity index of 78.3%. The standard mean error due to variation in ranking by respondents was 2.96%, an indication that the variations in ranking by respondents did not affect the position accorded this factor. The problem of unexpected site conditions was attributed to inadequate feasibility studies before project authorisation and insufficient geotechnical investigations at the feasibility stage which ultimately led to design changes ranked 6th in the survey. The findings of Mansfield *et al*. (1994) study, although carried out more than 2 decades ago, appears to still have a significant bearing in this research.

Other empirical studies carried out for other forms of construction works equally identify ground related factors as being responsible for cost overruns. Typically, Le-Hoai *et al. (*2008), Olawale (2010) and Rahman (2013) who carried out their studies based on projects located in Vietnam, the U.K and Malaysia respectively, rated changes in design occasioned by ground conditions among the top five in the list of identified factors. It can thus be seen that ground related factors rank high among the factors that can cause delays and consequent overruns in all forms of construction projects.

6.3 Technical Literature Statistics on the Impact of Ground Risks

Engineering and re-engineering issues related to ground conditions have being consistently discussed in the technical press, as the cause of significant overruns in highway projects located in different parts of the world, with significant economic implications (NEDO, 1983, 1988; NAO, 1994; ICE, 2001; Alavi and Tavares, 2009; DETR, 2014).

The National Economic Development Office (NEDO, 1983; 1988) in a review of 13,000 building construction projects: 5,000 industrial; and 8,000 commercial, revealed that ground related problems accounted for 37% and 50% of projects delays encountered during construction. In 1990, an analysis of 67 highways contracts in the UK, revealed average cost overrun value of 28%, 17 of which showed 44% cost increases due to earthworks and unforeseen ground conditions (ICE,1991). The National Audit Office (1994) also reported 210 cases of premature failures, worth about £260 million, due to inadequate ground investigations. Also the National Audit Office (2001) further revealed that 70% of public sector projects experienced delays, with 73% over budget, in the face of dwindling investment in ground investigations. The New Civil Engineer (NCE) (2011), reported an audit of geotechnical failures, in the Netherlands, which were estimated as costing between 5% and 13% of annual expenditure (€70bn/£61b).

Significant cost overruns of up to £516 million were revealed by, the Department of the Environment, Transport and the Regions (DETR, 2014), in the seven largest road projects executed, due to unforeseen ground conditions, accounting for a 63% increase above budgeted funds. Of the seven projects, the M60 Manchester ring road incurred the highest cost overrun of £184 million, on account of unforeseen ground conditions amounting from delays of 35 to 46 weeks, and claims worth £30 million. Five of the schemes included within the DETR analysis were also revealed to be between one to five years behind schedule.

The Hallandsås Tunnel Project, Sweden, designed for the construction of two 8.6 km long railway tunnels at an initial budgeted cost of £440 million in 1992, escalated to £840 million in 2008, due to unforeseen ground and water conditions (Creedy, 2010). The project was abandoned at 3 km (30%) completion in 1995, resumed in 1996, discontinued in 1997, and resumed again in 2004, after seven years. Work progress in as at 2009, was measured to at 59% completion, with a final completion in 2015, as reported in the technical press (IRJ, 2015).

Also, the critical factor cited as responsible for the controversial £900m cost overrun reported in the Big Dig, United States Boston Artery project, were technical issues due to unforeseen ground conditions compounded by a high water table two to three meters below the surface which was discovered during construction (Creedy, 2006).

As noted from the different popularly cited statistics and case histories of highway project cost overruns in the technical press, ground conditions constitutes a major risk factor that can ultimately determine the successful performance of a contract. The literature in subsequent sections thus explores the nature of geotechnical risk factors which constitute latent pathogens at the pre-contract phase of highway projects, leading to cost overruns at the post contract phase. As Sower (1993:238) asserts: "*Ground-related problems often originate in an earlier phase than* *the phase in which they occur…out of 500 failures evaluated, 58% originated in design, and manifested in construction".*

Subsequent sections provide a kaleidoscopic view of the various geotechnical routes to managing risks due to the ground, at the preconstruction phases of highway projects, and how a lack thereof, can culminate to determine the trend of high levels of cost overruns in highway projects. The nomenclature of the pre-contract phases of highway projects is however analysed as a prelude to this, due to the discrepancies reported on various studies, on how highway projects progress through phases.

6.4 Nomenclature of Highway Project Phases

Project development phases have been outlined in the literature to portray how highway projects advance from inception to completion (Chou, 2002; Phaobunjong, 2002; Tan and Wakmasha, 2010; Asmar *et al.,* 2011).

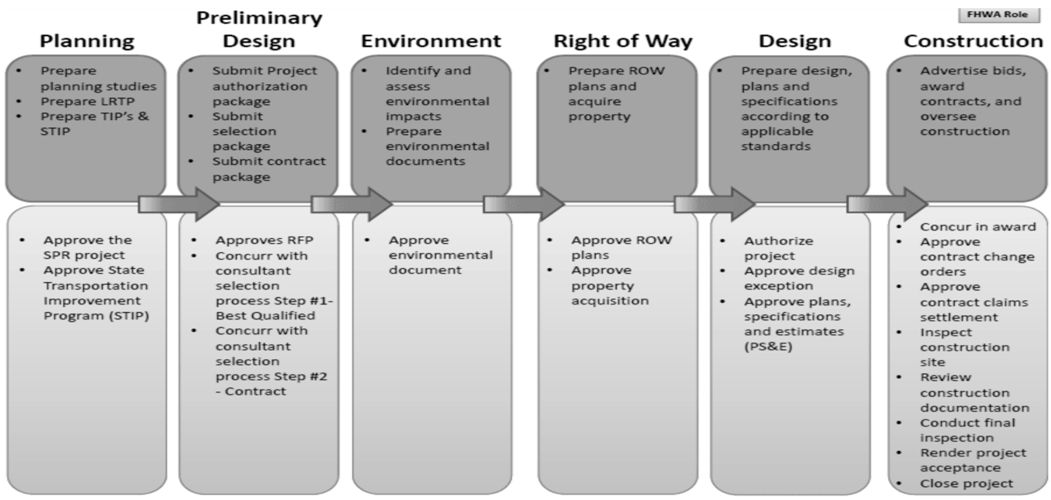


Figure 6.3: Typical Project Phase Configuration for US DOTs

(Source: USDOT, 2006)

In the United States, the configuration of project development phases by local and regional DOTs, generally follow the outlined process, in accordance with the Federal Highways Authority (FHWA) requirements (in Figure 6.3), from its inception to construction, with responsibilities that include: estimating, cost control and adhering to environmental requirements. The literature, however, draws attention to the fact that these developmental phases are not uniformly labelled by highway agencies, but vary according to their individual practices.

Typically, Asmar *et al.* (2011) outlined the five stages in project development, in terms of the level of completeness of design details at each phase of highway project development. The authors discussed these phases in relation to the typical project lifecycle for the Wisconsin Department of Transportation (WisDOT): Planning and scoping; Environmental process; Preliminary design; Final design and Advertise and bid.

Chou (2002) analysed timeframes over which various estimates are prepared for highway projects in the US, using an illustration of the major stages of estimate development in projects. The author categorised the stages of project development in the context of the Texas Department of Transport The first stage of project development for the agency is the investment stage. Chou (2002) stated that this is the crucial initial point, where a project is introduced into the department's long range plans, which are prepared to span a period of twenty years. The estimate at this point is prepared to analyse the feasibility of proposed schemes, with high feasibility projects given higher priority. The project then proceeds to the next phase where alternative layouts are compared for their environmental impacts. Subsequent to this, schematic estimates are then prepared which determine the funding requirements of projects. Chou (2002) stated that this is the point at which a scheme can be definitively described as a project, with responsibility passing from planners to designers at the Plan, Specifications and Estimate stage.

Similarly, Evans and Peck (2008) in their study of costing practices, noted the differences in the phase configuration of Australian highway agencies. The authors described the lack of commonality in the nomenclature of the phases adopted by highway agencies, with different terminologies being adopted. However, according to the Australian Federal Infrastructure's Notes on Administration (2015) project phases were labelled: Project Identification; Project Scoping; Project Development; and Project Delivery Phase.

The researcher thus notes that the development phases specific to highway projects, like most publicly funded projects, are often structured in recognition of the necessary technical bureaucratic details and procedures, requisite for obtaining environmental and funding approval, needed in public infrastructure projects. Irrespective of the varied nomenclature of project phases, three broad pre-construction phases can be identified as common to all forms of highway development.

- The conceptual/budgetary phase;
- The design/engineering phase;
- The procurement/contracting phase.

The accuracy of cost estimates prepared by the highway agencies, in these distinct pre-construction phases, have implications for cost overruns, as identified and synthesised, based on geotechnical best practices perused in the literature (Table 6.2).

Table 6.2: Geotechnically Induced Cost Overrun Drivers in Highway Projects

Phase	Geotechnical Practices
Conceptual Phase	Underestimation of budgetary estimates due to cost projection from historical data which does not account for differing or heterogeneous soil profiles.
Design Phase	Weak and insufficient preliminary ground engineering leading to design and specification deficiencies; Inaccurate engineering design estimates.
Contractual	Inadequate ground investigation data in contract documentation provided for contractors during bidding leading to unexpected site conditions; Poor geotechnical risk containment due to lack of Differing Site Conditions clauses; Lowest bid contactor selection without geotechnical input.

These geotechnically induced cost overruns drivers, representing latent pathogens, are triggered, when the various mediums of ensuring geotechnical input in highway projects, are not adhered to. The subsequent subsections evaluate the dictates of best practices, as potential mediums for ensuring geotechnical input at the conceptual, detailed, and contractual phases of highway projects, highlighting their distinct contributory implications in averting cost overruns.

6.5 Geotechnical Pathogens in Conceptual Cost Estimates

A conceptual estimate is an estimate prepared at the phase of highway development, whereby only a general idea exists about what the project will entail (Lowe *et al.,* 2006). Various terminologies have been used to label this estimate in a project. Typically, such terms as '*early stage estimates', 'initial estimates', 'top-down estimates', 'preliminary estimates'* and *'investment estimates*' are also used in the literature to label this point of initial arbitrariness in project details and definition (Phaobunjong, 2002; Chou, 2005: Tan and Wakmasha, 2010; Asmar *et al.,* 2011).

Despite the different terminologies used to identify phases of highway project development in the literature, the starting point, or basis of estimation, for any project is the one projected at the planning stage, during which a business case is identified, and investment decisions have to be made. The proper planning of highway construction programs thus necessitates the accurate estimation of funds to be budgeted for individual projects, to circumvent the occurrence of cost overruns (Tan and Wakmasha, 2010). It has been opined that highway projects have historically experienced significant cost overruns, often rooted at the point of the decision to build, which ideally corresponds to the conceptual phase (Moleenar, 2005; Cantarelli *et al.,* 2010).

The current practices of highway agencies, reveal varied methodologies of approximating conceptual estimates (Chou, 2005; Alavi and Tavares, 2009). Different agencies have used differing approaches at the preliminary phase to project budget estimates in line with their organisational needs. It was thus commented that:

> "*Cost estimation is a complex practice impacted by the unique characteristics of an agency's organizational structure.... Those unique characteristics make the problems associated with cost estimation practices different among agencies.* (Alavi and Tavares, 2009: 10).

Based on the literature, the methodologies used by highway agencies in the computation of conceptual estimates in budgeting, vary, and is dependent on needs specific to the highway agencies. The findings for several highway agencies perused in the literature, however showed that there are certain methods which are conventionally associated with their early stage estimation practices. From the analysis of costing practices, summarised in Table 6.3, it is noted that none of the methodologies can be identified as having any basis of geotechnical input. As such:

- Unique characteristics and other variables such as ground conditions were noted as not accounted for in these estimates;
- A high element of subjectivity is required on the part of estimators in deducing to the level of ground similarity with past project.

Table 6.3: Conceptual Costing Trends in Highway Agencies

Highway Agency	Conceptual Costing Practice
Wisconsin Department of Transportation (WisDOT),	Project divided into functional elements; *Apply Historical bid data* early phase generated quantities; Historic percentages for the remaining work items; Add contingency allowance.
Virginia Department of Transport (VDOT)	*Apply pre-formulated concepts from database;* Generate computed cost figures for different elements; Sum up for components relating to individual projects; Periodic adjustments to update cost to current market values;
California Department of Transport (CDOT)	Determine the appropriate unit price range for work items; *Adjust price for location; quantity and other factors;* Prepare Standard check lists as a base; Add allowances for inflation, contingency and overheads; Contingency allowance set at 25% of base estimate.
Alabama State Department of Transportation (ADOT)	*Extract Historic lane mile averages* from updated databases; Apply to the different work elements; Sum-up; Add contingency allowance range of 5- 15%;
Chou (2005) 31 State DOTs	*Historic lane-mile cost averages* for similar works; Bridges estimated based on historical square-foot or square-meter.
NCHRP (2006)	*Historical lane-mile cost averages* based on similar projects; Contingency and engineering costs added as % of the total cost.
Turouchy *et al.*, (2001) -8 DOTs Delaware, Florida, Kentucky, Minnesota, Pennsylvania, Texas, Washington, and West Virginia	Use of tables of *generic "cost-per-mile" values* by typical section or; Estimation of "rough" quantities for all major items or; Lack of any uniform or documented method.

Turouchy *et al*. (2001) explained that these methods, based on cost per-mile tables, usually have adjustment made for project specific incidentals, using informal engineering judgment. Methods based on the estimation of "rough" quantities for all major items, basically apply the generic LWD (length, width, depth) method which involves estimating pavement volume, and then adding costs for other items. The LWD method however does not make adjustments for possible variability in cross sectional details along the proposed route. Unforeseen ground conditions were thus provided for using contingency allocations, ranging between 5 and 20% of estimated cost.

As such, it can thus be deduced that the technique of 'lane mile extrapolation' typically used by most highway agencies, may not necessarily account for external environmental influences such as subsoil conditions. Turouchy *et al*. (2001) however reported that a fair attempt to account for ground conditions was observed in the Tennessee Department of Transport, (TnDOT), which goes through a vigorous process, where cost estimates are developed after site visits, supplemented with the use of aerial photography and topographic sheets. This is reproduced in a CAD drawing system scaled plan sheet, where a rough layout of the road is produced, based on which the road centre line is drawn to envision the typical section for subsequent detailed measurement to generate quantities for 20 major cost items.

Turouchy *et al.* (2001) further reported that most of the DOTs surveyed revealed that the pavement cost, and associated preliminary engineering required to develop more accurate forecast, represented the most difficult cost item to estimate and often accounted for the largest deviations from detailed design estimate and final cost. This contrast with few states DOTs such as Tennessee that dedicate a relatively large amount of financial and human resources to preliminary engineering, and have very low deviations from their initial cost estimates. Despite this technical shortcoming noted, several highway agencies still deploy these qualitative methods due to the speed and ease of its applicability, which could be due to low risk perception/lack of skills to use more advanced conceptual estimation techniques (Chou, 2005). This may thus account for the trend of significant disparity between budgeted and final out-turn cost reported on highway projects (Chou, 2005).

These forms of estimating practice, principally based on cost extrapolation from historical data with subjective adjustment, has being subject to criticism, by a robust scholarly and technical literature base as well as best practice, advocating for the improvement of estimates in this phase, against the background of the paucity of technical information. The literature is replete with a wide variety of cost estimating models and tools proposed for use at the conceptual phase of project developments. (Watson, 1995; Kim *et al.,* 2004, Lowe *et al.,* 2002; Salem *et al.,* 2003; Chou, 2010). These tools and models are based on differing quantitative and analytical approaches. Several professional bodies and government agencies which address the issue of improving accuracy by providing recommended practices are also evident, and include: NASA (2008); GAO (2009); DOE (2011); AACE (1997, 2011, 2012).

Best practice cost estimation standards, proposed for use by highway agencies, have been drafted to serve as a benchmark to upgrade methodologies adopted by the agencies in relation to project cost estimation. Typically, the AACE (1997) as far back as almost two decades ago, advocated for more stochastic approaches to conceptual cost estimation (In Table 6.4).

Table 6.4: AACE Best Practice Cost Estimation Standard

Estimate Class	Level of Project definition as % of complete definition	End usage Typical purpose of estimate	Methodology	Expected Accuracy range	Estimate preparation Effort relative to least cost index of 1
Class 5	0 – 2%	Screening or Feasibility	Stochastic or Judgment	L:20% to -50% H:+30% to +100%	1
Class 4	1to 15%	Concept Study or Feasibility	Primarily Stochastic	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10 to 40%	Budget, Authorization, or Control	Mixed, but Primarily Stochastic	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30 to 70%	Control or Bid/Tender	Primarily Deterministic	L: -5% to -15% H: +5% to +20%	5 to 20
Class 1	50 t0 100%	Check Estimate or Bid/Tender	Deterministic	L:3% to -10% H: +3% to +15%	10 to 100

(Source: AACE Recommended Practice No. 17R-97, 1997)

The Department of Energy (2011) cost estimation guide also stresses the need for high quality conceptual cost estimates as pivotal to successful project execution. Four characteristics are established by this standard as criteria for assessing the quality of such estimates: "*they should be credible; well-documented; accurate; and comprehensive"* (DOE, 2011:11). The DOE (2011: 11) guide further defines these criteria. An estimate should be:

- *"Credible when the assumptions and estimates are realistic relative to the level of confidence*
- *well-documented showing methods used to create the estimate and identify the underlying data and assumptions used to develop the estimate;*
- *accurate when actual costs deviate little from the assessment of costs likely to be incurred;*
- *comprehensive when it accounts for all possible costs associated with a project"*

Competent application of the cost estimation process is thus a pre-requisite to obtaining the goal of a quality conceptual cost estimate. It is thus discernible that the methodology deployed in the computation of the conceptual estimate, is a festering latent pathogen in the practice of highway agencies, which can be triggered to result in cost overruns in the long run. The poor quality of estimates relied on by highway agencies from the conceptual phase, thus represents a viable pathogen identified in this study, as possibly accounting for cost overruns.

Adequately defining ground conditions at increasing levels has thus been advocated to ensure higher levels of accuracy in estimates, from the conceptual phase to the detailed design phase (Reiley *et al.,* 1994, 2004; Evans and Peck, 2009; Romero and Stolz, 2009). Geotechnical input from comprehensive desk studies at the conceptual phase, to site specific detailed ground explorations at the detailed design estimate phase, has thus been argued as necessary to improve the accuracy of estimates, as a mechanism of financial and technical risk containment, necessary to subvert cost overruns (Reiley *et al.,* 1994). Romero and Stolz (2009) also expressed such opinion and principally advocated for improving the accuracy of conceptual cost estimates on a non-uniform basis predicated on adequate information of ground conditions. They observed that for transportation projects which have a high level of interface with the ground, the use of this uniform 'off-the-shelve basis' of cost extrapolation was not adequate and thus no more than just a guestimate. In this vain, the Romero and Stolz (2009:186) stated that:

> *"Reliance on historical cost data are not well suited for feasibility studies, because not only do construction costs vary widely because of subsurface, geographic, and other project-specific parameters, but also because such construction costs are not generally available in cost databases… This could result in significant budgetary shortfalls as projects progress through the developmental phases of planning and design to construction".*

Geologic conditions according to Romero and Stolz (2009) should be defined to various degrees and applied to the estimates with applicable contingency allowance, depending on the level of confidence in the geologic conditions. As such at the planning or feasibility stage geologic mapping and case histories from desk studies in the area can be deployed to characterize geologic conditions. It was further stated that as a project develops from this phase to the preliminary design stage and to site specific geotechnical exploration, the estimates may be correspondingly reviewed and the level of contingency allowance reduced. As Reiley *et al.* (1994:5) asserts:

> "*The base cost should be broadly complete, although still subject to refinement, and potentially growth, as the design becomes better understood and more developed"*.

Evans and Peck (2008) equally noted that although engineering definition may not be sufficiently developed at the conceptual phase, there was a need for more a more rigorous approach to cost estimation at the conceptual phase. As such a recommendation for producing reliable conceptual cost estimates, that can be used for making long term project decisions, was suggested:

> *"Preliminary estimates must be underpinned by a combination of sufficient investigation and definition, preliminary design of key elements to ensure constructability, expert knowledge to advise on the design, definition and construction, comparison with benchmark costs, appropriate risk and contingency allowances and a rigorous review" (*Evans and Peck, 2008:19)

Further emphasis was placed more on getting the right information at the right time, necessary to get the project scope defined to the best possible degree at conceptual phase:

> "*The more effort that goes into getting the parts of base estimate correct means less effort that has to be made to assess, and less reliance placed on, the contingency allowance*" (Evans and Peck, 2008: 41)

Evans and Peck (2008) illustrated three scenarios of project cost performance: An ideal project; an acceptable project; and an unacceptable project. The ideal project was defined as one in which the final cost coincides with the conceptual cost without reliance on contingency allowance. The acceptable project was defined as a project whose final outturn cost does not exceed the sum of the initial projected cost and contingency allowance.

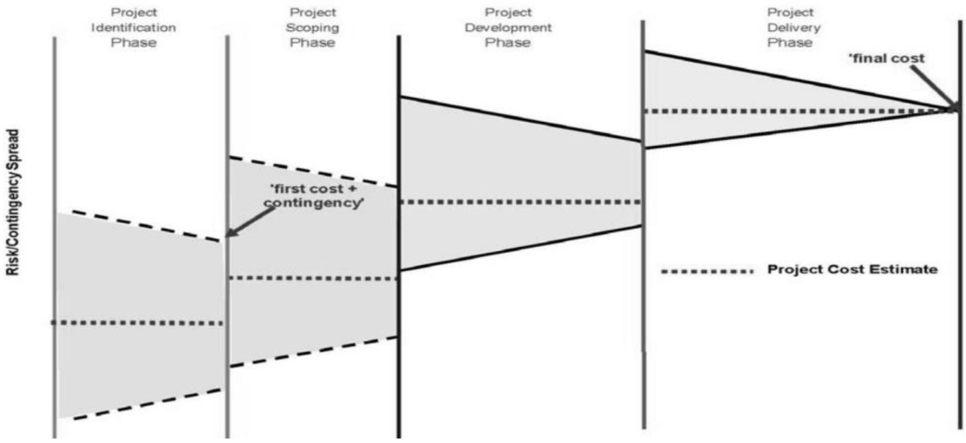


Figure 6.4: Cost growth in Project Phases **Source: Evans and Peck (2008)**

An unacceptable project was defined as a project whose final cost far exceeds the initial cost plus the contingency allowance as shown in in Figure 6.4. Evans and Peck (2008) noted regrettably that this last project scenario, was however the common trend in highway projects, and attributed this to the approach used in generating the initial estimates.

6.6 Geotechnical Pathogens in Detailed Designs and Estimates

Detailed estimates are prepared at later stages of projects, often before the contractual phase, when all project details and cost data previously not adequately defined at the conceptual stage are available. Turouchy *et al. (*2001) opined that each successive phase of the project life cycle is more influential as the focus narrows on the amount each project will cost with a corresponding reduction in contingency allowance (Figure 6.5).

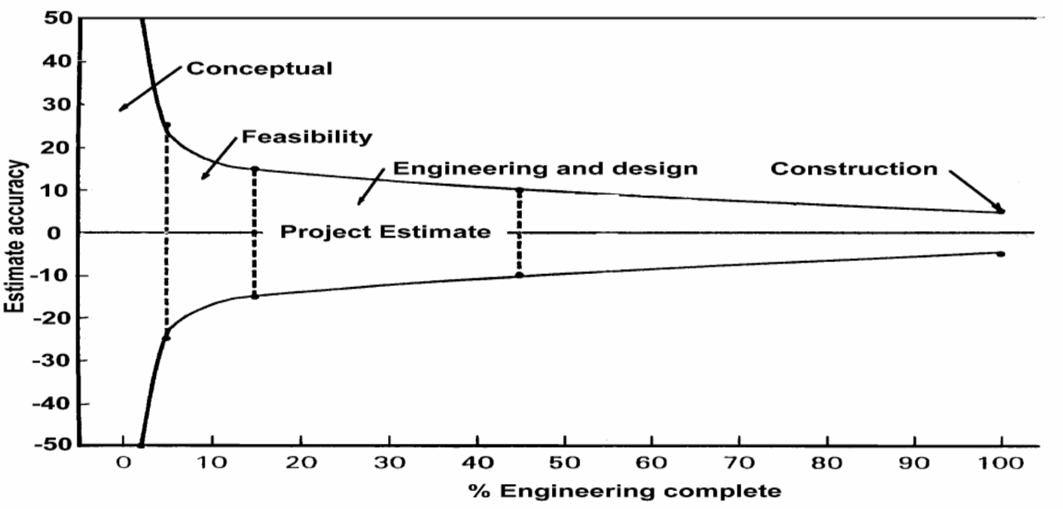


Figure 6.5: Typical Bounds of Estimate Accuracy Source: Schexnayder *et al.* (2003)

Schexnayder *et al.* (2003) thus stated that subsequent estimates are made throughout project design as continuing checks on cost expectations, and the confidence intervals decline to where the final definitive estimate is expected to be very close (plus or minus 5 per cent) to actual project costs and that the estimates are symmetrically distributed around the actual costs as shown in Figure 6.5.

Detailed design estimates are typically prepared by breaking down work into the lowest level of detail, (Level 4 Rate Build-up of the WBS) that comprehensively captures all cost components, before a contract is awarded and construction commences (DOE, 2011)). Detailed design estimates ideally should cater for all major cost contributors and financial risk factors in the project (GAO, 2009). It is thus an underlying basic assumption that the cost estimate prepared by clients at the detailed design phase is an accurate predictor for future costs of a project, having taking into consideration, condition of the ground at the proposed site, with the Institution of Civil Engineers (1991) publishing several articles on this theme. It is therefore logical that at this point of detailed estimating, that the cost implication of ground related risk in projects, recognized to be a major cost driver, particularly in transportation projects, has been adequately established.

Reiley *et al.* (2004:20) in their discussion of the Cost Estimate Validation Process (CEVP), developed for the Washington Department of Transport emphasized that:

> "*Every project is unique, particularly in the geotechnical uncertainties and risks to which its eventual "cost to complete" will be subjected, as it goes through the stages of concept design, preliminary design, detailed design, bidding and construction".*

Reiley *et al. (*2004) further stated that an investment in the gathering of additional design information can change the understanding of a risk. Typically, a comprehensive geotechnical investigation in this regard, was noted as a useful avenue of relevant information that can serve to confirm that a geotechnical risk, perceived at the initial project conceptualisation phase, is active and therefore constitutes a basis for preparing detailed designs, and its quantification in estimates.

Ashton (1997) as well as the Institution of Civil Engineers (1991), stressed the need to accommodate geotechnical risk in designs, to avert the likely series of ground related problems, which will carry significant financial connotation. This is particularly important for road works which basically entail modifying the natural ground structure (sub-grade) to create motorable conditions for vehicles via the construction of pavements (Bell, 2007). Consequently, it can be deduced that defining the geotechnical properties of the ground, in sufficient detail and accuracy, is of vital importance in the preparation of highway designs and cost estimation, as unanticipated poor sub-grade can undermine the overall financial performance of a highway project. This is because the properties of the ground are not known and its behaviour is not one that is uniform, but rather differs over distances and with depth (Coduto, 2007). Ground related risks therefore can only be unravelled through detailed investigation, which should be carried out prior to the award of contract. The planned execution of ground investigation is a means for reducing ground related uncertainty, both in designs and during construction (ICE, 1999). To this end, the level of ground investigation carried out prior to the estimation of costs, necessary to reveal subsurface conditions, and which should adequately capture the geotechnical properties of sub-soils, is of crucial importance.

The general objective of a ground investigation is to assess the suitability of a site for a specific purpose (Bell, 2007). As such, it involves exploring the ground conditions at and below the surface (Anon, 1999). It is thus a prerequisite standard for the successful and economic design of highways, recommended by various construction institutes, professional associations and international standards:

- Institution of Civil Engineers (ICE);
- Construction Industry Research and Information Association (CIRIA);
- Association of Geotechnical and Geo-Environmental Specialists (AGS);
- British Standards Institution (BSI);
- Transport and Road Research Laboratory(TRRL);
- American Society of Civil Engineers (ASCE).

Accordingly, a site investigation should attempt to foresee and provide against technical and financial difficulties that may arise during construction because of ground and/or other local conditions (Ashton, 1997). A site investigation as stipulated by best practice should consist of three stages, namely a desk study, a preliminary reconnaissance and a site exploration. These are discussed in further detail in the subsequent sections.

6.6.1 Desk Study

Bell (2007:231) stated that a desk study is undertaken in order to make an initial assessment of the ground and to identify, if possible, any potential geotechnical problems.

> "*A desk study is the collation and review of information already available about a site, and is carried out at an early stage of site appraisal to inform and guide the remainder of the site investigation*".

The desk study can thus be described as phase-1 of a site investigation process (AGS, 2003; Bell, 2007). Rys and Wood (1986) opined that for road works, valuable information can be obtained from desk studies at low cost, but insufficient attention is often given to this phase of ground investigation, which should be a routine exercise before the commencement of detailed exploration. The British Standard Institute (1999) in their Code of Practice for Site Investigations, BS 5930 recommends that:

> *"To obtain best value from a site investigation, it is essential to carry out a desk study as the first stage of a site investigation".*

Requisites for any comprehensive desk study should therefore include an investigation of geology, geomorphology, aerial photographs and archival data (Bell, 2007). This should form background information before the actual ground investigation. Bell (2007) further stated that topographical and geological maps are particularly useful in planning and design of route ways. As such available archival records, literature, maps, imagery and photographs relevant to the proposed site is relevant to ascertain a general picture of the existing geological conditions prior to a field investigation (Bell, 2007).

According to the ICE (2001:3) literature and map surveys may save time and thereby reduce the cost of the site investigation programme:

> *"Without a desk study the site investigation may be little more than a random search for data, so that the usefulness of the investigation may be jeopardised if the desk study is omitted"*.

The Institution of Civil Engineers (1999) explained that from a client's perspective, best value can be obtained through desk studies by minimising the risk of unforeseen ground conditions, which might cause increased costs and/or lengthy equally costly delays in programme.

6.6.2 Preliminary Reconnaissance

The preliminary reconnaissance involves a walk over the site and its surrounds based on visual inspection. Bell (2007) underscored the need for the inspection not to be restricted to the site but extended to adjacent areas to assess their potential impact on the proposed construction. Although some authors such as Clayton (1995) regard preliminary reconnaissance as part of a desk study, others including Bell (2007) have identified it as a distinguishable phase in ground investigations. Clayton (1995) explained that a desk study report would be expected to equally incorporate the results of the walk-over survey. However, Bell (2007) stated that a walk-over survey is carried out after a desk study, and before the detailed ground investigation, the primary objective being to confirm information gathered from a desk study and collect additional information about a site. The Institution of Civil Engineers (2001) equally, stated that the preliminary reconnaissance allows a check to be made on any conclusions reached in the desk study.

According to Clayton (2001) the importance of the preliminary reconnaissance is that it assesses the suitability of the site for the proposed works, a basis upon which the detailed ground exploration is planned. Bell (2007) outlined that, although the fundamental information to be gathered in a preliminary reconnaissance depends on the nature of the site and proposed project, typical features such as the distribution of the soil and rock types present, the relief of the ground, the surface drainage and associated features should be noted. Limiting ground investigations to this preliminary visual site inspection phase, is one of the critical issues suspected as prevailing in the practices of highway agencies in the Niger Delta, which would likely increase the probability of encountering unexpected ground conditions and lead to cost overruns. This would thus be investigated as one of the potential cost drivers to cost overruns in the fieldwork.

6.6.3 Detailed Ground Exploration

Geotechnical uncertainty is always high before a comprehensive site investigation is completed (Aston and Gidado, 2001). The aim of a detailed ground exploration is to try to determine and thereby understand the nature of the ground conditions on site and those of its surroundings (Clayton *et al.,* 1996). The site exploration must be concluded by a report embodying the findings, which can be used for design and contract documentation purposes (DRMB, 2006). Such report, called a 'Ground investigation report', according to Bell (2007) should contain geological plans of the site with accompanying sections, thereby conveying a 3D picture of the subsurface strata. It should also report on the rock and soil types, which should be described using internationally recognised engineering soil classification standards, such as the USC and the AASHTO systems. Furthermore, geomorphologic conditions, hydro-geological conditions, borehole and field-test information should all be recorded on geotechnical maps (Bell, 2007).

It was further clarified that the extent to which this stage of a site investigation is carried, depends upon the size and nature of the construction operation. Ashton (1997) opined that in most construction works, where the level of geotechnical risk is not particularly high, routine investigations carried out by experienced personnel may suffice. However, with high risk geologic settings with poor ground conditions, more sophisticated analytical geotechnical investigation techniques may be required (DRMB, 2006). This directly reflects the ideally higher levels of site investigation requirements, implicit in the high risk wetland terrain of the Niger Delta region, characterised by difficult expansive soils, analysed in chapter Five.

The literature, based on an analysis of expenditure on ground investigations, however shows that clients are rarely willing to expend adequate funds on procuring detailed or more sophisticated ground investigations (ICE, 1991; Alhabyl and Peacock, 1992; Paul *et al.,* 2002; Albatal *et al.,* 2010). This trend is suspected as one of the fundamental geotechnical shortcoming of highway project delivery in the Niger Delta. The ICE (1999) thus emphasized that a desk study and preliminary reconnaissance should not be regarded as an alternative to detailed ground exploration for a construction project. Clayton *et al. (*1995:38) contradicts this stance by opining that:

> *"The desk study and walk-over survey are the two essential components of ground investigations. Other parts (such as boring, drilling, and testing) may sometimes be omitted, but these parts of site investigation must always be carried out*".

These contradictory stances in the literature may thus imply that this critical phase of ground investigation may be overlooked, leading to significantly high cost overruns that could have being prevented (Institution of Civil Engineers, 1999).

Several authors (Clayton, 2001; Paul *et al.,* 2002; Albatal *et al.,* 2010) have also noted that the cost of site investigations in relation to the total project cost is small. Typical values in roads are

0.20 to 1.50 per cent of total project cost were revealed by Albatal *et al. (*2010), in a study in which it was recommended that site investigation should proceed until the ground conditions are well established to generate safe designs and construction. The Institution of Civil Engineers (1991) stated that expenditure on ground investigation was often accorded a low priority by clients, and often procured based on *'minimum cost and maximum speed'*, which increases the risk of poor quality design. The Institution of Civil Engineers (1991) emphasized that most investigations, typically procured on this minimalistic basis, fail to present an accurate account of the ground conditions, which in effect accounts for significant levels of cost overruns. Clayton (2001) in an empirical study found a direct positive relationship between expenditure on site investigations and the level of cost overruns experienced in projects. (In Figure 6.6).

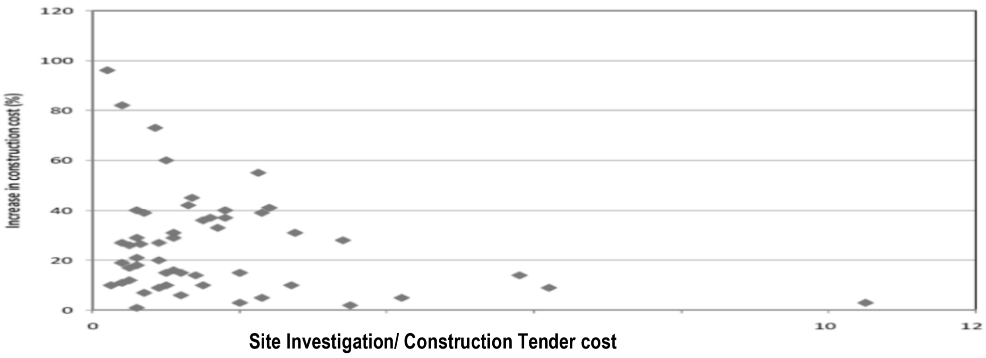


Figure 6.6: Association between Expenditure on Site investigations and Cost overruns

Source: Clayton (2001)

This implication of this finding is that higher investments in ground investigations would yield correspondingly lower cost overruns. Cathie (2000:1) in alignment with Clayton (2001) consequently stated that: "*Spending money on geotechnical investigations and engineering is like a good insurance policy*". The Institution of Civil Engineers (1991) attested that expenditure on ground investigation was low and that this increases the risk of cost overruns in civil engineering projects.

Peacock and Whyte (1992) used data from a case study to model risks associated with inadequate ground investigation as a demonstration of the level of project financial uncertainty. The study quantified the benefits and returns to the client, of quality of site investigation work on a scale of 1-5, and computed the effect of ground condition uncertainty (ranging from a residual level of 20% corresponding to the highest quality of investigations) on the estimated project cost and duration. The findings based on simulations revealed that for a very good quality site investigation work at level 5, the project would experience a negligible 0-2 weeks' delay, while for a poor quality investigation at level 1, delays of up to 14 weeks were possible. This corresponds to a 15% and 85% respectively for earthworks and 4% and 20% of the total project cost.

There however exists no clear benchmark on spending on site investigation works as a proportion of the overall contract sum of a project, with various views expressed in the literature. The National Economic Development Office (1988:8) thus recommended that in any particular case: "*A balance should be struck between the substantial cost of an exhaustive site investigation, and the risk of extra cost and delay arising from an inadequate one.* Whereas, the Institution of Civil Engineers (1991) advocated that clients should be persuaded to have site investigation undertaken for every site, with an adequate cost margin provided.

The literature thus hinges the accuracy of detailed design estimates, on the quality of ground investigations carried out. Carrying out comprehensive and accurate ground investigations, is evidently a critical decisive factor, which can result in significant cost overruns, particularly under poor ground conditions, such as in the deltaic setting of the case study area. Adequate ground investigations can thus be inferred as a worthwhile medium of ensuring geotechnical input in detailed estimates, a lack of which can serve as a stimulus, triggering cost overruns in the geologic context of the Niger Delta. The researcher equally notes the argument in the literature, surrounding the financial justification for the high expenditure requisite for detailed ground investigation, as opposed to preliminary desk studies and site reconnaissance. The potential impact that this perception may have on the design practices of highway agencies in the Niger Delta will thus be further explored in the subsequent field work.

6.7 Geotechnical Input as a Financial Risk Containment Strategy in Tender Estimates

At the contractual phase of highway projects, the tender price forwarded by contractors, is fundamentally determined by the level of 'knowns' about a project (Moleenar *et al*., 2006). The literature establishes the importance of making fully known, the level and types of risks associated with any project, so that inconsistencies on the basis of computing the tender figure do not arise (DRMB, 2006; Moleenar *et al.,* 2006). Achieving realistic tender estimates is necessary to avoid costly disputes and delays, which can affect the ability of the project to be completed under budgeted cost (Wong, 2012).

The literature on geotechnical risk containment in highway contracts, provided in this section, is thus closely linked to the dynamics of game signalling and risk aversion by clients and contractors, theorised by Ganuza (2003) and Cantarelli *et al.* (2013), as a pervasive culture of most infrastructure projects. In recognition of this intricate dynamics inherent in transportation projects, Moleenar *et al*. (2006:31) stated:

> *"The contract is a vehicle for risk allocation ... it defines the roles and responsibilities for risks. Risk allocation in any contract affects cost, time, quality, and the potential for disputes, delays, and claims. In fact, contractual misallocation of risk has been found to be a leading cause of construction disputes.*

The subsequent sub-sections therefore emphasize the contractual perspective to geotechnical input in highway project estimates: In contract documentation and contractor selection, and how the dynamics of geotechnical risk aversion and the strategic behaviour of both parties to a contract has important implications for the accuracy of the client's final outturn cost. The issues, bordering on the containment of ground related risk and how this creates a propensity for cost overruns, are however discussed in relation to the two popularly adopted procurement systems: Traditional versus Design and Build.

6.7.1 Geotechnical Pathogens in Traditionally Procured Highway Projects

Risk management in construction projects, aim to minimise the total cost of potential risk on a project (Rahman and Kumaraswamy, 2001). A fundamental principle of risk sharing in construction projects, recommended in the Groove Report (1998: 23), '*the allocation of risk to the party most suited to manage it*', was noted and discussed by both Moleenar *et al.* (2006) and Romero and Stolz (2009) in respect of geotechnical risks inherent in highway projects. Moleenar *et al.* (2006) asserted that clients, were in the best position to assume responsibility for ground related risks, as indicated in Table 6.4 via geotechnical investigations and contract clauses.

Table 6.4: Risk Allocation Matrix for Highway Projects

Risk	Party recommended to assume risk	Medium of Risk Management
Site access	Owner	Advanced Planning
Methods of construction	Contractor	Specific Contract Clause
Site conditions	***Owner***	***Geotechnical Investigations; Contract Clauses.***
Weather/Acts of God	Shared (Owner assumes delay risk; contractor assumes financial risk).	Contract Clause

(Source: Moleenar *et al.,* 2006)

Romero and Stolz (2009) equally took the same stance that, Ground Investigation Reports and the various contractual clauses which are included for highway projects, serve as risk allocation measures. Typically, O' Toole (2006) discussed the use of a '*Differing Site Conditions (DSC) clause'*, the implication of which is that, in the event of encountering a subsurface condition different from that which was indicated in the contract, the owner bears the additional cost for executing the work under such conditions. The efficacy of how these measures serve to optimally allocate geotechnical risk and therefore avoid costly disputes, largely lies with the client and how the contract is packaged (O' Toole, 2006).

The contractual packaging, in relation to whether a ground investigation report for the proposed site is included by the client as part of the contract documentation, is the key feature of contracts around which hinges the magnitude of risks borne by both parties to a contract (Moleenar *et al.,* 2006). The inclusion or exclusion of geotechnical investigation reports determines the level of risk borne by the contractor. Consequently, Romero and Stolz (2009:8) was of the view that:

> "*The types of risk allocation measures, or the lack thereof, have a profound influence on a contractor's decision whether to bid for a project and the amount of contingency placed in a bid for risk".*

Several authors (Geddes, 1985; Smith, 1986; Tah *et al.,* 1994) have thus identified the containment of risks in contracts, as a major factor driving the estimation basis of contractors. Where ground investigation reports are included, the literature states that a significant reduction in the level of bids received is noticeable (Geddes, 1985; O' Toole, 2006; Romero and Stolz, 2009; Wong, 2012). This reduction in the level of bids received by clients, was attributed to the reduction in the level of risk borne by the contractors relating to ground conditions, and therefore the level of contingency that is included in the bids tendered. Geddes (1985:2) remarking on this stated that:

> "*Although including ground investigation reports, and as such adding a differing site condition clause to a construction contract, introduces some uncertainty for an owner regarding the ultimate cost of a project. This uncertainty, however, may be offset by lower bids from contractors who will not have to account for unknown conditions by including contingencies in their bids"*.

A note of caution is, however, sounded by O' Toole (2006), who raises valid concerns about the accuracy and representativeness of ground investigation reports, suggesting that where incomplete or inaccurate reports are used as a basis of financial and risk assessments by contractors, the client faces significant financial risk due to contractual change events resulting from report inaccuracies. Supporting this view, Wong (2010) identified two common arguments often raised by contractors when faced with the unforeseen ground conditions during the progress of works. Firstly, whether a ground investigation report was included as part of the contract documentation, and secondly whether the report provided, was truly representative of the physical conditions of site.

In the event that a ground investigation report was included as part of the contract, and was subsequently found not to be representative of the ground conditions experienced during construction, this can provide sufficient basis for claims and variations to arise in a contract. As a result, case law related to construction projects, is rife with cases where the core argument revolves around the issue of non-representative ground investigation reports. For example, the landmark case of *E. H. Morrill Co. versus. State of California,* is both a classic example of one such dispute, and the underpinning case law used by contractors wishing to challenge the employer's ground investigation report. The client in this case had tried to avoid the liability for unknown or unforeseen site conditions by incorporating '*Disclaimers and Exculpatory Clauses*', which as the literature shows, do not often hold up to detailed legal scrutiny in the final judgement (O'Toole, 2006).

6.7.2 The 'Differing Site Condition'(DSC) Clause Debate, as a Geotechnical Trigger to Cost Overruns

The Institution of Civil Engineers (1991) argue that, since it is the client that bears most of the geotechnical risk, they stand to benefit the most from carrying out detailed ground investigations, including adequate and representative ground investigation reports along with DSC clauses in contracts. This stance is equally corroborated by the fundamental basis of the enactment of the DSC clause in engineering contracts, as analysed by O'Toole, (2006: 5):

- *"The owner is best able to assess and avoid risks relating to ground conditions;*
- *The owner has time for detailed investigations, and benefits from them by using the information to refine the design;*
- *The owner employs engineers to research the project and draw the plans who get unlimited access to the site.*

On the other hand, it was rationalised that:

- *A contractor at the tender phase is under time pressure to submit his bid and therefore has limited time and access to the job site.*
- *A contractor bids on many jobs, but is awarded few and as such money spent on investigations can only be recouped on the projects awarded to the contractor. Contractors on this basis cannot afford to carry out more than a cursory investigation.*
- *The contractor is bound to rely upon experience and the information provided with the bidding documents".*

Clients would thus only have to resort to the use of DSC clauses, which would mean paying for those conditions that could not have been revealed in detailed investigations, archetypally expressed in the form of '*Unforeseen Ground Conditions*' or a type-1 DSC (ICE, 1991).

Different internationally recognised standard forms of contracts and regulations thus have various adaptations of a DSC clause: The ICE form of engineering contracts (1991); The FIDIC Red and Yellow Books (1999), The American Federal Acquisition Regulations (2005). Even the most recent, newly released version of the Engineers' Joint Contract Documents Committee (2016) contracts prepared as a joint document between The American Council of Engineering Companies (ACEC), The National Society of Professional Engineers (NSPE) and The American Society of Civil Engineers Institute (ASCE), contains adaptations of the differing site condition clause.

The 7th Edition of the ICE Standard Form of Engineering Contract: Clauses 11 and 12, later replaced by the suite of New Engineering Contract (NEC) forms (1993, 2001, 2005, 2013), focuses on the theme of managing ground risks. Typically, Clause 12 of the 7th Edition of the ICE Form states:

> "*If during execution of the Works the Contractor encounter physical conditions (other than weather conditions or conditions due to weather conditions) or artificial obstructions which conditions or obstructions he consider could not reasonably have been foreseen by an experienced contractor…he shall give notice to the Engineer…*"

The ICE Form of contract was intended to rationally share the risk on ground conditions between the employer and the contractor, as a basis of fostering adequate management of ground risks in engineering and construction contracts (Wong, 2012).

The FIDIC Red Book (1999) focuses on client designed projects, while the FIDIC Yellow Book (1999) focuses on contractor designed projects. Clause Clause 4.10 -12, of the FIDIC Red Book, centers on three main themes: Information on sub-surface conditions and inspection of site; Interpretation by the contractor; and physical conditions revealed during contract execution. Typically, Clause 4.10 of the FIDIC Red Book (1999) stipulates:

> *"The Employer shall have available to the contractor for his information, prior to the Base Date, all relevant data in the Employer's possession on sub-surface and hydrological conditions at the Site, including environmental aspects. The Employer shall similarly make available to the Contractor all such data which come into the Employer's possession after the Base Date. The Contractor shall be responsible for interpreting all such data".*

Clause 4.11 focuses on the interpretation and accuracy of the data, stating:

> *"The Contractor shall be deemed to: (a) have satisfied himself as to the correctness and sufficiency of the Accepted Contract Amount, (b) have based the Accepted Contract Amount on the data, interpretations, necessary information, inspections, examinations and satisfaction as to all relevant matters referred to in Sub-Clause 4.10"*

Wong (2012) interpretation of this requirement was thus that: Employer's obligation to provide information does not end after the tender submission, and that contractors are responsible only to the extent of interpreting the data furnished. Clause 4.12 however, focuses on the physical conditions, which come to light upon commencement of the contract, with the stipulation that the risk of physical conditions established as unforeseeable by an experienced contractor at the date of tender, is borne by the client, similar to Clause 12 of the ICE form.

However, some other forms of contracts used in different countries adopt common law position. Typical wordings contained in JCT forms of contract (1999), used by the Nigerian Federal Government, states:

> "*…the Contractor shall be deemed to have visited the site and satisfied himself that he has allowed in his price for everything necessary for the completion of the Works*".

Similarly, Clause 13(1) of the Hong Kong Government General Conditions of Contract (GCC) for civil engineering or building works states:

> "*The Contractor shall be deemed to have examined and inspected the Site and its surroundings and to have satisfied himself, before submitting his Tender... as regards the nature of the ground and sub-soil, the form and nature of the Site... the nature of the work and materials necessary for the execution of the Works… and generally to have obtained his own information on all matters affecting his Tender and the execution of the Works."*

Others, even within the jurisdiction of the countries which adopt the requirement of differing Site Condition clauses, have resorted to including 'Site Inspection Clauses' stipulating that contractors carry out all requisite inspections, typically worded as:

> *"The contractor further covenants and warrants that he has had sufficient time to . . . examine the site of the project to determine the character of the subsurface materials and conditions to be encountered; that he is fully aware and knows of the character of the subsurface materials and conditions to be encountered; that he has compared the actual site conditions with those reflected in the contract documents; . . . and that no additional compensation will be paid as a result of unforeseen site conditions" (O'Toole, 2006;7).*

The preceding arguments indicate a divergence between best practices, as some highway agencies tow the latter, and try to transfer the risk associated with the ground conditions to contractors in their misguided notion of ensuring certainty of final outturn cost (Harrison, 1981; Geddes, 1985; Chan and Au, 2007). As such adequate containment of risks due to potentially undetected ground conditions, requisite for contractors to prepare their estimates, may be missing from such contracts. Contractors thus have to rely on guesswork to project estimates, which are forwarded in bids. Remarking on this scenario, as a financial gamble by clients, Chan and Au (2007:3) opined that:

> "*The owner risks tragedy, first, from cost-cutting measures the contractor will take if it hits unforeseen conditions, and then, from fighting contractor claims and picking up the pieces if the contractor abandons the project or goes bankrupt*".

The geotechnical risk allocation measures deployed by highway agencies in contract documentation, during bid solicitation constitutes a latent pathogen in highway projects, and would thus be established in the field work, as a basis of ascertaining if this scenario plays out to trigger cost overruns in the context of highway delivery in the Niger Delta.

6.7.3 Geotechnical Pathogens in Design and Build Contracts

The literature in the preceding section has identified insufficient data on ground conditions, and poor geotechnical risk measures in contracts, as potentially one of the main causes of failures in traditional Design-Bid-Build (DBB) projects, which fundamentally increases technical and financial risks at the post-contract phase. Ashton and Gidado (2001) noting this, attributed the spiral upward increase in the adoption of Design and Build (DB) contracts, to clients seeking to allocate and identify one point of responsibility for all design and construction risks. Franks (1994) distinguished the traditional DBB procurement system from the DB system based on the liability for the supply and flow of ground investigation information. Figure 6.7 shows the contractual relationship with respect to geotechnical information flow for both contract types.

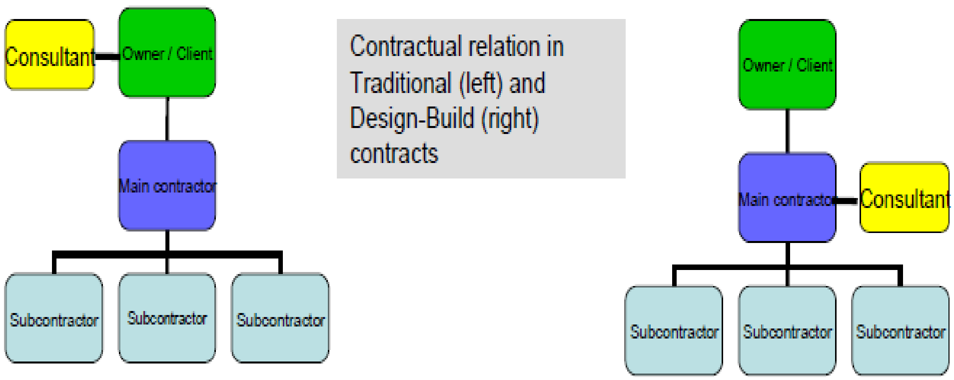


Figure 6.7: Geotechnical Information Flow for Traditional/Design and Build

Source: (Tolla and Valkeisenmäki, 2012)

It is shown in Figure 6.7 that under the traditional system of procurement, the client takes the position of the party providing the ground investigation information, while in DB systems, it is the contractor's prerogative. Findings of an empirical study conducted by Tolla and Valkeisenmäki (2012) on ground investigations practices for DB road projects executed by the Finnish Traffic Agency, evidenced that the level of availability and utilisation of ground investigations in sampled road projects was in most cases classified as 'just satisfactory'. Additionally, the research also suggested that ground investigations were often poorly utilised by contractors at the initial phase of highway procurement.

According to Franks (1994), the contractor in the DB contract, bears the sole liability for any consequences of proceeding with the work based on inadequate ground investigation. Based on the findings of Ashton and Gidado's (2001) empirical study, it was revealed that 78% of the Design and Build contractors employed the services of external structural or geotechnical consultants for the development of designs work. Whilst 95% of those contractors, further stated that the appointment of such a specialist is done only after the award of the contract. The contractors surveyed justified this approach, by arguing that the expensive nature of the tendering process, together with a need to cut tendering overheads often prevented them commissioning geotechnical specialists. It was thus opined by Clayton (2001) that often inadequate information, 'is made do with'. Ashton and Gidado (2001: 964) however, remarked on the implications of this for clients by querying:

> *"Having committed to a fixed contract sum, it begs the question, is 'best practice' and therefore 'best value' achieved from geotechnical specialists when such an important appointment is made following the commitment to an outline planning design*?"

Ashton and Gidado (2001) thus described this as a flawed system of geotechnical input, since the changes and refinement of designs should logically flow from the initial planning stage.

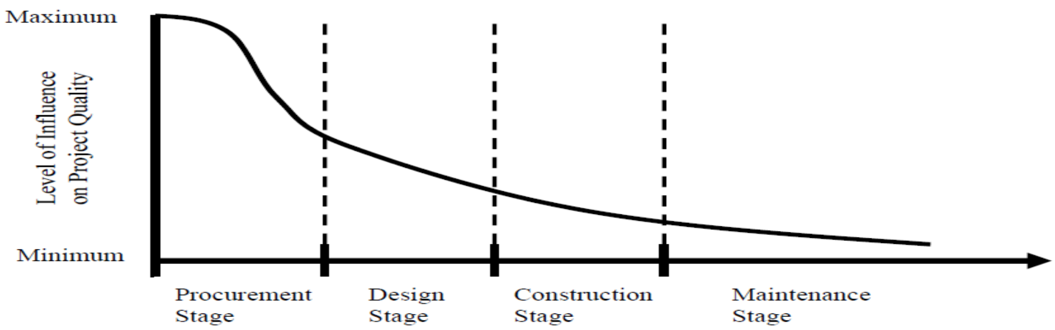


Figure 6.8: Impact of Geotechnical Information on Designs in Highway Project Phases

Source: (Gransberg and Gad, 2014)

As Grasberg and Gad (2014:20) illustrate in Figure 6.8:

> *"The impact of the quality of geotechnical information on designs is predominantly defined at the earlier stages of highway project development and rapidly dwindles in subsequent phases".*

Tolla, and Valkeisenmäki (2012) equally corroborated this by asserting that detailed geotechnical information on ground conditions was necessary baseline data for the award of design and build contracts.

6.7.4 Geotechnical Pathogens in Contractor Selection

A key underlying feature, implicit in the successful execution of a highway contract, is the efficiency of the contractor. The selection of a contractor has thus been emphasized in the literature (Holt *et al.,* 1995; Crowley and Hancher, 1995), as a risk variable to which utmost consideration should be given during the procurement phase, as it has significant connotation to undermine meeting project performance objectives of cost, quality and time. Holt *et al.* (1995) thus distinguished between the lowest initial bid and the most competitive/viable price for a project under an existing investment climate. This is against the misguided notion of clients often opting to award contracts on a lowest bidder basis, at the risk of incurring significant cost overruns due to contractor's incompetence (Crowley and Hancher, 1995; Akon, 2011).

The need for an informed unbiased appraisal of contractors' technical capabilities relative to bid price has thus resulted in the development of multi-parameter quantitative models for contractor selection (Gransberg and Gad, 2014). Gransberg and Gad (2014) asserted that comprehensive quantitative approaches to contractor selection require the assignment of relative weighting of critical geotechnical factors, aggregated in making a decision on the winning bid. Gransberg and Gad (2014:967) further stated:

> *"it is during the development of the RFQ [Request for Qualifications] and RFP [Request for Proposals] that the ultimate quality and cost of the project can be most influenced"*

Gad (2014) explained that in the United States, during this phase, the inclusion criteria of the project RFQ or RFP, is however established based on state laws or published DB procurement guides of the highway agency, and not just on a project specific basis. The findings of Gransberg and Gad (2014) study revealed the various approaches adopted by US highway agencies, in DB projects. These are shown in Table 6.5.

Table 6.5: Geotechnical Input Approaches in DB Contractor Selection

Highway Agency	Approach
Minnesota DOT	Higher scoring weights Bonus scoring for exceeding minimum requirements;
UDOT	Heavier emphasis on the technical aspects via a 50/50 cost/technical weighting.
Delaware	Submission of a narrative outlining the various geotechnical risks and proposed method of construction
Maine DOT	Superior scores in geotechnical category
Minnesota	5-year warranty for geotechnical failure on a pass/fail basis
Florida	20 points awarded for quality of design and ground Investigations plan and minimization of design changes

Source: Gransberg and Gad (2014)

As can be discerned from the various methods adopted by highway agencies, geotechnical input is ensured either on the basis of the weightings or extra scores in the technical proposal. The geotechnical input weightings or scores are also noted as proportionate to its magnitude of impact in specific project contexts. Minimal geotechnical requirements relative to other factors may thus be necessitated under routine construction work in better ground conditions, with higher requirements in more complex projects or in adverse difficult ground conditions. This higher geotechnical input requirement for difficult ground conditions thus has particular bearing in the context of highway project delivery in the study area, due to its wetland geologic setting.

The underling computational techniques, adopted by the highway agencies in choosing a winning contractor, were based on averaged price and technical scores following a 3-step procedure outlined by Gransberg and Gad (2014):

- Appraisal of contractors' qualifications and past experience: specific geotechnical qualifications for key personnel; geotechnical project experience; references from past projects with specific geotechnical issues; and proof of local geotechnical project experience.
- Evaluation of contractors' technical proposal;
- Deployment of a defined algorithm: A function of technical/financial evaluation

Subjectivity in the process of contractor selection was therefore eliminated by the explicitness of the procedure. Increased emphasis on geotechnical input requirements in the RFQ or RFP were considered an incentive to competing contractors bidding for the contract. Geotechnical factors weighting therefore need to be assigned proportionately to other factors in the award decision for the successful contractor.

The qualitative/quantitative mechanism deployed to ensure that geotechnical requirements are incorporated into contractor selection decision, therefore represents another potential geotechnical pathogen at the contractual phase of highway projects, a lack of which can trigger calamitous financial consequences on projects. The practices of highway agencies in the Niger Delta, in the process of contractor selection, investigated as part of the fieldwork, thus follows this logic.

6.8 Post-Contract Implications of Triggering Geotechnical Pathogens

The preceding literature has evaluated the contractual impacts of lack of geotechnical input, by weighing the arguments posed by various authors and standards of best practice, implicit in the lack of geotechnical input in highway projects. It has been shown that a 'whole can of worms' can erupt if adequate geotechnical risk containment measures are not taken. As such, if risks are not properly shared or managed through the various mediums of geotechnical input outlined, particularly at the contractual phase, variations, claims and disputes may be some of the post contract consequences. The subsequent sections explore the mechanism by which claims and variations from geotechnical issues, often arise in highway contracts, leading to cost overruns.

6.8.1 Variations

A variation can be defined as any deviation from an agreed well-defined scope/schedule, or any modification to the contractual guidance, provided to the contractor by the owner or owner's representative (O'Brien, 1998; Arain and Pheng, 2005). The total cost of a project can therefore significantly differ from the initial estimated cost, due to variations occasioned by changes in scope of work, specifications, or any other contract documents, with several negative effects to both the client and the contractor (Halwatura and Ranasinghe, 2013).

Chan and Yeung (1995) were of the view that the more the variation orders are on a project, the greater the likelihood that they become time consuming and costly elements in construction projects. The authors opined that when a variation order occurs, the contractor tends to charge higher rates for the variation items. Other authors have also noted the adverse implication of variation orders in contracts and their impact on project performance, in terms of the level of cost and time overrun often elicited (Mansfield *et al.,* 1994; Odeck, 2004; Kaliba *et al.,* 2008, Halwatura and Ranasinghe, 2013). As illustrated in Figure 6.9, the ability to make a non-disruptive change in projects decreases correspondingly in response to the advancement of project.

Figure 6.9: Cost Impact of Variations in Projects with Project Advancement (CIOB, 1997)

Recognising the potential impact of change orders in contracts, due to variations, is the first and most fundamental step to minimising their negative potential financial impact (CIOB, 1997). During the early phases of projects, such changes could be easily accommodated without adversely affecting the projects viability or its ability to be completed in time and under budget. However, a similar change made at the latter phases such as after contract award, during construction could lead to significant financial losses, due to the requisite changes in designs and construction work on site.

Variations, leading to cost overruns in highway contracts, have been attributed to a number of factors, notable among them being unforeseen ground conditions, due to lack of, or inadequate ground investigation. Halwatura and Ranasinghe (2013) identified poor designs without recognising ground conditions, as the main cause of variation orders in the road construction industry in Sri Lanka. Similarly, Perera (2009) identified variations elicited due to unforeseen site ground in an empirical study of Sri-Lankan road projects. Perera (2009) explained that due to differing weaker sub-grade and unexpected high water table, the use of rock fill and additional depth of excavations were often required. Wu *et al*. (2005) identified the most significant cause of design variations in Taiwan highway projects, based on statistical and case study analysis of several projects, as being mostly due to the disparity in the engineering properties of road subgrade used in preparing designs, and those encountered on site. Therefore, several unanticipated site conditions may crop up in the construction phase, leading to unnecessary, avoidable and irrecoverable delays, which often elicit disproportionate increases in the cost required to correct design inadequacies (Chan and Yeung, 1995). The adequacy of initial feasibility studies and approach to managing geological concerns at the design stage, were thus emphasised as necessary to prevent design variations.

A contrary stance was however adopted by the National Economic Development Office (1988); in stating that variations due to unexpected site or soil conditions may be unavoidable. Justin (2012) backed up this stance and thus categorised contractual risks due to ground conditions as 'foreseeable', 'unforeseen', and 'unforeseeable'. The distinction between these adjectival descriptions were made, by defining foreseeable ground risks as those that can be reasonably anticipated, while unforeseen risks are those that were unanticipated due to incompleteness or short comings in the investigations. Unforeseeable risks on the other hand, were defined as those risks that cannot be eliminated, and are therefore beyond the contractors control, regardless of the level of experience on his part or how much ground investigation is undertaken. Wong (2012) however asserted that although ground investigation reports cannot disclose all details, it can to a great extent, reduce the likely ground related risks to clients and be of use for dispute resolution in contracts.

6.8.2 Claims

A contract claim is a written demand submitted by the contractor in compliance with the contract documents, and seeking additional monetary compensation, time, and/or other adjustments to the contract, the entitlement or impact of which is disputed by the client (Thompson and Perry, 1992). It has been argued that adequate contractual provisions will ensure the right allocation of risks in the event of adverse events during construction (Thompson and Perry, 1992). Construction contract documents thus include provisions for altering plans, including additional work within the original scope, changed site conditions, and extending contract time to address unanticipated conditions encountered in the field during construction, via contractual clauses.

Disputes however may occur due to unclear stipulations, on the basis of the fairness of the risk allocation mechanism (Wong, 2012). The school of thought which emphasizes that that '*all the risks should rightfully reside with the owner, and therefore transfer to another party should entail fair compensation*', has led to claims from contractors (Kartam and Kartam, 2001: 329). This is because, responsibility for increases in cost and time that may occur, is an important factor for the contractor when preparing bid estimates, and any upward deviation could lead to losses. As such, if geotechnical risks are not properly shared or managed through the various mediums of geotechnical risk containment outlined earlier, claims and disputes may be some of the consequences during the construction. This is because contractors may only add contingencies to their tenders to cover the costs of foreseeable risks. Figure 6.9 captures the contractor's perspective in bidding for projects, on an ill-informed geotechnical basis, and the likely consequent contractual impacts of this gamble on project delivery.

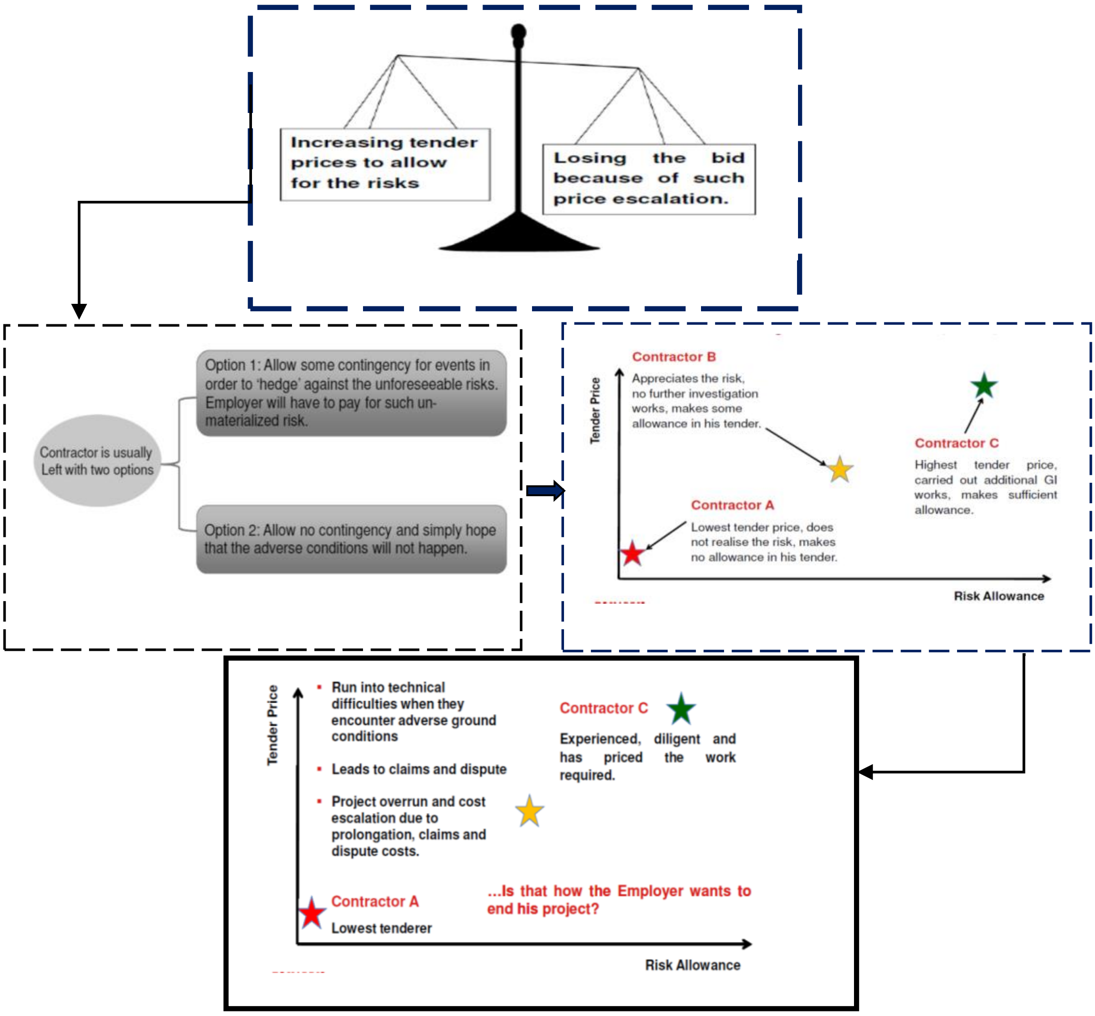


Figure 6.9: Contractual Impact of Lack of GI on Highway Project Delivery

(Source: Wong, 2012)

This illustrates the likely consequences for highway agencies, if the dictates of best practice for managing geotechnical risks are not adhered to, in their contractual practices. The ensuing delays will invariably lead to the deferment of usage or income/returns on capital invested in the highway project. Crowley and Hancher (1995) rationalised that the implied *ex-post* transaction costs, expended on dispute resolution and litigation, can accumulate to disproportionate dimensions. Crowley and Hancher (1995) cited figures as high as 2.8% of the annual administration costs for the Texas Department of Transportation, were expended on account of construction claims filed against the agency.

The Grove Report (1998: 22) targeted to address fundamental contractual concerns plaguing the Hong Kong construction industry, further reinforces this contractual scenario, in asserting that "*Contractors who are gamble and claim artists will predominate among winners of contract award*". The well-publicised Latham Report (1994) which was prepared to address key issues in the UK construction industry, also underscored that, the nature of contracting arrangements inherent in the construction industry, creates a significant propensity for disputes, which erodes the potential for added value for funds invested in construction. Latham (1994:12) thus asserted that "*Risk cannot be eliminated; it can only be transferred, reduced or shared*". In the absence of adequate geotechnical input in contracts, the literature asserts that contractors will ultimately seek to transfer the cost of such uncertainty to the client. On this basis, the Groove Report (1998: 27) recommends that "… *Risk is best borne by the party who gains the long term benefit of the project, namely the employer*…", which is further re-stated in the recommendation of the Latham Report (1994:15), "… *Risk should be allocated to the party best suited to manage that risk*..."

Based on these assertions, and following the arguments in the literature, a direct financial implication of inadequate designs due to limited ground investigations, inflexible contract clauses/weak documentation and poor contractor selection criteria, is the notable trend of claims, illustrated in Figure 6.9. It is has further being rigorously argued, that the client ultimately stands to bear the financial loss associated with a lack of geotechnical risk containment in estimates, as a result of the ensuing project delays leading to cost overruns or even outright abandonment by contractors. This trend of negative contractual impacts has been evidenced by the local literature, to be rife in the delivery of highway projects executed in the Niger Delta. The practices of the highway agencies responsible for the delivery of such projects, are thus investigated in the subsequent field work, for the prevalence of underlying geotechnical pathogens.

6.9 Conceptual Model

The exploratory analysis of the technical literature has revealed various geotechnical pathogens, latent at the conceptual, detailed design, and contractual phases of highway projects. The presence of these geotechnical pathogens in highway projects, have implications for the accuracy of initial budgeted funds, detailed design estimates, contractor's tender estimates and final outturn cost of project, as captured in the conceptual model, shown in Figure 6.10.

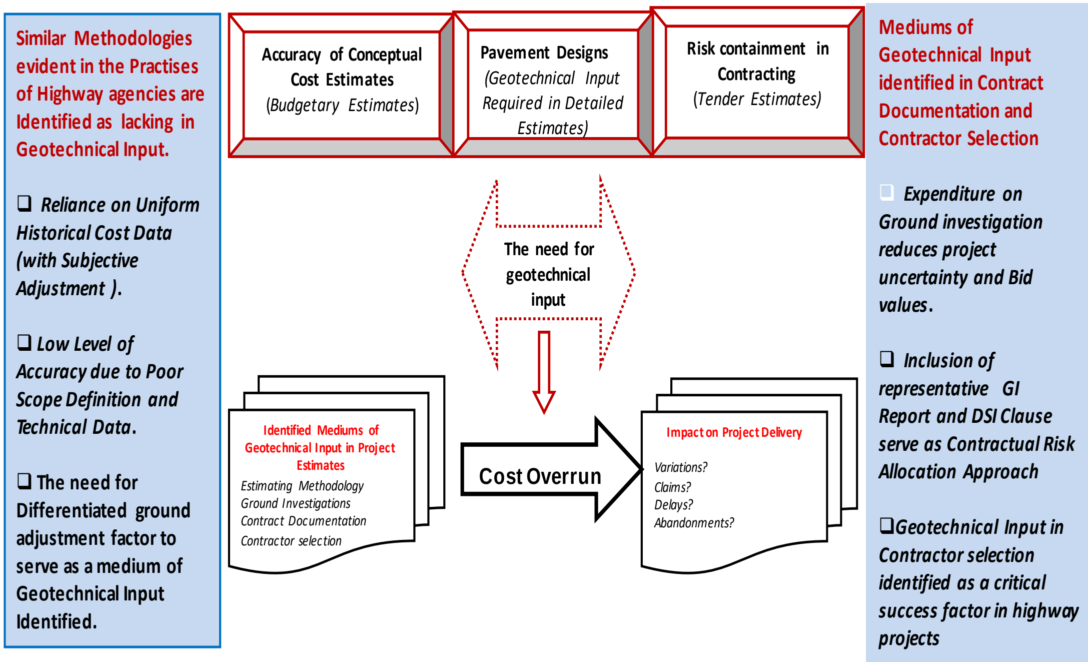


Figure 6.10: Conceptual Model of Geotechnical Pathogens

As Figure 6.10 illustrates, the various mediums of geotechnical input in the literature, recommended as best practices for clients of highway projects at the pre-contract phases, necessary for clients of highway projects to avert cost overruns, can thus be deduced as the:

- Use of differentiated costing profiles as opposed to uniform historical rates at the conceptual phase of budget preparation;
- Carrying out adequate levels of ground investigations: Desk studies; preliminary reconnaissance; and detailed explorations, as a basis of preparing designs and computing detailed estimates;
- Inclusion of Ground Investigation Reports (GIR) in contract documentation with provision for Differing Site Condition (DSC) clauses;
- Mechanism deployed to ensure an adequate geotechnical basis in contractor selection criteria.

The researcher thus uses the findings from this exploratory literature analysis of geotechnical best practices, as a logical theoretical perspective, necessary to understand cost overruns experienced in the delivery of highway projects in the Niger Delta. The findings thus serve as a prelude to the descriptive phase of the study in chapter eight, which thematically analyses the prevailing levels of geotechnical input in highway projects executed by the highway agencies in the region. The identified mediums of geotechnical input at the pre-contract phases of highway projects, conceptualised in Figure 6.10, thus served as a guide in drafting the interview template. The field work was thus structured to specifically investigate: the technical details of how funds budgeted for proposed highway projects are estimated; what levels of ground investigations are carried out as a basis for designs; and the modalities of contractor selection/contract documentation.

6.10 Chapter Summary

The literature analysis in this chapter has explicitly illuminated geotechnical best practices, which represents the various progressive mediums of risk containment in highway projects, at the conceptual costing phase of budget estimate computation, detailed estimate preparation phase and contractual phase. A lack of which represents potential pathogens in highway projects. The findings have thus revealed how the myriad of issues arising from mismanaged geotechnical risks at the pre-contract phase, can trigger a series of claims and variations, leading to significant levels of cost overruns at the post contract phase. This scenario played out in this chapter, is tested in the case of the Niger Delta, by investigating the geotechnical practises of the three highway agencies responsible for the delivery of the sample of highway projects, previously analysed in chapter five of this thesis. Chapter seven of this thesis, however, is a prelude to the presentation of the interview analysis results, setting out the background information on the highway organisations investigated, and further providing a detailed breakdown of the analytical procedure used to analyse the collated qualitative data from the fieldwork.

CHAPTER 7

Background to Interview Analysis: Organisational Context, Respondent Demographics and Qualitative Analytic Procedure

7.0 Introduction

This chapter sets out and discusses the contextual background to the interview analysis, by providing a description of the three highway organisations sampled, the demographics of the interviewees, and the detailed procedures used for coding and analysing the interviews. To introduce each of the highway organisations, the organisational structure of each highway agency has been prepared, from a combination of preliminary information provided by respondents, and published government reports. The institutional context of the three highway agencies in the Niger Delta was further provided, to serve as a backdrop to understanding the intrinsic geo-political dynamics inherent in highway development in the Niger Delta. Relevant, descriptive, and more specific background information on the spatial extent of the geographic boundaries, which define the constitutional obligations and duties of the highway agencies are also laid out. The demographics of the respondents interviewed is discussed, before a detailed description of the coding procedure used in developing the themes from the interview data is provided.

7.1 Background Reports on Highway Agencies

None of the highway organisations had a definite organogram, it therefore became necessary for the researcher to draft them. As such information were elicited from the respondents, on the hierarchy of authority, job designations, and intra-organisational processes, in relation to cost estimation, design preparations, and procurement functions, for road projects executed by the highway agencies. In addition, related published background information on each organisation, was obtained from the websites and the grey literature, published by each of the agencies. Based on the information gathered, the researcher diagrammatically captured the relevant sub-divisions of the highway agencies as organisational charts. The level of detailing in the organisational charts reflects the requisite data used as a basis of describing related functions and processes. As a result, details considered not to be fundamental to the analysis have been left at a generic level.

7.2 The Niger Delta Development Commission (NDDC)

7.2.1 Institutional Background

The Niger Delta Development Commission (NDDC) was established in 2000 by the Federal Government based on the Niger Delta Regional Development Master Plan (NRDMP) draft master plan for the region, whose implementation was estimated to cost US$2.9 billion over a fifteen-year period (NDDC Act, 2000). The commission was setup to prepare a 'Niger Delta Regional Development Master Plan' (NDRMP) designed on a long-term basis to integrate the different intervening agencies and tiers of government. NDDC is a regional interventionist developmental body in the Niger Delta whose delegated mandate includes the development of social and physical infrastructure, ecological/environmental remediation and human development across all the nine states that now constitute the political Niger Delta, as listed in Table 7.1 (NRDMP, 2006).

The constitutional mandate of the NDDC is thus supplemental, as the traditional three-tier structure of highway development in Nigeria: Federal; State and Local Government, discussed in chapter two, was considered inadequate to cater for the developmental needs of the region (NDDC Act, 2000). In the present democratic dispensation, the geo-political structure of highway development specifically in the Niger Delta, has being modified to feature family/clan representation with traditional leaders playing effective advisory roles within specific areas. Under the present arrangement, every community is headed by a chief or king, clusters of which form the council of chiefs, headed by an officially recognised traditional ruler (NRDMP, 2006).

The internal structures of communities, often living in clusters on the limited amount of dry land available in the region, are typically dichotomised on the basis of age group into youths and elders (NRDMP, 2006). The council of elders are constituted of elderly persons who are considered to have played active roles in fostering the development of the community, and thus act in an advisory capacity to the chief/traditional ruler. This council accorded a high status in the communities, make development decisions at the community level (NRDMP, 2006).

However, in recent times, youths baying for change have been increasingly challenging the status quo, owing to the perceived inaction of the elders with respect to securing anticipated communal benefits from government agencies and corporations operating within the communities (Oviasuyi and Uwadiae, 2010). Typically, the lack of internal community link roads in these remote and often isolated settlements, was a major contention of the youths, who have resorted to widely publicised violence and hostage taking in the bid to gain the attention of the government (The United States Institute of Peace, 2011).

As a result, the listed terms of reference of the NDDC specific to highway development included the:

- "*Formulation of policies and guidelines for the development of the Niger Delta area.*
- *Conception, planning and implementation, in accordance with set rules and regulations, of projects and programs for sustainable development of the Niger Delta area in the field of transportation including roads, jetties and waterways, health, employment, industrialization, agriculture and fisheries, housing and urban development, water supply, electricity and telecommunications.*
- *Surveying of the Niger Delta in order to ascertain measures necessary to promote its physical and socio-economic development*" (NDRMP, 2000: 45).

Highway development, typically the development of major roads (intra-regional and intra-state) and community roads (intra-Local Government Areas), constitute an integral part of the development projects embarked upon by the NDDC. Projects executed by the NDDC are carried out in liaison with the state and local governments.

From its inception in 2000 to 2005, the NDDC had initiated 2,035 physical development projects across the nine states constituting the '*Political Niger Delta*'. Table 7.1 shows the types and volume of major infrastructure stocks initiated by the NDDC in the different states of the region bases on the regional master plan.

Table 7.1: NDDC States and Volume of Infrastructure executed from 2000-2005

States	Buildings	Electrification	Roads	Jetties	Water Supply	Shore protection
Akwa Ibom	190	50	19	-	31	-
Abia	79	12	112	22	19	-
Bayelsa	147	10	15	3	41	7
Cross River	39	6	6	19	9	-
Edo	46	12	6	-	-	-
Delta	128	42	41	19	59	12
Imo	133	25	6	-	30	-
Ondo	179	27	2	19	35	=
Rivers	85	12	37	6	32	-

Source: (NDDC, 2006)

No comprehensive report outlining the current status of these projects is presently available. However, years of community protest and uproar over the abandonment of most of these projects have become a major cause of public concern (Vanguard, 2016). Respondents from the agency further revealed that to date, an additional 4000 projects have been initiated by the NDDC, most of which were delayed or abandoned at various levels of completion. This assertion was validated through both articles in the local and national press.

Due to this high spate of project delay and abandonment, a Presidential Projects Assessment Committee (PPAC) was set up in 2013 by the Federal Government to investigate cases of abandoned NDDC projects. Their report concluded there were 1,886 abandoned projects across the nine different states of the Niger Delta. Following the report's publication, the Managing Director and board of the (NDDC) jointly commissioned an extensive audit of all on-going and abandoned projects, awarded since the inception of the NDDC in 2000. The findings of this audit had unfortunately not being published at the time of writing this thesis. The emphasis of this research however, is limited to highway projects executed in Bayelsa and Rivers State, justified as the states which constitute the geologic Niger Delta, as earlier defined. Details of the highway projects proposed, under construction or abandoned in these states are presented in the chapter Eight.

7.2.2 Organisational Structure

Figure 7.1 shows the organisational hierarchy of the Niger Delta Development Commission (NDDC).

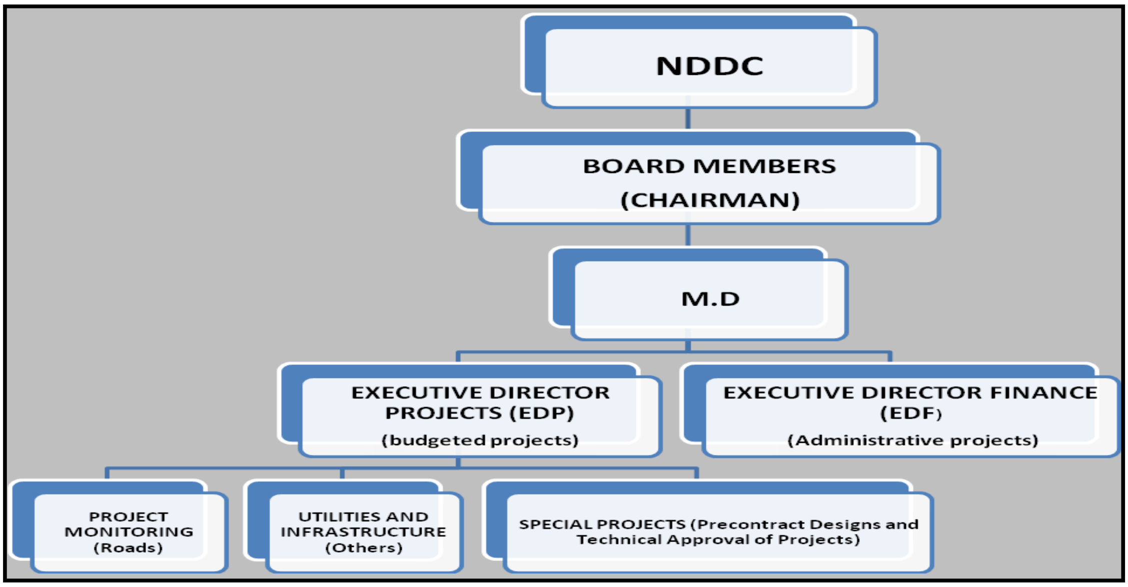


Figure 6.1: Organisational Structure (NDDC)

There are board members who vote and make strategic development decisions for the commission, and are direct representatives of the government. The board is comprised of representatives of the federal government and the nine oil producing states: Abia, Akwa-

Ibom, Bayelsa, Cross River, Delta, Edo, Imo, Ondo and Rivers., which make up the commission. The Chairman of the board heads the institutional structure.

The management staff of NDDC have the rank of the Managing Director at the apex and moves down the hierarchy to the Executive Directors: Finance/administration and Projects. The Executive Director Finance (EDF) operates in an administrative capacity and executes projects such as lower order roads that may be required to calm local community agitation and youth restiveness. The following directors report to the Executive Director Finance (EDF):

- Director of Finance and Supply;
- Director of Administration;
- Director of Legal Services;
- Director of Planning, Research and Statistics;
- Director of Education, Health and Social Services.;
- Director of Youth, Sports and Women Affairs.

The role of Executive Director Projects (EDP) is designated to be occupied by a qualified registered construction professional: An Architect; Quantity Surveyor or Engineer. The three departments headed by the Executive Director Projects include:

- **Special Projects**: This unit has registered professionals such as engineers, architects and quantity surveyors. The in-house engineers are responsible for the vetting and technical approval of the design of major road projects, while the architects vet building projects. The quantity surveyors cross-check quantities and cost elements in the bill of quantities prepared by consultants, as a basis for costing the proposed projects prior to budgetary approval;

- **Project monitoring**: This unit is responsible for post contract monitoring of awarded major road projects, via the use of consultants. As such the project monitoring department oversees the supervisory activities of the consultants charged with the responsibility for ensuring adherence by contractors to stipulated construction standards;

- **Utility, Infrastructural Development and Water Ways**: This unit is responsible for the execution of projects such as water purification, shore protection, building of schools etc.

They are also in charge of pre and post-contract management of other intercommunity road projects executed by the EDF. They also work with consultants for the post contract management of major projects.

7.3 The Rivers State Ministry of Works and Transport (RMWT)

7.3.1 Institutional Background

The Rivers State Ministry of Works is a state based highway agency, responsible for the development of Trunk B state roads in the urban and rural areas of the Rivers state. Rivers State is one of the 36 states of Nigeria, located in the southern parts and at the core of the Niger Delta. The state was formed in 1967, with the split of the Eastern Region of Nigeria. It occupied an area of 21,850 sq. Km, and until 1996 the state contained the area which is now Bayelsa State. It has a present geographic size of 10,077sq. Km and is bounded to the south by the Atlantic Ocean, to the North by the Anambra, Imo and Abia States, to the East by Akwa Ibom State and finally to the West by the Bayelsa and Delta States, as shown in Figure 7.2 (Iloeje, 1982).

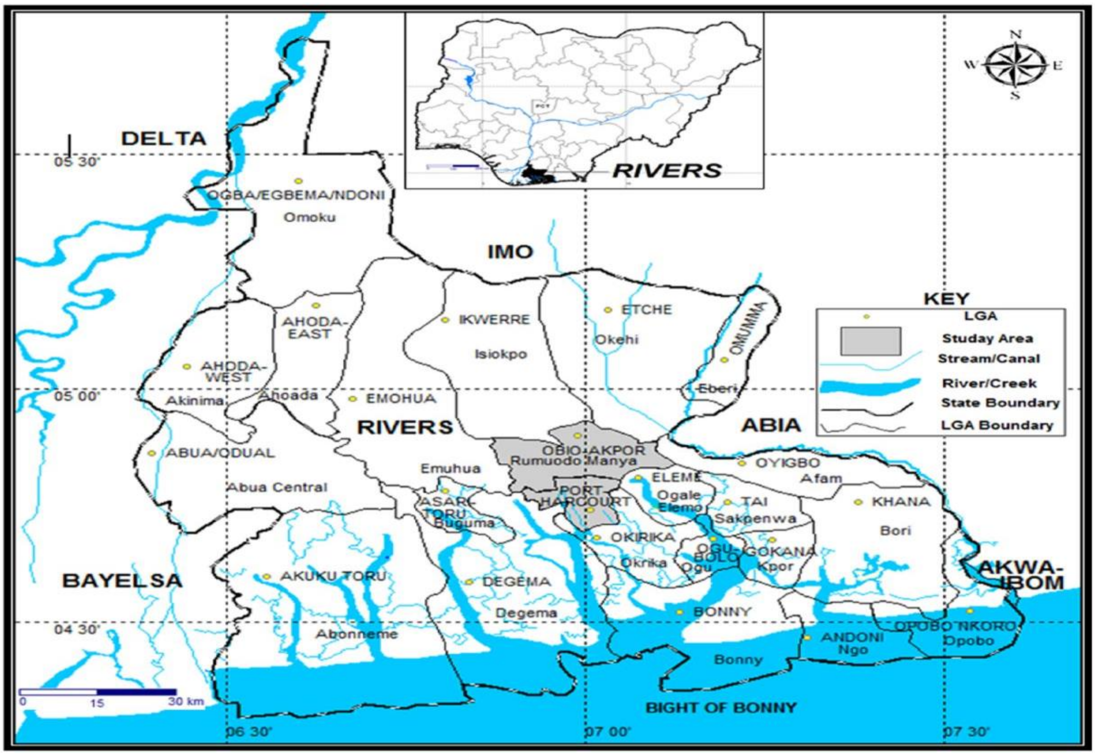


Figure 7.2: Map of Rivers State **Source: RMW (2014) Home page**

With two thirds of the state in the Niger Delta's water shed, the inland part of Rivers State consists of tropical rainforest which is of higher relief, and declining towards the coast as shown in Figure 7.3, where the typical river delta environment features dense mangrove swamps.

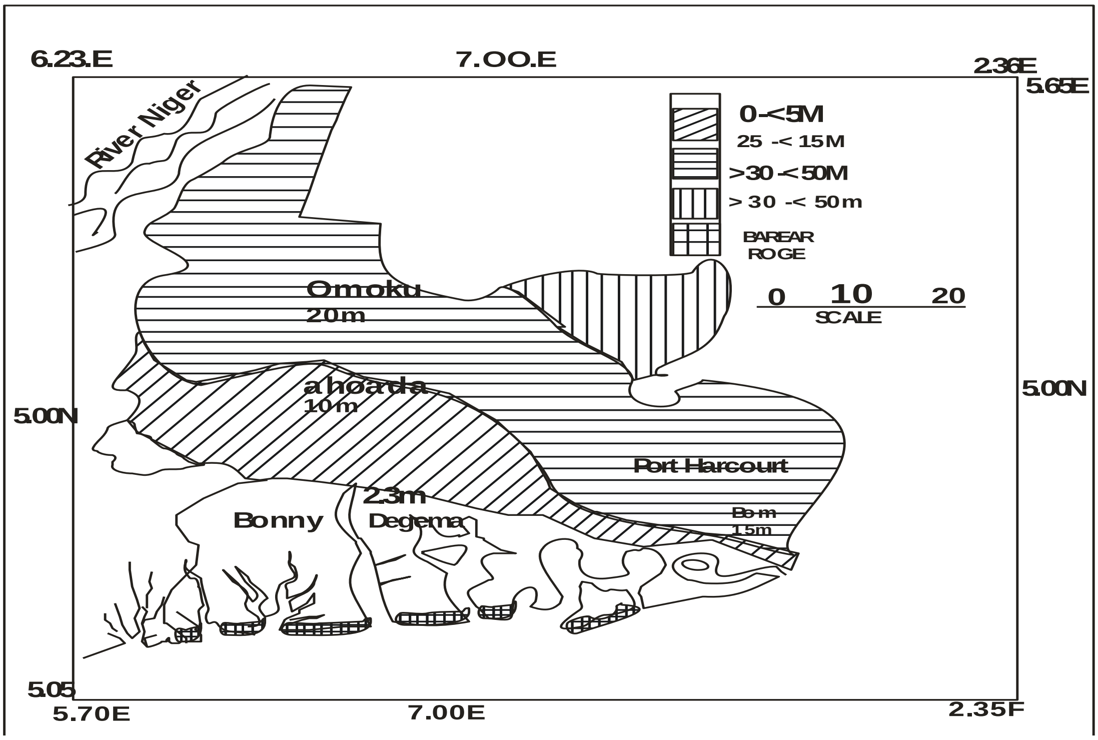


Figure 7.3: Map of Rivers State Showing Relief **Source: Aisubeugon (2006)**

As a result, sub-soils are predominantly made up of organic clays, silts and sand deposits. Rivers State as the name implies is one of the two states that comprise the core delta based on a geologic definition of the Niger Delta region of Nigeria. An aspect of the administrative structure of the federation, which is of importance to highway development in Rivers state, is the distribution of resources. Under section 16 of the 1999 constitution, all revenues of the Federation are paid into the federation account (Constitution of the Federal Republic of Nigeria. 1999). The criteria for the distribution of the funds in the federation is determined using factors such as terrain; population density; and ecological damage. These revenue is shared vertically among the tiers of government and horizontally among states. On this basis, Rivers State due to its wetland terrain and high population of 6,185,400 based on the 2006 census, occasioned by oil and gas exploration, unlike other states in the political Niger Delta, receives the highest revenue allocation for funds to be invested in highway development.

Administration of funds for highway development at the state level is vested in the elected Governor, who appoints a Commissioner to head the state's bureaucratic structure, referred to as the 'Civil Service' under the Rivers State Ministry of Works (RMW). The State House of Assembly, constituted of elected members, approves budgets for funds to be invested in highway development.

Rivers State is divided into twenty-three Local Government Areas (LGAs), as shown in Figure 7.4, which handle administration and construction of local government rural roads.

Figure 7.4: LGAs in Rivers State **Source: Rivers State Homepage (2014)**

Each LGA has an administrative capital for handling its developmental affairs, which is overseen by a constituted authority. At the Local Government level, elected chairmen resident in the administrative capitals, as listed in Table 7.2, and assisted by supervisory councillors who constitute the legislative arm, are responsible for the administration and approval of budgets for highway development.

Table 7.2: Local Government Areas in Rivers State

LGA Name	Area (km2)	Administrative capital
Port Harcourt	109	Port Harcourt
Obio-Akpor	260	Rumuokoro
Okrika	222	Okrika
Ogu/Bolo	89	Ogu
Eleme	138	Eleme
Tai	159	Sakpenwa
Gokana	126	Kpor
Khana	560	Bori
Oyigbo	248	Afam
Opobo/Nkoro	130	Opobo Town
Andoni	233	Ngo
Bonny	642	Bonny
Degema	1,011	Degema
Asari-Toru	113	Buguma
Akuku-Toru	1,443	Abonnema
Abua/Odual	704	Abua
Ahoada West	403	Akinima
Ahoada East	341	Ahoada
Ogba/Egbema/Ndoni	969	Omuku
Emohua	831	Emohua
Ikwerre	655	Isiokpo
Etche	805	Okehi
Omuma	170	Eberi

(Source: RMW, 2014)

7.3.2 Organisational Structure

The Rivers State Ministry of Works (RMW) is headed by the Commissioner for Works, as shown in Figure 7.5, who is appointed by the governor of the state. However, in the hierarchical structure of the agency, the permanent secretary is the functional head of administration. The Senior Director of Works, who occupies a professional and managerial role, works directly with the commissioner. He is one of the three directors responsible for the execution of highways and bridges, and whose role includes organising logistics during project supervision.

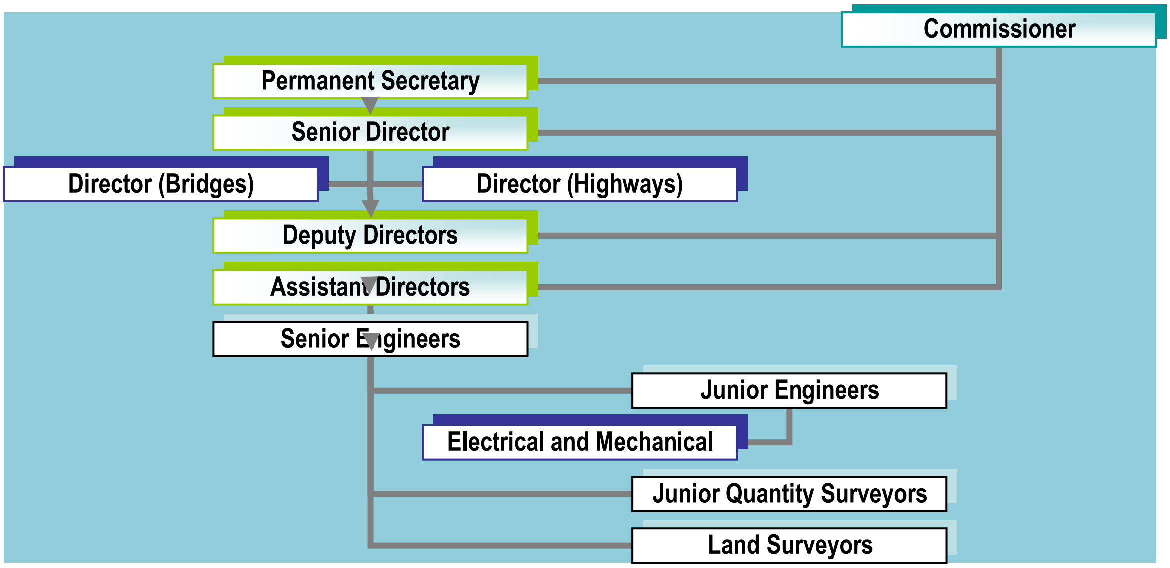


Figure 7.5: Organisational Structure- RMW

Further down the hierarchy are Deputy Directors and Assistant Directors, who work with the directors in a supportive role. However, with respect to professional roles involved in the management of projects, the Senior Civil Engineer is the head of all other professionals responsible for pre-contract preparation of proposed highway projects. As such operational level civil engineers and quantity surveyors work directly under the senior civil engineer, along with electrical/mechanical engineers and land surveyors.

7.4 Bayelsa State Ministry of Works and Infrastructure (BMWI)

7.4.1 Institutional Background

Bayelsa State was formerly part of the Eastern Region in the three-region structure of 1954. Following the creation of twelve states by the military government in 1967, Bayelsa state was part of Rivers State from which it was later carved out in 1996. It is thus one of the newest states of the Nigerian federation. Lying between latitude 4°45' north and longitude 6°05' east, Bayelsa State covers a geographical area of 9,415.8 square kilometres, a significant part (three-quarters) of which is covered in water (Aisubeugon, 1995).

Figure 7.6: Map of Bayelsa State **(Source: Bayelsa Home Page, 2015)**

Consequently, agricultural practices are very limited with the primary occupation of the local population being fishing, on a subsistence and commercial level amongst mainly rural dwellers. The state has a population of 1,704,515, based on the 2006 census figures with a population density of 158 people per square kilometre. As a result, the state accounts for only 1.2% of Nigeria's total population.

Figure 7.7: Bayelsa State showing Relief **Source: Online Nigeria Homepage (2014)**

Bayelsa has a predominantly riverine and estuarine setting lying below sea level, as depicted in Figure 7.8 in which dry land is sparse. This dictates the pattern of human settlement which is mostly located on patches of dry land, islands and levees.

Figure 7.8: Human Settlement in Bayelsa State   Source: Bayelsa-State Homepage (2104)

Bayelsa state is thus frequently described on this basis as:

> *"A floating settlement of villages and towns, amidst brackish swamps forming an intricate maze of water courses and highlands, regularly affected by the ebb and flow of tides"* (Ossai, 2012. P.23).

This has had a significant influence on the pattern of human life and economic activities in the state with the limited highlands which are relatively drier used as settlement sites for the major cities. Due to its peculiar terrain, characterised by extensive mangrove swamps, excessive rainfall, prolonged, disastrous floods, creek erosion, and lack of adequate transportation or other infrastructure, the state has an almost non-existent level of commerce. Despite the marshy nature of the soil and its implications for highway development, official reports published on the website of the Bayelsa State Ministry of Works and Infrastructure (BMWI) reveals the construction of:

- over 350 kilometres of completed road projects;
- 15 bridges;
- 2 flyovers;
- Dualisation of 18 roads in progress.

Plans for the award of contracts relating to the construction of fifteen internal roads in Yenagoa, the state capital, which is to be replicated in all eight Local Government headquarters of the state, are also said to in progress. The unusual volume of construction works going on in the state, was explained by respondents from the state highway agency, as being due to the significant developmental backlog still existing in the state as a result of decades of neglect from past successive government administrations on the premise of the difficulty of the terrain.

The Bayelsa State Ministry of Works and Infrastructure (BMWI) is one of the newest highway agencies in Nigeria. The BMWI is located in the state's administrative headquarters, Yenegoa, and is charged with the responsibility for highway development and other forms of physical infrastructure works in Bayelsa State. The institutional administrative and budgetary authorities for highway development is similar in structure to that of Rivers State. However, there are only eight local government areas (LGAs) in the state, as shown in Figure 7.9.

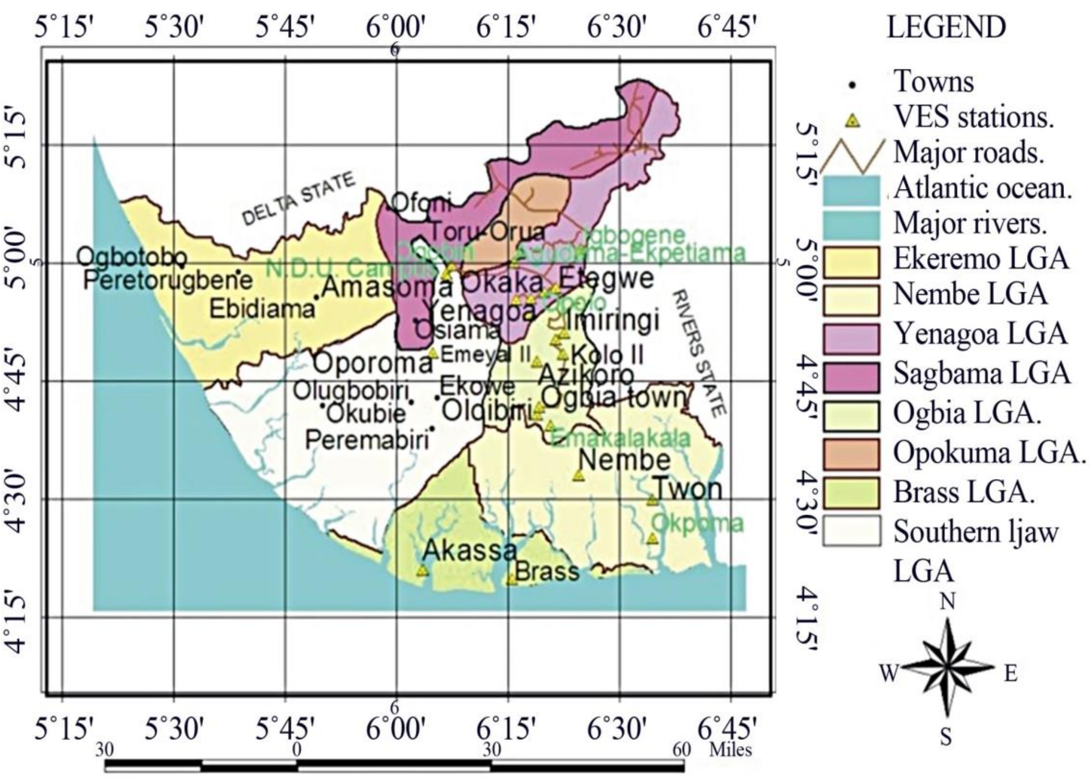


Figure 7.9: Map of Bayelsa State Showing LGA's Source: Nigeria Home Page (2015)

The chairmen of these LGA's are responsible for the construction of local government roads:

7.4.2 Organisational Structure

The Bayelsa State Ministry of Works like all other state highway agencies is headed by the commissioner for works who is appointed by the governor of the state. The permanent secretary is the functional head of administration, and works directly with the commissioner. The permanent secretary is supported by a team of directors who head each department. As shown in Figure 7.10, there are several departmental divisions, four of which are directly responsible for the execution of highway projects:

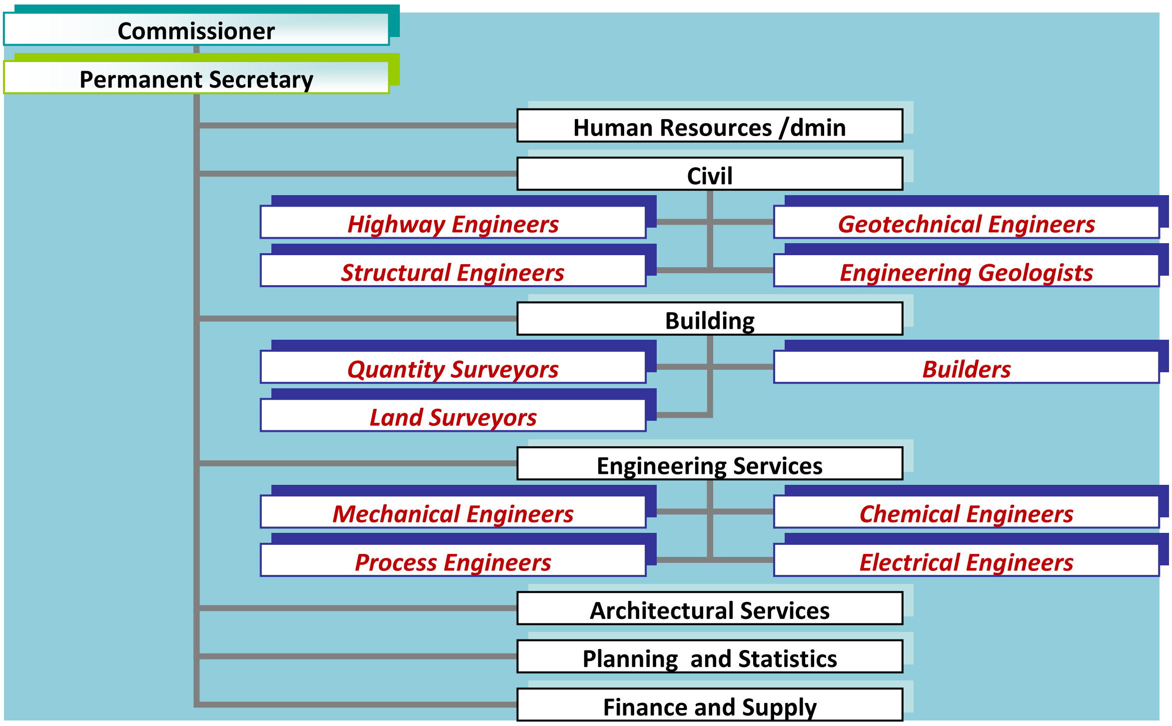


Figure 7.10: Organisational Structure – BMWI

- **Department of Civil Engineering Services:** The department of civil engineering services is responsible for the management of roads, bridges and other civil engineering structures. The department is also responsible for the design of community projects. Detailed designs for projects are prepared in-house, by the department's highway engineers, reflecting all relevant inputs from the related design professionals in the ministry: structural, geotechnical and mechanical engineers. Major road projects are, however, designed and monitored by consultants who are supervised by ministry staff.

- **Department of Engineering Services:** The Department of Engineering Services is responsible for the provision of all other engineering services in projects such as for mechanical and electrical works. Process and chemical engineers working under this department are also responsible for the management of inter-phasing professional project processes within the agency, and quality control in projects. As such, the services of the professionals working in the department of engineering services cuts, across all other project departments;

- **Department of Architectural Services:** This department is responsible for the design and management of building projects undertaken by the BMWI. The department comprises of a team of architects who are responsible for the management of other infrastructure projects such as hospitals, health centres and schools. The department of architectural services is also responsible for preparing designs for the agency's internal administrative building projects.

- **Department of Building Services:** The department of building is comprised of land surveyors, quantity surveyors and builders. The land surveyors prepare survey drawings for proposed project sites, after identification of projects, prior to the preparation of designs. Builders supervise the construction of internal administrative building projects, which are sourced in-house by the procurement department. Quantity surveyors in the ministry are responsible for costing projects and the preparation of contract documentation. However, their services under the agencies organisational process arrangement basically involves collating quantities and cost estimates from the related design professionals. Typically, mechanical engineers would quantify and estimate the cost of all mechanical services and forward these estimates to the quantity surveyor. Structural and electrical engineers would also do same for structural and electrical design components of projects. The quantity surveyor working in the building services department would then produce a contract estimate reflecting the inputs from these other departments.

7.5 Interview Participants

7.5.1 Demographics within the Organisational Structure of the Agencies

The preceding subsection has clarified the geo-political backgrounds and organisational structures of the highway agencies, and the related internal processes which define the prevailing design and costing practices of the professionals, to serve as a backdrop to the analysis. The distribution of respondent demographics within the highway agencies is thus predicated on their respective structures, which is further used as a basis of analysing the organisational setting in which professionals responsible for design, costing and award of highway projects, work.

Table 7.3 shows the distribution of professional roles within the organisational structures, in relation to job description. From Table 7.3, the total number of respondents (Quantity Surveyors and Civil Engineers) interviewed in the highway agencies is lower, as compared to the original twelve respondents proposed in the methodology. This was due to difficulties experienced in gaining access to members of the senior executive in the agencies, namely two Senior Civil Engineers in Rivers and Bayelsa State Ministries of Works respectively. However, this did not affect the reliability of findings, as the information sought was elicited from the junior civil engineers and cross-validated with responses from the quantity surveyors.

Table 7.3: Interview Response Rate

Cases	Management Staff		Operational Staff		
	Civil	***Q.S***	***Civil***	***Q.S***	***Total No.***
NDDC	1	1	1	1	4
RMW	-	1	1	1	3
BMW	-	1	1	1	3
Total	1	3	3	3	10

7.5.2 Demographics outside the Organisational Structure of the Agencies

The information provided from interviews conducted within the organisational settings of the highway agencies, was further complimented by information provided by external registered consultants and contractors, employed by the agencies but outside the organisational settings of the highway agencies. The level of experience and academic qualifications, necessary to provide the required technical information sought, was used by the researcher to adjudge the respondents' adequacy. The years of experience and qualifications for the registered consultants and contractors, are shown in Table 7.4.

Table 7.4: Respondents' Affiliations,Years of Experience and Qualfications

	Years of Experience				Qualification		
	0 –10	0 – 10	10 -15	15-25	Civ/Eng	Geo/Eng	Qty/Surv
Consultants			1	2	1	1	1
Contractors			2	1	-	-	3

7.5.2.1 Consultancy Firms Registered with the Highway Agencies

Two of the three interviewees from consultancy firms, working with the highway agencies stated that they had been with the firms for over 15 years, while one less experienced (10 - 15 years) consultant, had worked for other consultancy firms prior to joining the current firm. The respondent was thus able to recount experiences from other firms in relation to the questions asked, and not just from their work with the highway agency. Two of the three interviewees were design professionals (a highway engineer and a geotechnical engineer), while the third was a quantity surveyor. All the respondents had worked with contractors on design and build contracts procured by the highway agencies. This established their appropriateness to provide balanced answers to questions pertaining to the design and costing of highway projects.

7.5.2.2 *Road Contracting Firms Registered with the Highway Agencies*

Two of the three respondents interviewed were from medium sized firms, whilst the third was employed by one of the biggest and oldest construction firm in the region. The respondents were all experienced quantity surveyors. Two had worked with construction firms for between 10 to 15 years; whilst the third had over 15 years of experience. This was considered necessary to ensure the respondents had adequate professional experience to answer questions related to how they priced works for bids submitted to the highway agencies, during the contracting phase. Difficulties experienced by the researcher in negotiating access to the contractors, and the commercially sensitive information of their firms, were overcome with the help of respondents from the highway agencies. However, during the course of the interviews, the researcher had to repeatedly emphasize the academic nature of the exercise and the assurance of complete confidentiality and anonymity in reporting the study, as outlined in the ethical approval/informed consent documents (see Appendix B, C and D).

7.6 Interview Data

The responses of the participants' accounts on the design and costing practices in the highway organisations, consultancy firms and contracting firms were tape recorded. Full transcription of the taped interview conversations however was not made, rather notes taken from recorded taped conversation where used, and supplemented by relevant quotes (Bazeley, 2007). The notes were, however, taken in the context of the flow of the interview conversation based on the interview protocols, and not under predetermined headings, so as not to distort there intended meaning. This was considered sufficient to extract information on design and costing practices as a basis for assessing the prevailing level of geotechnical input at the development phases.

Whilst offering the added benefit of a much reduced, richer and denser body of data (Bazeley, 2007).

However, for interviews conducted over the internet, such recorded conversations were by implication not available and therefore for these specific interviews, were not used as a basis for making notes, but rather the typed online conversations were used with minimal editing. The bulk of text generated from these online sessions were more comprehensive than those generated from initial telephone interviews. This was attributed to the fact that by that stage of the fieldwork, a higher percentage of the interviews had been conducted, and the approach to presenting the interview questions by the researcher were more established, with less digression in the information provided by respondents.

7.6.1 Mode of Data Analysis

Analysis of textual data can be carried out manually or computer aided using appropriate qualitative software such as NVivo 8, MAXQDA, ATLAS and NUDIST, which have proliferated the field of qualitative research (King 2008). The advantage of using computer aided qualitative data analysis software (CAQDAS)

over manual analysis include: being freed from manual and clerical tasks; and time saving in managing significant amounts of qualitative data (Connor and Gibson, 2003). Also having increased flexibility, validity and editability of qualitative research are particular added advantages. Typically using this medium, the researcher was able to systematically trace and account for the various stages of data analysis, particularly at the coding phase. The use of NVivo 10 was the chosen as the option of analysis due to the relative familiarity, and ease of its use for the researcher, facilitated by the practical advanced training courses undertook on the software.

However, as opposed to completely using the NVivo 10 software, the analysis was initially started manually from hand written notes, prepared from the taped interview responses. The debates and concerns in the literature espoused by King (2008) over the issue of analytic distance in qualitative research, was fundamental to this choice of methodological mix. The researcher's experience during the analysis sustains the argument on the advantage of closeness to data enhanced by manual analysis of textual data, albeit the unsophistication and technologically disadvantaged nature of this technique.

The manual analysis of the notes prepared from the interviews, were carried out under predetermined themes derived from the literature review, with a clear outline of the criteria used in the analysis. This was considered necessary to clarify the presentation and provide structure and organisation to the significant amount of data. The researcher, upon conclusion of each interview, quickly scribbled down reflections on the responses, and before the taped conversation was transcribed verbatim into notes, ready for analysis. This enabled the researcher to get more intimate with the data, uncover subtleties, which lent further insights that enabled the more efficient conduct of subsequent interviews. As such between interviews, manual coding of the initial set themes commenced.

This is rationalised on the grounds of the limited number of similar interview questions asked of the various groups of respondents interviewed, which made the need for the complete deployment of the NVivo 10 software for the analysis, less practical. This was because the interview questions were drafted from different but converging perspectives, to accommodate for differences in respondents' professional roles and academic backgrounds. As such four sets of interview questions structured in non-revealing patterns were used to elicit information relevant to confirming the earlier stated gaps in knowledge, deduced from practices evident in the literature: These included different sets of interview questions for:

- Civil engineers from the highway agencies (5 Nr);
- Quantity surveyors from the highway agencies (5 Nr);
- Consultants registered with the highway agencies (3 Nr);
- Road Contractors (3 Nr).

On conclusion of all the interviews, all the researcher's notes and reflections had been written and coding of the initial themes had been manually concluded. Subsequent to this phase of the analysis, the notes were typed and imported from MS Word into the NVivo 10 software, a process, which was considered a fresh re-familiarisation with the data. However, at this point of the analysis, the researcher was solely seeking to uncover other themes which were emerging from the data. This two phase manual/CAQDAS coding process is considered a very vital aspect in the analysis process, as it made for clarity of purpose in the coding, and prevented the researcher from falling into the syndrome of 'over-coding' that often plagues the inefficient use of CAQDAS, as noted by King (2008).

The operational capabilities and visualisation features of the NVivo 10 software, enabled the researcher to explore the wealth of visual functions, such as graphical tools, cluster analysis tools, and modelling tools, which were used to richly enhance the analysis process. It thus afforded the researcher a medium of thoroughly exploring the data in different dimensions that were not easily discernible during the manual analysis. This facilitated the process of discovering key emerging trends and relationships in the data.

7.6.2 Respondents Anonymous Reference Codes

A worthy point of note in the reporting of the analysis of the interview data, is that the analysis was carried out in a manner necessary to retain a level of ambiguity as to the identity of the specific agencies was being discussed. This was considered adequate, since the specific identity of the agencies did not necessarily add more depth to the research or detract from its theoretical significance. The structure of the qualitative analysis chapters of this thesis: Chapter eight and nine, is a reflection of this consideration. The demands of maintaining anonymity of respondents thus informed the researcher's reflexive choice of later segregating and writing a distinct chapter (seven), as a background to the analysis, prior to the detailed analysis and discussion of the geotechnical and emergent themes, presented in chapters eight and nine respectively.

As such in the inferences, quotes and discussions, specific reference to the names of the agencies or the respondents was not made, rather codes were used to identify the specific respondents, in line with the ethical necessity of maintaining confidentiality and anonymity of respondents. In fulfilment of the ethical requirements of maintaining anonymity of respondents, the following reference codes were used in identifying respondents, giving an indication of their hierarchical organisational status, affiliation and professional background. This is set out in Table 7.5.

Table 7.5: Anonymous Reference Codes for Respondents

S/No	Interview Transcript	Reference Code
1	Highway Agency 1- Management Civil Engineer	HA1-MCV
2	Highway Agency 1- Operational Civil Engineer	HA1-OCV
3	Highway Agency 1- Management Quantity Surveyor	HA1-MQS
4	Highway Agency 1- Operational Quantity Surveyor	HA1-OQS
5	Highway Agency 2- Operational Civil Engineer	HA2-OCV
6	Highway Agency 2- Management Quantity Surveyor	HA2-MQS
7	Highway Agency 2- Operational Quantity Surveyor	HA2-OQS
8	Highway Agency 3- Operational Civil Engineer	HA3-OCV
9	Highway Agency 3- Management Quantity Surveyor	HA3-MQS
10	Highway Agency 3- Operational Quantity Surveyor	HA3-OQS
11	Highway Agency 1- Design Consultant	HA1-DC
12	Highway Agency 2- Design Consultant	HA2-DC
13	Highway Agency 3- Design Consultant	HA3-DC
14	Highway Agency 1- Road Contractor	HA1-RC
15	Highway Agency 2- Road Contractor	HA2-RC
16	Highway Agency 3- Road Contractor	HA3-RC

As such quotes from specific interviewees in the discussion, a basis on which inferences were made by the researcher in the analysis of the interview data, are referenced using the above codes.

7.7 Themes. Coding and Analytical Procedure

The approach adopted by the researcher in carrying out the interview analysis is a hybrid form of thematic and content analysis. Template analysis, which is a form of thematic analysis was used in defining the initial codes (King, 2004). The appropriateness of this qualitative methodology is justified on the basis of the geotechnical issues pre-conceived by the researcher, as the fundamental drivers of cost overruns in the Niger Delta region, due to its peculiar geologic setting. According to King (2004:21) when using template analysis:

> "… *the researcher produces a list of codes ('template') representing themes which will usually be defined a priori, but are modified and added to as the researcher reads and interprets the texts. The template is organized in a way which represents the relationships between themes, as defined by the researcher*".

King (2004) further buttressed the need for reflexivity in other to capture richness of the data in the descriptions of the codes. Reflexivity thus offered the added advantage of flexibility, afforded by the use of both deductive and inductive coding. Inductive analysis was thus carried out as the second phase of the analysis, following the deductive phase. The inductive phase, thus identified emergent themes which act to impact on the level of geotechnical input in highway projects. The following logical steps inspired by King (2004), were thus used in the deductive/inductive analysis of the interviews (Table 7.6).

Table 7.6: Qualitative Analytic Procedure used in this Thesis

	Qualitative Analysis	Stages	Description
1.	Deductive Thematic Analysis	Development of Template	Projection of conceptual mind map in relation to logical flow of geotechnical themes derived from the literature;
2.		Initial Read through	Air brush reading of the interview notes;
3.		Deductive A priori Coding	Sorting and categorising interview responses into apriori geotechnical themes
4.		Deductive Axial Coding	Discovering subthemes and patterns around the parent geotechnical themes
5.	Inductive Content Analysis	Second Read Through (Bottom-up reading)	Reading the interview notes afresh from a new perspective
6.		Inductive Micro Coding	Induce further micro themes related to and impacting on geotechnical themes
7.		Inductive Cluster analysis	Cluster analysis of induced micro themes into subthemes and emergent parent themes;
8.		Content analysis	Further content analysis of induced themes;
9.		Cognitive mapping	Conceptualisation of Cognitive map of interrelated geotechnical and emergent cost overrun drivers

7.7.1 Conceptual Projection of Template Coding Structure

The drafting of the interview template was carried out with the objective of ascertaining the suspected gaps in knowledge, presupposed as the existing cost overrun drivers in the practices of highway agencies. Following the conceptual model deduced from the literature in chapter six, Figure 7.11 shows the researcher's initial pre-conceived mind map which served to define logical flow of geotechnical themes in the thematic analysis of the interview notes.

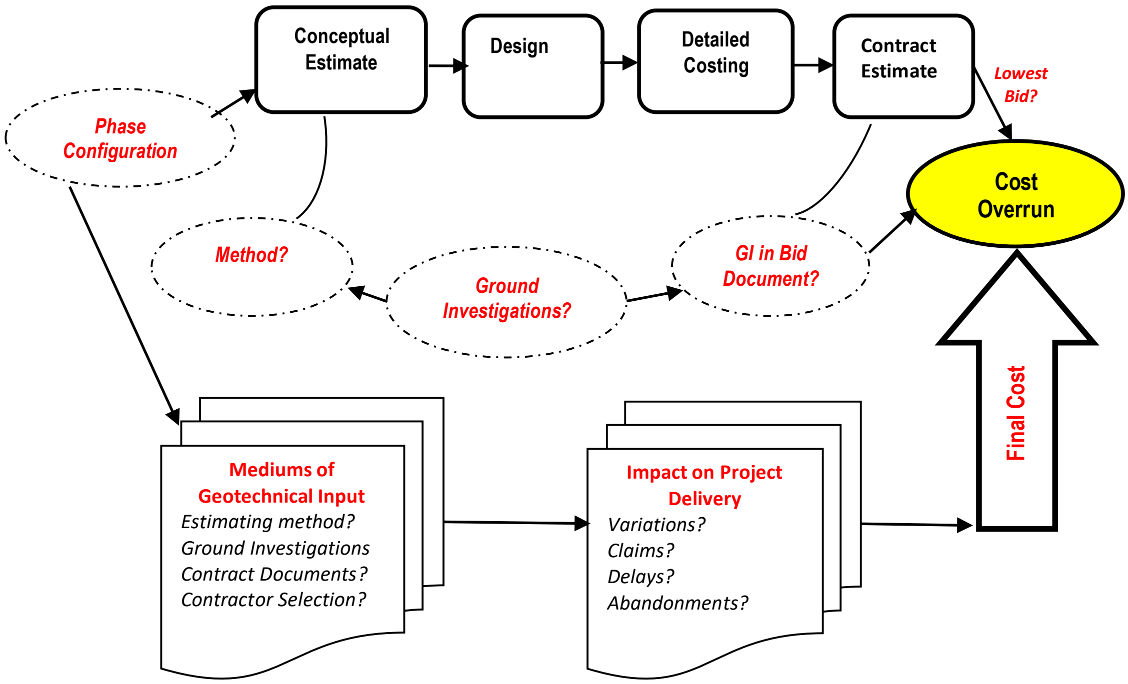


Figure 7.11: Conceptual Template of Apriori Themes highlighting the flow of Geotechnical Input (GI) and Impact on Project Delivery/Final Cost

This progressive linear phase configuration, served as the blueprint, around which further emergent interwoven themes, induced as impacting on the level of geotechnical input in the development phases of the highway projects, were inferred. The resulting cognitive map of cost-overrun drivers is thus structured following this core conceptual projection.

7.7.2 Air Brush Reading of the interview Notes

The interview notes were taken in the context of the flow of the interview conversation, guided by the semi-structured flexible format of the interview protocols, and not under predetermined headings, so as not to distort their intended meaning. The purpose of note taking was to produce a richer and much denser body of data, more focused to the objectives of the study. According to Connor and Gibson (2003: 65):

> *…The amount of data generated by one interview could answer an incredible number of questions. You could spend the rest of your life trying to analyse all of that information. That's why it is important to go back to the original questions that you are trying to answer. Analyse your data always keeping in mind what you are trying to find out and why you wanted to do the interviews in the first place"*

Air brush reading of the interview notes was thus the next logical step necessary for the researcher to familiarise with the data, in line with the objective of assessing the level of geotechnical input in the progressive project phases.

7.7.3 Deductive Apriori Coding

The next phase was the sorting and categorisation of the text in the notes into individual interview questions, which had been pre-coded in the template analysis. Six major initial geotechnical themes, deduced from the literature findings formed the basis of the interview structure:

1. *Nomenclature of the development phases;*
2. *Level of geotechnical input in preliminary planning phase;*
3. *Level of geotechnical input at the conceptual costing phase;*
4. *Level of geotechnical input at the design phase;*
5. *Level of geotechnical input at the contractual phase in relation to procurement route;*
6. *Post contract Impact of prevailing levels of GI on Project Delivery.*

These pre and post contract themes thus informed the drafting of the interview questions for each group of respondents**.** The post contract theme was set as a single parent theme '*Differing site conditions*, to establish whether variation orders, delays and abandonment on the premise of unexpected ground conditions, often occur when adequate geotechnical input is not ensured in highway projects at the pre-construction phases of highway development. The post-contract theme was thus set to capture the technical and financial risks/issues, that arose during the construction phase, and have plagued projects executed by the highway agencies on account of these factors. This was dialectically inferred by the researcher from the perspectives of the inferences drawn from further analysis of both clients' and contractors' responses, supplemented by documentary evidence from project records.

The researcher used a reverse evaluation approach, inferred from the contractors' perspective to get a dialectical feel of the impact of inadequate geotechnical input on project delivery. This was used to identify areas of dissatisfaction with prevailing contractual practices of the highway agencies, which may account for claims and other contractual issues posed as a consequence of inadequate information on ground conditions. As such a similar line of questioning included in clients' interview templates, was replicated in the contractors' interview templates, designed to elicit contractors' perceptions of the current level of geotechnical input, evident during the contractual phase of the executed highway projects. The information elicited, was used to further assess the financial impact of unexpected ground conditions on contractors' bid estimates and their post-contract execution. The corresponding interview question numbers (in Appendix A), whose responses were sorted and coded, in relation to these initial apriori themes derived based on the initial conceptual model developed from the literature, is set out below in Table 6.6.

Table 6.6: Structure of A priori Themes in Template as linked to Interview Questions

	Interview Templates for:			
Themes	Highway Civil Engineers	Highway Quantity Surveyors	Design Consultants	Road Contractors
Nomenclature of project phases		3		
Level of GI in preliminary Planning	12, 13	3	10	
Level of GI at the budgetary phase	12,13	4, 8	10	
Level of GI at the design phase	4, 7, 8, 9,10, 11, 12,13	8	5, 6, 7, 8, 9, 11, 12, 13	6
Level of GI at the contractual	12,13	9, 10, 11, 12	10	3,4, 5,6,7,9,10,11
Post contract impact of GI		5, 6, 7,13		10

7.7.4 Deductive Axial Coding

During the course of the coding, further sub-themes were derived from the parent geotechnical themes. The induced subthemes noted in the institutional practices of all three of the cases (Highway agencies), which are primarily linked to the previously deduced themes were:

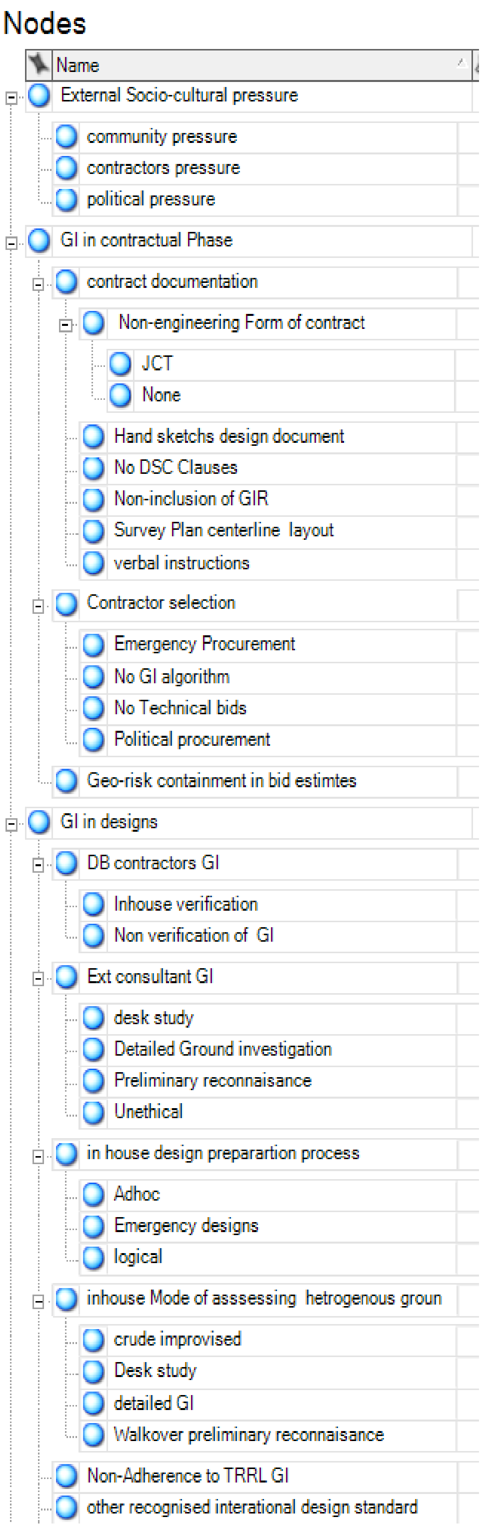
- Level of geotechnical input in relation to project size (Defined the researcher's interpretation of initial themes 1-6);
- Level of geotechnical input in relation to pre-contract preparation (merged into the researcher's interpretation of initial theme 1);
- Political Planning (merged into the researcher's interpretation of initial theme 2);
- Adequacy of in-house design preparation processes projects (deduced as a distinct sub-theme under initial theme 4);
- Mode of in-house assessment of heterogeneous soil conditions (deduced as a distinct sub-theme under initial theme 4);
- Adherence of designs in relation to GI requirements of TRRL (1993) (deduced as a distinct sub-theme under initial theme 4);
- Adequacy of external consultant's GI (deduced in relation to traditional procurement of major project);
- Adequacy of contractor's GI in DB Designs (deduced as a distinct subtheme under in the initial themes 4 and 5, which had to be merged for DB projects);
- Tender price relative to geologic uncertainties (deduced as a distinct sub-theme under initial theme 5);
- Delays and project abandonments due to DSC approval protocol (deduced as a Post contract subthemes deduced from the highway organisations practice).

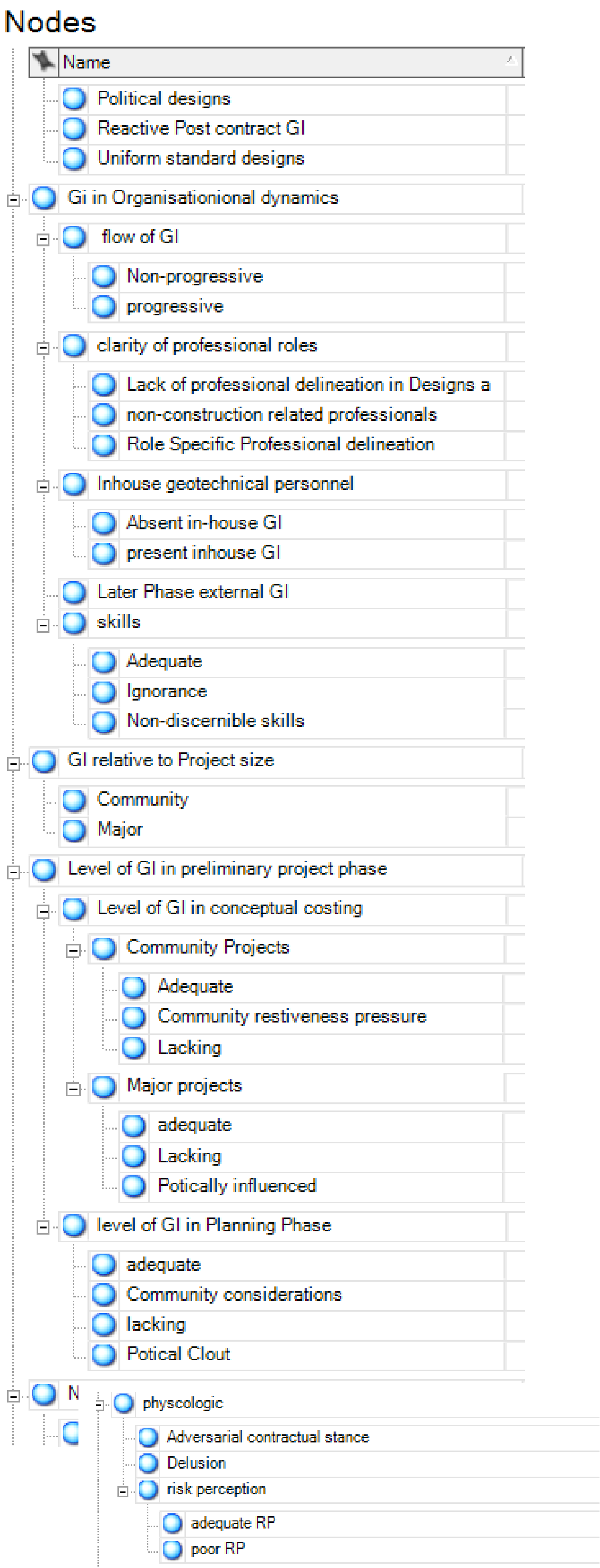
7.7.5 Second Read Through

In line of the necessity of thinking outside the confines of the initially predetermined themes, requisite to maintain a measure of analytic distance, the researcher re-read the interview data from a fresh perspective, to further induce themes which were displaying a discernible pattern across the data. A wide range of issues interlinking with the initial themes were noted as possible drivers to cost overruns, as they were consistently represented across most of the data.

7.7.5 Inductive Air Brush Micro Coding

At this phase of coding a long listing of about 89 themes and subthemes had been derived, including the fundamentally core geotechnical themes.





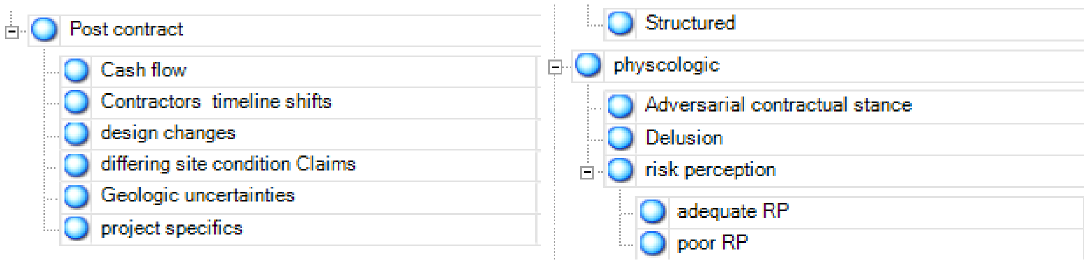


Figure 6.12: Snapshot of NVivo Coding

The additional themes, although linked to other themes, were not previously deduced through the synthesis of the literature, but were noted as repeatedly emphasized in the responses, and therefore inferred and included by the researcher. This is captured in the snapshot of the NVivo 10 coding, shown in Figure 7.12.

The creation of new nodes to account for these emergent themes, during the coding was thus informed by the researcher's perception of their over-arching interface with, and impacts of differing magnitude on, the agencies' levels of geotechnical input/ ground risk containment in the phases of development, and by implication their complicity in determining the resultant level of cost overrun.

7.7.7 Inductive Cluster Coding:

Two stages of cluster analysis were carried to bring the number of codes down, and to a more hierarchically structured network, more specific to the objectives of the study: Clustering of interrelated micro-codes into more distinct subthemes; and clustering of sub themes into parent nodes. Some of the less distinct micro themes, which less repeatedly occurred were thus merged into each other, before clusters of parent themes were derived. This is captured in the NVivo 10 snapshot shown in Figure 7.13. Typically, the political related micro themes such as political designs, political procurement, and political influence, were clustered into a subtheme labelled political pressures. Similarly, all micro themes related to pressures from the local communities, such as community considerations and community youth restiveness, were clustered in to the subtheme labelled community pressures.

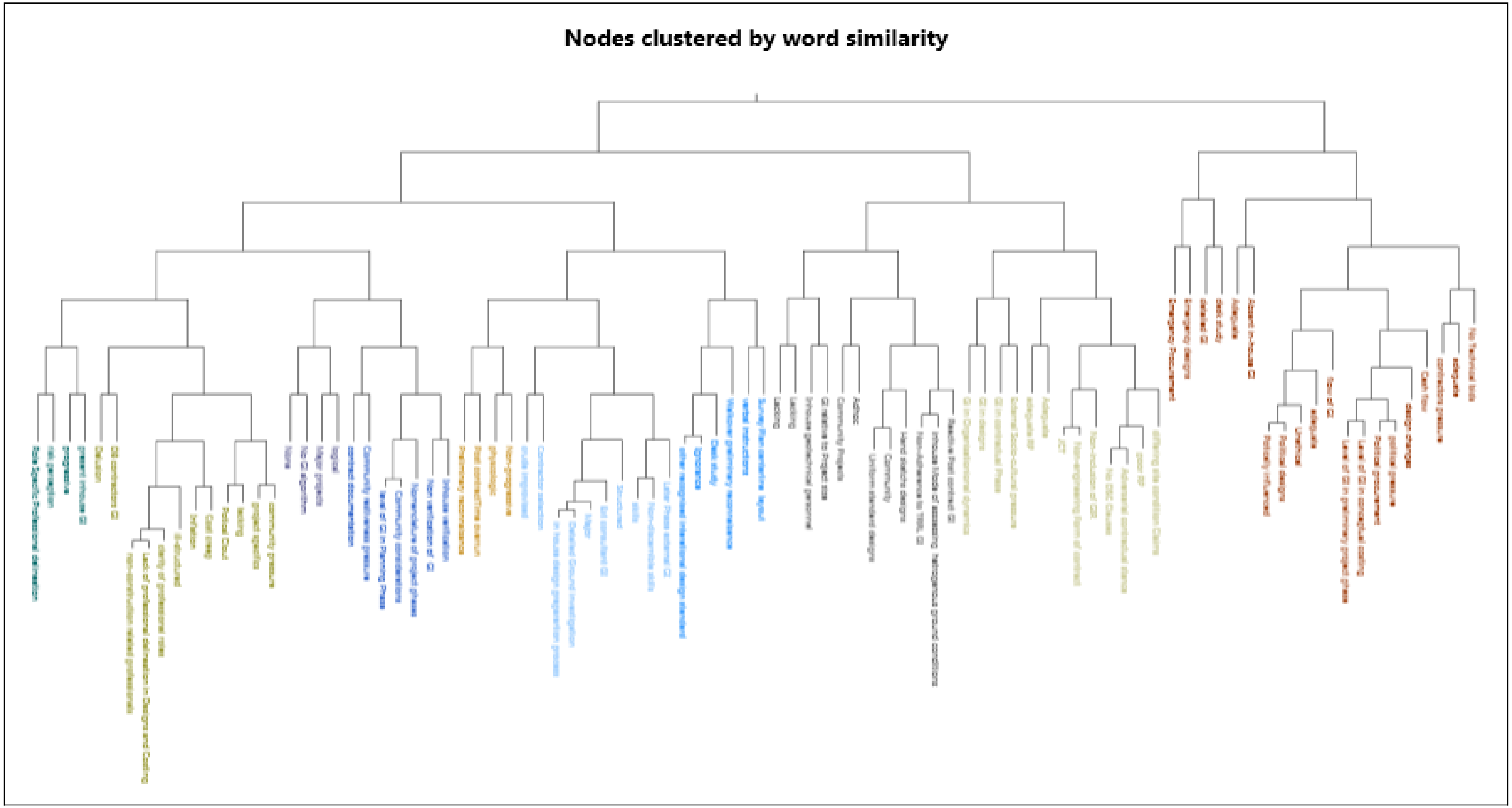


Figure 7.13: Clusters of Emergent Sub-Themes and Themes

The following distinct major sets of technical and human related clusters were noted as emerging parent themes from the clusters of subthemes, evident in the technical details of the internal organisational set-up of the agencies, their respective constituted institutional authorities; and the respondents' personnel and external socio-politically driven environments:

1. **Adequacy organisational setting for ensuring geotechnical input**
   - *Clarity of professional roles and skills in relation to GI in highway designs and costing;*
   - *Adequacy of organisational environment for ensuring progressive flow of GI.*

2. **Socio-political pressures impacting on level of geotechnical input**
   - *Adequacy of in-house GI in Projects in relation to Community Pressures;*
   - *Adequacy of in-house GI in relation to the influence of geo-political structures;*
   - *Adequacy of GI in relation to contractors' pressures*

3. **Psychological factors**
   - *Risk perception in relation to GI*
   - *Adversarial contractual stance*
   - *Awareness/ignorance/ Delusion in relation to designs*

The resulting hierarchical structure of the coding of the interview results is shown in Figure 7.14.

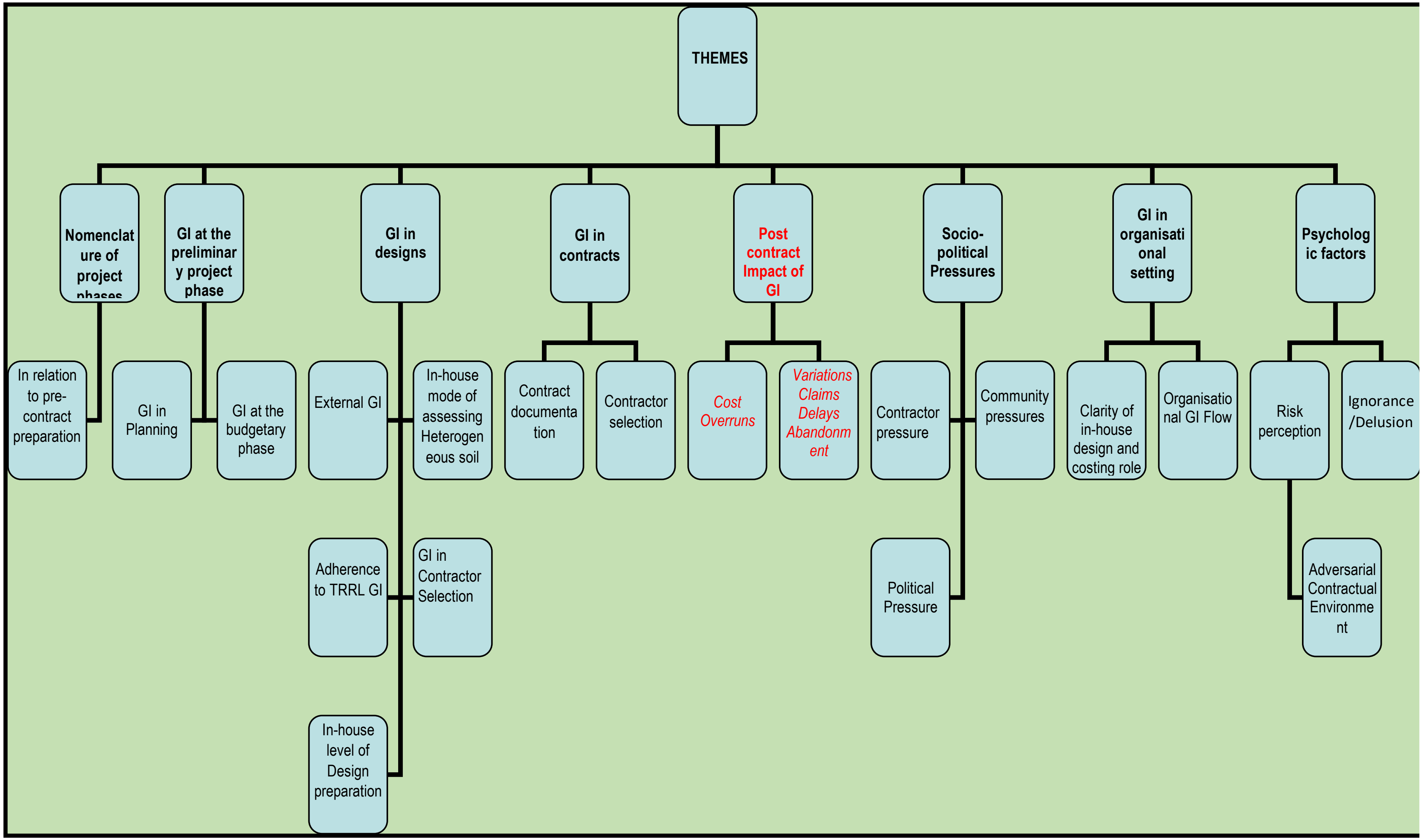


Figure 7.14: Hierarchical Structure of the Themes

This hierarchal thematic structure thus defined the basis of making inferences in the analysis. However, the analysis results are split into the initial deduced and later induced themes. The A priori geotechnical themes on the levels of geotechnical input, and the resultant post impact of these themes on project delivery and levels of cost overruns are analysed and discussed in chapter eight. The emergent themes are analysed and discussed in chapter nine.

7.7.8 Content Analysis of Induced Themes

Further content analysis of the induced themes, based on the frequency of the coded references, provided the researcher the necessary quantitative platform to weigh the salience of the emergent themes, which were unanticipated in the drafting of the interview templates. This weighting is reflected in the relative sizing of the node representation used in the cognitive mapping of all themes. More frequently coded emergent themes, were inferred as having more significant impact on the levels of geotechnical input, and were thus represented in larger nodes.

7.7.9 Cognitive Mapping

The final step in the qualitative analysis was the conceptual visual representation of the interdependent web of emergent cost overrun drivers, which ultimately interlinked with the linear construct of the core a priori geotechnical themes. The cognitive mapping further built in the interactive impact of the emergent cost overrun drivers, upon the initial conceptual projection of geotechnical drivers, which was used as a template for the deductive analysis.

Figure 7.15 is a generic categorisation of cognitive mapping approaches generally used in qualitative organisational research. In line with the aim of developing an explanatory concept of cost overruns in highway projects, the researcher used a combination of type 1 and 3 of Huff's generic categories of maps in the cognitive mapping.

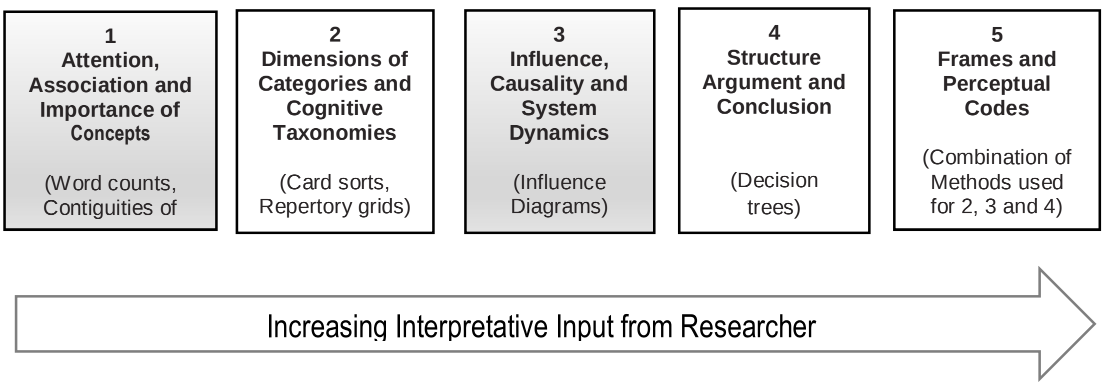


Figure 7.15: Huff's Generic Families of Cognitive Maps (Source: McDonald *et al.*, 2004)

The cognitive mapping thus sought to highlight the complexity and impact of the latent geotechnical pathogens, and the contextual drivers causing the unusually high levels of cost overruns experienced in high projects executed in the Niger Delta. It conceptually maps out the system dynamics of causality, between the wetland geologic setting of the Niger Delta, prevailing geotechnical practices and other unanticipated contextual organisational, human and sociocultural factors, which have culminated to define the state of highway delivery in the region.

7.8 Chapter Summary

This chapter has clarified the geo-political background and the organisational structures of the highway agencies investigated, and the related internal processes which define the prevailing design and costing practices of the professionals. This clarification was considered pivotal to understand the nature of the interview responses, and discussions in subsequent analysis. The coding procedure used to analyse the initial themes, deductively inferred from the interview responses as latent geotechnical pathogens, has thus been explained. However, several other unanticipated themes were simultaneously induced, and inferred as emergent contextual drivers, due to their dynamic interaction effects with the latent geotechnical pathogens. The subsequent chapters are thus structured, with the initial deductive analysis result presented in chapter eight, describing the prevailing levels of geotechnical input inherent in the highway agencies, while the inductively analysed themes, which represent the emergent social constructs constituting barriers to geotechnical input, are presented in chapter nine.

Chapter 8

Latent Geotechnical Pathogens in Practice: Interview/Documentary Analysis

8.0 Introduction

This chapter deductively analyses the geotechnical practices of the three highway agencies in the Niger Delta, whose organisational structures and respondent characteristics have been discussed in the preceding chapter, for the presence of latent pathogens. The presentation of the analysis follows the hierarchical structures of the initial geotechnical themes set out in the conceptual framework used as a template for data analysis. The analysis is carried out with the objective of understanding the budgetary, design, and procurement practices of the highway agencies, and to what extent geotechnical best practices are adhered to in highway projects, throughout the pre-contract phases. The inferences made were elicited, based on the responses of the various groups of respondents within or affiliated to the respective highway organisations: Civil engineers; Quantity Surveyors; Consultants; and Contractors. Also related issues on the post contract impact of the analysed geotechnical pathogens, are further elicited from the responses, and supported by available documentary evidence, to infer a chain of causality. The prevailing levels of geotechnical input at the pre-contract phases, and their post-contract implications in projects executed by each of the three agencies, are thus evaluated and discussed in this chapter.

8.1 Nomenclature of the Development Phases in Relation to Pre-Contract Preparation

All respondents interviewed in the highway agencies, explained that the approach to project development by their respective agencies, was determined by the class/size of the road project. The phases of project development thus vary according to the size of projects: Major or community road projects. Major roads were described as those projects typically running into multi-million dollars (inter-city roads, highways and bridges), while community roads were the most common types of roads constructed as minor roads in urban and rural areas. The typical description of the project phases for both types of road projects, provided by respondents from

Highway agency-1 (HA1), the management (HA1-MQS) and operational (HA1-OQS) quantity surveyors is illustrated in Figure 8.1.

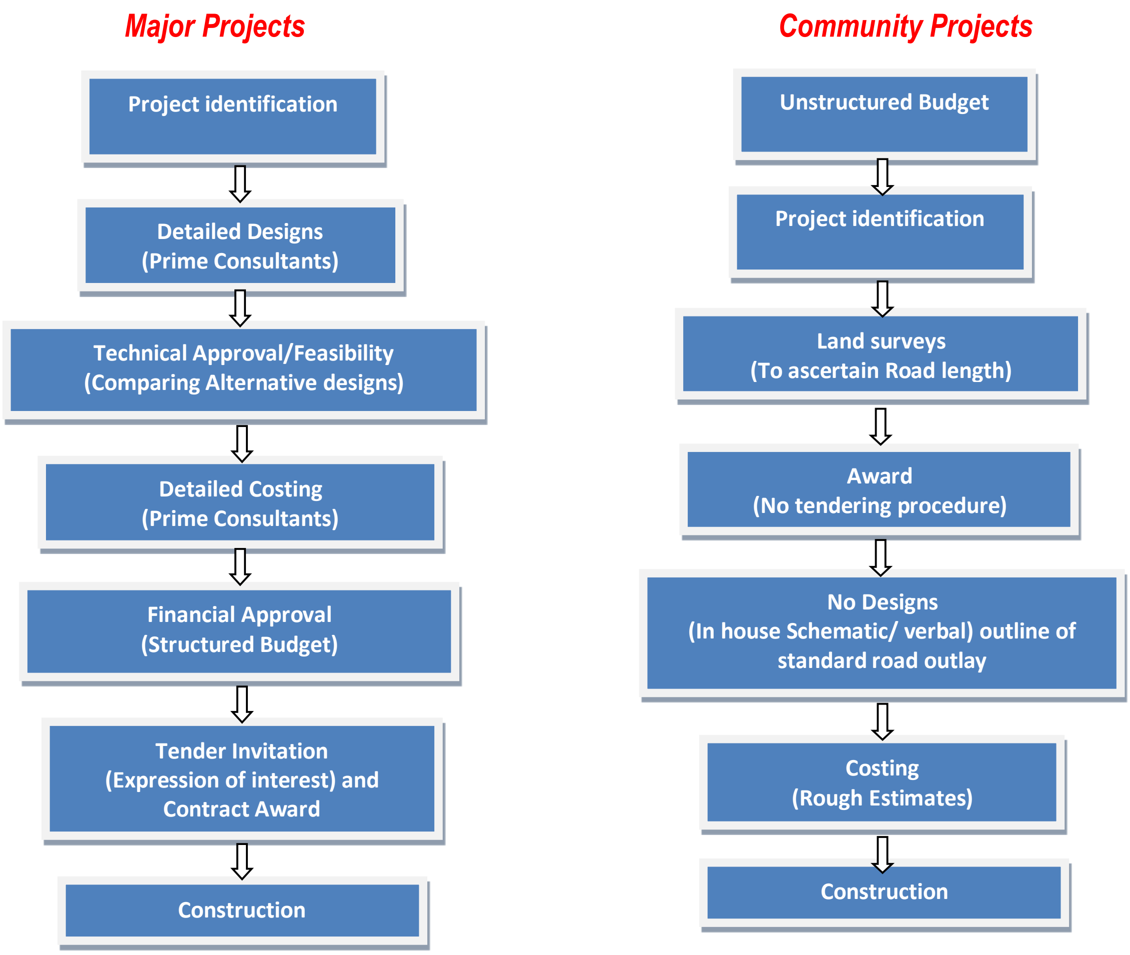


Figure 8.1: Configuration of Pre-Contract Phases for HA1

For HA1, the researcher noted the poor structuring of project phases for community projects. Response from HA1-MQS, a management level Quantity Surveyor, who admitted their project cycle is not well defined, and is largely determined by the specific circumstance, validates the researcher's observation. However, respondent HA1-OQS, an operational level quantity surveyor provided an unreserved description of the internal arrangement for the procurement of community road projects. He termed the current practice as a '*Mad House*', stating:

> *"...There are no designs, no detailed costing or even the inclusion of standard contract documentation in the award of contracts. Projects may even be awarded before the survey plans, useful in determining length of the roads are out. Verbal instructions to the contractor on the scope of work can even be a sufficient basis for the award of contracts"* (HA1-OQS).

Respondents from Agency 2 (HA2-MQS and HA2-OQS) stated that both major and community projects had no definite procedure, and were largely determined by the urgency induced from political quarters. Both respondents, however emphasized, that community projects were more often initiated without any formal process and lacked adequate pre-contract preparation. Commenting on the poor level of pre-contract preparation for most community road projects HA2-OCE stated:

> *"Most of our projects are always rushed at the initial point, with lots of details that should ideally be in place to provide a sound basis for contracting, missing. This has given room for contractors to reap the government of significant sums of money..."* (HA2-OCE)

However, respondents from HA3, provided a contradictory picture of practice, suggesting most of their major and community projects follow a pre-determined and structured process for project development. The interviews revealed that HA3 adopt a standard project configuration system, similar to those identified in the literature, which moved through the following distinct phases of activity:

- Planning/Identification;
- Conceptual/Budgetary Estimates;
- Preliminary Designs;
- Detailed Designs;
- Detailed Costing;
- Contract Award.

Respondents from HA3 also stated that major projects were awarded and executed, after they were identified and budgeted for, by the Planning, Research and Statistics (PRS) unit, and designed by consultants. Community projects on identification and approval by the governor or commissioner, were designed and costed with input from all relevant professional units in the agency, before they were awarded.

The researcher thus infers, that in terms of the phase configuration of projects for highway development, there appears to be better conceptualisation and pre-contract basis for major road projects executed by the agencies, than for other lower order community roads in the Niger Delta. The breakdown of this pre-contract phase configuration, as it impacts on the levels of geotechnical input at distinct project phases, is fully analysed based on all supporting direct quotes under subsequent more specific themes.

8.2 Geotechnical Input in Preliminary Project Phases

Figure 8.2 shows the coding structure for the themes deduced in relation to geotechnical input at the initial planning and conceptual phases of project development.

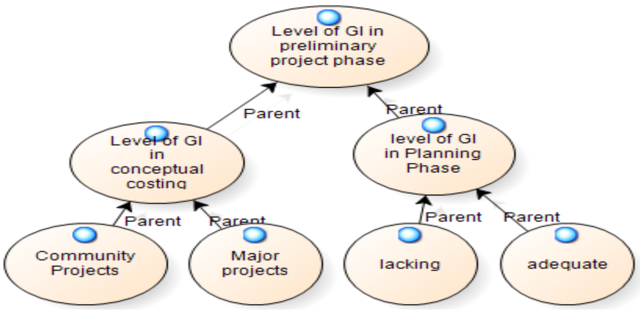


Figure 8.2: Coding Structure for Geotechnical Input in Preliminary Phases

8.2.1 Geotechnical Input in Planning

HA1- MQS stated that ideally, based on the laws setting up HA1, the identification of major road projects to be executed and therefore included in the budget, should be carried out based on the outcome of a stake holders meeting comprising of communities, oil companies and the agency. This would in turn, provide the basis for identifying projects to be included in budgets. However, both quantity surveyors interviewed from HA1, confirmed that this still was not the basis of planning. Oftentimes, projects are introduced into budgets based on the level of political clout, which the interested parties have:

> *"Most of our projects are influenced from the very top ranks in the hierarchy of government. ... Some political father would simply express interest in a particular project and push for it to be included in the budget"* (HA1-MQS).

Also the operational QS, HA1-OQS re-affirmed this stating:

> *" .. Most of our major projects have powerful political figures pushing for them ... You cannot have a road leading to a 'nobody's' community or house in the budget"* (HA1-OQS).

For HA2, it was explained that most major and community road projects, were planned to favour active politicians, as compensation for their political contributions in the present administration.

Respondents from HA3 further acknowledged the influence of political presence in the planning of major road projects. It was however stated that, this would have to fall into the overall master development plan for the state, based on projections made by the Planning, Research and Statistics (PRS) unit.

"Questionnaires are usually administered to communities by the agency's Planning, Research and Statistics (PRS) department, responsible for planning of major projects to be executed on an annual basis" (HA3- OQS).

Community projects, according to HA3-OQS and HA3-MQS, were mostly executed in response to communal demands. Typically, the management QS stated:

"...Community projects are however identified and executed in direct response to pulse of the people. As such when the governor goes on courtesy calls and visits to the communities, he is accompanied by the commissioner for works and a director, to take note of the community's development demands" (HA3-MQS).

Based on the interview responses, of primary significance at this phase of highway development in the Niger Delta, is the impact of political and communal influences which serve as the basic consideration in planning for road projects to be executed. This practice contravenes the requirements of best practice, where the ultimate goal during planning and feasibility analysis of highway projects, should be a more comprehensive approach using Cost Benefit Analysis of competing options, with social and economic considerations factored in (Steenbrink, 1994).

Therefore, it can be inferred that planning and approval of highways in the Niger Delta do not necessarily strive to achieve optimal long range benefits relative to cost, an underlying assumption which may create a motive to deliberately under-represent cost to get project approved, from the perspective of strategic misrepresentation, argued in the developed world. Rather satisfying immediate political and community demands, dictates the pattern of project planning, costing, design and execution in the Niger Delta region. This fundamental theme thus underpins all subsequent themes, as shown from the detailed analysis of the interview data.

8.2.2 Geotechnical Input at the Conceptual Costing Phase

8.2.2.1 Major Roads

Respondents from HA1 stated that, after the project identification phase, budgets for major roads are prepared, using the costs estimated for projects by the consultants, who equally prepared the highway designs, after carrying out geotechnical investigations. This often follows technical debates between the consultants and the in-house group of chartered professionals, necessary to finalise the highway design, before detailed costing of projects for use in budgets are subsequently prepared by the consultants. HA1-MQS stated:

"After the project design has been cross checked by the department of special projects, the project will now be costed and queued up for inclusion in the subsequent annual budgets".

However, not all projects whose detailed design work and costing have been carried out, are included in the immediate upcoming budget. This was explained by both quantity surveyors in the agency. It was stated, that projects not included in the current budget, are carried forward for inclusion in successive years, a time lag which causes inflation to set in:

> "*Major Projects may be costed and budgeted several years in advance of their award. During this time lag, fluctuations due to inflation usually sets in and project cost may shoot up far beyond the budgeted amount by the time the call for tenders is carried out. There has been a typical instance of a project where the contract figure at the point of award was N5.4 Billion, approximately 40% higher than the initial budgeted figure of N4 billion." (HA1-OQS).*

HA1-MQS further argued:

> *"Sometimes, the project, having been costed may remain at this phase for several years before a formal call for expression of interest is made".*

In HA2 however, it was noted that budgets for both planned major and unplanned community projects, were not dichotomised, and projects were mostly executed from the annual budgetary pool, based on the Governor's priority until it is exhausted. As a result, various major and community projects were simultaneously executed from the same budget, and may be delayed or abandoned until more funds are available. Supplementary budgets within the same financial year may then have to be approved for continuation of construction works. Higher preference, however, is given to highly visible major projects. Conceptual costing methods for such projects were described as basically being projected on a cost per kilometre of road length basis:

> *"We are often asked to produce quick estimates for major projects, without any much formal notice...We simply look for any past project which is most similar to the proposed one and adjust the figures on a per kilometre basis based on the project location. We will then add about 20 to 30% as contingency to cover any probable cost"* (HA2-OQS).

For HA2, the costing practice of what appears to be a conceptual/detailed costing phase, used as a basis of contract award is synonymous with the conceptual estimating practices in the literature. Rough estimates, which are often a cost breakdown per kilometre of road length basis, are prepared on project identification. These are then used directly for contract award without any apparent form of differentiated costing, such as is necessary to account for heterogeneous ground conditions which may occur along the proposed length of the road. It was thus stated by the management quantity surveyor (HA2-MQS), that such estimates were prepared using approximate quantities based on the standard dimensions of community road projects executed by the agency:

"...Most of the items in our bills are standardised and do not vary irrespective of project location. Typically, ... one-meter depth of excavation, though in some locations, excavations may not necessarily be up to this depth, particularly in the uplands were most of our projects are located. This is followed by 750mm fill with imported laterite or sharp sand depending on project location and based on experience. Materials and thicknesses for the various structural layers, typically primer, base course and finishing course, are also standardised..." (HA2-MQS).

Respondents from HA3 also stated that conceptual estimates for longer range planning of major roads by the PRS, and for use in budget preparation are prepared on a uniform cost per kilometre basis, but with the rates adjusted for different locations in the state, before detailed costs are prepared at the contracting phase.

"Our budgets are prepared based on projections made relative to the length and location of the proposed road. Typically, a project to be executed in Yenegoa which is an urban centre with a denser network of roads, will be cheaper compared to those executed in the heart of the swamps, where access to site and haulage of materials will be a major issue. We use location adjustment factors to pro-rata the projected standard cost per km of length, in order to arrive at a budget figure. After the full designs have been prepared, we can now prepare more detailed cost estimates" (HA3-OQS).

8.2.2.2 Community Roads

For the execution of local community projects, respondents from HA1and HA3 stated that there were two separate budgets, one for major and the second for smaller community projects. This is different from the practice in HA2, where both classes of project had a single budgetary provision. It was explained that local projects executed by HA1 and HA3 are executed on demand from a fixed annual unstructured budget which serves as a funding pool. There is thus no structured budgetary allocation for individual community projects. Based on the practices of all three agencies, a fixed allocated budgetary limit determines how many projects can be accommodated as the need for them arises. As projects are awarded, the funds required for their execution are drawn from the funding pool, subject to approval from the constituted authority and the availability of funds.

For HA1 and HA2, there appears to be no preliminary cost forecast for community roads. Projects are commenced as they are identified and approved in response to community demand, due to the level of urgency associated with these projects. HA1-OQS observations in this regard were typical of the responses received:

"For EDF projects we simply use rough estimates prepared from the land survey plans which indicates the length of the road… This serve as schematic drawings for a road

> *project before we estimate the cost. Since we know the standard width of most community roads, we use it and multiply to get the area which is then multiplied by the various standard thicknesses of the base layer and the sub-base as well as the prime coat. We then add other standard items for clearing, excavation and preliminaries to arrive a contract sum"* (HA1-OQS).

As such funds are drawn from this fixed budget, and so the project stops when the budget is exhausted, until more funds are available in the subsequent annual budgetary allocations. The project is however not terminated. The respondents from the agencies thus explained that projects may get delayed for prolonged periods, or may be completely abandoned if there is no sustained interest in the project from political quarters, to push for it to be carried over to successive budgets. Describing a similar situation in the HA2, respondent HA2-OQS observed:

> *"… our community projects, where everything is upsidedown, are almost always delayed and abandoned. I think if things were properly done in the process of contracting for community projects, some level of sanity will be achieved in project delivery". (HA2-OQS).*

For HA3, respondents however stated that preliminary forecast were often prepared, in a similar cost per Km fashion to major projects, to determine if a proposed community project could be accommodated in the fixed annual budget. This was carried out before approval can be given for further in-house pre-contract preparation of detailed designs and other contract documentation.

8.2.3 Theme Summary: Level of Geotechnical Input in Preliminary phase

It can thus be inferred that the preliminary budget preparation practices for highway development in the Niger Delta, shows variation in organisational conceptual costing approaches, similarly evidenced in the literature. The different highway organisations all have conceptual costing approaches which reflect their distinct organisational structures and institutional backgrounds. This, and not the motive of strategic under-estimation, has largely defined the methods used in preliminary estimating, and budgeting for road works executed in the Niger Delta.

For HA1, budgets for major roads can be inferred to have an adequate level of geotechnical input, since conceptual estimates are prepared from fully designed projects, after all design details have been ascertained, based on geotechnical investigation reports. This practice is similar to that of the Norwegian house of parliament, in the literature, which Odeck (2004) advocated as being ideal, stressing the need for budget preparation, after, and not before detailed designs had been completed, as a panacea for higher levels of accuracy. However, the inflation induced by the lengthy period between the time of cost estimation preparation and the award of the contract, may counter this advantage of accuracy.

For major road projects executed by HA2, there is no apparent geotechnical input which should ideally reflect sub-soil variations at the conceptual costing phase. This was deduced, from the uniformity in base rate computation, used in projecting probable construction cost. Estimates thus used in budget preparation in HA2, is carried out on a uniform cost per Km basis based on subjective adjustments of historical cost data without any form of geotechnical input.

For community road projects executed by HA1 and HA2, there is no explicit conceptual estimating phase as comparable to practices evident in the literature. For these two agencies, the conceptual phase cannot be clearly defined and appears non-existent or merged with the detailed costing phase. There is however no element of geotechnical input.

HA3, however, has a defined conceptual costing phase for both major and community projects. Although also on a cost/ break down per km of road length basis, HA3 has an inbuilt subjective mechanism to account for costs due to locational variations. However, no references to the use of any form of preliminary desk studies typically from topographical maps, aerial photographs or geotechnical data from past projects in the vicinity of proposed highway is made, to ensure higher accuracy of estimates at the budget preparation phase.

The researcher thus infers, based on the responses, that there is generally no apparent, well defined medium of ensuring geotechnical input for road works in conceptual costing by all three agencies, with the exception of major projects by HA1. The highway agencies still deploy these qualitative methods, criticised in the literature by Chou (2005), which may be due to the speed and ease of its applicability or lack of skills to use more advanced conceptual estimation techniques, or some form of optimism bias. This may thus contribute to account for the trend of significant disparity between budgeted and final out-turn cost reported on highway projects in the Niger Delta.

The literature however emphasizes that the containment of ground related risks should begin from the early developmental phases of highway projects which should be correspondingly accommodated in estimates. Reiley *et al.* (2004) as well as Evans and Peck (2008), thus underscored the need to invest in the gathering of additional design information such as geotechnical investigations. Typically, such preliminary geotechnical investigations at this initial point of estimation, would entail carrying out desk studies in relation to the proposed site location as a means of making informed judgement about subsoil conditions, and improving the accuracy of budgetary allocation. In line with this stance, Clayton, (2001) asserted:

> *"The base cost should be broadly complete, although still subject to refinement, and potentially growth, as the design becomes better understood and more developed" (*p. 9).

The practices of the highway agencies contravene the dictates of best practice, which underscores the need to use available data from various sources including engineering-geological or hydrological maps on areas through which the proposed route traverses. Such effort made at this phase of ill-defined project definition, can serve to better capture the cost implications of subsoil conditions, thus minimising the likelihood of significant disparity between budgetary allocation, tender estimates and final cost.

8.3 Geotechnical Input at Design Phase

Under this section, the researcher's interpretation of the level of geotechnical input at the design phase is dialectically inferred from the responses of interviewees from the highway agencies, consultants, and main contractors. This is considered appropriate, due to the fact that for DB projects, the bidding/tender stage of project development often overlaps with the design phase, as responsibility for design under this procurement system shifts to the contractor. The themes under this phase are represented in Figure 8.3.

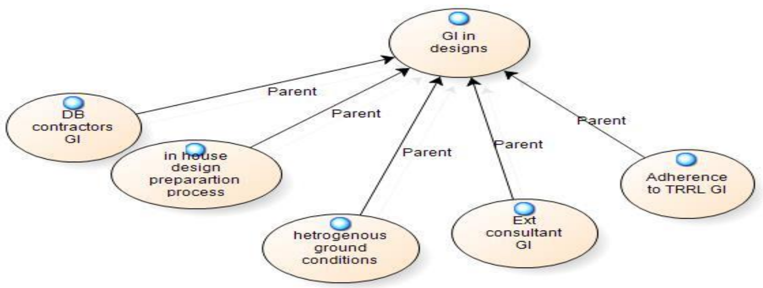


Figure 8.3: Coding Structure for Geotechnical Input in designs

The inferences made in respect of the level of geotechnical input, specifically relates to the adequacy of ground investigations carried out by clients or contractors at the pre-contract design preparation phase. For DB projects, this is assessed in relation to the procurement climate inherent under competitive, and not selective negotiated bidding.

8.3.1 Community Projects: Adequacy of In-house Designs

Everything relating to pre-contract preparation, including designs for community road projects, is sourced in-house. In the prevailing practice of HA1, most community road projects are executed without any formal engineering drawings or designs. Schematic outlines of the scope of work contained in the survey plans are used to prepare bill of quantities, supplemented by specification notes:

> *"For our community projects, there are actually no real design drawings that are used for our road projects…what serves as designs are the land survey plans prepared to show the location and dimensions of the road...Sometimes we may prepare rough sketches of the road to guide the contractor if need be"* (HA1-OCE).

For HA2, the design practice for community projects is also much removed from the ideal. The interviews revealed that:

> *"... For most of our road projects, there are no designs...We engineers then go to site to check if there are any specific site details that need to be captured ...to be included in project description and specifications contained in the BOQ"* (HA2-OCV).

A secondary response on the agencies design practice was elicited from HA2-MQS, who unequivocally confirmed:

> "*90% of all our community road projects are awarded and executed without designs: No drawings, not even a sketch or land survey plans. It is a political regime and things are done in consonance with the dictates of the present administration"* (HA2-MQS).

For HA3, contrary to the practices in the aforementioned agencies, the interviews revealed that preliminary and detailed designs are prepared for community projects. The department of Civil Engineering Services, which has both geologists and geotechnical engineers working in the unit, carry out all preliminary investigations including site visits, before detailed ground investigations and testing of soil samples in the agency's materials and geotechnics laboratory take place. HA3-OCV stated that these were mandatorily carried out before detailed designs are sent to the other relevant professional service units.

8.3.2 Community Projects: Mode of In-House Assessment of Heterogeneous Soil Conditions

For HA1, interviews with both management and operational staff revealed contradictions in their views of current practice. The senior staff in the agency (HA1-MCE), was perceived by the researcher as towing the pre-scripted management line, often painting a picture of proper site investigations being carried out before designs. The operational staff however, seemed more inclined to explain the details of the realities of the situation. A typical self-contradiction by the management Civil Engineer, HA1-MCE, was noted by the researcher. In response to the question: "*What is the approach to designing your road projects: do you prepare designs for individual road projects or do you use standard designs?"* HA1-MCE, had earlier mentioned that ground investigations were carried out, and used as a basis for designing individual road designs:

> *"We always organise site visits to proposed sites to assess the nature of the sub-soils for our community projects, before detailed ground investigations are carried out."* (HA1-MCE).

In response to the same question which was restructured as "*How does your organisation identify varying subsoil conditions along a road length?"* HA1-MCE, later stated:

> *"...Let me educate you on how designs are prepared in the agency. We prepare uniform designs for our road projects using worst case scenario designs that are simulated for the worst possible soil conditions based on expert judgement*" (HA1-MCE).

The operational staff, HA1-OCE, however revealed that site visits were the only form of geotechnical input for community projects:

> *"We engineers then go to site to check if there are any specific details that need to be captured before we report back to the office, based on which we prepare rough sketches of the road to guide the contractor"* (HA1-OCE).

For construction of roads in swampy areas having the typical fibrous peaty Chikoko soils, earlier described in the preliminary geologic exploratory phase of the study, it was explained that provision is usually made for soils to be stabilised with sharp sand before pavement construction using the standard pavement thickness configuration is commenced. In addition to visual inspection, the only element of geotechnical input in community road projects were crude forms of improvised desk studies. As HA1-OCV reveals:

> *"...Sometimes we ask indigenes of the communities if there are any bad spots were water tends to pool or which are usually in a perpetual state of water-logging, so that we can make provision for higher depths of excavation and fill at these sections"* (HA1-OCE).

Also, in HA2, the interviews revealed that similar improvised measures may be deployed, with HA2-OCE attesting:

> *"... We can assess the nature of soils in the project location from the type of vegetation growing. On frequently inundated and waterlogged areas, you will notice that farmlands with cassava plantation cannot be found with the vicinity"* (HA2-OCE).

Reactive geotechnical input during the construction phase, in response to unexpected ground conditions, may later have to be reflected on site as expressed in one of the typical responses:

> *"... For upland areas having better soil conditions, whereby the contractor reports back to us that bad waterlogged spots were experienced along the road way, the designs will have*

to be altered to allow for excavation of such soils and replacement with imported laterite filling" (HA2-OCE).

For HA3 however, it was emphatically stated:

> *"…the predominantly difficult swampy terrain dictates that geotechnical investigations are a must for all our road projects. The outcome of the investigation will determine the designs and specifications for proposed road projects".* (HA3-OCV).

This is corroborated by the organisational structure of HA3, which has a relevant departmental unit for carrying out ground investigations, to ensure geotechnical input for community projects sourced in-house.

8.3.3 Major Projects: Adequacy of External Consultants GI

It was clarified by the respondents in all of the cases, that for major road projects procured under traditional contracting arrangement, external consultants, handle the full preliminary works and designs. The geotechnical input in such projects were provided by consultants external to the highway organisations, and are thus accountable for level of ground investigations carried out prior to the design preparation. Typically for HA1, it was stated that:

> *"Designs and costing for all our major projects as executed by the EDP are handled by prime consultants, a partnership of chattered construction professionals. Geotechnical professionals are part of this team of consultants and prepare detailed soil investigation reports for major projects" (HA1-MCE)*

Interviews with professionals in the consultancy firms whose services are employed by the highway agencies confirmed this. Two of the respondents from the consultancy firms (HA1-DC and HA3-DC) who were chief consultants, stated that detailed geotechnical investigations were carried out, emphasizing that designs were prepared based on complete geotechnical investigation reports. HA1-DC discussed one of the biggest projects designed by the firm:

> *"The ongoing **** road which spans 48km was designed by us. The road has proved a challenge to develop by successive governments, due to the challenging terrain along the proposed alignment, which is predominantly underlain by very soft and weak clay".*

It was also clarified that such reports were prepared after the preliminary site visits to locate the boring locations for drilling, before detailed ground investigations, laboratory analysis of samples obtained from borings and logs maintained during the field work. HA1-DC thus described some of the rigours faced in carrying out soil investigations for the project:

> *"The highway traverses 5 major rivers of varying depths, through the mangrove and fresh water forests. We thus opted to use potable and easily dismountable investigative*

equipment such as drilling rigs and CPT machine due to the challenging terrain. With this we were able to drill a total of 30 boreholes, necessary to determine the stratigraphy of the superficial deposits as well as the engineering properties of the deeper underlying layer".

The respondent further went on to describe an outline of the final design for the highway:

"Due to the super saturated and weak highly compressible clay soils existing to depths more 8m, the ultimate and allowable bearing pressures were unsatisfactory in large sections of the alignment, to permit the use of conventional pavement designs. We thus designed a combination of piling and ground improvement technique, requiring the placement of fill, as opposed to excavation and replacement, for the bridge and pavement foundation, to minimise the cost".

However, one of the respondents HA2-DC, a lower cadre civil engineer from another consultancy firm told a different tale. It was revealed that sometimes ground investigations were not carried out, and ground investigation reports for previous similar projects were used in designs. As such ground investigation reports for past projects, often within the vicinity of the project, were obtained and presented to the agencies.

"...Sometimes geotechnical investigation reports and design drawings are photocopied from other similar previously executed projects and modified". (HA2-DC).

Interview response from HA2-OCE, an operational civil engineer who had previously worked in a consultancy firm before being employed by HA2, also supported the notion of the prevalence of such unethical practices:

"... we have experienced cases were the proposed plans and structural drawings prepared and presented by consultants for approval did not match…" (HA2-OCE).

This was explained as some of the issues that the department of special projects in the agency experience, when plans for proposed highway projects prepared by consultants were vetted by the in-house group of chartered professionals. The management level quantity surveyor, HA1-MQS, equally expressed similar views.

"…We have had issues were the designs are completely unsuitable for the soils at project location and latter had to be redesigned...What is particularly funny is that these designs prepared by consultants are supposed to have been thoroughly vetted in the department of special project by chartered civil engineers before approval".

Respondents from HA3 differed in their views stating that:

"We maintain a set of highly qualified and reputable consortium of professionals, who are responsible for the design of our major projects They have the requisite high level of technical skills necessary for the specialised designs that are compatible with our marshy terrain".

8.3.4 Adherence of Designs in Relation to GI Requirements of TRRL (1993)

This theme was set to establish the general practice of road designs, in respect of their level of adherence to the stipulated highway standard adopted by the Federal Ministry of Works (FMW) for the construction and rehabilitation of road projects, TRRL (1993). The Transportation and Road Research Laboratory (TRRL, 1993) Overseas Road Note 31, prepared as a form of technical assistance by the British Government, for the design of bituminous pavements in tropical countries, is the current version of the guide adopted, which provides a catalogue of road design configurations suitable for the various sub-soil types in Nigeria. An extract from this document is shown in Figure 8.4.

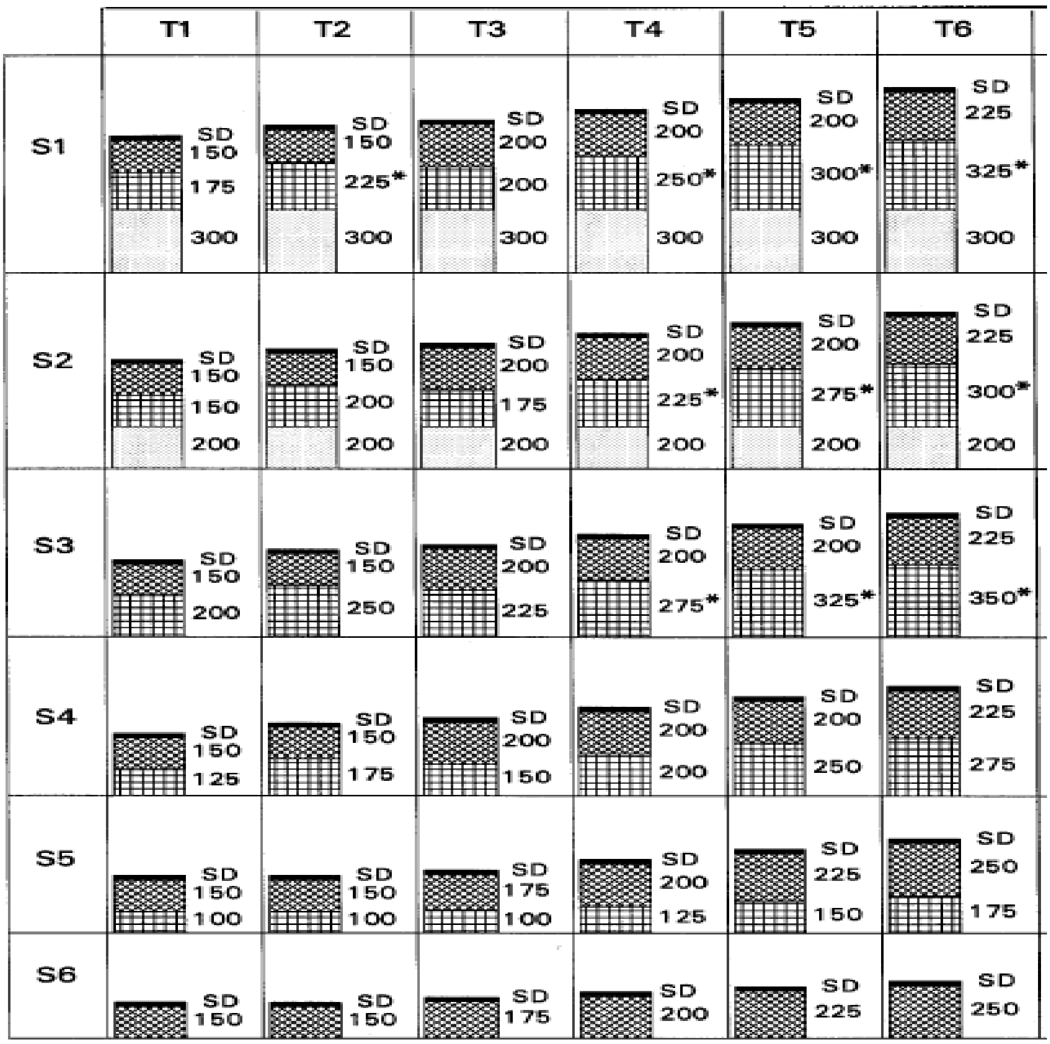


Figure 8.4: Design Configurations **(TRRL 1993, ORN 31)**

Key: TI -T6 Traffic Classes; S1 to S6: Subgrade Soil Classes

Community projects as earlier discussed in the previous analysis, mostly lacked any form of design preparation, except for HA3, where designs are prepared in house by the department of civil engineering services:

> "*Preliminary and detailed designs are prepared for community projects by the department of Civil Engineering Services"* (HA3-MQS).

The follow up questions eliciting information on the level of adherence in designs to the TRRL requirements, were logically deemed by the researcher as being more applicable to HA3, and consultants for the major projects who actually prepared detailed designs. However, this line of questioning was still retained to assess the respondents' level of knowledge on the technical requirements of the TRRL (1993) guide

The limited response of the operational civil engineer for HA3, however did not display adequate knowledge of the TRRL, (1993) design guide, sufficient to infer if the agency actually deployed this guide for the design of community roads or the level of adherence to the minimum GI requirements for various classes of traffic load:

> *"Of course we use standards, there are standards for everything. We use the latest 2015 standard…" (HA3-OCE)*

Further enquiries on the class of traffic that the roads were typically designed for revealed that none of the agencies incorporated this variable in the design of community roads as noted from all the responses. HA1-MCV was unable to answer the question, stating: "*I am not sure but I can always find out."*, while HA1-OCV appeared amused by the question, exclaiming unequivocally that: *"Ah! we don't even prepare full design drawings, yet you are asking of traffic class. That one is text book story, nobody bothers with all that.* HA2-OCV gave a similar response, in less certain terms*: "Oh, do you mean vehicles per day or what? I have forgotten about all that. I know from text books that this should ideally be the case. But I don't think we go to all that length".* HA3-OCV was more guarded and evasive in response*: "Well, I am not certain of that, but of course this should be the basis of designs",* which led the researcher to doubt the truthfulness of HA3-OCV's assertion.

However, the two external design consultants stated that the TRRL (1993) was used as a basis for the design of major roads, quoting some of the minimum CBR requirements for subgrade and discussing other technical details in the guide. HA1-DC commented:

"The CBR method, which is used by the federal government to set regulatory design standards for the quality of subgrade, has gained credibility in federal highway designs in Nigeria, as it gives a good indication of subgrade strength".

However, (HA3-DC) stated that he had presented a paper at an engineering conference on the TRRL guide, in which he pointed out some limitations of the guide and advocated that Nigeria needed to develop a highway design guide specifically tailored to reflect local conditions. It was commented that:

"It is high time Nigeria developed its own highway design standard. Look at a developing tropical country like India which has its own highway design manual specifically for the construction of their roads. Nigeria like most other African countries still has to depend on using highway manuals prepared by other developed countries" (HA3-DC).

8.3.5 Adequacy of Contractors GI in DB Designs

Responses by HA1-RC and HA2-RC revealed that they often times did not carry out ground investigations before bidding for jobs, on the premise of the uncertainty of being awarded the contract. This was expressed in the responses by HA1- RC and HA2-RC, who stated that site visits and information from previous projects executed in the area often constituted the geotechnical input when designing such schemes. It was explained by HA1-RC that the time frame normally allocated for contractors in the competitive bidding phase was too short to allow for a thorough examination of the project and the ground condition at project site and that irrespective of this, the contractor would only carry out detailed ground investigations if they were reasonably certain of being awarded the contract. It was stated that:

"... Due to uncertainty of being awarded the contracts, we are often reluctant to incur such high expenditure associated with ground investigations. We often times engage civil engineers who prepare the designs for such projects from visual inspection of the sites" (HA1-RC).

HA2-RC expressed similar reservations about the level of financial resources required to carry out detailed ground investigations suggesting that the cost of such studies constrained the level of geotechnical input in designs prepared when bidding for design and build contracts. It was explained that:

"We approach engineers to prepare designs, but we do not employ geotechnical consultants to carryout soil investigations…soil investigations are very expensive and we cannot afford to commit such an amount, when we are not certain of getting the job" (HA2-RC)

HA3- RC however seemed to adopt a different approach, explaining that prior to bidding for such contracts, geotechnical professionals employed by the firm were responsible for all site investigations requisite for designs. HA3-RC stated that the firm carried out ground investigation reports before concluding the final designs:

> *"We have staff who are geotechnical professionals ... For all our DB contracts…we carry out desk studies on the proposed project area, organise site visits before detailed ground investigations are carried out to determine the engineering characteristics of the sub-soils to be inputted in designs"* (HA3-RC).

It was also noted that most jobs awarded to this firm were DB projects due to their level of established efficiency. It is one of the largest and well established construction firms in the region. It was stated that although several of the DB contracts executed by the firm were negotiated contracts for specialist highway projects with multiple bridge crossings, they also handled less complex DB projects contracted on a competitive basis.

8.3.6 Theme Summary: Level of Geotechnical Input in Design Phase

Geotechnical input is noted as completely lacking in design preparation for traditionally procured community projects for HA1 and HA2. It was made clear to the researcher that what constitutes designs in HA1 is a schematic outline of the scope of work as contained in the survey plans used to prepare bill of quantities, supplemented by specification notes. For HA2, the mostly non-existent designs/sketches, inferred as prepared on a discretionary basis by the agency's in-house civil engineers, clearly did not have any form of geotechnical input. It was also inferred from the responses that the professionals did not see any particular relevance in carrying out ground investigations for small scale road projects. However HA3 seemed to have adequate in-house geotechnical input for community road projects, and the design professional appeared to understand the risk implications of inadequate ground investigations.

The researcher thus inferred that in HA1 and HA2, heterogeneous soil profiles, not discernible during site visits were not reflected at the design phase and were approximated. Designs with standard items are used uniformly throughout the length of the road, with the depth of excavation and fill adjusted in response to soil conditions noted from visual inspection. The tenets of best practice outlined in the literature, however dictates that the site inspection serve as a basis to assess the suitability of the site for the proposed works, a basis upon which the detailed ground exploration is planned. Limiting ground investigations to this preliminary phase, can thus be inferred as a critical issue, which would likely increase the probability of encountering unexpected ground conditions and lead to cost overruns. As such differences in the geotechnical properties of sub-soils along a proposed route will not necessarily bear upon such designs for community projects. A case for over design or under design of such road projects could be made for sections of roads underlain by firmer or weaker subsoil strata.

The level of geotechnical input in designs prepared by consultants for major roads procured traditionally, could not be ascertained, due to contradictory responses from the chief consultants, lower cadre staffs in the consultancy firm, and the highway agency. However, from the response pattern of the chief consultants, the researcher inferred that only preliminary site reconnaissance are carried out, before the detailed ground investigations. No reference, however, was made to carrying out desk studies (related searches on the geology of the project site) which should ideally precede detailed investigations. This gives an indication which serves to reaffirm literature assertions, by the ICE (1999) that this phase of ground investigation is often overlooked, leading to cost-overruns that could have being prevented.

The response pattern of the civil engineers in the highway agencies leads the researcher to infer, that the local highway agencies in the Niger Delta do not adopt the TRRL (1993) design guide, required by the Federal Ministry of Works. By implication, the geotechnical requirements of the TRRL (1993) guide, which is now widely used in developing countries, to provide guidance on the structural design of roads within tropical regions, and define the construction material requirements, are not ensured on highway projects in the region. The use of homogenous designs in the award of contracts, particularly for community road projects, clearly evidences this. This has significant consequences for cost overruns, as the TRRL (1993) guide, explicitly provides a catalogue of design configurations, which determines the required thickness of the pavement structural layers, from sub-grade to surfacing, and by implication, the financial sensitivity of project estimates to changes in sub-grade properties.

It is also apparent that the level of geotechnical input in DB road projects executed by the highway agencies still remains in doubt. Poor geotechnical input and ground related risk management at the pre-contract phase of DB contracts, awarded before detailed ground investigations have being carried out is indicative of this. Contractor’s responses on the level of geotechnical input in design and build projects, was noted by the researcher as directly reflecting the firm’s size and relative risk perception. DB projects executed by the larger more established construction firm (HA3-RC), which has a geotechnical division, was inferred to have an adequate level of geotechnical input. The precise level of pre-contract GI by the smaller firms however remains un-established due to the financial loss implied by losing the contract. This finding aligns with the literature, which questions the adequacy of geotechnical input in DB designs procured under competitive tendering, as the quality of designs may be compromised. It can thus be inferred that a chain of geotechnical shortcomings has plagued the designs for community and major projects executed in the Niger Delta.

8.4 Geotechnical Input at the Contractual Phase: Clients Vs Contractors

This theme is set to elicit information regarding the level of geotechnical risk containment in highway contracts awarded by the three organisations, following the coding structure shown in Figure 8.5. The researcher analyses the responses of the respondents from the highway agencies, on how projects are procured and the criteria for contractor selection. The researcher also analysed responses elicited from contractors, relating to their firm's geo-risk containment strategies, in response to the level of detail provided by the highway agencies, and the approach to managing risk inherent in the geologic setting of the region, during bidding.

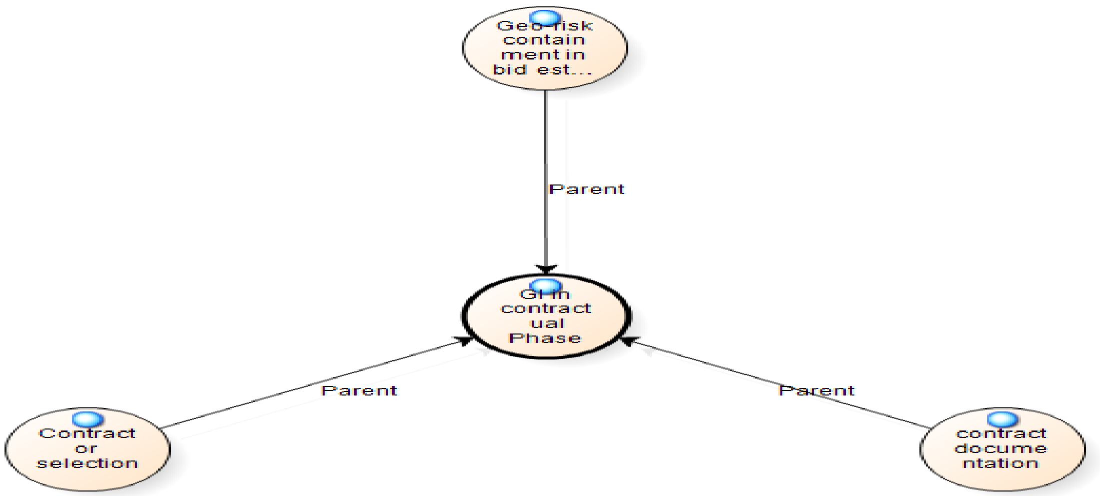


Figure 8.5: Coding Structure for GI in Contracts

8.4.1 Clients: Adequacy of GI in Contract Documentation

The level of geotechnical input in traditionally procured contracts was inferred on the basis of the inclusion/exclusion of Ground Investigation Reports (GIR), or any provisional Differing Site Condition (DFC) clauses, in the contract documentation provided for contractors, at the tender phase, when bids are solicited. Respondents from HA1 and HA3 stated that traditional procurement was principally used for major and community projects. For HA2, all major projects are procured on a DB basis, while community projects may be discretionarily procured either on a traditional or DB basis.

> *"In the past, traditional contracting was the norm… where comprehensive designs are prepared, bids were solicited, before the selection of a successful contractor. However, in the current practice of the agency, almost all projects including numerous small community roads are procured on a DB basis, depending on the urgency". (HA2-MQS).*

The typical contract documents used as a basis of traditionally procuring major and community projects as commonly listed by all six quantity surveyors from the three agencies are summarised in Figure 8.6.

Traditional Major Projects

HA1 and HA3:

- **Form of Tender;**
- **Bill of Quantities;**
- **Engineering Drawings;**
  (*Structural, mechanical, electrical....*)
- **Conditions of Contract.**
  (*Joint Contract Tribunal - JCT*)

HA2 (DB)

- **JCT**

Community Projects

HA1:

- **Approximate Bill of Quantities;**
- **Survey Plans/Sketches;**

HA2

- **No designs or sketches**
- **Approximate Bill of Quantities;**

HA3

- **Form of Tender;**
- **Bill of Quantities;**
- **Detailed Design Drawings;**
- **JCT Conditions of Contract.**

Figure 8.6: Contract Documentation provided by Clients to Contractors in Bidding

Respondents were asked whether GIRs were included as part of contract documentation or if there were any form of DSC clauses in contracts used. For HA1, the operational level Q.S did not give any confirmation to this for major projects, while unequivocally responding in the negative for community projects as stated:

> *"For major projects, I am not sure. But I think if the contractor requests for the ground investigation report, it can be made available. As for community projects ... there is absolutely nothing of that kind in the contract documents*" (HA1-OQS).

However, HA1-MQS stated that although ground investigation reports were part of the design drawings and reports prepared by consultants, they were not necessarily included as part of the contract documentation. The respondent thus argued against the use of a DSC clause, asserting that:

> "*It is clearly stated in the conditions of contracts, that contractors are advised to visit site and verify the conditions of the site for themselves. With this clause in the contract, it is the contractors' prerogative to ascertain things for themselves and not have to rely on us to define the conditions of site. The ground investigation reports prepared by consultants for major projects are for the agency's internal use in designs"* (HA1-MQS).

Respondents from HA2 and HA3 also stated that GIR and DSC clause were not incorporated in the standard contract documentation used for the award of contracts in the agency.

HA3-MQs stated that the agency does not include GIR or incorporate DSI clauses, but in cases where the original designs are inadequate to suit specific conditions at site, variations are approved.

> *"Plans and designs for most roads have also needed to be revisited …. Sometimes site conditions at project sites may be worse than was designed for. In such instances, the agency will investigate the validity of the contractors claim".*

8.4.2 Contractors: Bid Price in Relation to Contract Documentation

The scale of the problem, as noted from the responses, was that the contractors attributed major difficulties experienced during the pricing of earthworks, to the lack of information on ground conditions, which often resulted in significant financial losses. The contractors thus rated risk due to unexpected ground conditions, as having a high impact on the viability of contracts. It was explained that sometimes, this could lead to projects requiring different construction methods, materials, and other temporary or permanent works. It was stated:

> *"Changes in ground profile which may require different construction methods or materials are rated as very high risks to the viability of our contracts particularly when we bid without adequate ground investigation information…" (HA1-RC)*

All the contractors stated that the required standard documentation are usually provided by the consultants, other than ground investigation reports on subsoil condition, which was the critical factor that largely influenced the firm's bidding pattern. This appeared to constitute a main area of uncertainty for all the contractors. Typically, HA3-RC stated that: *"It is the critical factor that largely influences our bidding pattern.* HA2-RC further stated that the contingency allocation included, is influenced by how clear the details regarding the ground conditions at proposed sites, are set out, and how management foresees its likely impact. He further explained:

> "… *if ground investigation reports are included it would drastically reduce the risk associated with unforeseen ground conditions during construction and we can more comfortably reduce our contingency allowance in our bids*".

HA1 explained that in the absence of such reports, the firm usually carried out preliminary site investigations by visiting adjoining areas of the proposed site locations, as well as assessing them from soil maps where available, to determine the likely fluctuations in ground water levels or the possible existence of soft clayey/peaty soils. Typically, HA1-RC stated that:

> *"It is difficult for us the contractors to know the right prices for earthworks and other elements of the project that may be potentially affected by poor ground conditions without ground investigation reports. However, in order to meet a deadline, we would rely on our own experience to arrive at a rough approximate estimate…"* (HA1-RC)

Each of the contractors relied on applying different approaches in pricing such works. According to HA1-RC:

> *"In certain aspects of the work where a lump sum is required, we allow about 15% in the price…this or a higher percentage is also applied in areas of the work that we often view as complex or particularly if poor soil conditions are suspected..."*

HA2-RC also pointed out that:

> *"... We build up unit rates for the material, plant, and labour component of each job bearing in mind the likely risk factors which includes poor soils and then apply a fixed percentage of around 25% for profit and overheads".*

HR3-RC stated:

> *"...The profit margin allocated in conjunction with overheads and contingency is adjusted ... is not apportioned as a fixed percentage of the total estimated project cost, but is apportioned locally on the estimated costs for the items in each work section. As such for earthworks which is mostly influenced by ground conditions, we increase the margin significantly to cover for such unforeseen but likely ground conditions".*

The contractors particularly emphasized that the lack of clarity in designs and inconsistency in contract documentation further worsened the situation. This was stated as the norm. Typically, HA2-RC criticised the quality of documentation, stating:

> *"... The quality of tender documents from the *** is so poor and seems to be getting worse over the past decade. In the past, the *** prepared complete and accurate contract documents, and if changes did occur, they were relatively minor" (*HA2-RC).

From the responses, ground condition of the project site was a major risk factor for road projects in the region. It can thus be inferred that contractors; standard practice is to build in extra price margins in their rates or in bid mark-ups as strategies of risk containment during bid preparation, similar to literature assertions.

8.4.3 Contractors: Bid Price in relation to Geologic Uncertainty

The contractors emphasized that the high level of geotechnical uncertainty in the execution of highway projects awarded by the highway agencies, is further exacerbated in the riverine areas of the Niger Delta:

> *"Pricing road contracts to be executed in riverine areas can be tricky because of the level of familiarity that one must have with the terrain in such areas to be able to successfully execute roads jobs in these areas. Several unanticipated cost associated with the terrain may crop up and completely wipe out anticipated profits and you may even end up executing such jobs at a loss. We charge much higher margins for profit and overheads (30-45%).* (HA2-RC).

HA2-RC explained that for a typical distance of 20km in the upland areas, fare price of about N800 per passenger is normal, while the same distance via waterways would cost about N2, 000, which is more than twice the cost.

> *"We may need to employ skilled labour from urban cities such as Port Harcourt and transport them to sites in riverine areas. We sometimes need to sub-contract this aspect of its pre-contract arrangements into the care of specialized firms for a fee or use the ferrying boats available at the water fronts or other departure points in the uplands to convey our skilled craftsmen, however the costs of transportation per seat, of these ferrying boats to riverine communities, is always unstable due to fuel scarcity".*

HA1-RC stated that*:*

> *"There a lot of financial risks to materials being transported on the turbulent waters of the sea or along rivers, as the riverine areas, which are often cut off by lack of existing roads to transport materials."*

HA2-RC further pointed out technical issues in riverine settings which majorly impact on contract execution in these areas and can constitute a basis for claims:

> *"Flooding and higher ground water tables during the rainy season, existence of unstable soft soils to depths that were not anticipated for, hikes in transportation and haulage costs in projects were we need to replace existing subgrades with suitable materials are some of these technical risks".*

HA3-RC, however stated that:

> *"We often request to be compensated for unpredictable issues in riverine settings which may not have been included in setting our contingency funds. However, sometimes the highway agency may refuse to grant this request. We may thus have to bear the financial risk associated with working in such areas".*

The increased financial requirement and geologic uncertainty, associated with executing highway projects in riverine areas, is unanimously expressed in the contractors' responses. Contractors' abilities to manage the high level of geologic uncertainty associated with physical configuration of the terrain, against the background of difficulties typically associated with construction works in the swamps and coastal zones, is apparently a key success factor for highway projects. This will thus require a high level of geotechnical experience by contractors, and familiarity with the rigours and uncertainties of construction works in these areas, for a project to be successfully completed under budget and time. The technical criterion adopted in contractor selection is thus deduced, as a crucial factor, which can determine the level of cost overrun experienced upon completion.

8.4.4 Clients: Adequacy of GI in Contractor Selection Criteria

Traditional procurement system was stated by respondents from HA1 and HA3 as the common procurement route for major and community projects executed by their agencies. Contracts are awarded on either a competitive or selective tendering basis. This is in line with the Federal Government Procurement Act of 1991, based on which a formal '*Call for bids*' or '*Expression of interest'* is mandatory to be made for all public works. At present times, for some mega projects running into multi- billion Naira, the respondents clarified that the need to integrate project design and construction, has resulted in a shift towards Design and Build (DB) contracting system, in a bid to achieve cost, schedule and quality objectives.

The interview revealed that, the selection of contractors is based on the lowest bid criteria, repeatedly discouraged in the literature. Typically, it was thus stated:

> "*…for traditionally procured major highway projects, subsequent to the 'call for bids', financial evaluation, determine the successful contractor, which often goes with the lowest bid value.* (HA3-MQS)

Respondents from HA1, however stated that, this was with the exception of community projects, which do not necessarily follow any formal protocol, due to the community pressure and urgency associated with calming youth restiveness in the region.

> *"For community projects … it is a mad house. Projects are usually emergency projects which are executed to settle community demands and reduce tension. They are often rushed" (HA1-OQS).*

For HA2, respondents explained that in the past, the traditional design-bid-build system, was the dominant procurement route adopted, but at present times only a few community projects were awarded following the traditional route. As such it was clarified that most projects awarded by HA2, were DB projects. For HA1 and HA3 the interviews revealed that that the agencies only awarded projects on a Design and Build Basis for mega highly technical projects, and that the awards for such contracts were usually based on the established technical competence of the contractor. Such contracts were emphatically stated has always being awarded to well qualified contractors.

> *"Most mega projects, are awarded on a design and build negotiated basis, as they require the particular technical expertise of an experienced construction firm with the requisite level of technical know-how and efficiency" (HA3-MQS).*

HA2-MQS also expressed similar personal opinion and stated that: "*ideally only highly technical road projects should be awarded using DB procurement".* However, HA2-MQS, the management level Q.S who had worked in HA2 for more than 20 years recounted that in the past this was the practice for major roads, while traditional contracting was the norm for community roads, where bids were solicited before the selection of a successful contractor. The current practice in HA2 based on the response as recounted by HA2-MQS is that:

> *"Many smaller scale community projects are equally awarded on a DB basis, without any formal call for bids, following the dictates of the political regime"*.

Both respondents from HA2 expressed concerns about the current contractor selection practices prevailing in HA2. HA2-OCE thus stated that most of the contractors were completely inexperienced, often awarded contracts on the basis of their level of political clout, and not on the basis of their technical efficiency. It was commented that:

> *"... The contractors do not know how to execute the jobs... they often had to privately hire the services of the in-house professionals to supervise their projects. What most of the contractors basically managed to do is to employ consultants to design the geometric alignment of the road using the levels from survey plan"* (HA2-OCE).

HA2-MQS also stated that:

> "*Most of the contractors for community projects, are not even registered construction firms, and have no prior knowledge of road construction, much less the relevance of geotechnical investigations*".

This contrast with the DB procurement practices of HA1 applicable only to mega projects, which are usually negotiated. Typically, HA1-MQS stated that:

> *"Most of our major projects are traditionally procured, except for specialized DB projects designed by the contractor and which may be negotiated". (HA1-MQS)*.

Respondents for HA3 stated:

> "*It is the standard practice by the agency for our DB contractors to prepare detailed design for projects, before placing their bids for consideration in a selective tendering arrangement".*

8.4.5 Theme Summary: Level of Geotechnical Input at the Contractual Phase

The interviews have revealed the inadequate level of geotechnical input by highway agencies in the Niger Delta in procuring highway projects. The principal findings from this theme reveal a lack of geotechnical input at the contractual phase in projects procured via the traditional versus Design and Build contracts. Typically issues noted include:

- The high potential for inaccurate over-inflated bid estimates due to non-inclusion of GIRs and DSC clauses, which may not still offset the associated contractual consequences of claims and variations in traditional contracts;

- The adoption of the lowest bid criteria and lack of an explicit basis of geotechnical input in contractor selection by the highway agencies, which raises doubts about the technical qualification of contractors executing highway projects;

- The geologic concerns and difficulties experienced in pricing for road construction works in the riverine areas, which increases the bid values of experienced contractors, who may ultimately loose out to inexperienced and unqualified contractors with lower bid prices.

The findings thus capture the geotechnical risk containment shortcomings in the prevailing contractual practices of the highway agencies. Contractor selection by the highway agencies based on the lowest bid criteria, without incorporating geotechnical bid evaluations of the contractors' capabilities to execute the project, particularly in riverine areas directly connotes catastrophic consequences. This may account for the higher level of cost overruns recorded in the swampy and coastal zones of the region, and the incessant trend of project delays and abandonment rife in highway project delivery in the Niger delta. As Chan and Au (2007:3) asserts:

> "*The owner risks tragedy, first, from cost-cutting measures the contractor will take if it hits unforeseen conditions, and then, from fighting contractor claims and picking up the pieces if the contractor abandons the project or goes bankrupt*".

The practice of highway agencies in the Niger Delta thus confirms literature that highway agencies try to transfer the risk associated with the ground conditions to contractors in their misguided notion of ensuring certainty of final outturn cost (Harrison, 1981; Geddes, 1985; Chan and Au, 2007). The use of JCT, a non-engineering standard form of contracts, by the highway agencies is also noted. Typically, an engineering form of contracts such as the NCE/ICE, Clause 12 of which, makes provision for contractors to recover costs, in the event that an adverse physical condition is encountered, would be more applicable.

The interview analysis results, from the contractors' perspective, further reveals that the non-inclusion of GIR/DSC clause, lack of clarity and in-consistency in designs and contract documentation are the principal issues which affected their ability to make informed pricing decisions when bidding for contracts. It is therefore apparent that mismanaged risk arising from unforeseen ground conditions can cause project inefficiencies and make contract relationships adversarial (Latham, 1994). This is further inferred against the backdrop of the literature, which particularly emphasises that higher level of pre-contract engineering will result in the production of a '*cleaner set of contract documents which are less vulnerable to cost overruns'* (WSDOT, 1991).

The contractors' explanations of their firms pricing approaches, plays out the literature narrative, mapped out by several studies, such as Wong (2012) and Cantarelli *et al*. (2010), on the financial implications of geotechnical poor risk apportionment and containment in the award of contracts. It illustrates, the dynamics of Cantarelli *et al*. (2010) theory of '*game play'* between contractors and clients, in setting price margins during the bidding phase. Lack of awareness of the need for ground-related financial risk management in contracts, evidenced by the non-inclusion of ground investigation reports, has been shown to either elicit higher levels of contingency allowance that have to be provided for in such bids, or higher levels of claims and variations, as confirmed by all the contractors interviewed. This scenario further corroborates the assertions of the Grove Report (1998) which states that "*Contractors, who are gamble and claim artists, will predominate among winners of contract award".*

The analysis thus shows that most of the contractors handling community projects lacked the relevant technical expertise and experience, which is a definitive parameter necessary to ensure geotechnical input in the award of contracts. Political and community pressures, appear to constitute the basic consideration by the highway agencies in contract award. Further analyses of quotes, descriptive of this external interference in contractor selection within the highway agencies, are coded under the emergent themes.

From the interview response, it is also noted that for major DB projects, none of the respondents described carrying out preliminary technical bid evaluation, such as using any systematic form of composite algorithm that incorporates geotechnical criteria in contractor selection. The literature however advocates geotechnical input in contractor selection, as subjectivity in the process of contractor selection is eliminated by the explicitness of the procedure, with increased emphasis on geotechnical input requirements in the RFQ or RFP. Gransberg and Gad (2014) emphasized the need for an informed unbiased appraisal of contractors' technical capabilities relative to bid price via the development of multi-parameter quantitative models for contractor selection.

Adequate geotechnical input, which is a key investment strategy for any road project, necessary to avert the risk of variations and claims leading to delays and cost overruns, represents the missing link, highlighted in the analysis. The researcher thus infers that the various geotechnical issues at the contractual phase, represent the 'bowl of contention', between contractors and clients in highway contracts, and are therefore, the festering latent pathogens, which ultimately manifest in the post contract phases. These issues which ideally ought to be resolved at the pre-contract phase, are allowed to spill into the post contract phase by the highway agencies, and have to a large extent resulted in the state of highway project delivery and cost overruns in the Niger Delta.

8.5 Post Contract Impact of Geotechnical Risk

This theme was set to analyse the impact, that the prevailing levels of pre-contract geo-technical input evident in the practice of the highway agencies, has had on highway project delivery in the Niger Delta region. This inference is deduced based on the typical responses, elicited from the clients and contractors, on the issues and tensions, that are precipitated as a chain of contractual impacts, upon encountering differing physical conditions of site, other than anticipated by contractors, when bids were placed, based on insufficient geotechnical information (Figure 8.7).

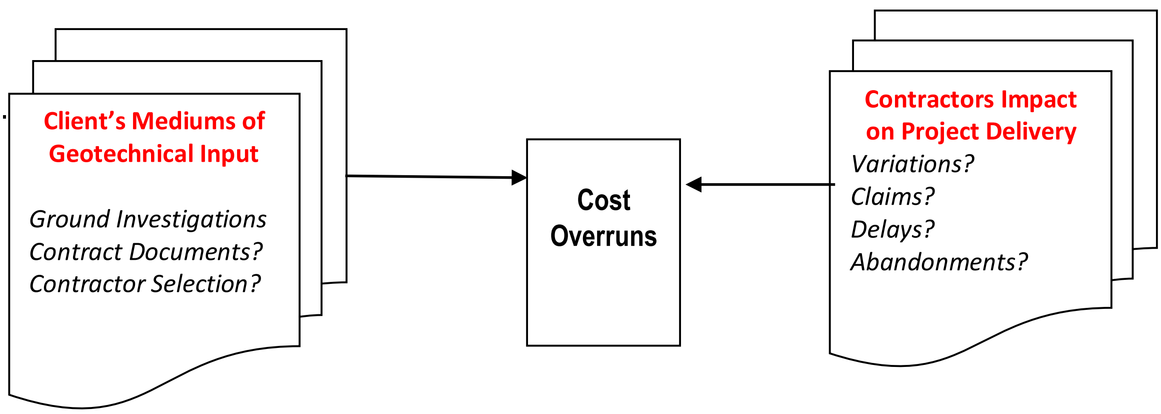


Figure 8.7: Post contract Impact of Geotechnical Risk

A descriptive analysis of the level of delays, and its impact on project delivery, typically occurring in response to differing site conditions and other contractual claims arising on this premises is used to corroborate this inference.

8.5.1 Variations and Claims Due to Differing Site Conditions

For HA1, the respondents explained that claims and variation orders made on the basis of unexpected ground conditions were relatively fewer in major projects than in community projects. HA1-OCE explained that:

> *"For major roads, if before the award of the contract, that is during bidding, if one of the contractors discovers that the site conditions are different from what is provided for in the BOQ prepared by the consultants, we simply go to site to verify it and communicate this information across to all the other contractors bidding for the job. This may happen since site investigation reports and costing of proposed major roads are usually prepared several years in advance of the procurement phase. However, after contract award we have limited numbers of such case".*

It was however, explained that although less frequent cases of unexpected site conditions occur in major projects, than in community projects, when it did, the cost implications were often more significant. As HA1-MQS stated:

> *"…We have had issues were the designs were completely unsuitable for the soils at project location and latter had to be redesigned. For one particular major project, this had meant a colossal increase in project cost because of the lengthy delay it caused in the project".*

For HA2, respondents expressly stated that most of their projects were awarded on a DB basis, yet frequent changes and variation orders due to unexpected ground conditions, were approved in response to demands by contractors, who were supposed to have prepared detailed designs, as specified in the contract documentation, and for which a provisional sum for site investigation is provided. According to HA2-OCE:

> *"...Contractors collect money for site investigations and the preparation of detailed designs and simply pocket it. It is only when they encounter poor unexpected soil conditions that they may eventually employ a geotechnical consultant to determine its extent, to demand extra payment"* (HA2-OCE).

HA2-MQS described a typical instance of a mega project where unexpected ground conditions occurred due to inadequate ground investigation:

> *"The *** road project traversing several soil types from the uplands all the way through the riverine areas was abandoned on the basis of inaccurate estimate resulting from inadequate ground investigation. The project ideally supposed to cost 1.2billion Naira, was initially priced at 800million Naira by the contractors, but was later down scaled to*

> *600million Naira after lengthy negotiations with the government. However, when the project commenced, several significant unanticipated cost cropped up due to unexpected ground conditions and the project had to be abandoned for several years after payment of mobilisation fee"*.

For HA3, the respondents explained that any claims made by contractors on the grounds of unexpected site conditions experienced during excavations and ground work, such as due to ground conditions, were not entertained by the agency, on the basis of the contract terms which required that contractors should verify site conditions.

> "*It is clearly stated in the conditions of contracts, that contractors are advised to visit site and verify the conditions of the site for themselves. With this clause in the contract, it is the contractors' prerogative to ascertain things for themselves …"* (HA1-MQS).

It was argued that such financial claims were considered unjustifiable, and as such no demands for extra payment can be granted to contractors. It was thus stated that:

> *"… if the contractors for major projects still persist in demanding financial compensation for such claims, the project has to be halted, and the agency's legal unit will have to pursue settlement in court"* (HA1-MQS).

The researcher thus noted that, lengthy delays will occur on account of this ensuing legal tussle, which will likely drive the final cost of such major projects beyond the initial budgeted cost. The lack of flexibility in contractual documentation, with respect to the exclusion of GIR, and the lack of contractual provisions made via DSC clauses, to equitably allocate and contain risks, due to differing physical conditions on site, may still have a high financial impact on projects executed by the HA3.

8.5.2 Delays: Project Timeline Shifts due to DSC

This theme investigates the contractors' perceptions of how the practices and timeline of the highway agencies, has affected their approach to geo-risk containment during and after contract award. This is deduced in line with the literature assertions, about the chain reaction impact of lack of adequate pre-contract GI, at the construction phase:

> *"Most major construction activities involving the ground lie on or are sufficiently close to the critical path for any delay to that activity to affect the whole of the project. The consequences of inadequate investigations are shown to be severe for both the engineering and construction phases of a project…"* (ICE, 1991:8).

Along this line of enquiry, HA3-RC clarified that this was because:

"If permanent or temporary works are affected, we have to apply for a variation order and time extension, particularly if the contract is likely to be delayed beyond the contract completion date".

It was however stated that they still experienced lengthy delays due to the non-availability of funds, after the approval process, which often lead to the disruption of the construction timeline, as other construction activities are pushed forward.

HA2 stated that cases where claims where granted, typically due to unforeseen groundwater during earthworks, excavation and all other follow up activities are delayed:

"We have to wait for approval of variation order before we can proceed to install a dewatering system. This delay will consequently affect other items of work in the programme schedule and may push other earthworks and pavement works into the rainy season month, during which not much construction work can be done" (HA2-RC).

HA2-RC expressed particular dissatisfaction with the time lag between the application, approval and the remittance of funds:

"Our cash flow on these contracts are very unpredictable. There was a time, we sank in most of our capital into a project, after our application for variation was approved. We were assured that we would receive payment within a week. Due to flooding of the project location, which caused very high water table, and we had to hire machinery to access the swamps in order to commence ground works, and suddenly, there was a change in administration. The payment was delayed for more than 2 years. The firm almost ran aground, as we became cash strapped".

8.5.3 Delays and Abandonment: Post-Contract Protocol for Approval of DSC Claims

The protocol followed by the agency in response to contractual claims and variation orders related to ground conditions, and the approximate timescale requisite to resolve such issues at the post contract phase was elicited from participant responses. For all major projects executed by the highway agencies, monitoring and supervision of contractors, is carried out by consultants who have to verify reports on progress of work and make recommendations for milestone payments to contractors. As such in instances were issues of differing site conditions were verified by the consultants, the respondents from the agencies explained that they have to ascertain the validity of contractors' claims before a variation order can be approved. Following the verification of formal written application for claims and variations, the application is forwarded to the relevant higher authorities. The practice for community projects however requires the in-house quantity surveyors or engineers to directly visit site based on the contractor's application and verify such claim.

HA1-OQS stated that the approval processes for such applications though confined within the organisational structure of the agency, implies that the associated bureaucracy of gaining further budgetary approval can amount to lengthy delays since these additional costs were not part of the planned budget of the agency, and projects had to be suspended until funds are available to foot the bill. For major projects, it was stated that:

"The contractor has to wait for the variation order to be approved. The approval process requires a lot of paper work and the application would have to move from one office to another before it can be approved".

HA1-OQS explained that community projects, usually get delayed for very lengthy periods. The respondent further provided evidence to this effect. Table 8.1 is an extract from the list of abandoned community projects awarded by HA1, showing the date of award, most of which are over a decade ago. These projects were explained by the respondents as being abandoned on the grounds of funding shortfall, resulting from variations and claims due to technical issues related to ground conditions.

Table 8.1: An Extract of Community Projects Currently Delayed and Abandoned by HA1

DESCRIPTION	LOCATION	STATUS	% COMP	TYPE	DATE OF AWARD
OKOGBE OGBOLOGBO OCHIBA ROAD	AHOADA WEST	STALLED	75	ROAD	1-Jun-02
AJA-ETIE AKPOALOKA	VARIOUS	STALLED	45	ROAD	4-Nov-02
CONSTRUCTION OF CONCRETE FOOTBRIDGE	OLOIBIRI	STALLED	75	ROAD	2-May-03
OBOHIA - MKPOROBE ROAD PROJECT	OBUOHIA-MKPOROBE	STALLED	55	ROAD	3-Jun-03
CONSTRUCTION OF OMOKU OKPASIMINI - ORASHI RIVER ROAD/BRIDGES (2.7KM ROAD AND 273M LONG BRIDGE)	OMOKU OKPASIMINI, ORASHI RIVER	STALLED	10	ROAD	28-Jul-03
CONSTRUCTION OF UMUWANWA - OBIZI ROAD	UMUWANWA - NWA OBIZI	STALLED	24	ROAD	10-Dec-04
CONSTR. OF IKOT - AKPADEN - NDON OBODOM - IKOT EKPUK - IKOT EDEGHE IKOT USOP ROAD	IKOT - AKPADEN - NDON OBODOM	STALLED	40	ROAD	10-Dec-04
CONSTRUCTION OF INTERNAL CONCRETE ROAD NETWORK/DRAINAGE & FOOTBRIDGE	OTUOKE	STALLED	40	ROAD	10-Dec-04
CONSTRUCTION OF INTERNAL CONCRETE ROAD NETWORK AT SANDFILLED AREA, BASSAMBIRI, (4 KM, PHASE 1)	BASSAMBIRI	STALLED	30	ROAD	10-Dec-04

It was further explained, that the disruption of work schedule caused by unanticipated ground conditions often elicits further claims, on the basis of lost/un-productive plant and man-hours.

"... The contractor at this point has to suspend the work on site until he is given a go ahead to continue with the work, otherwise he will not get paid for any additional expenditure. Meanwhile, the contractor has hired equipment on site and other overhead expenditure which are running on a daily basis irrespective of the fact that work progress has stopped. The contractor would equally make claims on this ground" (HA1-OCE).

As such, the respondents explained that:

> "… *if the contractor does not have the financial capacity to continue work on site after the variation orders and claims have being processed, the project will simply stop until budgetary approval is gotten" (HA1-OQS).*

This cycle, according to HA1-OQS may continue up until the end of the financial year at which point any unspent funds will have to be returned to the treasury, and the increased financial requirements for the project will have to be considered in the budget for another financial year.

It was explained by respondents in HA2 that:

> *For community projects, a quantity surveyor or engineer has to visit site based on the contractor's written application and verify such claim. When we have gone to site and assessed the claim made by the contractor, we then report back to the agency, for the variation order to be approved. (HA2-OCE).*

It was however emphasized, that if the contractor does not have any strong links with the current political administration, or with in-house staff to facilitate the approval process, the contract may just lie in an endless limbo, with the contractor eventually having to abandon the project.

> *"…this may take lengthy periods of several months and even up to a year, depending on the contractor's personal political connections to push for his application to be handled" (HA2-OCE).*

It was also stated:

> *"… If the contractor does not have an insider, his file and application will not be pushed forward for approval and he would keep running around in circles waiting for the approval which may never surface" (HA2-OQS).*

Delays due to this, may span several months or even years. Based on current information accessed on 12/04/2015 from the official website of HA2, over 170 roads are being constructed, most of which are major projects executed in upland areas, with few located in riverine areas, listed as been completed and near completion as shown in Table 8.2.

Table 8.2: Highway Projects Executed by HA2

Project	Status
First Bank/Rumuobiakani/Old Aba Road	Completed
Oginigba /Slaughter Road	Completed
The Elekahia/Rumuomasi road	Completed
Rumuola Road (completed)	Completed
Eneka/Igbo-Etche/ Iriebe road	Near Completion
Woji/Okujagu/Elelenwo road.	Near Completion
Rumuagholu /Ada George road	Near Completion
Ken Saro Wiwa road/ Stadium road	Near Completion
Rumuibekwe/Elelenwo road and bridge	Near Completion
Rumuekini/ Aluu road	Near Completion
Ozuboko/Elelenwo road-	Near Completion
Rukpokwu/Eneka/Eligbolo road	Near Completion
Rukpakwulusi /Eligbolo /Rumuodomaya road	Near Completion

Confirmation was sought from the respondents, who unequivocally stated that publicised projects were for media purposes.

> "*All what is projected to the public, are less than 20% of contracts awarded in 2008. As I speak to you, over 75% of these projects are not publicised because they have been delayed and abandoned. Several of these projects experienced technical hiccups and had no political god father to rescue them" (HA2-MQS).*

For HA3, the management QS explained that the agency had put in place pro-active measures to curtail the negative practices of contractors always devising avenues to make claims:

> *"We have recently devised a financial risk management system for contractors' payment through banks. The banks which have to insure the contractors therefore bear the risk of project failure. This system requires the contractors to sign an insurance bond with the banks who have an independent set of professionals to cross-verify the recommendations for milestone payments made by agencies consultants and in-house professionals..."* (HA3-MQS)

HA3-MQs further enumerated several ongoing and completed major projects awarded in 2012, which were already completed or near completion, and referring to documentary evidence to this effect as shown in Table 8.3.

Table 8.3: Extract of Completed and Ongoing Road Projects Awarded by HA3 in 2012

TITLE	DESCRIPTION	IMAGES
Edepie-Tombia Bridge (Completed)	Newly Completed Edepie-Tombia Bridge 3 Showing Before and Present States	, 
Edepie-Tombia Bridge (Completed)	Edepie-Tombia Bridge 2 Showing before and after Completion States	, 
Edepie-Tombia Bridge (Completed)	Edepie-Tombia Bridge 1 Showing before and after Completion States	, 

TITLE	DESCRIPTION	IMAGES
Ox-Box Lake Road (Completed)	Newly Constructed Ox-Box Lake Road	
Ox-Box Lake Pavilion Road (On-going)	Aerial View of Ox-Box Lake Pavilion Under Construction Showing,	
International Cargo Airport Road (On-going)	Cross Section and Aerial View of International Cargo Airport road Amassoma Under construction.	, ,

It was thus explained that under the closely monitored and standard contractual environment maintained by the agency, budgeted funds for major projects, as projected at the conceptual phase are paid to the collaborating banks, based on which all subsequent disbursements were made, although subject to necessary verification and approval.

The respondents from HA3 explained that in the long run, claims made by contractors soliciting additional funds, due to differing site conditions in major projects, in the few cases where approved, implied a lengthy bureaucratic protocol:

> "…*the agency has to seek for budgetary approval, which has to go through the organisational hierarchy of the organisational set up, headed by the commissioner for works. This had to be done before further approval from the State House of Assembly, which constitutes the legislative arm of government and the Governor is sought".*

HA3-OQS explained that for community projects, the contractor's application for variations on the grounds of unexpected ground conditions, after in-house verification, will ultimately proceed to the governor's office, before approval for the release of extra funds can be gained. It was further stated:

> *"...How soon the eventual payment for such changes will be made however depends on how long it takes to process the application, the availability of funds as well as on the urgency of the project"* (HA3-OQS).

This aligns with literature findings by Cusworth (1993), who provided a schematic outline of the typically lengthy budgetary approval process for public projects in developing countries. The researcher thus infers that the total cost of the overall delay and disruption can build up to disproportionate financial proportions for the highway agencies.

8.5.5 Theme Summary: Level of Post-Contract Impact due to Geotechnical Risk

The findings on this theme has captured the post-contractual management issues experienced by highway agencies and contractors in the delivery of highway projects in the Niger Delta region. The chain of evidence, established from the analysis has therefore provided qualitative explanations, about how the prevailing levels of geotechnical input, has impacted on project delivery in the Niger Delta. The findings thus reinforce local literature evidence, which alludes to the poor procurement practices of public agencies in Nigeria, as the fundamental cause of project delays and abandonment. It has provided contextual information which clarifies the mechanism of the build-up of unusually high cost overruns previously analysed in chapter 5. The geotechnical shortcomings of the highway agencies represent the latent pathogens, which have provided a fertile ground for contractors to make claims leading to delays and project abandonment at the post contract phase.

8.6 Chapter Summary

This chapter has provided a detailed analysis and evaluation of the levels of pre-contract geotechnical input, and its post-contract implication in the geologic setting of the Niger Delta region. The themes have thus defined the technical basis of qualitatively assessing the prevailing level of geotechnical input evident in the practices of highway agencies. The findings have served to provide a descriptive snapshot of the design and costing practices of the highway agencies in the Niger Delta, which shows that the reality of the situation for project delivery, depicts a far departure from the theory of good practice relevant for the delivering cost effective delivery of highway projects. An array of factors predicated on the need for geotechnical input have thus been identified as contributing to the unusually high levels of cost overruns evidenced by highway agencies in the Niger Delta (In Table 8.4).

Table 8.4: Assessment of Level of Geotechnical Input in Highway Projects

Themes	**Organisational Scores**		
	HA1	**HA2**	**HA3**
▪ *Nomenclature of Project Development Phases*			
❖ *Major Projects*	Consistent	In-Consistent	Consistent
❖ *Community Projects*	In-Consistent	In-Consistent	Consistent
Level of GI at the Preliminary Project Phases			
▪ *Level of Geotechnical Input in Planning:* ❖ *Major Projects;* ❖ *Community Projects.*	 None None	 None None	 None None
▪ *Level of Geotechnical Input at the conceptual phase:* ❖ *Major Projects;* ❖ *Community Projects.*	 High None	 Low None	 Low Low
Level of Geotechnical Input at the Design/Contractual Phases in Relation to Procurement Route			
GI in Designs			
▪ *Adequacy of External GI in Major Projects* ▪ *Adequacy of In-house Design preparation* ▪ *Adherence of in-house designs in relation to GI requirements of TRRL (1993);* ▪ *Adequacy of GI in DB Contractor's Designs*	Unverified Inadequate Unverified	Unverified None	Adequate Adequate
▪ *Mode of In-house Assessment of Heterogeneous Soil Conditions*	Inadequate	Inadequate	Adequate
▪ *Adequacy of Contract Documentation (Client's):* ❖ *Major Projects* ❖ *Community Projects*	 Inadequate Highly Inadequate	 Inadequate Highly Inadequate	 Inadequate Inadequate
▪ *Adequacy of GI in Contractor Selection Criteria* ❖ *Traditional Major* ❖ *Traditional Minor* ❖ *DB Mega* ❖ *DB Minor*	 Subjective (political) Subjective (community) Adequate NA	 N/A N/A Adequate Subjective (Political)	 Adequate Subjective Adequate NA
D&B Projects: Level of Geotechnical Input (Client/Contractor) ▪ *Adequacy of GI in DB Contractor Selection Criteria*	Adequate	Inadequate	Adequate
▪ *Adequacy of GI in DB Contractor's Designs*	Verified	Unverified	Verified
Adequacy of Institutional/Organisational Setting for Ensuring Geotechnical Input			
▪ *Adequacy of organisational environment for ensuring progressive flow of External GI.*	Inadequate	Inadequate	Adequate
▪ *Clarity of professional roles in relation to internal GI in highway designs and costing;*	Not Clearly Defined	Not Clearly Defined	Clearly Defined
▪ *Professional Skills* ❖ *Management Civil Engineers* ❖ *Operational Civil Engineers*	Non-Adherence Not-Discernible Low	Non-Adherence Unverified Low	Unverified Unverified Moderate

The interview findings reinforce the assertion that low level of in-house pre-contract preparation and geotechnical input are still considered normal practice, despite the calls in the literature for a step change, or a paradigm shift in practice (Figure 8.8).

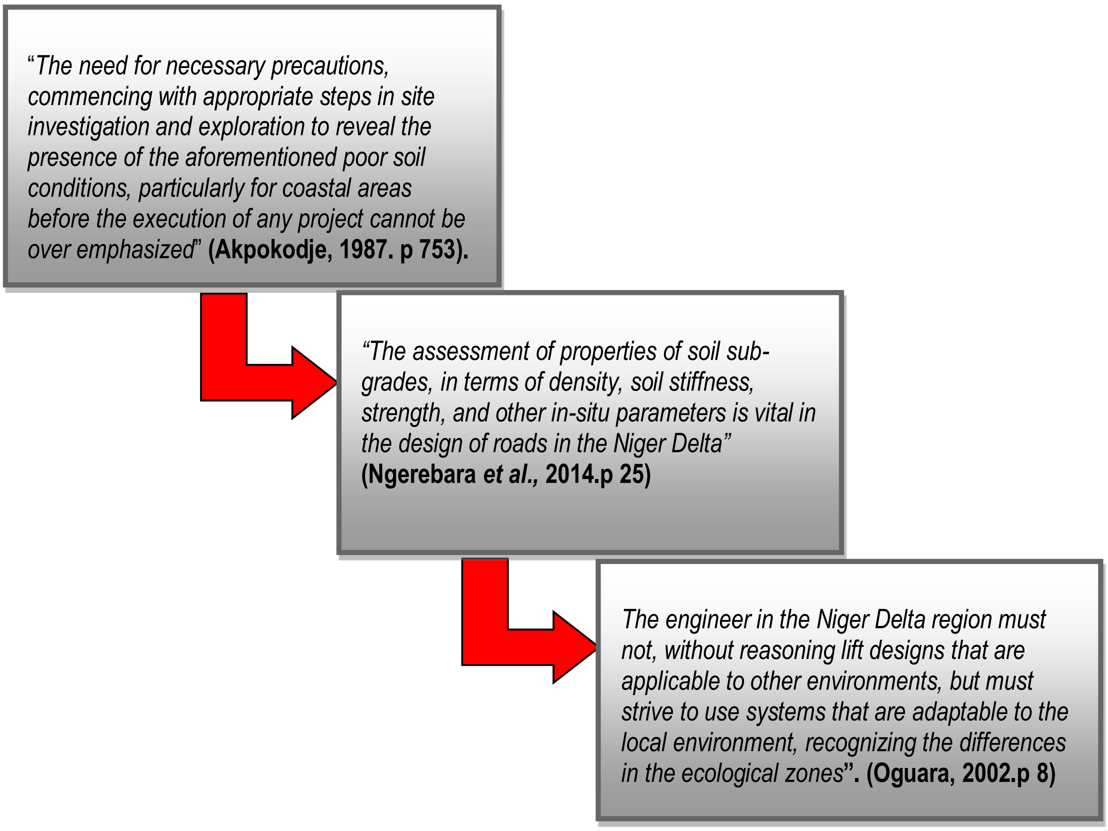


Figure 8.8: Calls in the Literature for a Step Change in Geotechnical Practice

These findings thus suggest that despite several calls for improved planning and the adoption of a more comprehensive pre-construction geotechnical evaluative stage for all highway projects in the Niger Delta, community projects, which are mostly situated in these riverine areas, still exhibit an almost complete lack of planning and geotechnical input in the pre-construction, design phases of the project. This is typified by (1) the inconsistency of phase configuration of projects for highway development. (2) The use of ad-hoc and inconsistent pre-contract preparation and design processes for community projects executed in-house by the three highway agencies evaluated.

In an attempt to further understand the barriers to the paradigm shift in practice called for by these scholars, the research has attempted to uncover the significant organisational, human and psychological barriers to change within the highway agencies, emergent from the interview responses in the subsequent chapter. Chapter nine, thus unveils the contextual factors inherent in the institutional setting of highway development, that account for the prevailing levels of geotechnical input inherent in highway projects executed in the Niger Delta region.

Chapter 9

Contextual Cost Overrun Drivers: Emergent Social Constructs as Barriers to Geotechnical Input (GI)

9.0 Introduction

The foregoing analysis of the core geotechnical themes in chapter eight, has been framed within the lenses of an organisational perspective, as opposed to the more common approach of using project level characteristics to account for cost overruns, as evident in the literature. This has revealed the geotechnical pathogens, latent at the pre and post-contract phases of highway project execution in the Niger Delta, as major risk factors accounting for the high level of cost overruns. This finding aligns with numerous case histories in the literature, which shows that failure to anticipate ground conditions can have significant post-construction cost implications for highway projects. Further inductive analysis of the interview data, however highlighted the dominant role of the organisational settings, people, and external factors, inherent in the institutional system, in determining the level geotechnical input. These socially constructed forces, constitute the emergent barriers to geotechnical best practice in the highway agencies. They are by implication the contextual drivers actively triggering the latent geotechnical pathogens, which often lie dormant in the highway organisations, and have resulted in the unusually high levels of cost overruns experienced in highway projects in the Niger Delta. These emergent issues, visualised in Figure 9.1 as a word cloud, will be discussed in this chapter.

Figure 9.1: Word Cloud Showing Frequently Discussed Issues

9.1 Adequacy of the Organisational Environments for Ensuring GI

9.1.1 Non-Progressive Flow of External GI in Project Phases

For all the highway agencies, it has been noted that geotechnical input in projects commence at the design phase. Prior to this phase, the researcher could not discern any apparent evidence of geotechnical input at the initial the planning and budgetary phases, for both major and community projects. The researcher also noted a lack of continuity in the services of external consultants, who were responsible for ensuring geotechnical input at the design phase of major roads procured traditionally, into the contractual and construction phases.

Respondents from HA1 explained that consultants responsible for preparing designs at the pre-contract phase were different from those used in project monitoring at the post-contract phase. The researcher thus sought to establish the contractual protocol followed by the highway agencies to make relevant changes to designs, in the event of encountering unexpected site conditions, after commencement of works on site. The respondents revealed that if differing site conditions were identified by contractors during the pre-contract phase, this would be communicated to the client and brought to the attention of other bidders, to make all necessary financial adjustment. However, at this point of contracting, it was noted by the researcher that geotechnical input at the detailed design and budget preparation phase, are not necessarily carried forward into the post-contract phase by the design consultants. This was inferred from the respondent's explanations that consultants who designed projects at the budgeting phase concluded all design preparation and their services were terminated:

> *"The department of project monitoring is responsible for the post-contract monitoring of awarded major road projects, via the use of consultants. However, the consultants used at the post contract phase are usually different from the pre-contract team, as designs and costing for major projects may be prepared years in advance of the contract award"*. (HA1 MCE)

This was clarified by the respondent, as being due to the lengthy time interval between the initial long range budgeting phase, when detailed designs are prepared and the contractual phase, before a formal call for bids is made. Accordingly, any necessary adjustments to designs have to be made by in-house professionals who did not prepare the original designs, leading to potential inconsistencies in geotechnical input.

For HA2, all major projects are procured using Design and Build. HA2-MQS thus explained:

"*the services of consultants were only engaged for the purpose of project monitoring. Technical details of design adaptation or changes are thus the responsibility of contractor's consultants*".

Finally, respondents from HA3 explained that the same sets of consultants are used at the pre and post-contract phases of all major projects, procured traditionally.

"For all major projects, the same consultants who designed the projects, are also responsible for project monitoring and for making any relevant design changes as may be required. The agency however has to approve such design changes before the contractor can proceed with the site works. The services of consultants define the successful completion of our projects, and so the agency does not change consultants arbitrarily..." (HA3-MQS)

9.1.2 Absence of In-house Geotechnical Professional

Based on the previous inferences drawn, it was noted that community projects procured traditionally by HA1 and HA2, have no geotechnical professional presence throughout the phases. In addition, analysis of the organisational structures for both organisations revealed there are no in-house geotechnical professionals employed by either agency, with the responsibility for geotechnical input in the design of community highway projects.

However, respondents from HA3, in describing the organisational structure and functionality of the units in the agency, explained that geotechnical professionals are employed within the department of civil engineering services. These professionals are responsible for ensuring geotechnical input in all highway design.

"The department of civil engineering services is responsible for the management of roads, bridges and other civil engineering structures. The department is also responsible for the design of community projects. Detailed designs for projects are prepared in-house by the department's highway engineers, reflecting all relevant inputs from the related design professionals in the ministry: structural, geotechnical and mechanical engineers" (HA3-OCE).

It was further explained that geotechnical input at the post-contract phase was maintained via laboratory testing of geo-materials as measures of quality control.

9.1.3 Clarity and Adequacy of Professional Roles responsible for Highway Designs and Costing

When describing the various functional units of their respective agencies, respondents interviewed from HA1 and HA2 revealed the agencies did not have a distinct design and estimating department who would be responsible for the delivery of highway projects. This was typified by this response from HA1-MQS who asserted:

> *... There are no specific departments for costing or design of projects. What we have are different professionals working under different departments* (HA1-MQS).

The response from a managerial Quantity surveyor employed by HA2 also relayed the apparent non-differentiation of functional units, confirming:

> *"...There are no departmental divisions within the agency, with respect to professional roles. Ideally, based on the initial organisational set-up of the agency, the professionals are supposed to be in their respective departments, but these are no longer functional...* (HA2-MQS).

It was thus inferred that quantity surveyors and civil engineers worked in dual capacities, often interchangeably, within the various departments. As such, the researcher noted that no clear cut definition of professional roles existed within the highway organisations. Consequently, most professionals serve in multiple capacities. For example, the researcher discovered from the responses that quantity surveyors often function as civil engineers. A supposition confirmed by an operational quantity surveyor employed by HA1 who conformed:

> *"...I am a quantity surveyor, working under the department of ***, I can perform the job of an engineer and often times go to site and based on the survey drawings, prepare schematic drawings for the road project before I estimate the cost* (HA1-OQS).

In HA2, a similar response was noted:

> *"...I am a quantity surveyor but most times, I serve in the dual capacity of both an engineer and a quantity surveyor: I learnt how to prepare highway designs..."* (HA2-OQS)

HA2-MQS also stated that:

> *"...The quantity surveyors and civil engineers all supervise projects, along with the electrical and mechanical engineers who are attached to them because we are badly short staffed"* (HA2-MQS).

HA2 MQS further stated the agencies lacked qualified technical manpower with the requisite qualifications, as a result they were badly under staffed:

"...We have a situation, whereby hundreds of projects being executed by the agency, and running concurrently, are managed and supervised by less than 10 persons. Most of the so called engineers are not experienced and don't even have adequate qualifications. They are mostly Higher National Diploma or first degree fresh graduates, who were just recently employed. You will find only one senior civil engineer in the lot, who will usually delegate responsibility for design preparation to these operational staff".

There were also instances of job descriptions not matching the qualifications of staff working on road projects. It was discovered during the fieldwork that completely unrelated (non-construction) professionals were working in the capacity of project managers and supervisors. This was captured in the very revealing statement from the management staff of the agency in which it was admitted:

"... We have cases of medical doctors, accountants, marine engineers and even petroleum engineers, heading departments in charge of road projects, and working as project managers: supervising projects and approving remittance of payment to contractors (HA1-MQS).

HA1-MQS further went on to express contempt of the situation exclaiming:

"It is a disgraceful state of affair, yet nothing is done about it. Once one has political connections ... they can easily find their way to gain employment and occupy positions not suited to their academic qualifications".

The organisational setting in HA3 in contrast to HA1 and HA2 appears to be well defined and patterned to a high degree of specialisation in professional roles as shown in Figure 9.2.

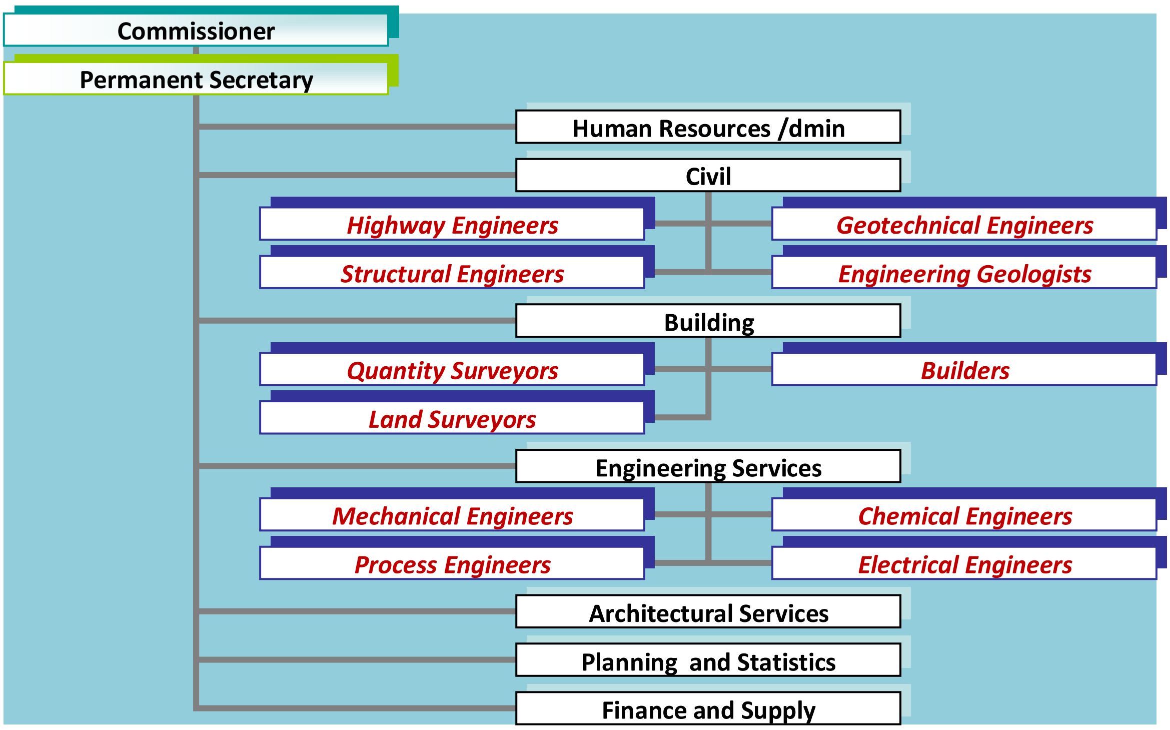


Figure 9.2: Organisational Structure HA3

The organisational structure for HA3 clearly reflects the multi-disciplinary roles relevant to highway project designs and costing: Civil Engineers; Geotechnical engineers; Geologists; Electrical engineers; Mechanical engineers; Quantity surveyors. It is noted that the various preliminary engineering and costing services were duly separated, and their respective inputs in designs and costing were limited to the ideal professional roles.

Also noted from the response of the Management Q.S, HA3-MQS, was that the co-ordination of the various inputs and processes in designs and costing during pre-contract preparation was overseen by the senior process engineer, who worked as a director heading the department of engineering services.

> *"... It is the duty of the process engineer to ensure that all interrelated design processes are in logical order at the phase of design preparation after project approval... without the process engineer coordinating the activities of all the design process, there may be loss of time..."* (HA3-MQS).

9.1.4 Contractual Porosity

Interview responses from registered contractors working for the highway agencies, revealed that the contractors were aware of the porosity of highway procurement in the Niger Delta. The contractors explained that although the level of financial risks due to unforeseen ground conditions could be high, they could still afford to reduce the contingency allowance provided in their bid submission. None of the firms, however, had ever opted out of bidding for jobs on the basis of the risk perceived, due to ground conditions:

> *Irrespective of such perceived risk, we are most times compelled to reduce our bid values so that we can win a tender as jobs are often awarded to the lowest price (HA1-RC)*

This was suspected to be because they know they would be able to recover any overspend. As to whether this situation discouraged the contractors from taking up further jobs with the highway agencies, two of the contractors responded in negative, stating *"…No certainly not. In fact, this is a major area where there is a significant potential for making profit …" (HA1-RC).*

When asked how this was possible, the contractors confirmed they considered these projects to be fertile ground for making extra profit due to the significant post-contract change that would (not may) occur. It was explained by the two medium sized contractors (HA1-RC and HA2-RC) that inconsistent and poor contract documentation, issued as part of the tender packages by the highway agencies, allowed the contractors to consider bidding for these projects. As such the contractors strategically deployed suicide bidding (bidding below cost to secure the work), even when they knew the contracts, were relatively risk laden. This would ultimately make up for any potential losses they suffer in the short term bidding stage. For example, HA1-RC explained it thus:

> *. For most projects, the reduced profit margin could be recovered since variations and delays will most likely arise from the inconsistencies in contract documents or lack of funds a basis of which we can get adequate compensation from making claims or due to price fluctuation"* (HA1-RC)

The situation was reinforced by a second contractor HA2-RC who confirmed:

> *"...we operate under cut throat competition in bidding for contracts. We would strategically reduce the profit margin to win a job and then take advantage of opportunities in the contract phase. There are lots of avenues for claims and variations in our contracts which we have to capitalise on"* (HA2-RC).

The respondent further explained that, most times consultants and in-house project monitoring teams did not bother to re-measure work during milestone payments. This therefore provided the contractors with a veritable means of recovering any losses due to unexpected ground conditions at the initial phase. HA2-RC went further stating:

> *"...we may still reduce the contingency allowance for perceived ground related risks in earthworks even if we are not provided with ground investigation reports, since if we are awarded the contracts, we could be able to recover any losses, due to unexpected ground conditions, through variations that almost always occur on road contracts"* (HA2-RC).

The researcher thus noted the implied and unspoken impression of the contractors, as being familiar with the known shortcomings in contractual arrangements by highway agencies in the Niger Delta. These assertions further corroborated the assertion of Sunjka and Jacob (2013), who criticised the basis of contract award and execution by highway agencies in the Niger Delta, as being as being poorly packaged, with contractors standing to benefit from this shortcoming.

However, HA3-RC, who worked for a large contractor that mostly executed major projects for the agencies, explained that the additional profit margin included in bids had meant that several bids had been lost since most of the highway agencies tend to award contracts to the lowest bidder. One problem highlighted with this, was that some contractors, mainly smaller scale indigenous contractors, often need to employ private quantity surveyors (consultants) to price jobs for them. As a result, in an attempt to save money, these organisations often bid without even bothering to ensure the adequacy of the price quoted to execute the job. It was thus regrettably expressed that:

> *"... Unfortunately, sometimes they get the job, and abandon it midway. There has been several of such cases where the highway agencies have come back to re-award the jobs for us to complete these projects that were initially awarded to 'quack' contractors"* (HA3-RC).

It can therefore be inferred that the contractors were provided with a fertile ground by the highway agencies for delaying and abandoning projects, often due to unresolved claims and variation orders arising during the contract execution phase.

9.1.5 Theme Summary: Adequacy of Organisational Environment for Ensuring GI

The findings from this parent theme have provided contextual understanding of how the poorly constituted organisational environments in the various highway agencies, has served to actively foster geotechnical pathogens inherent in highway projects executed in the Niger Delta. Several issues have been identified, principally in relation to HA1 and HA2, as constituting organisational barriers to geotechnical input in highway projects, these included:

- The lack of continuity in the services of external consultants for major roads;
- The lack of geotechnical professional presence throughout the phases of community projects;
- The lack of distinct in-house design and estimating units;
- Design and costing professionals serving in multiple capacities;
- Job description not matching the qualifications of staff working on road projects;
- Lack of qualified technical manpower, with the requisite qualification;
- Porosity of the contractual management system.

9.2 Knowledge and Skills Gap

9.2.1 In-house Knowledge Deficiencies Relating to Current Design Practices

This inference was drawn in relation to the preliminary line of questioning in the interviews, focused on the respondents understanding of and adherence with highway design specifications such as the TRRL (1993) highway design guide. Questions were also asked to elicit information on whether the highway agencies deployed similar design standards published by other recognised international bodies, such as the American AASHTO, or the British DMRB design guides. The questioning revealed significant knowledge deficiencies amongst the professionals interviewed, demonstrating worryingly low levels of awareness amongst the in-house civil engineers, of the fundamental tools of their profession, internationally recognised best practice design standards.

Three operational civil engineers out of the four design professionals interviewed demonstrated absolute ignorance about the existence of the TRRL or any other design standard. This observation is typically illustrated in extracts of typical response patterns in the four interview conversations carried out with civil engineers in the agencies, in response to the researcher's specific question*:*

> *"Do you use the Transportation and Road Research laboratory (TRRL, 1993) Overseas Road Note guideline or any other international design standard for the design of flexible pavements?"*

Some of the respondents, openly admitted their lack of knowledge, while others were defensive and tried to cover up their apparent ignorance:

> *"No, we still use analogue, we are not yet digital… we are doing hand sketches"* (HAI-OCE)*;*
>
> *"I don't understand"* (HA2-OCE*);*
>
> *"Of course we use standards, there are standards for everything. We use the latest 2015 standard".* (HA3-OCE).

Recognising the need for further clarification, the researcher stated:

> *"No what I mean is that do you use the Federal Government stipulated Highway design standard which adopts the TRRL (1993) Overseas Road Note. This is a guide for the design of bituminous paved roads in tropical countries prepared by the British government as a form of technical assistance. Successive versions of this standard have being used by the Federal Ministry of Works (FMW) as a guide for the design of roads without much alteration. The Current standard is the 1993 version".*

This clarification prompted the following responses from the interviewees:

> *"Oh, is that what you mean. Well I have heard about this standard, though, I have not seen it before".* (HA1-OCV);
>
> *"Is that the name of the Federal Ministry of Works design guide? A friend of mine has it; I will get a copy of it for myself"* (HA2-OCV*);*
>
> .
>
> *"The 1993 standard! That must be outdated. A more recent standard ought to be used"* (HA3-OCV).

The responses of the operational civil engineers were thus very revealing of this knowledge gap on highway design standards. However, the response of the management level civil engineer, was insufficient to infer his level of awareness on current design trends*:*

> *"I don't know the exact design standard used by our consultants for our major roads, but for our community road projects we have our own internal standard specifications we use" (HA1-MCE).*

As the researcher was unable to gain access to two out of the three senior civil engineers employed by the highway agencies, this inference could not be generalised to the senior civil engineers. The findings however seem to echo the assertion of HA2-MQS that:

> *"The entirety of the staff in the agency are not even in the know about current design practices or standards that are being used internationally or at the national level".*

9.2.2 In-house Knowledge Deficiencies Relating to Geo-Risk Containment in Procurement

The responses of the quantity surveyors to questions relating to the adequacy of geotechnical input, specifically structured to elicit information on, the inclusion/exclusion of Ground Investigation Reports (GIR), and Differing Site Condition (DSC) clauses, revealed deficiencies in their knowledge in relation to these geo-risk containment measures.

The responses from operational level quantity surveyors revealed knowledge deficiencies in relation to the use of GIR and DSC clauses as geo-risk containment measures in highway projects. The operational quantity surveyor from HA3, provided a response that typified those from all respondents at this level. He appeared to be surprised at this line of question exclaiming:

> *"...Are ground investigation reports supposed to be part of standard contract documentation? I thought these technical reports are required only by the civil engineers to prepare structural drawings. What does a contractor have to do with it? Is he going to redesign the project? ..."* (HA3-OQS).

The respondents also appeared not to have any prior knowledge as to what a DSC clause was, all the quantity surveyors interviewed either responded in mono syllables or simply asked for further clarification. For example, HA2-MQS responded "*No"*, while HA1-OQS, HA2-OQS and HA3-MQS needed the question to be clarified. Once this clarification was given, the response from HA1-OQS typified the views of the three quantity surveyors, who appeared confused by the question and its clarification, responding by simply asking*: "What do you mean?"* The researcher thus had to explain that a DSC clause was often inserted in to civil engineering contracts. The clause provides financial compensation for contractors, whereby should they encounter adverse ground conditions different from what was known at the time of bidding, the clause would provide mechanisms to determine responsibility. This means clients are responsible for paying for the additional costs triggered by physical conditions encountered on site, which differ from those which could have been reasonably foreseen by an experienced contractor in preparing his tender estimate. As such resorting to the use of DSC clauses in contracts, which would mean paying contractors for those differing conditions that could not have been foreseen. The Management level quantity surveyors from the highway agencies, upon clarification, however expressed adversarial perspectives. Typically arguing:

> *"It is the contractors' prerogative to ascertain things for themselves and not have to rely on us to define the conditions of site"* (HA1-MQS).

9.2.3 Theme Summary Knowledge and Skills Gap

Based on the general pattern of the responses, what became increasingly apparent, was that most of the agencies' in house professionals, were significantly uninformed about current issues in their profession, which clearly had a significant bearing on their ability to follow the underlying logic behind the line of questioning. The in-house design professionals exhibited very low levels of familiarity with the basic technical terminology of highway pavement designs and standards. This contrasts with the responses from consultants, earlier analysed in chapter eight, who demonstrated adequate knowledge of the TRRL design standard, and other international standards. Finally, the quantity surveyors' interviewed as part of this study also demonstrated an inadequate level of knowledge and understanding, in relation to contractual matters as they related to geotechnical risk containment in highway projects. This evident gap in the knowledge of the highway officials, can thus be said to be the blue prints, which fosters dysfunctional professional practises, that actively trigger geotechnical pathogens in highway projects.

9.3 External Socio-Cultural Pressures Impacting on Professional Roles

9.3.1 Political Pressure

The influence of political interference on in-house professional roles for the design and costing of road projects, was noted from the general trend of the responses of the in-house respondents (Civil Engineers and Quantity Surveyors) from the highway agencies. The pattern of the responses, depicted a politically driven mode of procurement practise, underlying the performance of professional responsibilities. This was clearly evident, as it was the most repeatedly mentioned theme, in all the responses elicited from the highway officials. Political pressure, is thus inferred as, significantly impacting on the level of in-house GI, evident in the progressive phases previously analysed. However, at the contractual phase the impact of geo-political structures appeared to be more tangibly manifested.

All six quantity surveyors commented on the impact of political interference on their professional roles in contract award. Typically, respondent HA3-OQS commented that:

> "*Most road contracts are usually awarded to the construction firms of active politicians"* (HA3-OQS).

The researcher however noted that respondents from HA2, particularly emphasised the impact that political factors had on procurement and project delivery in the agency. Respondent HA2-MQS stated that there were no standardised contracting system or pre-contract procedure for projects which were deduced as being procured politically, without following any formal protocol:

> *"In the present regime, all contracts are awarded based on recommendation from the *** or the *** without competitive bids being solicited from the public"* (HA2- MQS).

Respondent HA2- MQS further stated:

> *"... The politically driven and influenced mode of procurement of most of our projects affects everything. Due process in contracts is often not followed"* (HA2-MQS).

HA2-OCE, described a typical instance of how the political environment surrounding the procurement of road projects by the agency had impacted on their professional obligations. Specifically, the need to ensure the requisite level of geotechnical input in some of the major DB projects, during the pre-contract and post contract phase of the project developments:

> *"Those of us who are civil engineers may not even get to see the final designs that has being provided by the contractor, for our road projects ... As a consequence, the contractors who usually have political clout can get away with making significant claims, on the basis of variations due to differing ground conditions, which we may not even be allowed to verify* (HA2-OCE).

On this note, respondent HA2-MQS affirmed that:

> *... ideally, where requests for variation are not justified, such projects should be determined, re-advertised and re-awarded to technically qualified contractors.*

HA2-MQS, further stated that as a matter of fact, the harsh reality of the situation of the procurement climate of highway projects, prevented this from happening:

> *"... As a professional employed under the service of a government parastatal, you have to be careful with the due diligence and integrity with which you carry out your job. Overzealousness can lead to your being removed from being part of the project team or even dismissal from your job"* (HA2- MQS).

9.3.2 Local Community Pressure

Community pressure in the form of youth restiveness was described as a critical issue for projects executed in local communities, due to years of social deprivation and infrastructural neglect by successive government administration. This has led to a wave of insurgency characterised by violent demonstrations, hostage taking and bomb blasts by armed youths. This trend was thus described as constituting a major source of fear amongst professionals responsible for the execution of projects in these areas. Consequently, local community projects were normally executed on an emergency basis to calm youth restiveness in communities. Given the projects were awarded on an emergency basis without extensive pre-planning, these projects were unsurprisingly awarded to politically active indigenes of the community from where the clamouring for the construction of the road had emanated, without recourse to a planned budget. A situation affirmed by respondent HA2-OQS who commented that:

> *"...The contracts for such roads will end up being awarded to the project sponsor from the community who pushed for the project"* (HA2-OQS).

It was further explained by respondents from HA1 that the technical qualifications of the contractor in these situations was considered secondary to the urgent need to calm youths, and prevent further catastrophe. As respondent HA1-MQS states:

> *"If the contract is awarded to a contractor who is not an indigene of the community, the contractor is often faced with disruptions and threats from the youths. Typically, the contractor's equipment would be vandalised and site workers may be kidnapped"* (HA1-MQS).

In confirming this trend across the Niger Delta region, respondent HA3-OQS, representing the final highway agency in the region, affirmed that community projects were often awarded to indigenes of the community. Although he did qualify this assertion by acknowledging that the agency still tried to assess the contractor's technical capacity to deliver the job.

It was however clarified that although this trend was more common in community projects, such community pressures also impacted on the procurement of major projects at the post-contract phase during site works. For instance, respondent HA1-MQS avowed:

> *"We have also had these situations on major projects. Typically, the ****** road that was being executed by ****, one of the best international contracting firms operating in the region, had to be abandoned on these grounds".* (HA1-MQS).

The respondent further explained that this was despite the heightened security measures put in place by contractors, which had been approved by the agency as part of claims for additional funds. Several engineers and site workers were kidnapped as hostages, with the contractors having to pay significant ransoms to the community before the hostages were released. This in turn led to the collapse of the project, as respondent HA1-MQS confirms:

> *"Further to the release of the workers, the contractor refused to return to site, and the project was abandoned for several years, until recently when it was resuscitated by the new administration"*

9.3.3 Theme Summary: External Socio-Cultural Pressures impacting on Professional Roles

The impact of political and community interference on in-house professional roles for the design and costing of road projects is particularly noted by the researcher as being of a major influence in the Niger Delta, due to its overwhelming implication for the adequacy of geotechnical input in the procurement of highway projects. This is also due to the cautiousness it arouses in professionals in the performance of their duties to ensure geotechnical input. The impact of these contextual drivers, manifests in the:

- Emergency procurement of highway projects;
- Award of contracts to unqualified contractors;
- Lack of due process in contract award procedure;
- Unverified contractors' claims;
- Unplanned budgeting for highway projects;
- Heightened security risk to contractors;
- increased delays and abandonment of highway projects.

Due to the numerous multiplier impacts of external pressure from political and community sources, the existing socio-cultural setting of highway development in the Niger Delta region, has thus being inferred by the researcher, to have constrained the discharge of professional obligations, in ensuring geotechnical input in projects to an un-defined extent.

9.4 Psychologic Factors impacting on GI

9.4.1 Adversarial Contractual Relationship

The most significant attitudes noted from the interview responses was the adversarial and suspicious view of the client and contractors towards each other. This was particularly evident in the responses of the quantity surveyors interviewed from the highway agencies. For example, respondent HA1-MQS argued against the use of a DSC clause, asserting:

> "*It is clearly stated in the conditions of contracts, that contractors are advised to visit site and verify the conditions of the site for themselves. With this clause in the contract, it is the contractors' prerogative to ascertain things for themselves and not have to rely on us to define the conditions of site. The ground investigation reports prepared by consultants for major projects are for the agency's internal use in designs"*.

Also HA3-MQS in his description of the procurement practices of the highway agencies stressed:

> *"... We do not give room for contractors to swindle the government..*."

This psychological barrier may thus account for the divergence between the dictates of best practice and current practice within the highway agency organisations. Especially given the highway agencies attempts to transfer risks associated with ground conditions to contractors, in their misguided notion of ensuring the certainty of final outturn cost. However, as earlier sections of this analysis reveals, the contractors thus have to rely on guesswork in preparing estimates, which are forwarded in bids and typically see this as a non-risk, given the simplicity of post-contract financial recovery due to the poor drafting of contractual documents.

As HA2-RC, one of the medium sized contractors confirmed in response to a similar line of questioning relating to the inclusion of GIR, due to the current practices of the highway agencies, the firm was compelled to make claims and financial demands, through any available loopholes in the contract.

> *"We have no option but to seek avenues in the contract, which are never water tight, in order to recover our losses"*

However respondent HA3-MQS stated:

> "*… if the contractors for major projects still persist in demanding financial compensation for such claims, the project has to be halted, and the agency's legal unit will have to pursue settlement in court".*

These forms of inherent counter relationship within the project environment, effectively act to limit professionals in the highway agencies, in their ability to realise the contractual benefits of adequate geo-risk containment. Such attitudes from the client is also counterproductive when considering the delivery of best value or value for money within the commissioned projects. As these attitudes, ultimately are also counter-productive to the effective management of the financial risks associated with ground conditions in projects. Given the lack of geotechnical data, is prompting the contractor to simply guess too high or too low when bidding for the project, and then recovering any losses through the manipulation of the contract.

Ultimately the client will either miss out on the attainment of value for money, as they may pay a premium for the project, if the contractor values the risk too highly and thus submits a high bid. Or the project will be threatened by delays, disputes and even abandonment, if the contractor bids too low. Yet given the client's focus on 'lowest price wins', together with the contractor's perception that 'any suicide bid submitted to secure the work, can then be recovered using the myriad of contractual loopholes once the project has been awarded', extremely low bids would appear to be the most probable outcome. The adversarial contractual stance of client in highway projects, thus constitutes a psychological barrier to ensuring geotechnical input in highway projects, and a major trigger inducing cost overruns from latent geotechnical pathogens.

9.4.2 GI in relation to Risk Perception

The responses of respondents from the highway agencies, revealed inherent differences in the perceptions of the professionals, to ground risk. The researcher noted the poor risk perceptions of some of the engineers, as there appears not to be an understanding of the magnitude of financial risk posed to highway projects, undertaken without adequate ground investigations, irrespective of project size. Respondents from HA1 and HA2 did not see any justifiable need for detailed ground investigations for smaller community projects. An example of this can be seen in the response from the operational civil engineer from HA1, who suggested:

> *"We do not need to carry out ground investigations for community projects. As you know ground investigations are very expensive, and that level of expenditure cannot be justified for simple community projects. We simply rely on experience and professional judgement to adjust from previous projects to suit the present project" (HA1-OCE)*

Also the response from HA2-OCE revealed the low level of geotechnical risk perception inferred from the explanation of how the agency identified heterogeneous ground conditions at project sites. It was stated that:

> *"... We can easily assess the nature of soils in the project location from the type of vegetation growing"* (HA2-OCE).

However, respondents from HA3 seemed to have adequate in-house awareness of the need for geotechnical input for community road projects. based on their understanding of the risk implications of inadequate ground investigations, particularly for locations in wetlands. The respondents from HA3 made emphatic statements, dismissing this low risk view as to the relevance of ground investigations in projects. It was categorically opined that:

> *"… We cannot afford to build roads without taking necessary precautions in designs. In other states with better soil conditions, they can afford to take chances, but the*

predominantly difficult swampy terrain dictates that geotechnical investigations are a must for all our road projects" (HA3-OCV).

It was thus inferred from the responses that the professionals display differences in risk perception (in terms of geotechnical risk management) when they are involved in the delivery of small scale road projects. This is on the premise of some of the respondents' adjudged adequacy of relying on geotechnical input from site inspections, as a basis for design preparation, and due to the perceived non-justification of the expenditure associated with carrying out detailed ground explorations.

9.4.3 De-Motivation of Professionals

The motivation of professionals to apply their geotechnical expertise in designs and costing was identified as a factor, which plays out to affect the quality of GI in projects. For instance, respondent HA2-OQS expressed an attitude of unquestioning acceptance of the power of political influence which weighs in oppressively on the motivation of the professionals. He stated:

"... Our contractors are mostly political bigwigs and can get away with anything. We the professionals simply dance to the tune of our political superiors" (HA2-OQS).

A similar response from respondent HA1-OCE reinforced this view, asserting:

"Never underestimate the powers of politicians… the political entity or entities who pushed for the project to be approved, will also ultimately influence the speed of the design preparation process by mounting pressure on the consultants".

Finally, respondent HA1-MQS made similar references to the influence and power of politicians over the consultants:

"Often times, the consultants under pressure may over-design or under-design the project which would inevitably mean that the project estimate which is also prepared by the consultants would be much higher or lower than what it should. The successful contractor would end up being that same political father who lobbied and facilitated the speedy preparation of estimate, for the project to be included in the budget.

The overriding influence of political authority on professional duties was expressed un-equivocally by HA2-MQS who advocated:

"... As a professional employed under the service of a government parastatal, you have to be careful with the due diligence and integrity with which you carry out your job. Overzealousness can lead to your being removed from being part of the project team or even dismissal from your job" (HA2- MQS).

At the post contract phase, the respondents' resignation to accept the influence of political authority, considered necessary to facilitate in-house approval processes, is equally discernible:

> *"Several of these projects experienced technical hiccups and had no political god father to rescue them" (HA2-MQS).*

Also respondent HA2-OCE stated:

> *"…this may take lengthy periods of several months and even up to a year, depending on the contractor's personal political connections to push for his application to be handled" (HA2-OCE).*

Political authority thus appears to have usurped the role of project leadership, the dynamics of which ideally determines the motivation and performance of team members in highway projects. The subjugation of professional obligations and ethics in deference to political dictates, can thus be inferred to have had a psychological impact on the motivation of professionals in highway projects. This may ultimately have its fundamental roots in the wider socio-political climate surrounding highway development in the Niger Delta, characterised by both its political instability and poor governance (Ihuah and Benibo, 2014). Political authority which represents non-geotechnical decision makers in highway projects, thus impact on the performance of core geotechnical expertise, ultimately hindering the attainment of the value for money benefits of adequate geotechnical input in the Niger Delta region

9.4.4 Theme Summary: Psychologic Factors impacting on GI

Several issues have been discerned from the responses of the highway professionals, which constitute psychological barriers to ensuring geotechnical input in highway projects executed in the Niger Delta region:

- The adversarial contractual stance of client in highway projects;
- The lack of adequate geotechnical risk perception;
- The demotivation of design and costing professionals in the performance of their obligations by non-geotechnical decision makers.

It is inferred that these psychological barriers are put up by the professional actors in highway projects, in response to social conditioning inherent in the institutional setting of the highway organisations, and as a result of a lack of a clear-cut understanding of the benefits of geotechnical input. Psychological barriers thus represent the behavioural contextual drivers, whose negative aura facilitate the geotechnical pathogens, latent in the highway organisations, to act out their full potential in the human element underlying the execution of highway projects, thus inducing cost overruns.

9.5 GI Dichotomies

9.5.1 Major Versus Community Projects Dichotomy

Different combinations of ground related issues, previously inferred from the deductive analysis of geotechnical pathogen, have affected project delivery by the highway agencies to varying degrees of undefined impact. However, from the responses, there is an easily discernible dichotomy in the levels of geotechnical input, in major versus community projects. Community projects evident an almost complete lack of geotechnical input in pre-contract preparation, with ill-defined and illogical stages of project development. For major projects executed, the researcher noted the relatively higher level of pre-contract preparation by consultants, who are charged with the full responsibility for ensuring geotechnical input in the design of major projects.

This dichotomy in the levels of geotechnical input at the pre-contract phases, further differs in consonance with the adequacy of the distinct organisational settings in the Niger Delta, as presented in Tables 9.1, 9.2 and 9.3. As such, for the different organisations, the contrast between the levels of geotechnical risk containment, for both classes of projects, also differs.

As summarised in Table 9.1, major projects executed by HA1 have relatively higher level of pre-contract preparation via geotechnical input in budgeting; carrying out ground investigations prior to design preparation and contract awarded based on formal design drawings after some form of technical tender examination criteria.

Table 9.1: Levels of GI in Major and Community Projects Executed by HA1

	Major Projects(Traditional/DB)	**Community Projects (Traditional)**
Nomenclature of development phases in relation to pre-contract preparation	*Consistent with adequate pre-contract preparation*	*In-Consistent and poor level of pre-contract preparation*
Level of Geotechnical Input in Budgeting	*High (based on detailed designs)*	*None-No budgetary projections*
Adequacy of Designs	*Adequacy unverified (may be subject to unethical practices)*	*In-adequate- No formal design drawings, only discretionary sketches, based on survey plans...*
Mode of Assessment of Heterogeneous Soil Conditions	*Adequate (based on detailed ground investigations)*	*Inadequate (based on preliminary site reconnaissance and crude improvised desk studies)*
Adequacy of Contract Documentation:	*In-adequate (no GIR or DSC clauses)*	*Highly In-adequate (No GIR, DSC clause or other standard contract documentation)*
Adequacy of GI in In-house Contractor Selection Criteria	*In-adequate (Based on technical and Financial bids, but no GI algorithm)*	*In-adequate (based on community considerations)*

Respondents from HA2 did not imply any form of dichotomy for major and community projects, as they repeatedly emphasized that both major and community projects lacked adequate geotechnical input, and were fraught with variations and delays on the grounds of unexpected site conditions. This trend is inferred by the researcher to be closely linked with the almost complete lack of geotechnical input in pre-contract preparation evident at the phases of project development, which are ill-defined and follow no standard logically progressive stages. The prevailing very low levels of geotechnical input in major and community road projects are summarily outlined in Table 9.2.

Table 9.2: Levels of GI in Major and Community Projects executed by HA2

	Major Projects (DB)	**Community Projects (DB)**
Nomenclature of development phases in relation to pre-contract preparation	*Inconsistent with poor pre-contract preparation*	*Inconsistent and poor level of pre-contract preparation*
Level of Geotechnical Input in Budgeting	*low-based on uniform cost per Km with subjective adjustments*	*None-No budgetary projections*
Adequacy of Designs	*Adequacy unverified, may be subject to unethical practices*	*In-adequate- No formal design drawings or sketches.*
Mode of Assessment of Heterogeneous Soil Conditions	*Adequacy unverified (based on D&B contractor's discretion)*	*Inadequate (based on contractors' discretion)*
Adequacy of Contract Documentation	*In-adequate (No formal contract documentation procedure),*	*Highly In-adequate (Unverified DB designs in contract documentation)*
Adequacy of GI in In-house Contractor Selection Criteria	*In-adequate (Contractors selected without technical bids, based on political considerations).*	*In-adequate (Contractors selected without technical bids, based on political considerations)*

Respondents from HA3, in contrast to the scenario of project delivery in HA1 and HA2, stated that for both major and community projects soil conditions were reflected in designs prepared after detailed ground investigations. For major projects, it was stated:

> *"We maintain a set of highly qualified and reputable consortium of professionals, who are responsible for the design of our major projects. They have the requisite high level of technical skills necessary for the specialised designs that are compatible with our marshy terrain"* (HA3-MQS).

For community projects, respondent HA3-MQs further explained:

> *"For community projects, we prepare adequate and comprehensive designs that reflect all required professional expertise …* (HA3-MQS).

Table 9.3 captures the relatively higher level of geotechnical input in the pre-construction phases of development for both classes of projects executed by HA3.

Table 9.3: Levels of GI in Major and Community Projects Executed by HA3

	Major Projects (Traditional/DB)	Community Projects (Traditional)
Nomenclature of development phases in relation to pre-contract preparation	*consistent with adequate pre-contract preparation*	*consistent with adequate pre-contract preparation*
Level of Geotechnical Input in Budgeting	*low-based on uniform cost per Km with subjective adjustments*	*low-based on uniform cost per Km with subjective adjustments*
Adequacy of Designs	*Adequate-Formal designs inclusive of all relevant design drawings.*	*Adequate- formal design drawings are produced based on all relevant professional input.*
Mode of Assessment of Heterogeneous Soil Conditions	*Adequate-based on detailed investigations by consultants*	*Adequate-GI ensured by in-house geotechnical unit*
Adequacy of GI in Contract Documentation	*In-adequate, No GIR or DSC clauses. However, based on approved designs and other standard contract documentation.*	*In-adequate No GIR or DSC clauses. However, based on approved designs and other standard contract documentation.*
Adequacy of GI in in-house Contractor selection	*In-Adequate (Contractors selected based on technical and financial bids but no GI Algorithm).*	*Inadequate (Contractors selected, based on community considerations)*

9.5.2 Upland Vs Riverine Dichotomy

Some of the respondents from the highway agencies stated that only few of their road projects were located in riverine areas, whose locations are often remote. This was repeatedly emphasized by respondents from HA2. It was explained that this was because the government preferred to focus on highly visible projects located in densely populated areas, which can be used as a basis for political campaigns and adverts. Table 9.4 provides a list of projects executed by HA2 over the past 8 years, illustrating a predominance to commission upland projects, a finding which supports literature assertions.

Table 9.4: Projects Executed by HA2 in Different Upland and Riverine Locations

Project	Location
First Bank/Rumuobiakani/Old Aba Road	Upland
Oginigba /Slaughter Road	Upland
The Elekahia/Rumuomasi road	Upland
Rumuola Road (completed)	Upland
Eneka/Igbo-Etche/ Iriebe road	Upland
Woji/Okujagu/Elelenwo road.	Upland
Rumuagholu /Ada George road	Upland
Ken Saro Wiwa road/ Stadium road	Upland
Rumuibekwe/Elelenwo road and bridge	Upland
Rumuekini/ Aluu road	Upland
Ozuboko/Elelenwo road-	Upland
Rukpokwu/Eneka/Eligbolo road	Upland
Rukpakwulusi /Eligbolo /Rumuodomaya road	Upland
Ozuoba/Rumuparaeli/Choba road	Upland
The Okirika Ring Road	Riverine
The Ogoni/Andoni/Opobo Unity Road	Riverine
The Bonny- Bodo road	Riverine
Omofo/Agba/Ndele road leading to Abua.	Riverine

The respondents explained that most internal rural community roads initiated by HA2, located in different riverine areas, have been abandoned for several years. Respondent HA2-MQS, explained that minimising delays in more visible upland projects were often prioritised in budgets while delays in community projects often led to outright project abandonment:

> "*... It is these highly visible major projects in upland areas, which are often included in budgets and whose work progress is closely monitored to ensure completion, so as not to project a bad image for the government. These projects are the ones included in urban master plans. Most projects in riverine areas are executed adhocly, used to settle active politicians who have played major political roles*. (HA2-MQS)

It was further stated that:

> ""*The agency as it stands does not have any autonomy to make mile stone payments for awarded projects already included in budgets, it is at the discretion of the ***, depending on what are considered priority projects, to authorise payments and for projects execution to continue. This often results in other non-strategic projects often situated in riverine areas to be put on hold. As such cash flow to these other projects between instalments will experience frequent hiccups and may even be abandoned for several years (HA2-OQS)."*

Respondents' assertions revealed a very high spate of project delays and abandonment which appears to be clustered more in riverine areas mainly as a result of their low priority status within the agencies. This is despite the fact that these riverine roads, ideally should serve as inter community links necessary to foster economic growth and aid the mobility of the vast majority of the rural populace who reside in these areas. The researcher thus infers that this practice has doubly impacted on the levels of geotechnical input, particularly as most of these riverine roads are community projects, which completely lack pre-contract preparation. This may explain their relatively higher level of delays and project abandonments, leading to the significant infrastructural gap between the drier uplands and the riverine areas, repeatedly reported in the literature (Ogura 2002; Teme 2002; Ngerebara *et al.,* 2014). The literature thus shows that the few available roads in the Niger Delta are those within the towns and villages located in the uplands, a situation which has being frequently attributed to the terrain. As Ngerebara (2014:87) commented:

> *"The existence of roads which is taken for granted in some parts of the country is a luxury to the people of the predominantly riverine Niger Delta … A development blamed on the several abandoned government road projects, due to the developmental constraints posed by the difficult terrain"*.

For HA1 and HA3, no form of dichotomy in levels of GI for upland and riverine projects was implied. For instance, respondent HA3-OCE suggested:

> *"All our projects have to go through all relevant design procedures, with inputs from made from the professional departments such as mechanical, electrical, civil and geo-technics before they can be approved for detailed costing. They are also supervised by qualified engineers employed by the ministry."* (HA3-OCE).

Contrary to HA2, it was explained that projects commissioned in riverine areas were given closer attention due to the inherent difficulties associated with the terrain. As respondent HA3-MQS opined:

> *"Plans and designs for most roads in the riverine areas had needed to be revisited after the recent epoch of disastrous floods which destroyed so much of the existing meagre infrastructure in the state. The ministry has since then embarked on over 40 major construction projects and over 41 community road projects awarded in 2013".*

The respondents further explained that due to the state's predominantly swampy terrain, and the scarcity of dry land, most construction works undertaken by the agency were inevitably built on reclaimed land. Making any form of construction work not only expensive, but also time consuming. It is clear, this perception of the difficulties the Niger Delta, presently, may also account for the infrastructure deficit in the state, as it was further stated that:

> *"Prior to this, there was practically no infrastructure and that is why the Governor is angry to develop the State. The State is backward and unlike neighbouring oil producing states, has nothing to show in terms of development" (HA3-MQS)*

9.5.2 Theme Summary: GI Dichotomies

Findings from this theme has highlighted several dichotomous practices and issues in the highway agencies, which account for the poor levels of geotechnical input in highway projects. These factors include the:

- Preferential management of geotechnical risk, in relation to project size and location;
- Adequate versus poor pre-contract preparation for major versus community;
- Planned versus adhoc procurement practices for major versus community projects;
- Politically motivated selective project management practices;
- Unequal priority status in post contract management of upland versus riverine projects.

The negative trend of poor levels of geotechnical input, more evident in community projects, than in major projects, as well as the prioritisation of upland projects to the detriment of projects in remote riverine locations, is indicative of a preferential management of geotechnical risk, which is a recipe that would logically culminate in significant cost overruns. Considering the geotechnical difficulties and complementary cost associated with highway construction in the meander and coastal belts of the Niger Delta. This trend may account for the significant disparity in the levels of cost overruns, between the geo-zones in the sample of highway projects, previously analysed in chapter five. The inequalities in the level of geotechnical input in relation to project size and location, has major implications which constitute the barriers, latent in the entirety of the institutional system of highway delivery, to managing the ground risk inherent in the geologic setting of the Niger Delta.

9.6 Unethical Professional Practices

9.6.1 Unethical Consultancy Practices

Some respondents from the HA1 and HA2 emphasized the prevalence of unprofessional practices by consultants. Typical responses from the agencies' staff implied that consultants were unethical in the performance of their professional duties, and may be compromised. This can be inferred from the response of HA1-OCE who stated:

> *"Never underestimate the powers of politicians… the political entity or entities who pushed for the project to be approved, will also ultimately influence the speed of the design preparation process by mounting pressure on the consultants".*

Respondent HA1-MQS made similar references to the influence and power which may induce unethical practices by the consultants, suggesting:

> *"…the consultants, under pressure may over-design or under-design the project which would inevitably mean that the project estimate which is also prepared by the consultants would be much higher or lower than what it should".*

Respondent HA1-MQS further described some of the consultants as being more inclined towards promoting their financial interest, stating*:*

> *"...most times the consultants don't even have a motivation to manage cost ... sometimes over-designing projects to simulate worst case scenarios, ... to increase their fees which are payed as a percentage of the project cost..."*

The Interview response from HA2-OCE, an operational civil engineer who had previously worked in a consultancy firm before being employed by HA2, further supported the notion of the prevalence of such unethical practices, with the respondent admitting:

> *"... we have experienced cases were the proposed plans and structural drawings prepared and presented by consultants for approval did not match… were discovered during the vetting process" (*HA2-OCE*).*

This was explained as some of the issues that the department of *** in the agency experience, when plans for proposed highway projects prepared by consultants were vetted by an in-house group of chartered professionals. It was also revealed that sometimes ground investigation reports or designs for previous projects of a similar nature within the vicinity of the proposed project were obtained and presented to the agencies as part of their consultancy services:

> *"...Sometimes geotechnical investigation reports and design drawings are photocopied from other previously executed projects and modified"* (HA2-DC).

Respondent HA2-OCE further explained that some of unethical practices were still continuing, although the highway agency was not aware of these and expressed dismay that such practices went undetected by the agency:

> *"...The consultant still gets to be payed the full professional fees and makes a hefty profit"* HA2-OCE.

Respondents from HA3, however, did not make any assertions on the prevalence of such un-ethical practices.

9.6.2 Unethical Contractor's Practices

The responses of the agencies staff revealed various forms of unethical practices by contractors which has severe implications for the adequacy of geotechnical input in highway projects. For HA1, it was explained that due to the politicised procurement climate in the highway agency, some of the major projects were awarded to political figures, who lacked the technical capacity to execute the job. Most of the contractors were not registered construction firms and had no prior knowledge of road construction or the relevance of geotechnical input. This led to several unethical contractual practices, typically the subletting of contracts. It was stated:

> *"Most of the contractors are politicians, who do not have the technical capacity to execute major highway projects, the politicians often sub-let the awarded contract to other smaller unestablished construction firms who would then carry out the execution of the project. However, the firms to which the contracts are sublet have no direct contractual stake in the project" (HA1-MQS).*

Respondent HA2-MQS also alluded to unethical design practices by contractors in most of the agency's projects which were usually procured on a Design and Build basis. It was explained that often times the designs which are ideally supposed to be prepared by the contractor's consultant were never actually prepared. It was thus explicitly emphasized that at present times, the Design and Build tag attached to the procurement system was a farce, as detailed designs were hardly ever prepared by the contractors.

It was commented by respondent HA2-MQS that:

> *"... In reality what happens is different from what is projected to the public. For most of our so-called design and build projects, detailed designs may not necessarily be prepared, unless for mega high profile projects executed by efficient and established contractors".*

It was further stated that it was left to discretion of the contractor, to employ the services of a geotechnical professional for which a provisional sum for site investigation is provided. Respondent HA2-OCE also stated that:

> *"What most of the contractors basically managed to do is to employ engineers to design the geometric alignment of the road using the levels from survey plan provided"*.

Frequent changes and variation orders approved in such DB projects, in response to demands by contractors who were supposed to have prepared detailed designs, as specified in the contract documentation, and for which a provisional sum for site investigation is provided, was considered as proof of this. According to respondent HA2-OCE:

> *"...Contractors collect money for site investigations and the preparation of detailed designs and simply pocket it. It is only when they encounter poor unexpected soil conditions, that they may eventually employ a geotechnical consultant to determine its extent, to demand extra payment".*

9.6.3 Unethical GI Verification Practices

From the responses of the interviewees, the practices of the highway agencies in verifying geotechnical input by contractors and consultants was inferred. For HA2, whether ground investigations were actually carried out by the contractors as a basis of preparing detailed designs was not ascertained by the agency. Respondent HA2-OCE, described a typical instance of how the political environment surrounding the procurement of road projects by the agency has impacted on the professional obligation to ascertain the requisite level of geotechnical input in some of the major DB projects:

> *"Those of us who are civil engineers may not even get to see the final designs that has being provided by the contractor, for our road projects ... As a consequence, the contractors who usually have political clout can get away with making significant claims, on the basis of variations due to differing ground conditions, which we may not even be allowed to verify"* (HA2-OCE).

This was also implied in the response of respondent HA2-OQS

"... The contractors do not know how to execute the jobs... often had to privately hire the services of the in-house professionals to supervise their projects".

This form of unethical practice at the post contractual phase implies that the in-house professionals who are obligated to monitor post-contract project execution, to ensure geotechnical input as client's representatives are compromised, and thus function in a dual capacity as contractor's employees.

For HA1, the management level quantity surveyor thus explained the prevailing trend of unethical practices, had been noted by the management of the agency, who have put measures in place at the pre-contract phase to verify geotechnical input:

The agency has noted this trend and there have been recent changes in the scale of payment of their professional fees. We now negotiate with the consultants on a flat fee and vet their designs thoroughly before they are approved. It has been proposed that there should be a distinct estimating unit to equally vet proposed cost figures for projects and trim excesses" (HA1-MQS)

However, the operational quantity surveyor differed in his opinion, stating:

"Major Projects listed in budget are sometimes awarded by management … and site works commenced without the knowledge of the agency's professional staff... (HA1-OQS).

This implies that there will be project management lapses at the post contract phase in monitoring of projects, which would ultimately determine the adequacy of geotechnical input in the awarded highway projects.

Responses of interviewees from HA3, did not imply any form of unethical practices, in the verification of geotechnical input by consultants and contractors for major projects. Rather the respondents repeatedly stressed how rigorous the practice of the agency was in ensuring geotechnical input, it was asserted emphatically that:

"At the post-contract phase, we carryout laboratory testing of geo-materials as measures of quality control" (HA3-OCE).

9.6.4 Theme Summary: Unethical Professional Practices

The findings from this theme have highlighted three major underlying issues, external and internal to the organisational confines of the highway agencies, which constitute barriers to achieving adequate geotechnical input in highway projects:

- Unethical professional practices of consultants at the pre-contract phase;

- Unethical professional practices of contractors at the post contract phase;
- Lack of verification of geotechnical input by in-house professionals, who may be compromised.

It can be inferred that subtle unethical practices may thus be associated with the adequacy of geotechnical input in designs and the post contract management of highway projects executed in the Niger Delta. The researcher, however, cannot generalise the prevalence of such un-ethical practices to all registered consultants or contractors in the professional service of the agencies. Yet, based on the responses from the highway agencies' staff, the researcher has, however, discovered the existence of internal organisational loopholes, which create a viable ground for such unethical practices, where they do occur, to thrive. It can be thus inferred that some of the highway agencies operating in the Niger Delta are lacking a rigorously enforced organisational platform that will allow them to ensure and verify geotechnical input at the pre-contract or at the post contract phase of project execution. This internal shortcoming thus creates avenues for unethical practices by consultants and contractors, some of who may exploit the porosity of the prevailing organisational system to their advantage.

9.7 Procurement Irregularities

9.7.1 Hushed and Unrealistic Bidding Timelines

The contractors stated that coupled with insufficient geotechnical details provided the highway agencies, they were also mostly subjected to unrealistic timelines, during bidding. At the bidding stage, they often had to bid for projects, whose call for tenders were not formally publicised or were contracted on an emergency basis. Respondent HA2-RC stated:

> *"The call for tender, most times is not publicised, and is usually hushed. Unless you have an insider to relay information, the bidding process may be over before it is made public. We most times do not get adequate notice to prepare our bids. As such under this conditions, our bids may not be realistic".*

The contractors thus explained that it was impracticable for them to carry out their own pre-contract ground investigations within the time-scale of the tender period, and also in view of the prohibitive cost of detailed investigations. Respondent HA1-RC thus stated:

> *Contract documents may be provided just a week before the deadline for submission of tender, and we are thus expected to hurriedly ascertain ground conditions based on visual inspections.*

Additionally, respondent HA3-RC also suggested:

> *"The time normally allowed for bidding is too short to allow us to do a thorough examination of the project and the ground condition at project site in the calculation of our prices. The normal tender period is around 1-2 weeks on the average for most jobs…*

This has meant that the contractors invariably have to rely on subjective assessments made during expedited site visits at the time of tender. This risk of unforeseen ground conditions due to lack of adequate geotechnical input is therefore very high in such highway projects, procured under emergency conditions. Respondent HA2-RC thus explained that the compressed timing in addition to lack of geotechnical input in contract documentation, often meant that they had to seek avenues of recovering costs unaccounted for during bidding.

9.7.2 Subjective Procurement

Subjectivity in the procurement practices of the highway agencies was noted by the researcher from the responses to the interview questions. Some of the respondents explained that despite the outward policy projection by the highway agencies, most of their projects were subjectively awarded without any form of competitive bidding or following due process, and were influenced by the senior managerial staff of the agencies in response to contractors' demands. Typically, it was stated that:

> "… *There were no due contractual processes in the award of some of these projects…influenced by the agency's senior staff..."* (HA1-OQS)

HA1-OQS, thus explained that, most of the managerial staff award contracts for road projects, without following due contractual processes, against the agencies' technical regulations which ideally requires that due processes and ethical protocols be followed. The participants explained that some contracts were awarded to relations, and friends who were ill-qualified to execute highway projects.

> *"Imagine giving a highway project to a contractor who does not have the faintest idea about construction simply on the basis of his friendship with a senior staff" (HA1-OQS).*

Also respondent HA1-OQS explained that after contract award, applications for variations or claims made by contractors during project execution, were also subjectively processed within the internal organisational structure of the agency:

> *"… If the contractor does not have an insider, his file and application will not be pushed forward for approval and he would keep running around in circles waiting for the approval which may never surface" (HA1-OQS).*

In HA2, it was explained that most contracts were awarded based on the personal discretion of the current political authority:

> *"... Our contractors are mostly political bigwigs and can get away with anything. We the professionals simply dance to the tune of our political superiors"* (HA2-OQS).

Such similar politicised procurement climate, which imposes subjectivity on the professional staff of the agency during contractor selection is also noted in HA1:

> *"The successful contractor would end up being that same political father who lobbied and facilitated the speedy preparation of estimate, for the project to be included in the budget" (HA1-MQS).*

In HA3, the respondents however did not directly acknowledge subjectivity in procurement during the contractor selection process.

9.7.3 Multiple Contract Re-Award

The trend of frequent project delays and abandonment evident in highway projects was emphasized in the responses of the highway agencies' staff. Respondent HA2-OQS opined:

> *"Sometimes when the contractor ends up out rightly abandoning the projects, they remain in this state for several years, while degenerating and causing public nuisance, by hindering the mobility of goods and persons".*

Respondent HA1-MQS explained that when projects had been delayed for unusually long time, successive administrations will have to re-award the contract afresh to another contractor. A typical response by one of the participants in respect of this was:

> *"When a new administration comes into power, either in government or if the *** is changed, there is usually what we call 'clean-up'. This means all outstanding abandoned projects will have to be re-awarded as new projects and all the financial resources that may have gone into the project in the previous administration will be wiped off the slate as non-recoverable"* (HA1-OQS).

For HA2, the respondents explained that this was typical for community projects, where a project that ideally ought to be completed within a few months may span up to several years, being intermittently delayed for lengthy periods of times at various stages. Respondent HA2-OQS stated that:

> *"Most of our projects exceed our initial figures by a very wide margin. Sometimes you cannot even keep track of how much the project has exceeded the initial budget because projects just keep getting delayed and abandoned and re-awarded haphazardly".*

9.7.4 Theme Summary: Procurement Irregularities

The findings from this theme has shown that the socio-cultural system of highway projects execution in the Niger Delta, is fraught with in-effective procurement processes, which are also counterproductive to ensuring geotechnical input in highway projects, ultimately leading to excessive cost overruns. Such practices and inconsistencies include:

- Non-publicising of call for bids, which deters technically efficient contractors from bidding for jobs;
- Compressed timeline for contractors to bid, which increases clients' financial risk exposure to differing site condition claims;
- Award of contracts to unqualified contractors, which has led to an informal hierarchical chain of contract subletting with no binding geotechnical stake;
- Multiple contract re-award leading inconsistent and unaccountable geotechnical input in projects, which is further complemented by cost escalations.

9.8 Summary of Findings from the Interview Analysis

The deductive analysis of the interviews in the chapter eight, examined the design and estimating practices of highway agencies in the Niger Delta, and how they account for the level of geotechnical input in highway projects. The findings from the inductive analysis of the interviews in this chapter has served to create an awareness of the role of people, organisations/institutions and socio-cultural settings as factors in the management of geotechnical risk. These induced themes have thus been identified as the barriers to adequate geotechnical input, which equally represent the range of practical issues evident in the practices of highway agencies, driving cost overruns compounded by the deltaic setting of the region.

An array of factors predicated on the need for geotechnical input, has thus been identified from the deductive and inductive phases of the interview analysis, as actively contributing to the current state of highway development in the Niger Delta. Table 9.5 provides a summary of the factors and sub-factors extracted from the interview analysis, which constitute the latent geotechnical pathogens and contextual drivers, escalating costs for in highway projects executed in the Niger Delta.

Table 9.5: Cost Overrun Drivers Inferred from the Deductive and Inductive Analysis

Theme	Sub-Theme	Cost Overrun Drivers
Nomenclature of project Phases	Configuration Pre-contract preparation	Ill—Structured phase configuration Poor Pre-contract preparation
Level of GI in preliminary project phase	Lack of GI in conceptual costing lack of GI in Planning Phase	Community restiveness pressure Lack of preliminary GI Community considerations Lack of geo-route-selection
GI in designs	Design preparation Process Mode of assessing heterogeneous ground conditio Non-Adherence to TRRL GI Ext Consultant GI DB contractors' GI	Adhoc design preparation Emergency designs Reactive post contract GI Uniform standard designs Lack of desk study Lack of detailed GI Based on preliminary reconnaissance Non verification of GI
GI in contractual Phase	Contract documentation Contractor selection	No DSC Clauses Non-inclusion of GIR Non-engineering Form of contract Hand sketches designs Survey plan layout contract documentation Verbal instructions Emergency procurement No GI algorithm Non -Technical bids
Organisational dynamics	Flow of GI Clarity of professional roles Geotechnical Presence Contractual Porosity	Poor organisational structure; Mis-matched qualifications and job description Lack of qualified technical manpower Porosity of contractual system Non-progressive GI non-construction related professionals No role-specific professional delineation; Absence of in-house Geotechnical Personnel
External Pressure	Community pressure Political pressure	Community considerations Youth restiveness pressure Emergency procurement Contractors influence Political interference Unqualified contractors Lack of due process in contracts Unverified contractors' claims Fear by professionals Unplanned budgeting Heightened security risk to contractors
Psychologic	Adversarial contractual stance	Counter geotechnical relations; Oppressive political influence

	De-motivation of professionals Risk perception	Poor risk perception Unjustified expenditure for detailed GI;
Skills and Knowledge Gaps	Knowledge gaps in design Knowledge gaps in procurement	Lack of clear understanding of geo-risk Ignorance of geotechnical best practices Lack of awareness of current design practices Non-discernible skills
GI Dichotomies	Major Vs Community Projects Upland Vs Riverine	Preferential management of geotechnical risk in relation to project size and location; Planned vs adhoc procurement practices for major vs community projects; Politically motivated selective project management practices; Lower priority status in post contract management of riverine projects
Unethical Practices	Unethical professional practices of consultants Unethical professional practices of contractors Unethical in-house verification	Deliberate under-design of projects Replication of past GI reports Replication of similar designs Non-GI in DB designs Contractors Influence of design preparation Contractors Influence of contract award Stifled verification of post-contract GI In-house professionals serving in dual capacity as client and contractors representative
Procurement Irregularities	Hushed and Unrealistic Bidding Timelines Subjective Procurement Multiple Contract Re-Award	Non-adherence to due contractual processes Non-publicising of call for bid Compressed timeline for tender submission informal hierarchical chain of contract subletting Multiple contract re-award

Deduced Themes (Latent Geotechnical Pathogens)

Induced Themes (Contextual Drivers)

9.9 Chapter Summary

The findings from this chapter have served to fill in a major gap in the literature, against the backdrop of the paucity of organisational studies which have developed a robust and in-depth contextual explanation of cost overruns in highway projects in the Niger Delta. The findings thus highlight the fact that the high level of cost overrun evidenced in highway project execution in the geologic setting of the Niger Delta, are not purely triggered by technical factors. Non-technical factors, such as: human psychology; organizational setting; socio-political factors; knowledge gaps; procurement irregularities; as well as the current practice of prioritisation of projects according to project size or location/preferential management of ground related risk, also playout to culminate in the unusually high levels of cost overruns. Consideration thus has to be given to not only the geotechnical factors evident in the development phases as they relate to ground conditions, but also to the psychological interplay between the principal technical and non-technical actors in the prevailing organisational and socio-political context of the highway agencies.

The result of the earlier deductive analysis in chapter eight, had identified the geotechnical pathogens latent in the practices of the highway organisations, which as Love (2012) *'Latent Pathogen'* theory conceptualises, mostly lie dormant and have gone undetected, as they form part of the everyday practices of the highway organisations. However, the fundamental contextual drivers, representing the barriers to managing geotechnical risk uncovered in this chapter, actively combine with the geotechnical pathogens to trigger a '*vicious cycle of delays and short funding'*, which Morris (1990) conceptualises as leading to cost overruns in public projects. It thus cannot be easily isolated, which of the identified issues has had the highest impact on highway project delivery, as they all exist in a state of complex mutual interactivity. Chapter ten, nonetheless, attempts this, using regression modelling, to explain and account for the variance in cost overruns of the sampled highway projects, induced by the geotechnical pathogens, while -content analysis is used to rank the emergent contextual drivers.

Chapter 10

Geo-Spatial Regression Modelling, Content Analysis, and Cognitive Mapping of Geotechnical and Contextual Cost Overrun Drivers

10.0 Introduction

The findings of the previous analysis in chapter five and eight, has shown the latent geotechnical pathogens that have culminated in accounting for the recorded levels of cost overruns in highway projects, constitute a chain of causality, which is entrenched in the complex web of contextual dynamics (revealed in chapter nine). As captured in Figure 10.1, a multiplicity of latent variables and contexts appear to be directly relevant, when trying to explain why the cost overruns experienced on Niger Delta highway projects are so unusually high.

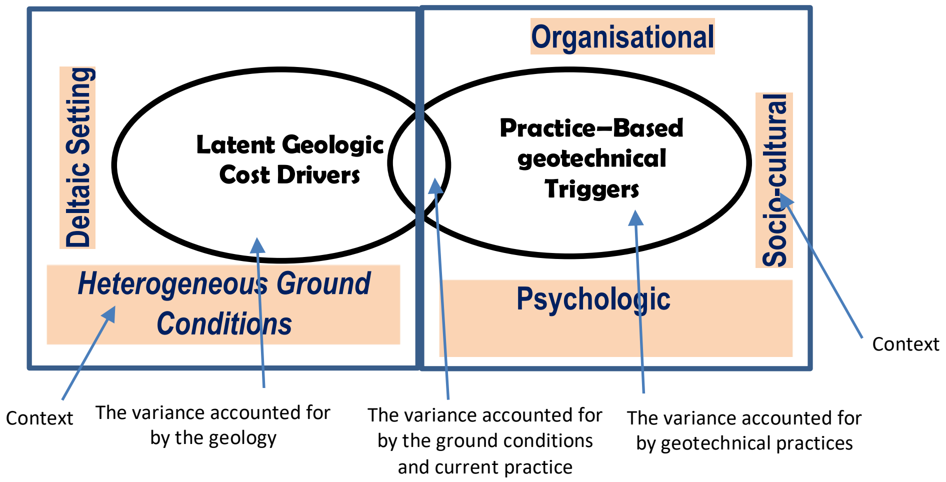


Figure 10.1: Complexity of Interaction and Contexts in Highway Projects in the Niger Delta

To explain and thus account for the recorded level of cost overrun, the researcher in this chapter, has attempted to triangulate the findings of the case study, by evaluating the distinct contributions of the geotechnical pathogens, and the contextual drivers inherent in highway development in the Niger Delta. This was achieved quantitatively and qualitatively, via regression analysis and content analysis/cognitive mapping respectively.

Regression modelling was used to statistically analyse how much variation in the recorded project cost overruns have been directly triggered by variation in the core geotechnical factors, namely: (1) the latent cost drivers as deduced from the geo-statistical analysis undertaken in chapter five and (2) the levels of geotechnical input by highway agencies explored in chapter eight. Secondly, the researcher has also applied content analysis to the qualitative data, to quantitatively assess the frequency of coded responses linked to the social constructs, which emerged as contextual drivers, as identified from the inductive thematic analysis presented in chapter nine. Finally, cognitive mapping has been adopted to allow the researcher to visually conceptualise the interactions between the emergent contextual drivers and the latent geotechnical pathogens.

10.1 Regression Modelling

Regression analysis has been defined *as "A statistical process for estimating the relationships among variables. It includes many techniques for modelling and analysing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables or predictors*" (Zwaing, 2014:84*).* Chou (2010) asserts that regression is a very powerful statistical tool that can be used as both an analytical and predictive tool in evaluating the sensitivity of project estimates to cost drivers. Such regression models of cost overrun, particularly have applicability and statistical significance that has been useful mostly in risk analysis (Zwaing, 2014), as they have the advantage of a well-defined mathematical basis. This is because regression analysis has the additional advantage of explaining the amount of variance, induced due to the predictor variables, on the basis of their individual effects or on the basis of their collective impact.

Regression analysis, as used in this chapter, is principally deployed as an explanatory analytical tool, and not a predictive tool, relevant to understand the individual and collective levels of impact of the geotechnically induced pathogens, driving the unusually high cost overruns experienced on highway projects executed in the Niger Delta. It is used to triangulate the findings from geotechnical strands of the case study: the geo-statistical analysis of geologic pathogens inherent in the wetland geology (chapter five), and the deductive interview analysis of practice based geotechnical pathogens (chapter 8). In this vain, the researcher uses multiple regression analysis, to deduce the proportion of variance in cost overruns that are explained by latent geologic factors, and the proportion that is explained by shortcomings in the geotechnical practices of the highway agencies. Regression analysis therefore, serves to quantitatively triangulate the core geotechnical explanations, emanating from the various data sources analysed in the case study (Geotechnical index data, Archival project data and Interview data).

10.2 Regression Analytic Procedure for Model Optimisation

In chapter five, the researcher carried out exploratory statistical tests between geotechnical variables and percentage cost overruns recorded by the three highway agencies. It was established that varying levels of association exist between cost overruns and geotechnical properties of sub-soils at project locations. It was also established that significant differences existed in the levels of cost overrun recorded in the three geo-zones of the Niger Delta, spatially synthesized from the literature on Niger Delta soils. The analysis continued in chapter eight, necessary to provide an in-depth qualitative evaluation of the geotechnical practices of the three highway agencies, in terms of their adherence or non-adherence to geotechnical best practices, which further explained the results of the previous geo-statistical analysis. The findings from Chapter's five and eight thus constitute the inputs that serve as the predictor variables in the regression model of geotechnical drivers explaining the variance in cost overruns.

The regression analysis was carried out using a stepwise approach, as a basis of optimising the final output of the model. The step wise approach entailed the selection of variables that yield the highest R^2, whereby at each step variables were introduced that increases the R^2, while ensuring that outliers and collinearity effects are simultaneously detected (Ngo, 2012). The stepwise procedure of model building used in the regression analysis, was thus aimed at systematically maximizing the explanatory capacity of the predictor geotechnical variables, to account for the unusually high levels of recorded cost overruns in the sampled highway projects. The process of model optimisation thus moved through several intermediary stages, shown in Figure 10.2.

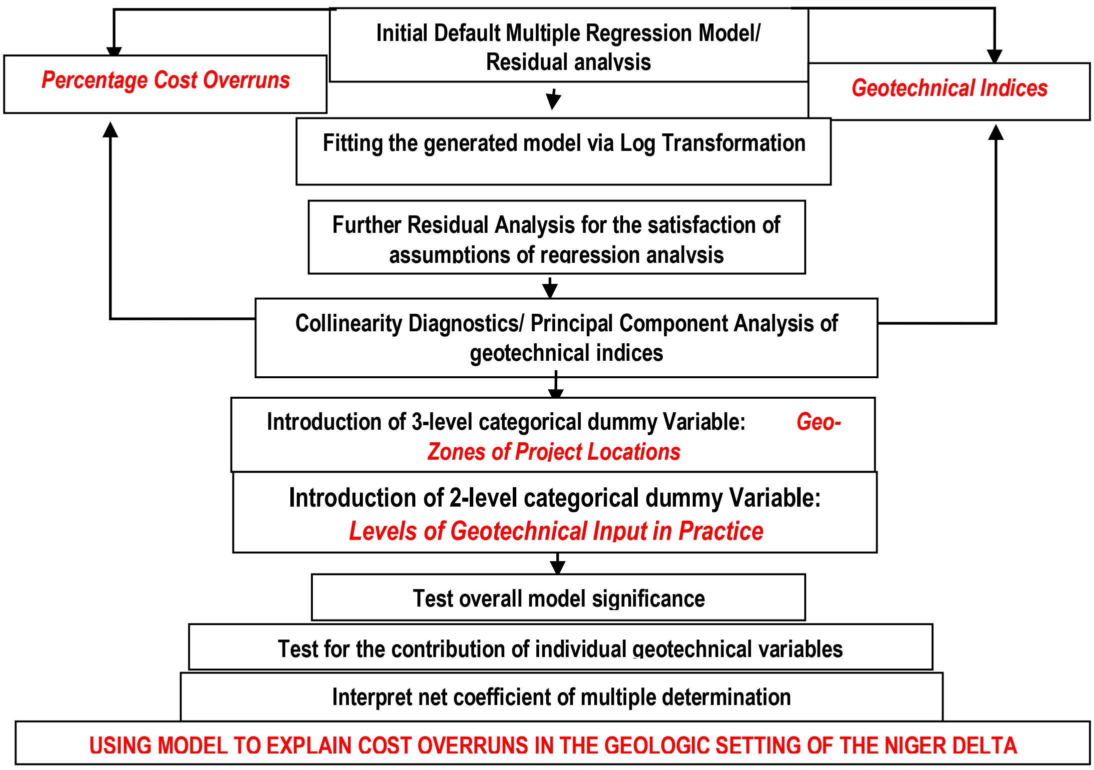


Figure 10.2: Flow Chart Depicting a Step-Wise Multiple Regression Explanatory Modelling

10.2.1 Development of Initial Multiple Regression Model

The initial model of the regression of Cost overruns (Y: Dependent Variable) versus Geotechnical indices (X_{1-n}: Independent Variables), i.e. the regression of Y on X_{1-n} was simply put as:

$Y=a + b_1X_1 + b_2X_2 + b_3X_3 + b_nX_n + e$ ....*Equation 2*

Where Y = Percentage Cost Overrun
X_1 = PI (Plasticity Index)
X_2 = FS (Free Swell)
X_3 = LL (Liquid Limit)
X_4 = PL (Plastic Limit)
X_5 = MDD (Maximum Dry Density);
X_6 = OMC (Optimum Moisture Content;
E = error term
a = Y-intercept for the population and
b_1 to b_6 = Net regression coefficients.

However, not all the variables may be imputed into the initial regression model, due to possible co-variance. Several methods of variable selection are possible in regression analysis. The forward and backward variable selection methods have the notable disadvantage of not necessarily yielding optimal variable selection, due to the 'one-at-a time' approach (Mendenhall and Terry, 2003). Therefore, although automatic variable selection is mostly adopted, Mendenhall and Terry (2003) caution that it is not a guarantee for optimal variable selection. As a consequence, stepwise regression modelling is advocated for. Stepwise regression modelling can thus be described as a combination of forward and backward approach of variable selection, as after each step in which variables are added, any nonsignificant variable found, is removed from the model (Ngo, 2012). The stepwise procedure for variable selection in the regression model, will however be treated in later phases of the analysis, after initial residual analysis of the data to:

- To identify outliers and influential points;
- Fit the initial model type;
- Ensure normality of the residual distribution;
- Detect auto-correlation of the residuals;
- Identify if there is a need for data transformation.

The researcher, however started the residual analysis of the regression model, using the default SPSS setting for variable selection, which automatically excluded Plasticity Index (PI), as shown in Table 10.1.

Table 10.1: Variables Entered/Removed

	Variables Entered	Variables Removed	Method
1	OMC, Plasticlimit, freeswell, Liquidlimit, Drydensity[b]	Plasticity Index.	Enter
a. Dependent Variable: Costoverrun			

		Collinearity Statistics		
		Tolerance	VIF	Minimum Tolerance
	plasticityindex	.000	.	.000

This selection criterion was based on the output of the default collinearity diagnostic test in SPSS, which showed very low tolerance of 0.00, for plasticity index. This was as opposed to the Tolerance and VIF values obtained for other geotechnical indices shown in Table 10.2.

Table 10.2: Collinearity Diagnostic for Geotechnical Index Variables

Coefficients[a]								
		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
	(Constant)	157.026	978.015		.161	.873		
	Freeswell	-.583	2.029	-.039	-.287	.775	.977	1.023
	Liquidlimit	.052	.743	.010	.070	.944	.897	1.114
	Plasticlimit	-.316	1.907	-.023	-.166	.869	.982	1.018
	Drydensity	-.551	401.949	.000	-.001	.999	.413	2.420
	OMC	5.820	18.279	.067	.318	.751	.413	2.424
a. Dependent Variable: Costoverrun								

The implication of this was, that plasticity index displays an almost perfect linear correlation, with of one or more of the independent variables already in the equation. However, it was not known with which of the variable(s) the collinearity existed, or if this default output represented an optimal variable selection. Table 10.3 and 10.4 illustrate the regression model summary and ANOVA test based on the default setting of automatic variable selection, which yielded an insignificant model which does not explain variance in the level of cost overruns in the highway project (R^2 =0.006). The residual analysis was, however, carried out on this default regression output.

Table 10.3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.077[a]	.006	-.084	352.14661	1.528
a. Predictors: (Constant), OMC, Plasticlimit, Freeswell, Liquidlimit, Drydensity					
b. Dependent Variable: Costoverrun					

Table 10.4: ANOVA Output

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	40406.071	5	8081.214	.065	.997[b]
	Residual	6820397.834	55	124007.233		
	Total	6860803.905	60			
a.Dependent Variable: Costoverrun b. Predictors: (Constant), OMC, Plasticlimit, freeswell, Liquidlimit, Drydensity						

10.2.2 Residual Analysis: Test for Fitness of the initial Cost Model and Potential Violations of Regression Assumptions

Residual Analysis was used to test the fitness of the initial default model. Residual Analysis is a graphical approach, used to evaluate whether the regression model that had been fitted to the cost overrun data and geotechnical data was an appropriate model (Ngo, 2012). In addition, it also enabled potential violations of the assumptions of the regression model to be evaluated. The residual or estimated error value *e,* is the difference between the observed *Y* and predicted *Y* of the cost overrun for any given set of geotechnical variables. Graphically, the residual for the data, has been depicted on a scatter diagram (in Figure 10.4), representing the plot of the values of the vertical distances, between the observed value of cost overrun and the line defined by the initial default model.

The fitness of the initial default model was evaluated, by plotting the residuals on the vertical axis, against the corresponding X_i values of the independent geotechnical variable on the horizontal axis. The criteria for the evaluation being that if the fitted cost model was appropriate for the data, there would be no apparent pattern. However, as the fitted cost model was not appropriate, there was a relationship between the values of the geotechnical variables and the residuals. This thus enabled the lack of fitness of the linear cost model to be filtered out, leading the researcher to explore the option of a non-linear transformation.

Table 10.5: Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	124.8866	271.9771	216.4657	25.95062	61
Residual	-231.34502	1718.04761	.00000	337.15471	61
Std. Predicted Value	-3.529	2.139	.000	1.000	61
Std. Residual	-.657	4.879	.000	.957	61
a. Dependent Variable: Costoverrun					

The histogram for the standardized residuals in Figure 10.3, as well as the data (Table 10.5), showed the smallest and largest residuals, and indicated a couple of very extreme residuals worthy of further investigation.

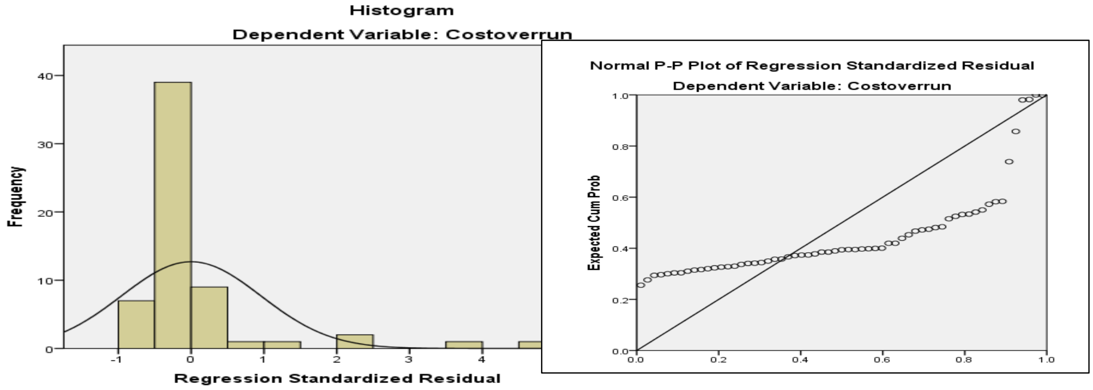


Figure 10.3: Histogram and Normality Plots of Residuals

The normality plots of the regression model residuals also showed large deviations from the assumption of normality of errors. The residual plot in Figure 10.4, indicated that the residuals were not evenly distributed about a central point or line, but show a significant number of very conspicuous residuals. The distribution also exhibited a level of curvature, suggesting the data did not fit a linear model. As such, a log-linear model or a quadratic model was considered more apt (Mendenhall and Terry, 2003; Ngo, 2012).

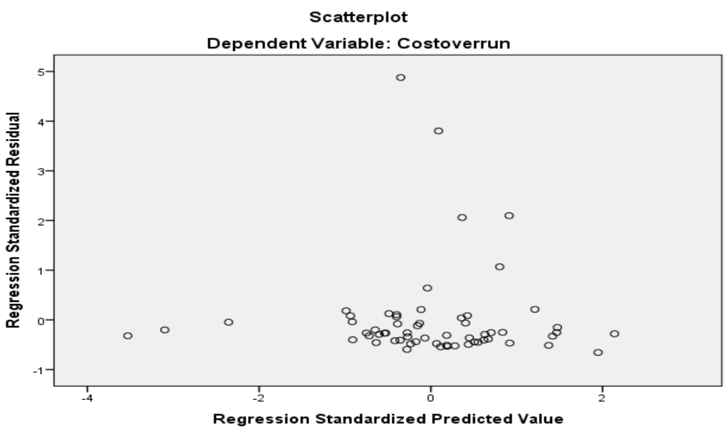


Figure 10.4: Residual Plot of initial Regression Model

The initial default regression model clearly violated all the assumptions of linear least squares regression analyses (Crawle, 2014), due to the numerous outliers, the very uneven, and non-normal distribution of the residuals. The option of log transformation was thus explored to normalise the distribution and linearize the fit of the dependent cost overrun variable.

Table 10.6: Model Summary Regression Re-run

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.327a	.107	.024	.95304	1.502
b. Dependent Variable: logcostoverrun					

Table 10.7: Residual Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	2.6616	5.3228	4.8390	.31541	60
Residual	-1.53461	2.76603	.00000	.91176	60
Std. Predicted Value	-6.903	1.534	.000	1.000	60
Std. Residual	-1.610	2.902	.000	.957	60
a. Dependent Variable: logcostoverrun					

The regression was re-run using the log-transformed cost overrun values, as shown in Table 10.7. The histograms of residuals before and after the log-transformation as shown in Figure 10.5, indicates that an improvement in the normality of the residual distribution had been attained.

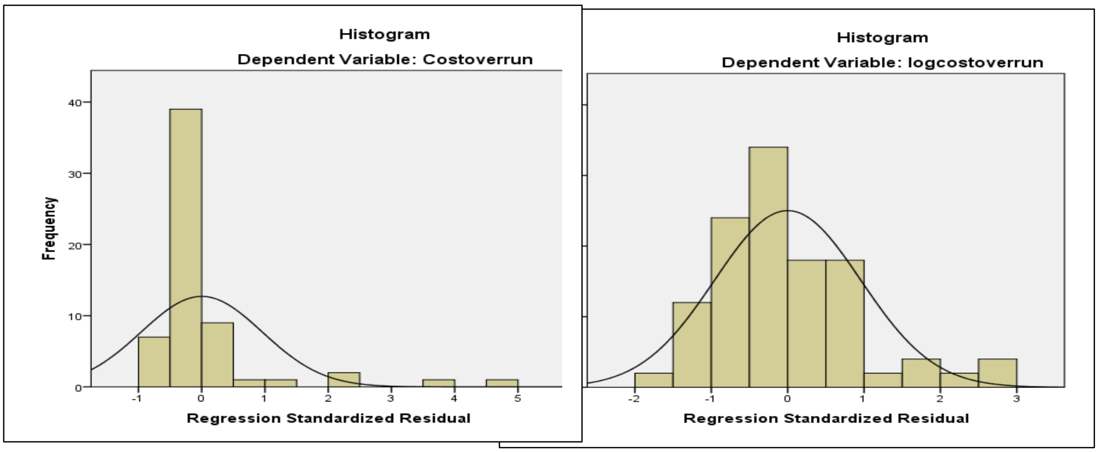


Figure 10.5: Histogram of Residuals before and after Log-Transformation

The normality P-P plot in Figure 10.6 further illustrates this improvement, with a stronger linearity within the data post transformation.

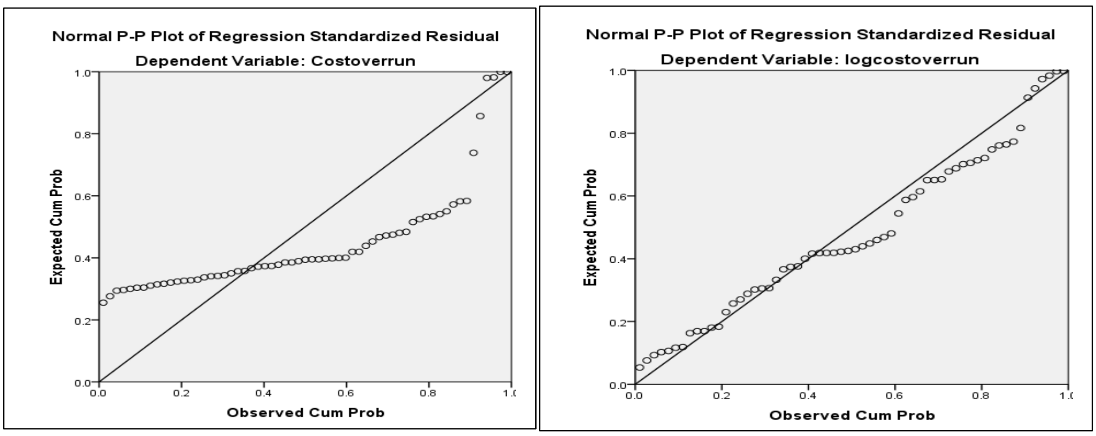


Figure 10.6: Normality P-P Plots before and after Log Transformation

However, although the residual plot reflected this improvement, there were still some extreme values that were relatively outlying (Figure 10.7 and Table 10.7).

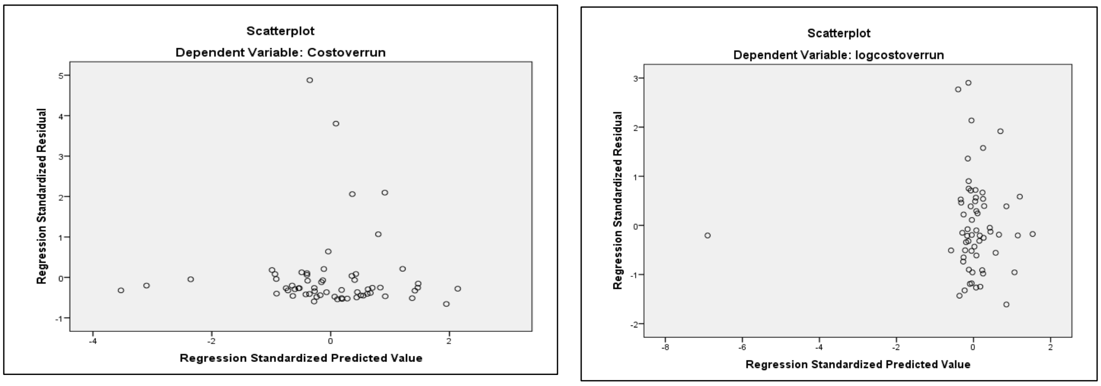


Figure 10.7: Residual Plots before and after Transformation

The case wise diagnostics for outliers, deduced based on the default critical SPSS thresholds for Mahalanobis Distances, Cooks Distances and Centred Leverage values were thus used to detect these outliers and observations with high leverage values. Table 10.7 shows that variable entry values for sample project number 37, 49 and 52 were still outlying.

Table 10.7: Case wise Outlier Diagnostics

Case Number	Std. Residual	Logcostoverrun	Predicted Value	Residual
37	2.136	6.86	4.8220	2.03574
49	2.902	7.56	4.7969	2.76603
52	2.768	7.35	4.7132	2.63806
a. Dependent Variable: logcostoverrun				

With the extreme values omitted, the Studentized Deleted Residual statistics for the regression re-run, is presented. The minimum and maximum Mahalanobis Distances, Cooks Distances and Centred Leverage values of the Studentized Deleted Residuals, is displayed in Table 10.8.

Table 10.8: Studentized Deleted Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation
Predicted Value	2.6616	5.3228	4.8390	.31541
Std. Predicted Value	-6.903	1.534	.000	1.000
Standard Error of Predicted Value	.127	.934	.242	.181
Adjusted Predicted Value	3.0970	9.3705	4.9139	.66120
Residual	-1.53461	2.76603	.00000	.91176
Std. Residual	-1.610	2.902	.000	.957
Stud. Residual	-1.758	2.933	-.019	.994
Deleted Residual	-4.21548	2.82495	-.07490	1.14978
Stud. Deleted Residual	-1.794	3.169	-.011	1.024
Mahal. Distance	.061	55.668	4.917	11.987
Cook's Distance	.000	3.131	.077	.410
Centred Leverage Value	.001	.944	.083	.203

The changes in the distribution shape of the residuals normality P-P plots in Figure 10.8, also reflects this improvement. The distribution of the residuals, has thus satisfied the underlying assumption of normality of errors, requisite for carrying out regression analysis.

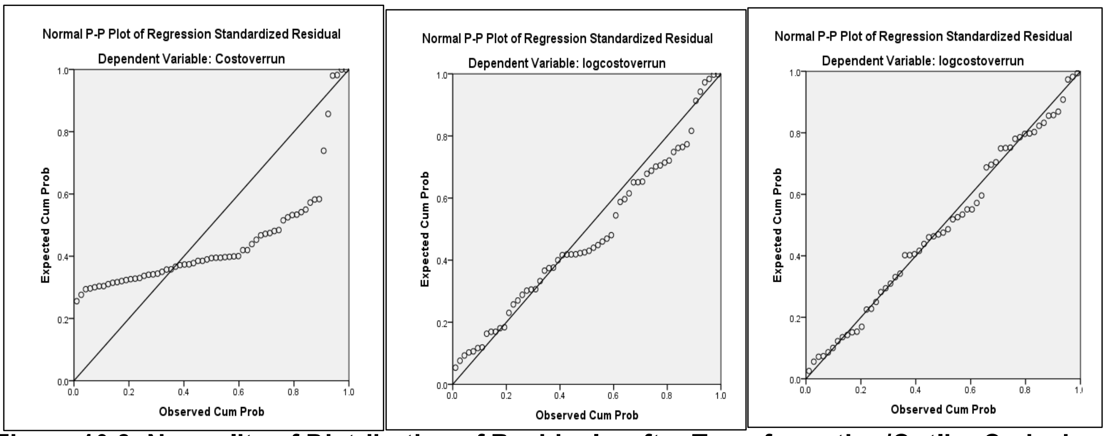


Figure 10.8: Normality of Distribution of Residuals, after Transformation/Outlier Omission

As shown in Figure 10.9, the requirement of independence of errors in the distribution, i.e. non-autocorrelation, is also satisfied.

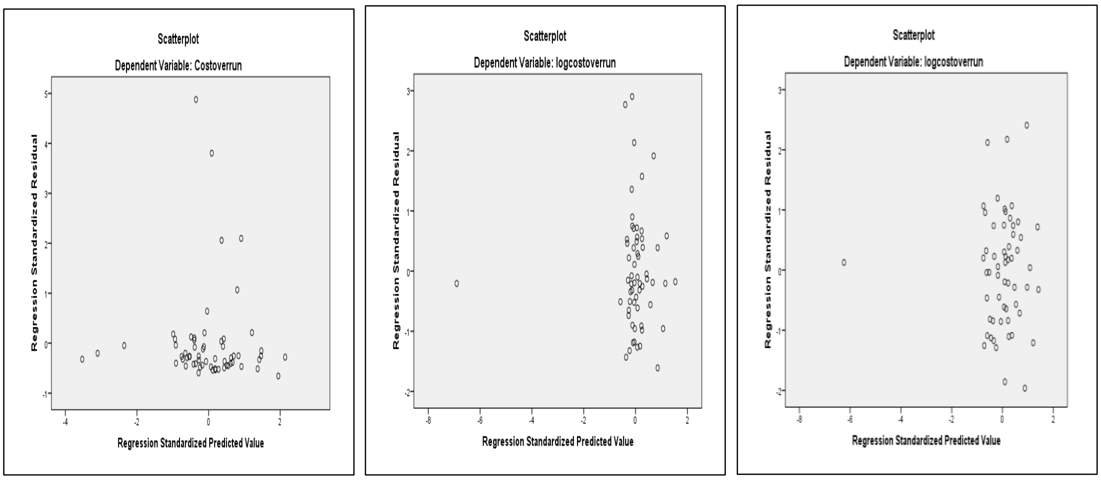


Figure 10.9: Residual Plots showing Improvement in Non-autocorrelation

Table 10.9 shows a value of 1.825 for the Durbin-Watson statistic, which is closer to 2.00, thus confirming the assumption of independence of residuals (Crawle, 2014). The log transformed cost-overrun values, with the three deleted outliers, leaving 58 sample points, were therefore used in re-running the regression analysis. The screened data thus satisfied the requirement of linearity, normality, and independence in the distribution of the residuals generated in fitting the regression model.

Table 10.9: Initial and Fitted Regression Model

R	**R Square**	Adjusted R Square	Std. Error of the Estimate	**Durbin-Watson**
.077[a]	**.006**	-.084	352.14661	**1.528**

R	**R Square**	Adjusted R Square	Std. Error of the Estimate	**Durbin-Watson**
.442[a]	**.195**	.117	.75554	**1.825**

The improved model fitness, was also reflected in the increased explanatory power of the geotechnical indices (R^2), from 0.006 observed the initial model, to 0.195 in the fitted initial model.

10.2.3 Collinearity Diagnostics: Principal Component Analysis

The existence of collinearity or multi-collinearity, although not a violation of the assumptions of regression modelling, via interactions amongst the predictor variables, will yield sub-optimal model output with poor explanatory power in accounting for relationships amongst the variables (Miles and Chelvin, 2001: Ngo, 2012). Detection of collinearity is carried out in this section, using Principal Component Analysis (PCA) as a useful step in selecting variables that were included in the initial regression model (Lawrence, 2006). Table 10.10, highlights significant bi-variate correlations between the geotechnical variables.

Table 10.10: Correlation Matrix of Geotechnical Variables.

		Plasticityindex	Freeswell	Liquidlimit	Plasticlimit	Drydensity	OMC
Plasticityindex	Pearson Correlation	1	**1.000****	.063	.052	-.122	.145
	Sig. (2-tailed)		.000	.627	.691	.349	.265
Freeswell	Pearson Correlation	**1.000****	1	.063	.052	-.122	.145
	Sig. (2-tailed)	.000		.627	.691	.349	.265
Liquidlimit	Pearson Correlation	.063	.063	1	.089	**-.301***	.289*
	Sig. (2-tailed)	.627	.627		.494	.018	.024
Plasticlimit	Pearson Correlation	.052	.052	.089	1	-.088	.114
	Sig. (2-tailed)	.691	.691	.494		.502	.383
Drydensity	Pearson Correlation	-.122	-.122	**-.301***	-.088	1	**-.761****
	Sig. (2-tailed)	.349	.349	.018	.502		.000
OMC	Pearson Correlation	.145	.145	.289*	.114	-**.761****	1
	Sig. (2-tailed)	.265	.265	.024	.383	.000	
**. Correlation is significant at the 0.01 level (2-tailed).							
*. Correlation is significant at the 0.05 level (2-tailed).							

The correlation matrix highlighted the perfect correlation, existing between PI (Plasticity Index) and FS (Free swell). It is not surprising that these parameters display such perfect collinearity, as they both describe the behaviour of fined soils, as they transition from their solid state to a more fluid-like state in the inherently wet geomorphologic setting of the Niger Delta. The analysis is consistent with geotechnical theories: that highly plastic soils display high volume changes or swelling with the introduction of moisture (Figure 10.10).

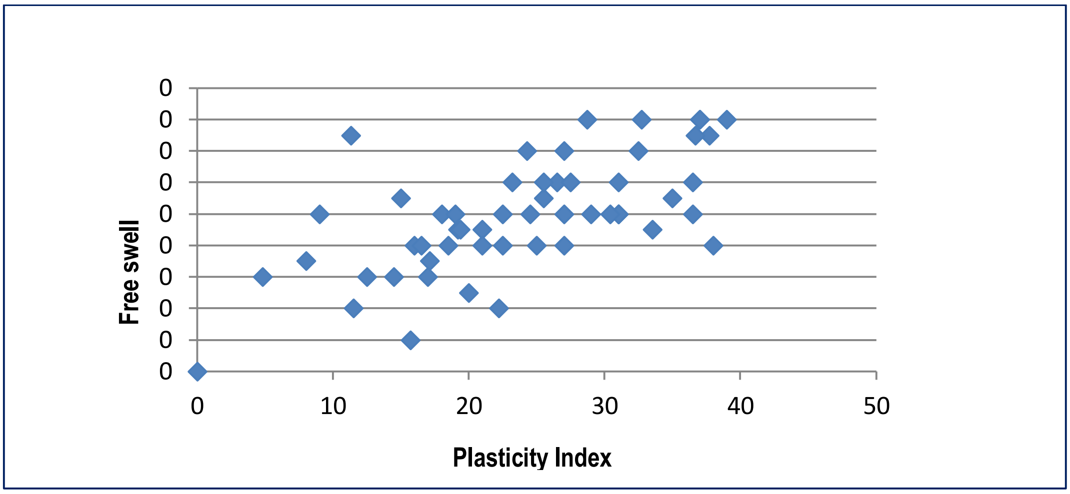


Figure 10.10: Scatter Plot of Free Swell Vs Plasticity Index

The correlation matrix also highlighted significant lower levels of correlations between the Maximum Dry Density (MDD) and Optimum Moisture Contents (OMC) of the soils, as well as between MDD and Liquid Limit (LL). The bi-variate analysis was however limited, as it could only detect significant bi-variate collinearity combinations and not multi-collinearity amongst the geotechnical variables. The researcher opted to use factor analysis as a useful step in detecting multi-collinearity, prior to the regression analysis as suggested by (Lawrence, 2006).

Principal Component Analysis was thus deployed in this instance as a factor classification tool, and not for reduction, useful to detect multicollinearity amongst the geotechnical variables, discernible from the pattern of loading of the analysed principal components in the varimax rotation. Lawrence (2006) however cautioned that the functionality of PCA in minimising collinearity amongst the explanatory variables, may lead to selected components with little explanatory power to account for variation in the dependent variable. Thus as opposed to performing a Principal Component Regression, in which the selected components are imputed into the regression model as the explanatory variables, it was used as preliminary variable selection tool to detect the groups of geotechnical variables, whose contribution to the model are similar. Therefore, geotechnical indices loaded principally onto a particular component were inferred as confounding, and only one variable was selected as input into the regression model. The criteria for this elimination, was however, further defined by their level of contribution to optimising the model's explanatory power (R^2), in terms of the dependent variable (Cost overrun).

Table 10.11: PCA output for Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.277	37.943	37.943	2.277	37.943	37.943	1.995	33.253	33.253
2	1.699	28.311	66.253	1.699	28.311	66.253	1.980	33.001	66.253
3	.975	16.251	82.505						
4	.812	13.529	96.034						

The PCA output in Table 10.11 highlights two principal components (1 and 2) based on the default Eigen value cut-off of 1.0 in the SPSS software, which explained about 66.25% of the co-variance amongst the geotechnical variables. However, this still left a significant portion of unexplained variance amongst the geotechnical variables. This was indicative of other potentially significant principal components, worthy of further investigation.

Table 10.12: Loadings of Principal Components

	Initial	Extraction
Plasticityindex	1.000	.999
Freeswell	1.000	.999
Liquidlimit	1.000	.322
Plasticlimit	1.000	.055
Drydensity	1.000	.801
OMC	1.000	.798
Extraction Method: Principal Component Analysis.		

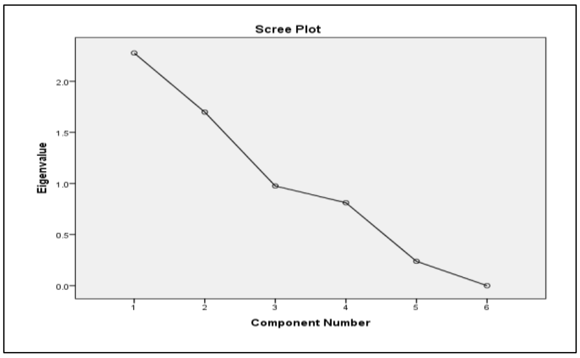


Figure 10.11: Scree Plot of Principal Components

Table 10.12 shows the loadings of the individual geotechnical indices in the two extracted components, before and after the varimax rotation. The varimax rotation in Table 10.13, has made the factor loading more clearly discernible.

Table 10.13: Component Loading before and after Varimax Rotation

Component Matrix[a]		
	Component	
	1	2
Plasticityindex	.772	.635
Freeswell	.772	.635
Liquidlimit	.398	-.405
Plasticlimit	.196	-.129
Drydensity	-.657	.607
OMC	.675	-.586
Extraction Method: Principal Component Analysis.		
a. 2 components extracted.		

Rotated Component Matrix[a]		
	Component	
	1	2
Plasticityindex	**.996**	.084
Freeswell	**.996**	.084
Liquidlimit	.003	.568
Plasticlimit	.050	.229
Drydensity	-.047	**-.894**
OMC	.075	**.890**
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.		
a. Rotation converged in 3 iterations.		

Plasticity index and free swell, were loaded primarily in component 1, while Maximum Dry Density and OMC are loaded onto component 2. Plastic limit and liquid limit, however seem not to be primarily loaded onto any of the two components. These two principal components could not be used to classify and detect structure amongst all the 6 geotechnical variables. The PCA analysis was thus rerun with a cut-off specification of four components, to explore for further principal components. Table 10.14 shows four principal components selected, and their loadings after the Varimax rotation with Kaiser Normalization. The selected components maximised all 6 geotechnical indices loadings.

Table 10.14: Rotated Component Matrix

	Components			
	1	2	3	4
Plasticityindex	**.997**	.069	.020	.021
Freeswell	**.997**	.069	.020	.021
Liquidlimit	.029	.187	.040	**.981**
Plasticlimit	.027	.058	**.997**	.038
Drydensity	-.054	**-.928**	-.023	-.131
OMC	.079	**.927**	.058	.110

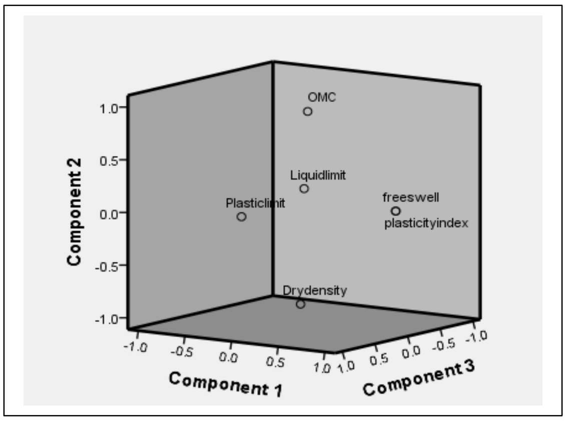


Figure10.12: Component Plot in Rotated Space

10.2.4 Selection of Optimal Model

The objective of using a step wise regression analysis to generate the cost overrun model, was in other to include only the geotechnical indices of subsoil characteristics that are useful in predicting cost overrun. Thus the geotechnical variables that were not significantly useful in predicting costoverrun, despite displaying a relationship with it, were deleted. A regression cost model with fewer geotechnical variables was used in its place, in other to ensure that the best explanatory approximation of cost overrun was obtained.

Based on the PCA outputs therefore, the researcher therefore selected the following principal groups of variables as input to the regression model: PI/FS, PL, LL, and OMC/MDD. Four regression models, representing all possible four combinations of variables were run in the following combinations, to test for the combination that yields the highest explanation of variance in in the log of cost overruns (R^2):

- PI, PL, LL, and OMC;
- FS, PL, LL, and OMC;
- PL, PL, LL, and MDD;
- FS, PL, LL, and MDD.

Table 10.15 shows the outcome of the regressions run with four sets of geotechnical index variables. The explained variances of the regression models are highlighted. However, it was easily discernible that for all the models, Plastic Limit (PL) has being automatically removed by the default SPSS setting. This implied that it was redundant, as its effect was already explained by the other 3 geo-technical variables in the models.

Table 10.15: Alternative Regression Models after Collinearity Diagnostic

Model Summary				
Model	R	**R Square**	Adjusted R Square	Std. Error of the Estimate
1	.442[a]	**.196**	.151	.73497
a. Predictors: (Constant), plasticityindex, Liquidlimit, Drydensity				

Model Summary				
Model	R	**R Square**	Adjusted R Square	Std. Error of the Estimate
1	.434[a]	**.188**	.143	.73831
a. Predictors: (Constant), freeswell, Liquidlimit, Drydensity				

Model Summary				
Model	R	**R Square**	Adjusted R Square	Std. Error of the Estimate
1	.432[a]	**.187**	.142	.73907
a. Predictors: (Constant), OMC, Liquidlimit, freeswell				

Model Summary				
Model	R	**R Square**	Adjusted R Square	Std. Error of the Estimate
1	.442[a]	**.195**	.150	.73532
a. Predictors: (Constant), plasticityindex, OMC, Liquidlimit				

The optimal model of geotechnical indices explained about 19.6% of the variation in cost overruns, based on the value of R^2 in the regression model of plasticity index, Liquid limit and Maximum Dry density. The explained variation by the initial model of geotechnical indices increased from 0.006, for the unfitted initial model for five variables versus cost overrun, to 0.196 in the optimal selected model, based on three variables versus log cost overrun, as shown in Table 10.16.

Table 10.16: Unfitted and Fitted Initial Models

Model	R	**R Square**	Adjusted R Square	Std. Error of the Estimate
1	.077[a]	**.006**	-.084	352.14661

. Predictors: (Constant), Freeswell, Liquidlimit, Drydensity, PlasticLimit, OMC

Selected optimal Model Summary				
Model	R	**R Square**	Adjusted R Square	Std. Error of the Estimate
2	.442[a]	**.196**	.151	.73497

The ANOVA Table for the fitted model also shows the significance of this fitted initial geotechnical model.

Table 10.17: ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	7.098	3	2.366	4.380	.008[b]
	Residual	29.170	54	.540		
	Total	36.268	57			
a. Dependent Variable: Logcostoverrun						
b. Predictors: (Constant), plasticityindex, Liquidlimit, Drydensity						

The model coefficients for the fitted initial model are presented in Table 10.18

Table 10.18: Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	6.166	1.141		5.402	.000			
	Liquidlimit	-.015	.004	-.438	-3.557	.001	-.420	-.436	-.434
	Drydensity	.000	.002	.033	.260	.796	.045	.035	.032
	plasticityindex	-.560	.571	-.126	-.981	.331	-.083	-.132	-.120
a. Dependent Variable: Logcostoverrun									

The optimal regression equation based on geotechnical indices would thus be:
Log costoverrun = 6.166 – 0.015LL – 0.560PI + e ....*Equation 10.1*

10.2.5 Introduction of a 3-Level Categorical Dummy Variable: Geo-Zonation of Projects

From the Analysis of Variance test carried out in chapter five, significant differences in cost were noted between the level of cost overruns experienced by the highway agencies in the upland, swamps and coastal parts of the Niger Delta. It was therefore determined that the geo-zonation of projects impacts on the level of cost overrun. Its impact on cost overrun was fundamentally attributed to the strength/weakness of sub-soils in each of these distinct zones, with projects constructed in swamps, which have the poorest soil types, demonstrating the highest levels of recorded cost overruns. The next phase in the stepwise regression modelling was therefore, the introduction of a 3-level categorical dummy variable to account for these geo-zones.

To achieve this, three sets of recoded dummy variables were imputed into the regression model based on the following specifications in SPSS variable data entry, with $\mathbf{Z_1}$ set as the control variable in the model:

- Recoded Dummy Variable 1: $Z_1 = 1$; $Z_2 = 0$; $Z_3 = 0$, for projects located in the uplands;
- Recoded Dummy Variable 2: $Z_1 = 0$; $Z_2 = 1$; $Z_3 = 0$, for projects located in the swamps;
- Recoded Dummy Variable 3: $Z_1 = 0$; $Z_2 = 0$; $Z_3 = 1$ for projects located along the coast**.**

Where $\mathbf{Z_1}$ = Uplands
$\mathbf{Z_2}$ = Swamps
$\mathbf{Z_3}$= Coastal

However, before the dummy variables were included in the regression model, they were used as independent predictors to test for their relationship with cost overruns, as presented in Table 10.18.

Table 10.18: Regression of Cost overrun Vs Geo-zone

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change	Durbin-Watson
1	.384[a]	.147	.118	317.63031	.010	2.026

Table 10.18: ANOVA Output for Regression of Cost overrun Vs Geo-zone

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1009241.097	2	504620.549	5.002	.010[b]
	Residual	5851562.808	55	100889.014		
	Total	6860803.905	57			
a. Dependent Variable: costoverrun						
b. Predictors: (Constant), coastal, swamp						
c. Predictors: (Constant), coastal, upland						

Tables 10.17 and 10.18 demonstrate that the geo-zones in which the projects are located, in isolation, explains approximately 14.7% of the variation in cost overrun.

Table 10.19: Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	117.354	64.836		1.810	.075
	Swamp	276.444	94.910	.392	2.913	.005
	Coastal	15.033	102.515	.020	1.147	.004
a. Dependent Variable: costoverrun						

Based on the regression coefficients in Table 10.19, the linear regression equations based only on geo-zones were:

- Costoverrun = 117.354 +276.44 + e ...*Equation 10.2 (For projects located in swamps)*
- Costoverrun = 117.354 + 15.033 +e .... *Equation 10.3 (For projects located in coastals)*
- Costoverrun = 117.354 + e .... *Equation 10.4 (For projects located in uplands)*

However, the regression output for the combined geotechnical index and geo-zone variables, presented in Table 10.20, shows the changes in the coefficients of the independent variables.

Table 10.20: Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	5.281	1.306		4.044	.000			
	Liquidlimit	-.014	.004	-.398	-3.131	.003	-.420	-.398	-.383
	Dry Density	.001	.004	.043	.349	.729	.005	.048	.043
	Plasticity index	-.210	.622	-.047	-.338	.737	-.083	-.047	-.041
	Swamp	.347	.265	.203	1.310	.196	.212	.179	.160
	Coastal	.210	.248	.119	.846	.402	.062	.116	.103
a. Dependent Variable: Logcostoverrun									

The optimised regression equations using the log transformed cost overrun values, and including the geotechnical indices of sub-soils for projects in the different geologic environments was thus:

Log costoverrun = 5.281 – 0.014LL + .001MDD – 0.210PI + 0.347 + e ....*Equation 10.5*
(Projects located in the Swamps)

Log costoverrun = 5.281 – 0.014LL + .001MDD – 0.210PI + 0.210 + e ....*Equation 10.6*
(Projects located in the coastal areas)

Log costoverrun = 5.281 – 0.014LL + .001MDD – 0.210PI + e ....*Equation 10.7*
(Projects located in the upland areas).

Table 10.21: Model Summary for Cost Overrun Versus Geotechnical Variables

Model	Variables Entered	Variables Removed	Method
1	coastal, plasticityindex, Dry Density, Liquidlimit, swamp[b]	.	Enter
a. Dependent Variable: Logcostoverrun			
b. Tolerance = .000 limits reached.			

Model	R	**R Square**	Adjusted R Square	Std. Error of the Estimate
1	.471[a]	**.222**	.147	.73685
a. Predictors: (Constant), coastal, plasticityindex, Drydensity, Liquidlimit, swamp				

Using the combined variables, it was thus noted that the explanatory power (R^2= 0.222) of the model, shown in Table 10.21, was greater than for the individual models generated for geo-indices and geo-zones (19.6% and 14.7%, respectively). This was an indication that accounting the geo-zones where the individual projects locations were situated, has further optimised the model.

10.2.6 Introduction of 2-Level Categorical Dummy Variables: Levels of Geotechnical Input

The outcome of the interview analysis in chapter eight, revealed varying levels of geotechnical input in highway projects. This was discernible from the standard geotechnical practices of the highway agencies, which revealed an apparent dichotomy for major and community projects, as well as differences in the in-house design, costing and procurement practices of the three highway agencies. Summative assessment of the levels of geotechnical input in the sampled highway projects, was thus deduced based on the dichotomous criteria outlined in Figure 6.9, which represents a linear conceptualisation of the flow of GI in the project phases, relative to standards of best practice, and the anticipated cumulative impact.

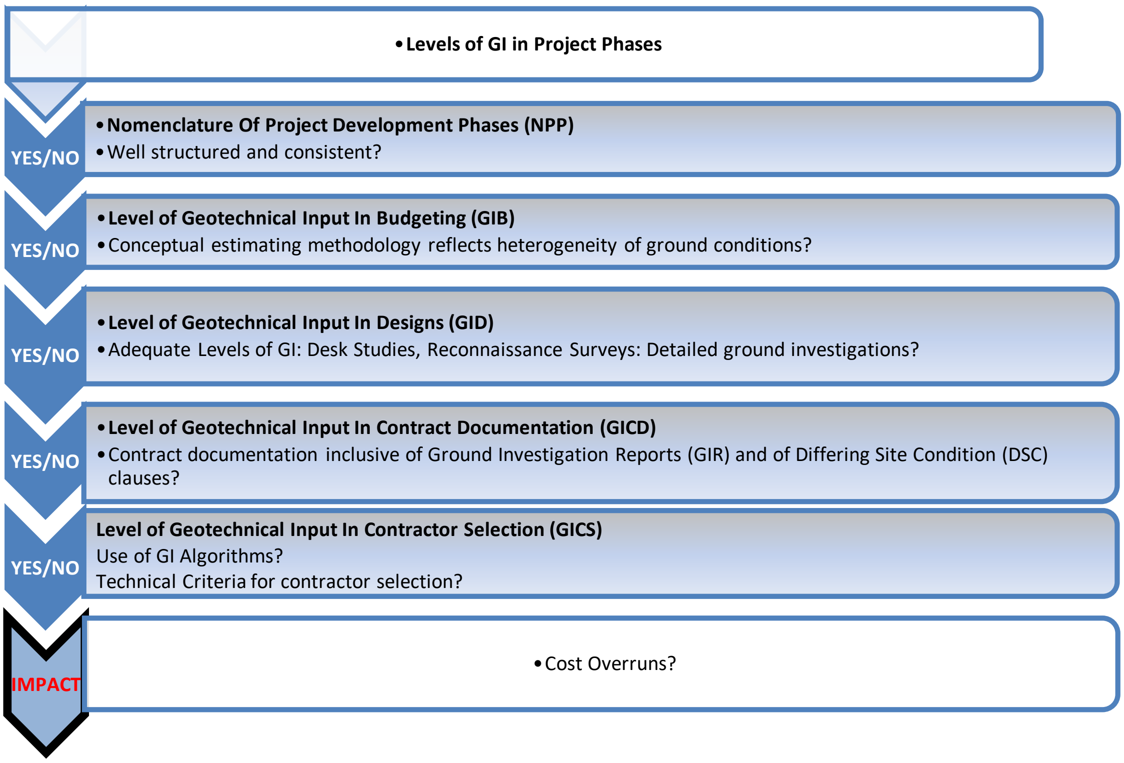


Figure 10.13: Assessment Criteria for Comparison of Level of GI

The inherent levels of GI in the sampled high projects executed by the different highway agencies, were represented as binary dummy variables, following the criteria outlined in figure 10.13.

Table 10.22: Levels of GI in Sampled Highway Projects

Project No	NPP	GIB	GID	GICD	GICS
1	1	0	1	0	1
2	1	0	1	0	1
3	0	0	0	0	0
4	0	0	0	0	0
5	1	0	1	0	1
6	0	0	1	0	1
7	1	1	1	0	1
8	1	1	1	0	1
9	0	0	0	0	0
10	1	1	0	0	0
11	0	0	0	0	0
12	1	1	1	0	1
13	0	1	0	0	0
14	1	0	1	0	1
15	1	0	1	0	1
16	0	0	1	0	0
17	1	1	1	0	1
18	0	0	0	0	0
19	0	0	0	0	0
20	0	0	0	0	0

21	1	1	0	0	0
22	1	1	1	0	1
23	0	0	0	0	0
24	1	1	0	0	1
25	0	1	1	0	1
26	1	1	1	0	1
27	1	1	1	0	1
28	1	1	1	0	1
29	0	0	0	0	0
30	1	0	0	0	0
31	0	0	0	0	0
32	1	0	0	0	0
33	1	0	1	0	1
34	1	0	0	0	0
35	0	1	1	0	1
36	0	0	0	0	0
37	1	1	1	0	1
38	0	1	1	0	1
39	0	0	0	0	0
40	1	0	0	0	0
41	1	0	0	0	0
42	0	0	0	0	0
43	1	1	1	0	1
44	0	0	0	0	0
45	1	1	1	0	1
46	1	1	1	0	0
47	0	0	0	0	0
48	1	0	0	0	0
49	1	0	0	0	0
50	0	0	1	0	0
51	0	1	0	0	0
52	0	0	0	0	0
53	1	0	1	0	0
54	1	1	1	0	1
55	0	0	0	0	0
56	0	0	0	0	0
57	0	0	0	0	0
58	0	0	0	0	0

Where **1** = Yes
0 = No

Table 10.23 shows the estimated overall regression model of cost overrun based on all deduced geotechnical cost overrun drivers for highway projects executed in the Niger Delta region.

Table 10.23: Regression Coefficients for Final Regression Model

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	6.501	.734		8.863	.000			
	Liquidlimit	-.010	.002	-.279	-3.849	.000	-.420	-.486	-.253
	Drydensity	.000	.001	.015	.203	.840	.045	.029	.013
	plasticityindex	-.545	.348	-.123	-1.565	.124	-.083	-.220	-.103
	Swamp	.363	.145	.095	1.126	.266	.212	.160	.074
	Coastal	.260	.134	.147	1.935	.059	.062	.269	.127
	uGIBUDG	-.435	.145	-.264	-2.996	.004	-.568	-.397	-.197
	NOMEN	-.139	.124	-.088	-1.120	.268	-.525	-.160	-.074
	GIDES	-.471	.193	-.296	-2.438	.019	-.743	-.332	-.160
	GICONTSEL	-.452	.211	-.280	-2.141	.037	-.784	-.295	-.141
Dependent Variable: logcostoverrun Constant: GICONTDOC									

The Log-Linear regression model of cost overrun drivers predicated on ground conditions and the current geotechnical practices of highway agencies in the Niger Delta was thus:

Logcostoverrun = 6.501 - 0.010LL - 0.545PI + 0.363 swamp + 0.260 coastal - 0.435GIB - 0.139NOM - 0.471GIDS – 0.452GICS + e. ……………………………………………Equation 10.8

The level of Geotechnical Input in Contract Documentation (GICONTDOC = 0), was, however, flagged by SPSS as constituting a constant, as the practices of all three of the highway agencies evidence that Ground Investigation Reports and DSC clauses were not incorporated in contract documents, provided to bidders for major and community projects.

10.2.7 Overall Model Fitness and Significance

Residual analysis was once again used to determine whether the generated final regression model was an appropriate one. The outcome of the residual analysis thus constituted the criterion used for adjudging whether the developed log-model defined the linear relationship between the level of recorded cost overruns and the set of explanatory geotechnical variables, as follows:

H_o: There is no linear relationship between cost overruns experienced on highway projects executed in the Niger Delta and the selected geotechnical cost drivers inherent in the deltaic geologic setting and organisational practices.

H_1: There is a linear relationship between cost overruns experienced on highway projects executed in the Niger Delta and the selected geotechnical cost drivers inherent in the deltaic geologic setting and organisational practices.

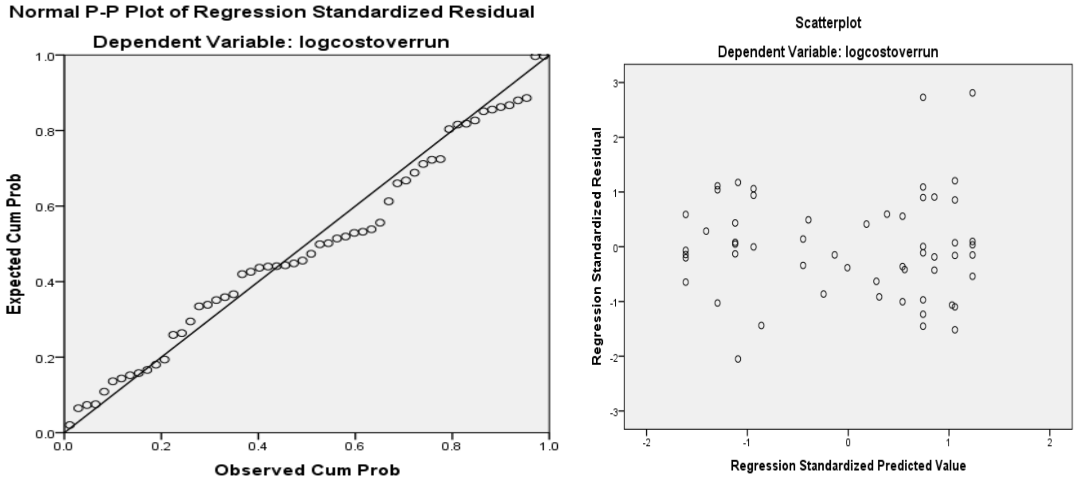


Figure 10.14: Residual Plots

Figure 10.14 shows that the residuals from the final regression model, generated using the log transformed values, are still normally and independently dispersed.

Table 10.24: Final Model Summary

Model	R	**R Square**	Adjusted R Square	Std. Error of the Estimate	**Durbin Watson**
1	.890[a]	**.792**	.754	.39596	**1.943**
a. Predictors: (Constant), GICONTSEL, plasticityindex, coastal, Liquidlimit, Drydensity, NOMEN, swamp, GIBUDG, GIDES					

The overall model summary also showed that the Durbin Watson Statistic of 1.943 is very close to the ideal value of 2.00, which indicated that there was no auto-correlation between the residuals (Crawle, 2014).

Table 10.25: ANOVA Output for Final Model

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	28.743	9	3.194	20.369	.000[b]
	Residual	7.526	48	.157		
	Total	36.268	57			
a. Dependent Variable: logcostoverrun						
b. Predictors: (Constant), GICONTSEL, plasticityindex, coastal, Liquidlimit, Drydensity, NOMEN, swamp, uGIBUDG, GIDES						

Based on the outcome of the residual analysis and the analysis of variance output, the null hypothesis was rejected, and the alternate accepted, as there exists a significant log-linear relationship between cost overruns recorded on the highway projects, and the selected geotechnical pathogens.

10.2.8 Explanatory Power of the Final Model: Coefficients of Multiple and Partial Determination

The coefficient of Multiple Determination (R^2) measures the proportion cost overruns, that is explained by the variation in set of geotechnical variables selected. The coefficient of Multiple Determination is equal to the regression sum of squares (SSR) divided by the total sum of squares (SST). i.e.

$$R^2 = \frac{SSR}{SST} \text{...} \textit{Equation 10.9}$$

From the model summary presented in Table 10.26, the coefficient of multiple determination (R^2) has improved from 0.222 to 0.792.

Table 10:26: Optimised Explanatory Power of the Cost Overrun Model

Model	R	**R Square**	Adjusted R Square	Std. Error of the Estimate
1	.471[a]	**.222**	.147	.73685
a. Predictors: (Constant), coastal, plasticityindex, Drydensity, Liquidlimit, swamp				

Model	R	**R Square**	Adjusted R Square	Std. Error of the Estimate	Durbin Watson
1	.890[a]	**.792**	.754	.39596	1.943
a. Predictors: (Constant), GICONTSEL, plasticityindex, coastal, Liquidlimit, Drydensity, NOMEN, swamp, GIBUDG, GIDES					

This implies that all the variables (cost drivers) in the regression model, combine to explain about 79% of the variation in the level of cost overrun experienced in the sampled highway projects. The inclusion of the levels of geotechnical input deduced from the practices of the three highway agencies, in the regression model, has had a drastic positive effect in optimising the explanatory power of the regression model. The researcher further examines the individual contributions of the variables in explaining cost overruns in the sampled highway projects. The Coefficients of Partial Determination for each explanatory geotechnical variable for the n^{th} geotechnical variable is defined in equation 10.10.

$$\mathbf{r_{yn}^2} \text{ (all variables except n) } = \frac{SSR(Xn) all\ variables\ except\ n}{SST - SSR(all\ variables\ including\ n) + SSR(all\ variablesexcept\ n)} \quad \ldots$$

Equation 10.10

The coefficient of partial determination for a particular geotechnical variable, means that for given constant values of all other geotechnical variables, the percentage variation in cost overrun due to is the value of the coefficient, multiplied by 100. Table 10.27 shows the values of the zero-order and partial correlation coefficients, computed.

Table 10.27: Zero Order and Partial Correlation Coefficients

Model	Zero-order	Partial	Ranking of Variable Contribution
(Constant)			
Liquidlimit	-.420	-.486	1
Drydensity	.045	.029	9
Plasticityindex	-.083	-.220	6
Swamp	.212	.160	7
Coastal	.062	.269	5
uGIBUDG	-.568	-.397	2
NOMEN	-.525	-.160	7
GIDES	-.743	-.332	3
GICONTSEL	-.784	-.295	4

The zero order correlation coefficients (Without including all the other variables) and the partial correlation coefficients (when the composite effect of the others is included in the model) differ. The partial regression plots of the three geotechnical indices in the regression model are shown in Figure 10.15.

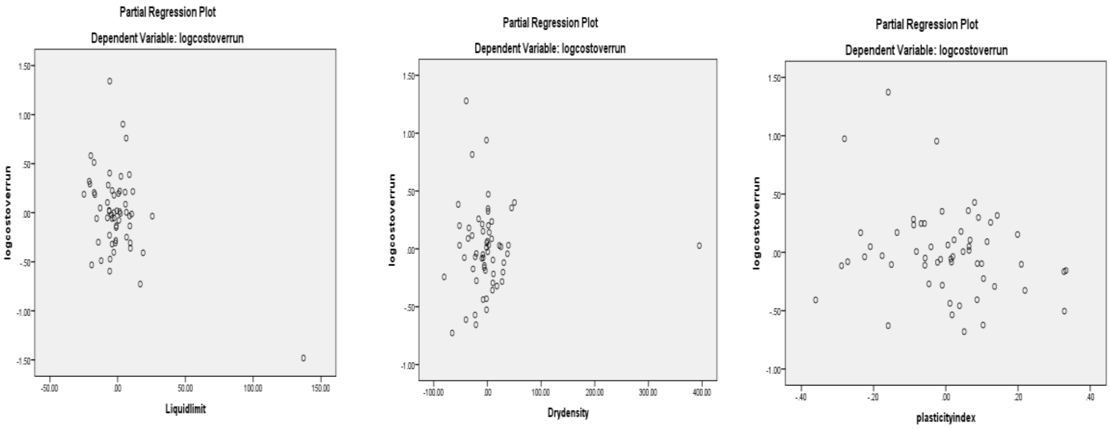


Figure 10.15: Partial Regression Plots of Cost overrun Vs geotechnical indices

For the three geotechnical indices of subgrade soils in the Niger Delta, the values of the partial regression plots show that the Plasticity index displays a more discernible correlation. The coefficient for Liquid Limit (LL) and Plasticity Index (PI), increased, however for Maximum Dry Density (MDD), the correlation coefficient has reduced.

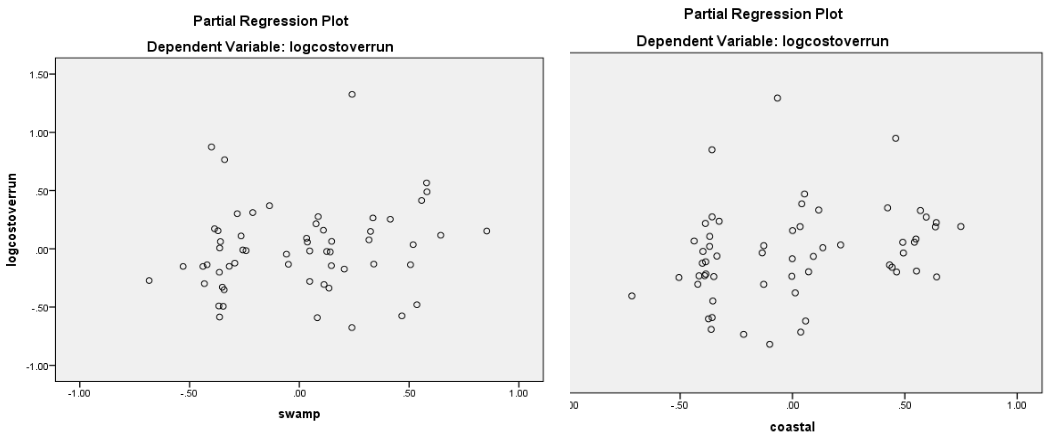


Figure 10.16: Partial Regression Plots of Cost Overrun Vs Geo-Zone

Figure 10.16 shows the partial regression plots for the geo-zones. For these geo-spatial regression variables, the correlation coefficient the swamps variable is reduced while the coastal variable increases.

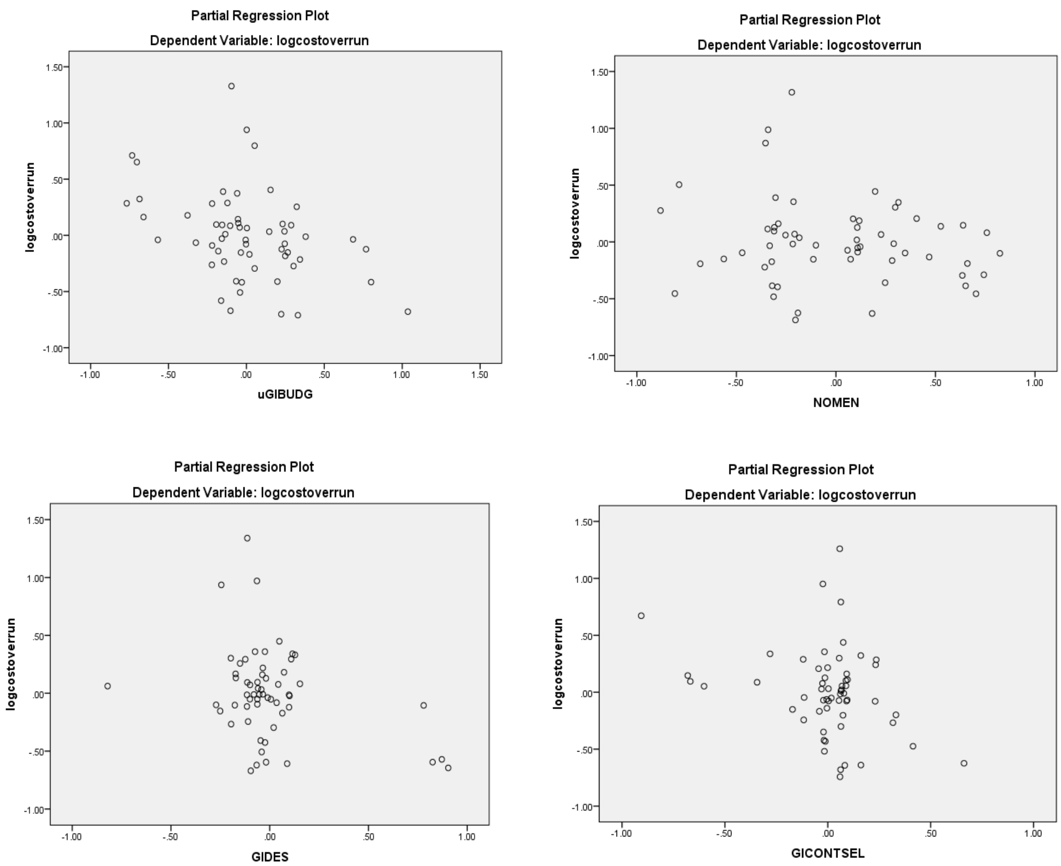


Figure 10.17: Partial Regression Plots for Levels of GI in Project Phases

Figure 10.17 shows the partial regression plots for the Levels of GI in Project Phases. For these practiced based variables, the correlation coefficient although initially having the highest zero-order coefficients are reduced.

From the ranking of the individual contributions of the geotechnical variables in Table 10.27, it was inferred that that Plasticity Limit, which is a geotechnical index of expansivity of subgrade soils in response to increasing water content, abound in the Niger Delta, accounts for the highest partial correlation with the levels of cost overrun experienced on the highway projects. This is followed by the level of GI in budgeting and the level of GI in designs. The wetland ground conditions at the project locations can thus be said to the primary cost overrun driver accounting for the unusually high level of cost overruns experienced in highway projects executed in the Niger Delta. However, the practice based variables, rank next in terms of their partial correlations with cost overruns.

The regression modelling of the core geotechnical variables, has being able to explain 79% of the variance in cost overruns recorded in the highway projects. 21% of this variation thus still remained unexplained by the regression model. The findings of the analysis in chapter 9, had however revealed a multitude of contextual barriers to geotechnical input, which were inferred as accounting for the unexplained variation in the level of cost overrun. As such, other than the core group of geotechnical cost drivers which defined the initial focus of the study, other emergent groups of explanatory social constructs were discerned: *Organisational, human and skills related,* as well as *Political and socio-cultural Influences*, which directly and indirectly impact on the geotechnical explanations, statistically provided. These other purely qualitative explanations are further analysed using content analysis, and are cognitively mapped by the researcher, to portray the complexity of technical and non-technical variables impacting on cost overruns in the specific context of the Niger Delta.

10.3 Content Analysis and Cognitive Mapping of Emergent Cost Overrun Drivers

To cognitively map out the prevailing scenario of cost overrun drivers as deduced from the interview analysis, the researcher matched the barriers to geotechnical input evident in the highway agencies, to the corresponding phases of projects where their impact is evident. This is shown in Table 10.28.

Table 10.28: Barriers to Geotechnical Input as Complementary Cost Overrun Drivers

Phases	Geotechnical Drivers	Barriers
Nomenclature of pre-contract phases	Phase Configuration Pre-contract preparation	Flow of GI Clarity of professional roles De-motivation of professionals
Preliminary Phase	Lack of GI in conceptual costing Lack of GI in Planning Phase	Risk perception Lack of geotechnical presence Political pressure Community pressure
Design Phase	Design preparation Process Mode of assessing heterogeneous ground conditions Non-Adherence to TRRL GI Ext Consultant GI DB contractors' GI	Unethical professional practices of Consultants Lack of Geotechnical Presence Risk perception Knowledge gaps in design Political pressure Unethical professional practices of contractors
Contractual Phase	Contract documentation Contractor selection	Contractual Porosity Adversarial contractual stance Knowledge gaps in procurement Hushed and Unrealistic Bidding Timelines Subjective Procurement Political pressure Community pressure Risk perception
Post contract Phase	Delays and abandonment due to DSC	Unethical professional practices of contractors Unethical in-house verification Major Vs Community Projects dichotomy Upland Vs Riverine Dichotomy Multiple Contract Re-Award

The implication of this is that the emergent themes induced from the analysis in chapter 9, plays out to ultimately distort the log-linearity of the regression analysis of the core geotechnical themes, which had been used to explain the build-up of cost overruns in the project phases. However, as these emergent themes are not susceptible to statistical manipulation, they are further analysed based on the frequency of text referenced to such nodes during the inductive coding of the interview responses, are graphically represented in Figure 10.18.

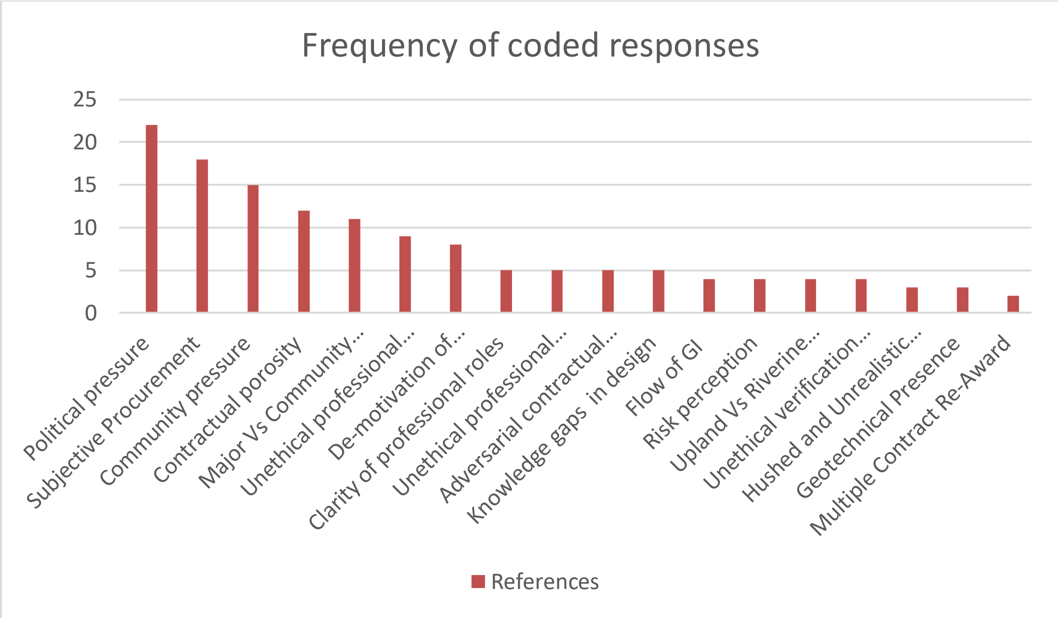


Figure 10.18: Bar Chart of Nodes Compared by Frequency of Coded References

The ranking of the barriers to geotechnical input are shown in Table 10.29, and used as a basis for assigning weights corresponding to the node sizes during further cognitive mapping.

Table 10.29: Content Analysis of Emergent Themes

Barrier	Sources	References	Weighting
Political pressure	10	22	11
Subjective Procurement	8	18	10
Community pressure	10	15	9
Contractual porosity	8	12	8
Major Vs Community Projects Dichotomy	10	11	7
Unethical professional practices of contractors	8	9	6
De-motivation of professionals	7	8	5
Clarity of professional roles	10	5	4
Unethical professional practices of consultants	4	5	4
Adversarial contractual stance	5	5	4
Knowledge gaps in design	4	5	4
Flow of GI	8	4	3
Risk perception	10	4	3
Upland Vs Riverine Dichotomy	3	4	3
Unethical verification practices	6	4	3
Hushed and Unrealistic Bidding Timelines	3	3	2
Geotechnical Presence	3	3	2
Multiple Contract Re-Award	2	2	1

The ranked profile of the emergent themes, can be visually assessed, as depicted in Figure 10.19, based on the content analysis of the frequency of coded responses to each node. Table

10.30 is a colour coded list of the emergent themes, as barriers to geotechnical input, which serves as a key to the cognitive mapping, presented in Figure 10.19.

Table 10.30: Colour Coded List of Emergent Themes as Barriers to Geotechnical Input.

Organisational Catalyst	Flow of GI Clarity of professional roles (CPR) Geotechnical Presence (GP) Contractual Porosity (CP)	Poor organisational structure; Mis-matched qualifications and job description Lack of qualified technical manpower Porosity of contractual system Non-progressive GI non-construction related professionals No Role Specific Professional delineation; Absence of in-house Geotechnical Personnel
Pressure Emitters	Community Pressure (CMP) Political Pressure (PLP) Contractor Pressure (CNP)	Community Considerations Youth restiveness pressure Emergency procurement Contractors influence Political interference Unqualified contractors Lack of due process in contracts Unverified contractor's claims Fear by professionals Unplanned budgeting Heightened security risk to contractors
Psychological Traps	Adversarial Contractual Stance (ADC) De-motivation of Professionals (DMP) Risk Perception (RP)	Counter geotechnical relations; Oppressive Political influence Poor risk perception Unjustified expenditure for detailed GI;
Skills Gaps	Knowledge Gaps in Design(KGD) Knowledge Gaps in Procurement(KGP)	Lack of clear understanding of geo-risk Ignorance of geotechnical best practices Lack of awareness of current design practices Non-discernible skills
Dichotomies	Major Vs Community Projects (MjCm) Upland Vs Riverine(UpRv)	Preferential management of geotechnical risk in relation to project size and location; Planned vs Adhoc procurement practices for major vs community projects; Politically motivated selective project management practices; Lower priority status in post contract management of riverine projects
Unethical Facilitators	Unethical professional practices of consultants (UPCL) Unethical professional practices of contractors (UPCR) Unethical verification Practices (UVP)	Deliberate under-design of projects Replication of past GI reports Replication of similar designs Non-GI in DB designs Contractors Influence of design preparation Contractors Influence of contract award Stifled verification of post-contract GI In-house professionals serving in dual capacity as client and contractors representative
	Hushed and Unrealistic Bidding Timelines (HBT) Subjective Procurement (SP) Multiple Contract Re-Award (MCR)	Non-adherence to due contractual processes Non-publicising of call for bid Compressed timeline for tender submission informal hierarchical chain of contract subletting Multiple contract re-award

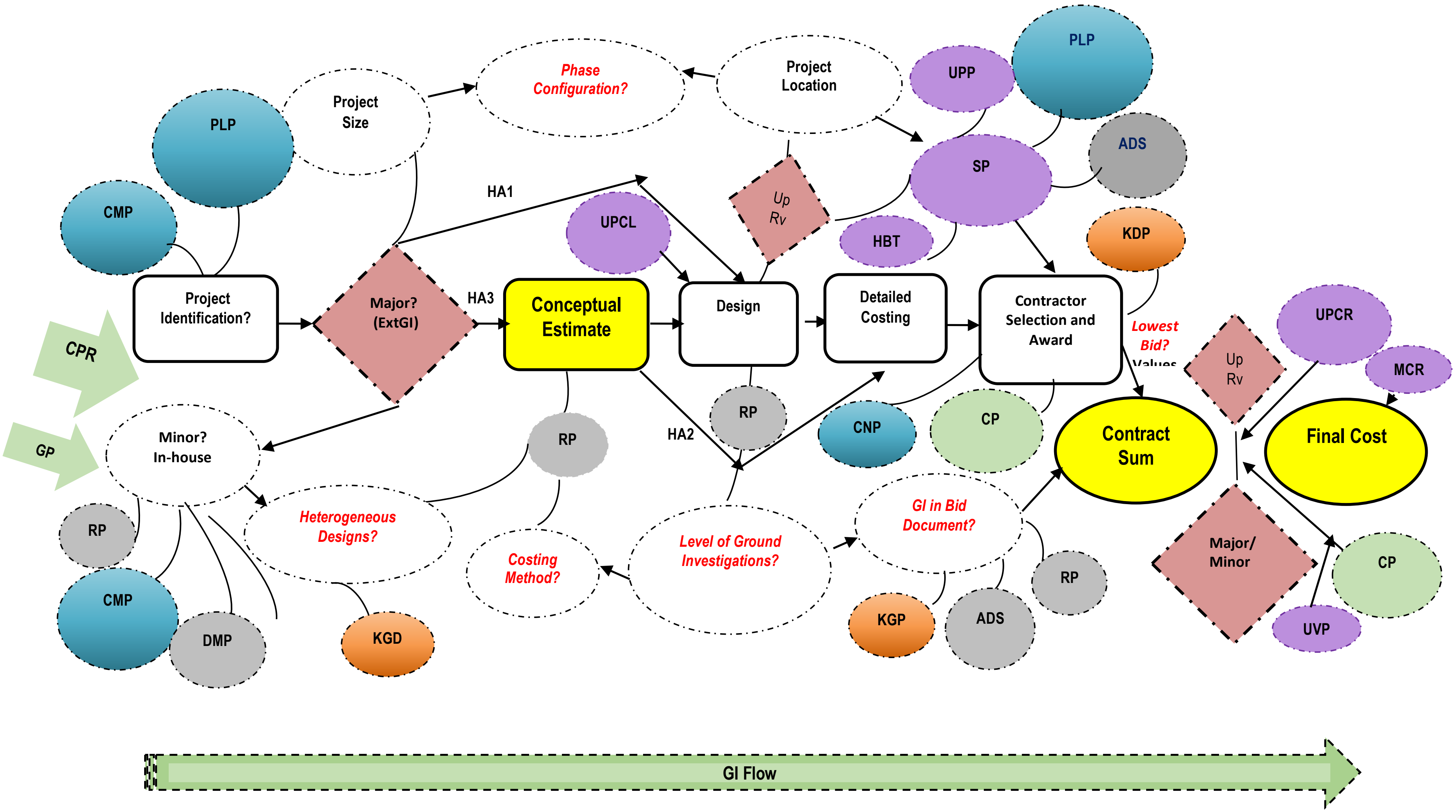


Figure10.19: Cognitive Map of Geotechnical and Emergent Themes as Cost Drivers

The core geotechnical themes thus interplay within bulbs of *organisational catalyst*', '*Pressure Emitters'*, '*Psychological Traps'*, '*Skills Gap*s', '*Dichotomies'* and '*Unethical Facilitators'* of various scales (as ranked), entrenched within the wider macro social value system and geo-political climate of highway development in the region. The intricate complexity of this interplay has been conceptualised by the researcher, the results of this process which is presented in Figure 10.19, as a cognitive map. The developed cognitive map is thus an intricately interwoven representation of near linear causality, between the core geotechnical themes, and the resultant cost overrun, with the emergent organisational and human related themes arrayed as influences, whose node sizes were proportionally assigned. The cognitive map thus portrays the visual ties of the dependent phase connectivity between the technical, social, organisational and institutional issues, driving the high level of cost overruns experienced on highway project development in the Niger Delta.

10.4 Chapter Summary: Explaining Cost Overruns in Highway Projects in the Niger Delta

The findings from the analysis has significantly expanded and created the more holistic picture missing in the disjointed findings of previous empirical studies on cost overruns. This is against the backdrop of the dialectical debate in the literature, between theoretical and technical schools of taught, which deploy single methods of data analysis typically correlations and cost overrun trend analysis; project specific case studies based on content analysis of documents; questionnaire survey of construction professionals; or using data mining and modelling techniques to argue on the fundamental cost drivers in highway projects. This research has deployed a multiplicity of quantitative and qualitative analytical tools: Geotechnical analysis; Analysis of Variance; Correlation/Regression Analysis; Thematic Analysis; Content Analysis and Cognitive Mapping too carry out the most methodologically robust and contextual study of the primary triggers to cost overruns in highway projects. Table 10.31 is a summary of the outcome of the explained variations for several statistically significant regression models run with different combinations of non-collinear predictor variables, during the model optimisation process of the regression analysis.

Table 10.31: Regression Model Optimisation showing Explained Variations

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Predictors
1	.434a	.188	.143	.73831	(Constant), freeswell, Liquidlimit, Drydensity
2	.442a	.196	.151	.73497	(Constant), plasticityindex, Liquidlimit, Drydensity
3	.432a	.187	.142	.73907	(Constant), OMC, Liquidlimit, freeswell
4	.442a	.195	.150	.73532	(Constant), plasticityindex, OMC, Liquidlimit
5	.471a	.222	.147	.73685	Constant), coastal, plasticityindex, Drydensity, Liquidlimit, swamp
6	.890a	.792	.754	.39596	(Constant), GICONTSEL, plasticityindex, coastal, Liquidlimit, Drydensity, NOMEN, swamp, GIBUDG, GIDES

The initial combination of geotechnical indices, which explained a maximum of 19.6% of the variation in cost overruns, was used as a basis for optimising the model with the stepwise introduction of other explanatory variables

The introduction of a 3-level categorical dummy variable to account for the geo-zones, optimised the explanatory power of the regression model, after a log-linear transformation of cost overruns, to 22%.

The introduction of dummy variables to account for current geotechnical practices in the highway agencies significantly optimised the regression model, as the explanatory power of the model increased from 22% to 79%. The Log-Linear regression model of cost overrun drivers predicated on ground conditions and the current geotechnical practices of highway agencies in the Niger Delta was thus:

- **Logcostoverrun = 6.501 - 0.010LL - 0.545PI + 0.363 swamp + 0.260 coastal - 0.435GIB - 0.139NOM - 0.471GIDS – 0.452GICS + e** **….** Equation 10.11

The regression analysis of geotechnically induced cost overrun drivers, has shown that the geologic setting coupled with lack of geotechnical best practices account for 79% of the variance in cost overruns in highway projects executed in the Niger Delta. The predictive transposition of the regression equation is thus:

- **Costoverrun = 10** $^{\mathbf{6.501 - 0.010LL - 0.545PI + 0.363 swamp + 0.260 coastal - 0.435GIB - 0.139NOM - 0.471GIDS - 0.452GICS + e}}$ **….** Equation 10.12

This represents an exponential model, whereby small changes in the cost overrun drivers would result in disproportionate changes in the levels of cost overruns recorded on highway projects. Equations 10.13, 10.14 and 10.15 represent the predictive models that estimate the cost overruns for highway projects executed in the different geo-zones of the Niger Delta, and in view of the current practices of the highway agencies:

- $10^{6.501 - 0.010LL - 0.545PI + 0.363 - 0.435GIB - 0.139NOM - 0.471GIDS - 0.452GICS}$ **(Swamps)…**Equation 10.13
- $10^{6.501 - 0.010LL - 0.545PI + 0.260 - 0.435GIB - 0.139NOM - 0.471GIDS - 0.452GICS}$ **(Coastal) ...** Equation 10.14
- $10^{6.501 - 0.010LL - 0.545PI - 0.435GIB - 0.139NOM - 0.471GIDS - 0.452GICS + e}$ **(Upland)** ... Equation 10. 15

This implies that positive or negative changes made to ground conditions or in the geotechnical practices of the highway agencies will produce an expected exponential increase or decrease in the level of cost overruns recorded in highway projects. However, since the inherent deltaic ground conditions at project sites cannot be changed, but only managed, the only interface based on which cost overruns can be exponentially minimised in highway projects lies in making positive changes in the geotechnical practices of highway agencies, principally in budget estimation and design practices (2nd and 3rd).

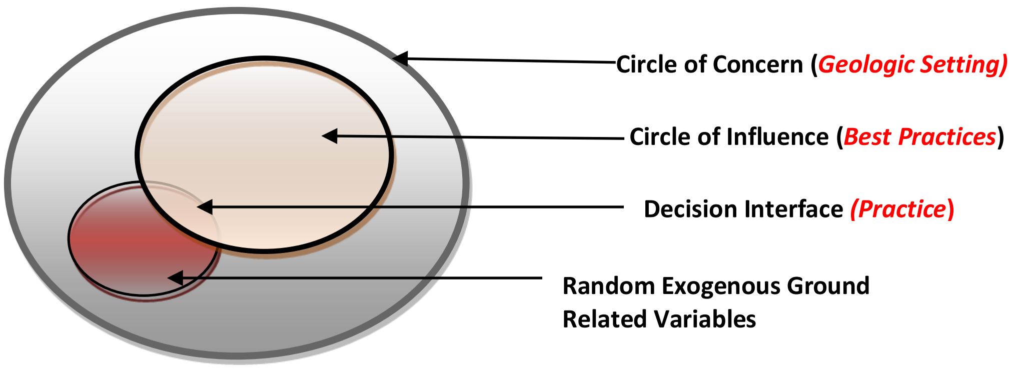


Figure 10.20: Conceptual Approach to Managing Ground Conditions after ICE (2001)

The regression analysis thus validates the assertions of the ICE (2001: 12), as shown in Figure 10.20: *that geotechnical risks associated with ground conditions can only be controlled within the limited decision interface via adequate geotechnical risk containment"*. As such it can be inferred that improved budget estimates and appropriate designs that reflect the geologic heterogeneity of the Niger delta terrain, will counteract the cost overrun propensity of projects, due to effect of poor ground conditions at project sites.

However, it is also recognised, as cognitively mapped out, that there exist a multitude of contextual barriers to the adequacy of geotechnical input in highway projects, which in turn constitute cost overrun drivers:

- ***Psychological Traps*** as used in the cognitive map, refer to those subconscious attitudes of client's and contractors, largely defined by their level of enlightenment on the financial implications of geotechnical risks containment as well as social conditioning, which may effectively serve as mental traps, and impede the realisation of the evident 'Value for Money' benefits of geotechnical input in highway projects. Typically, as noted from the responses, these include: *level of 'Risk Perception (RP); relating to the* lack of knowledge and understanding of geo-risk management in estimates and awareness of their benefits *(IA); Adversarial Stance (AS) and demotivation.*

- ***Pressure Emitters*** refer to those external elements/stakeholders in the institutional set up of highway agencies, which radiate compressive pressure on professional obligations, thereby constricting the potentials for ensuring technical requirements of geotechnical best practice. Typically, in the context of the Niger Delta, these include *Political Pressures (PLP), Community Pressures (CMP),* and all other forms of unethical pressures, such as from contractors (CNP).

- ***Organisational Catalysts*** are the adverse non-project specific 'Organisations' and 'people' related variables in the highway agencies which represent the deficient institutional arrangements within the highway agencies labelled as '*Organisational Structure*' (OS), *Pre-contract Phase Configuration* (PPC) and *Geotechnical Presence* (GP), *Mismatched Qualifications and Roles* (MQR), which can serve to speedily diminish or impede the progressive flow of geotechnical input in projects.

- ***Skills Gap*** refer to the individual specific knowledge deficiencies of professionals working on highway projects, such as low level of technical competence in design, and low level of enlightenment about issues related to the financial risk management of geotechnical issues in highway projects, which can be overcome by adequate training and enlightenment.

- ***Dichotomies*** are those inequalities and preferential practices of highway agencies, which result in uneven management of geotechnical risks in projects, such as the Major/Minor Dichotomy (MMD) in pre-contract preparation and the upland/riverine Dichotomy (URD) in post contract management of projects

- ***Unethical Facilitators*** represent those subtle unprofessional and unethical practices of the key actors in highway projects, primarily geared at personal gains, such as those by contractors, consultants and highway officials, as well as other forms of organisational and institutional irregularities in the procurement of highway projects.

It can thus be inferred that cost overruns experienced in highway projects executed in the Niger Delta, can be accounted for by a multiplicity of contextual variables, which have not been identified and explained in previous empirical studies on cost overruns in highway projects. It is also evident from the comprehensive analysis, that geotechnical explanations account for the majority of the variance in cost overruns recorded on highway projects executed in the Niger Delta. Thus the untested assertions of Flyvbjerg *et al.* (2002): that geology and geotechnical risks does not matter in explaining cost overruns, does not hold in the case of highway projects executed in the Niger Delta. It is thus the major corroboration of this study that, in the geologic setting of the Niger Delta, cost overruns recorded on highway projects are principally triggered by geotechnical factors, amidst a wide array of other contextual socio-politico-cultural factors, and not the outcome of strategic misrepresentation.

Chapter 11

Discussion, Conclusion and Recommendations

11.0 Introduction

This chapter summarizes the research process, and reviews the extent to which the aim of the study and its objectives have been achieved. It also discusses the wider implications of the study, in generalizing theory on the explanation for the phenomenon of cost overruns in public projects, and its more specific implication for highway development in the Niger Delta region. Recommendations for aligning highway delivery in the Niger Delta region, with geotechnical best practice are also made, based on relevant referrals to the literature. The chapter further outlines the originality of the study and its contribution to knowledge in the spheres of academe, practice and policy. The chapter is concluded by the researcher's reflection on the learning curve undergone in embarking on this research, and how this has shifted the researcher's positionality. Recommendations for further studies implicit in the findings from this research are also forwarded.

11.1 Review of the Research Process in Achieving the Study's Objectives

The research set off with the rationale of understanding the cause of the unusually high cost overruns experienced in highway projects, which as the local literature evidences, accounts for the state of highway development in the tropical wetland setting of the Niger Delta. A review of the scholarly literature on explanations to cost overruns, revealed a strong dialectical debate between the theoretical and technical schools of thought, as to what propagates relatively higher cost overruns in public infrastructure projects. The theorists are of the opinion that psychological issues, optimism bias and deliberate misrepresentation by project planners, largely accounted for cost overruns in transportation infrastructure projects. Principally, Flyvbjerg *et al.* (2002) challenged the validity of geology and geotechnical risk, tendered by the technical school in accounting for cost overruns in highway projects. Yet the literature continues to report, inadequate use of geotechnical risk containment in highway projects, resulting in considerable post-contract cost overruns. As a result of this controversy within the existing literature, and the lack of a robust empirical analysis to this effect, this research was carried out to explore the statistical validity of geotechnical risk factors in explaining cost overruns in highway projects, contextualised in the geologic setting of the Niger Delta region of Nigeria. The Niger Delta, was thus used as a case study site to test the validity of geotechnical risk factors in explaining cost overruns, due to its peculiar wetland geology.

Against this backdrop, the aim of the study was to explain the propagation of cost overruns in highway projects using a geotechnical narrative predicated on the financial risk implications of the heterogeneous geology of the Niger Delta wetland. To this end, seven objectives were set to achieve this aim, using the research process diagrammatically represented in Figure 11.1

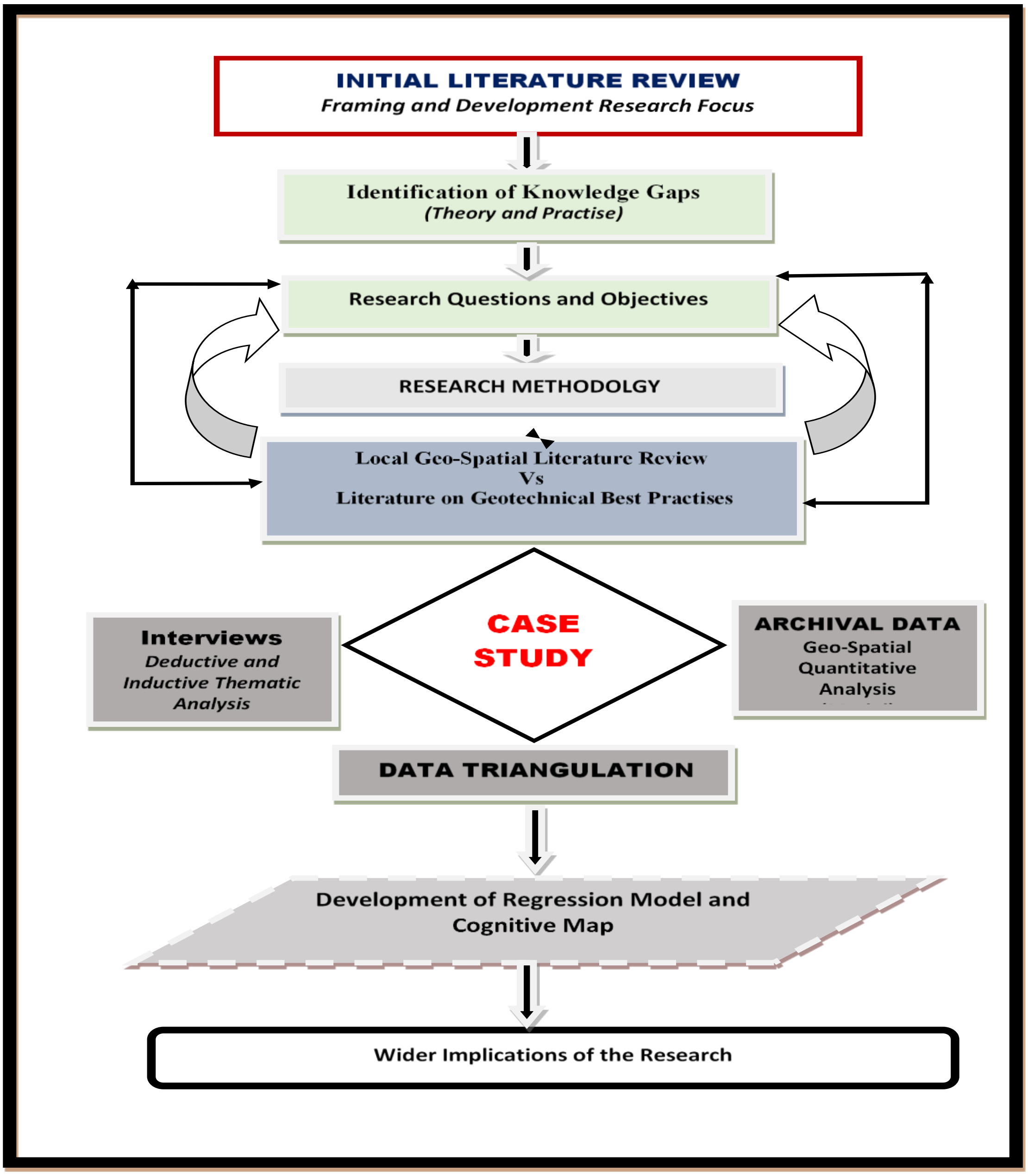


Figure 11.1: Summary of the Research Process

A reflective account of how well the predefined objectives of the study have being achieved using this research process is thus revisited:

11.1.1 Objective one: To synthesize the background literature on investment in highway development in Nigeria and the prevalence of delays and abandonment in project delivery, with emphasis on the Niger Delta region due to its peculiar geologic setting.

The study was commenced by synthesizing the geo-institutional background of investment in highway development in the Niger Delta, as the first objective of the study. Objective one was relevant to set the scene, and highlight the current trend of incessant project delays and abandonment, which created an impetus for the research. Objective one of the study has been achieved in chapter two of the thesis, which provided a detailed description of the regional and socio-economic background of the Niger Delta region, within the wider context of highway development in Nigeria as a developing country. The historical antecedent to the current institutional structure of highway administration in the Nigeria was thus chronologically and analytically traced, to serve as a backdrop to the existing framework for transportation infrastructure in the Niger Delta. This showed the significant level of investment channelled to infrastructural development through several foiled bodies, which were specifically set up in recognition of the physical environmental constraints of the Niger Delta. The historical background, also revealed the prevalence of project delays and abandonment, as an ongoing legacy from the past to the present. This thus served as a retrospective context to understanding the cycle of short funding, delays and incessant abandonment of highway projects, currently reported in the Niger Delta region.

Empirical literature sourced from both the wider context of developing countries, and more specific to the Niger Delta region, were further critically analysed to understand the significant causes of project delays and abandonment. The few studies specific to the Niger Delta region, repeatedly highlighted themes which revolved around funding shortfalls and technicalities associated the terrain. The findings led the researcher to hypothesize that the peculiar geologic setting coupled with the other underlying technical issues in practice, may be fundamental to the prevailing menace of delays and abandonment, leading to excessive cost overruns in the Niger Delta region. This set the background of the study, and created the impetus for probing further into what technical issues in the organisations responsible for procuring highway projects, have remained unresolved, from the past to present institutional arrangements.

11.1.2 Objective Two: To critically evaluate the theoretical and methodological lenses that have been used in previous studies, to explain the propagation of cost overruns in highway projects, as a platform for highlighting significant gaps which have implications for this study.

To achieve objective two, chapter three of the study analysed the various strands of the scholarly literature analysing cost overruns in highway projects, all of which were unanimous in stating that public infrastructure projects face significantly higher levels of cost overrun than those experienced by other construction industry sectors. The literature search revealed an expansive range of research identifying theoretical and technical explanations for this negative trend. A strongly contested debate, between the theoretical and technical schools of thought, was shown to dominate most of the discussion on cost overruns in highway projects. The theorists suggest that optimism bias and deliberate deception by clients and their professional advisors, due to corruption or politically induced malpractice, is the cause of the consistent cost overruns reported on public infrastructure projects. Whereas, proponents of the technical school suggest that cost overruns, most likely result from technical shortcomings in practice, referred to as '*Latent Pathogens'*, which often lying dormant in the complex interactive processes of infrastructure projects, are unintentionally triggered, leading to a series of events culminating in cost overruns. This latter argument, was supported in this study, based on the geotechnical risk perspective adopted to explaining cost overruns in the Niger Delta. A chief rival explanation to this stance, was however advanced by Flyvbjerg *et al.* (2002), a seminal author and leading theorist, specifically disputing the validity of geology and geologic risks in explaining transportation infrastructure cost overruns.

Further to this, chapter three took a comprehensive and critical outlook at the various approaches that have been used to explain the phenomena of cost overruns in public projects, with a view to establish the methodical lenses through which these wide proliferation of studies vying for explanatory supremacy, have been conducted. The outcome of the critical analysis revealed that several gaps in the literature exist in terms of: the lack of robust statistical evidence to support the assertions that geotechnical risks impact on cost overrun levels; the lack of contextual specificity in most studies, the predominance of mono-method studies, with a paucity of methodologically rigorous explanatory approaches; and the exclusivity and cluster in the geographical spread of in-depth qualitative narratives, to the developed world, which is mostly not reflective of developing nations such as those on the African continent.

Objective two of this study was thus achieved by identifying the knowledge gaps, which formed the basis on which this research was structured, as a distinctive and significant departure from previous studies on cost overruns. In the light of the literature findings, the study was conceptualised to significantly differ from previous cost overrun studies, by providing and analysing project data to argue the impact of geologic risk factors in the context of Nigeria, a developing country which relies mostly on technical assistance from developed countries, and particularly with respect to the peculiar wetland conditions of the Niger Delta region.Two complementary theories were further deduced from the literature as having significance in this study: Love *et al.* 's (2012) latent pathogen theory alongside Morris (1990) 'Vicious cycle of delays and short-funding' theory. These theories were adopted as the theoretical framework to strengthen the study argument, against the counter theory of strategic misrepresentation argued by Flyvbjerg *et al*. (2002). This was considering the limitations in Nigeria's engineering practice, and the historical trend of short funding, delays and abandonment by past and present institutional bodies in the Niger Delta, highlighted in the local literature.

To overcome the methodological limitations of previous studies in the literature, the study used a robust multi-method analysis to convergently provide in-depth geotechnical and geologic explanations to the prevailing trend of high cost overruns, using: Thematic analysis of 16 interviews; Documentary/Archival Analysis; and Spatial analysis of geotechnical data sets on sub-soils approximated at project locations. The multiple strands of the analysis were further triangulated, using regression modelling technique, to account for the variance in cost overruns experienced in 61 highway projects, executed by the three highway agencies operating in the Niger Delta. This was complemented by a quantitatively weighted cognitive map. Furthermore, the explanation proffered in this study, unlike previous studies, used a geotechnical narrative contextualised in the real life organisational setting of the highway agencies, supplemented by the views of contractors and consultants, external to but registered with the highway agencies.

11.1.3 Objective Three: To critically evaluate and select an adequate philosophical/methodological orientation relevant to provide rich insights into the phenomena of unusually high cost overruns experienced in highway projects delivery in the Niger Delta.

Chapter four of this thesis, critically evaluated and selected a philosophical/methodological orientation relevant to provide rich insights into the phenomena of unusually high cost overruns experienced in highway projects, executed in the Niger Delta. Based on an evaluation of the different philosophical orientations, the critical realist philosophical position, was rationalised and argued as most suited to achieve the research objectives. The critical realist philosophical underpinnings of the study, therefore informed the specification of the research methods that were deployed in the investigation of the phenomena of highway project cost overruns in the Niger Delta. Having adopted this philosophical orientation, a mixed method approach was considered the most practical methodological alternative, needed to achieve the research objectives. This was because it straddled the qualitative and quantitative frontiers, considered necessary to provide robust explanations beyond those evident in previous studies. Issues of reliability and validity were thus resolved along these lines, by incorporating relevant criteria from both the qualitative and qualitative strands.

Several potential research strategies were evaluated, and the case study approach, was selected to provide an in-depth contextual explanation to the unusually high cost overruns in the Niger Delta, due to its wholesomeness for investigating the study phenomena and its compatibility with the critical realist stance adopted. The appropriateness of using of the case study approach, was further enhanced due its capacity to simultaneously incorporate multiple methods. The applicability of the dialectical debate in the literature, to explaining the unusually high levels of cost overruns, experienced in Niger Delta's highway projects, was tested. As such this further constituted the study's core and counter propositions, in adopting a case study approach. The case study approach, was thus used to test the pathogenic effect of geotechnical risks in pre-contract preparation, and how these accounted for increased cost overruns, using a technical narrative predicated on the heterogeneous geologic setting of the Niger Delta region.

Objective three was thus achieved in chapter four, which outlined the research methodology of this study, where a coherent flow of well-articulated philosophical arguments was used to position the study, and choose a methodological route which served as an overall research design framework, that guided the practical deployment of the case study. The research design thus conceptualised, guided all aspects of this study, specifically targeted at understanding the contextual technical issues propagating cost growth and how these have resulted in the cost overruns reported in highway projects.

11.1.4 Objective Four: To analyse the heterogeneous configuration of the Niger Delta terrain, and the peculiar practicalities necessary for highway construction, as a case study justification of its inherent geologic distinctiveness for triggering cost overruns.

The achievement of objective one (background literature) was the basis that led to the researcher to speculate that the geology of the Niger Delta, and related geotechnical issues accounting for the excessive cost overruns, leading to the series of delays and project abandonment in the Niger Delta. However, the findings from objective two (targeted at understanding how previous studies have explained the phenomenon of cost overruns in public projects) revealed an unresolved debate between the technical and theoretical schools on the role of geology and geotechnical risk in accounting for cost overruns. This unresolved argument led the researcher, to propose a set of hypothesis, using the Niger Delta as a case study, due to its embodiment of geologic difficulties implicit in a wetland terrain. Chapter five of the thesis was thus structured to achieve objective four, by exploring the geologic peculiarities of the Niger Delta region, as test bed to show the potential of geology to trigger cost overruns.

An exploratory geo-statistical analysis was thus undertaken in Chapter five, to provide an empirical view of how the geologic variability of the terrain of the Niger Delta, implicit in the disparity of ground conditions across three physiographically synthesised geologic zones, fosters the potential for highway projects to run over budgeted cost estimates. Chapter five thus geotechnically described the difficult terrain of the Niger Delta region, in terms of the predominance of subgrade soils with poor engineering index properties, and statistically explored this geotechnical undertone as a potential trigger which creates a propensity for cost overruns. A descriptive geotechnical analysis of the engineering suitability of the subgrade soils approximated for project locations was carried out, based on available local literature, supplemented by the researcher's geotechnical field work data. Exploratory statistical tests of significant difference (ANOVA), and correlation analysis were further used to analyse recorded cost overrun data for 61 completed highway projects, in tandem with the spatially dispersed geotechnical index data.

The geo-statistical analysis established a high degree of association, between the heterogeneous geologic setting of the Niger Delta, and the cost overrun trends evident in the sample of highway projects. Significant differences in the levels of cost overruns experienced in the highway projects was inferred, between the three disparate geo-zones of the Niger Delta, synthesised from the local literature, based on the Analysis of Variance test conducted. The findings from further Turkey-Kramer Multiple comparisons tests, revealed that percentage cost overruns were significantly higher in the wetland areas with inherently worse soil conditions, particularly the swamps. The researcher's positionality at this point in the research, was that that the significant differences in cost overruns, might be primarily triggered by issues relating to ground conditions, which ideally ought to be clearly tackled, but were left unresolved early on in the project at the pre-tender stage, thereby spilling into the contractual and construction phase, leading to a significant disparity in cost overruns between the uplands and the risk laden wetland zones. Also several parameters of expansivity and compressibility of subsoils at spatially dispersed areas, indicative of problematic soils, correlated positively with the cost overruns recorded in the highway projects. The general trend evident in the data, was indicative that the level of cost overruns increased correspondingly with poorness and adverse nature of ground conditions at project locations.

These findings from the geostatistical analysis, achieved objective four, and reinforced the researcher's pre-conceived assertions, that the unusually high level of recorded cost overruns in completed highway projects, was strongly correlated with the peculiar geologic setting of the region. It thus provided an empirical justification of the need for a further in-depth investigation of geotechnically induced cost overrun drivers, in the practices of the three highway agencies that executed the sampled projects, which may have triggered this trend. This conclusion was drawn in tandem with the maxim of geotechnical risk management: '*the worse the ground conditions, the greater the risk'* (ICE, 1991:12). Identifying the geotechnical shortcomings/deviations from the dictates of best practice, was thus considered the next logical step towards achieving the study aim.

11.1.5 Objective Five: To identify the specific mediums of ground related risk containment, from best practice, which emphasize the need for adequate geotechnical input in highway projects as potential triggers to cost overruns.

Chapter six explored best practices in the literature, requisite to accommodate financial risks due to ground conditions, in designs and estimates, a lack of which was latter inferred as accounting for the unusually high cost overruns in the sampled highway projects. The exploratory analysis of the literature revealed various mediums of financial risk containment, via ensuring adequate geotechnical input in: conceptual cost estimation; designs; and contracting, and explicitly illuminated best practices necessary to curtail cost overruns in highway projects. Recommended best practices for clients of highway projects at the pre-contract phases, were by implication deduced as:

- Use of differentiated costing profiles as opposed to uniform historical rates at the conceptual phase;
- Carrying out adequate levels of ground investigations: Desk studies; preliminary reconnaissance; and detailed explorations, as a basis of designs and detailed estimates;
- Inclusion of Ground Investigation Reports (GIR) in contract documentation and provision for Differing Site Condition (DSC) clauses;
- Ensuring an adequate geotechnical criterion in contractor selection.

The researcher thus used the findings from this exploratory literature analysis of geotechnical best practices, as a logical theoretical perspective to understanding the propagation of cost overruns, recorded in the sample of 61 highway projects, previously analysed in chapter five. The significance of poor ground conditions at project locations, and what a lack of geotechnical risk management therof, portends for triggering costoverrun, was used to develop a conceptual model of the pathogenic impact of geotechnical risk in the phases of highway projects. The conceptual model thus highlighted various mediums of geotechnical input, that have implications for the accuracy of initial budgeted funds, detailed design estimates, contractor's tender estimates and final outturn cost of project. Findings from chapter six thus achieved objective five. These findings set the structure of the subsequent interview analysis, which sought to investigate the level of adherence to geotechnical best practices by the highway agencies, necessary to validate the earlier outlined suspected gaps in knowledge.

11.1.6 Objective Six: To examine the level of adherence/deviations in the design/costing practices of highway agencies in the Niger Delta, in line with the precepts of the identified geotechnical best practices, as a basis of ascertaining the suspected gaps in knowledge presupposed as the underlying cost overrun drivers.

Further to the identification of geotechnical best practices, the scale of the problem of inadequate geotechnical risk management, suspected as prevailing in the organisational dynamics of the three highway agencies which executed the sampled projects, was further established in the interview analysis. The identified mediums of geotechnical input were conceptualised to serve as a guide in designing a template for the Interview analysis. The field work was thus structured to specifically investigate: how well configured the phases of highway development were; the technical details of how funds budgeted for proposed highway projects are estimated; what levels of ground investigations are carried out as a basis for designs; and the modalities of contractor selection/contract documentation.

Chapter 7 served as a prelude to the interview analysis, setting out the background information on the highway organisations in the Niger Delta, and providing a detailed breakdown of the analysis procedure. The presentation of the findings in the interview analysis followed the hierarchical structures of the geotechnical themes set out in the conceptualised model of cost drivers. The interviews elicited information on the budgetary, design, and procurement practices of the highway agencies, and to what extent geotechnical input was ensured in highway projects at the different phases. The analysed interview data was generated, based on the responses of the various groups of respondents, within and affiliated to the respective highway organisations: Civil engineers; Quantity Surveyors; Consultants; and Contractors. Also related issues on the post contract impact of geotechnical risks on highway projects were elicited from the responses, and supported by available documentary evidence.

Chapter eight thus investigated the practices of the highway agencies and the various practical geotechnical issues evident, in relation to the predetermined themes, thus providing a descriptive snapshot of the design and costing practices of the highway agencies in the Niger Delta. The interview data was thematically analysed for the prevailing level of geotechnical input, in relation to their post-contract implications in the projects executed by each of the three agencies. The evaluation revealed the poor levels of pre-contract geotechnical evaluation, and the consequent post-contract impacts on highway project delivery. From the analysis, an array of factors predicated on the need for geotechnical input were identified as contributing to the unusually high levels of cost overruns experienced by the highway agencies in the Niger Delta. This served to achieve objective six, and confirmed the suspected gaps in knowledge, which were pre-supposed as existing in the practices of the highway agencies.

However, a further reflexive inductive analysis of the interview data was carried out in chapter nine, in response to unanticipated themes, and revealed the role of the organisational settings, people, and external factors in determining the level geotechnical input. The findings from the inductive analysis of the interviews, thus created an awareness of the socio-cultural settings as factors in the management of geotechnical risk. These induced themes were thus identified as the barriers to adequate geotechnical input, which equally represented the range of contextual issues evident in the practices of highway agencies, driving cost overruns in the region. The induced themes further reinforced the local literature evidence, which alludes to the poor procurement practices of highway agencies in Nigeria, as one of the fundamental causes of project delays and abandonment.

11.1.7 Objective 7: To develop a statistically valid model and cognitive map of geotechnical best practice based drivers to cost overruns, predicted on the heterogeneous geologic configuration of the Niger Delta region, as basis of accounting for the level of variance induced by geotechnical triggers.

Based on the findings of all previous findings, it was inferred that a counter factual chain of latent geotechnical pathogens, entrenched in a complex web of contextual dynamics, with all existing in a state of mutual interactivity, accounted for the unusually high level of cost overruns recorded on the sample of highway projects. As it could not be easily isolated, which of the identified issues accounted for the highest variance in the cost overruns experienced, an attempt to weight them was made via quantitative analysis. To explain and thus account for the recorded level of cost overrun, the researcher triangulated all the findings from the various strands of the case study. This was achieved quantitatively and qualitatively via regression analysis and content analysis respectively. Chapter ten of this thesis thus achieved objective 7, by using regression modelling to explain and account for the variance in cost overruns of the sampled highway projects, induced by the geotechnical themes, with content analysis used to rank the emergent contextual themes.

Regression modelling was used to statistically analyse how much variation in the recorded project cost overruns, was directly triggered due to the variation in the core geotechnical factors. Multiple regression analysis, was thus used to deduce the proportion of variance in cost overruns, that was explained by latent geologic factors, and the proportion that was explained by shortcomings in the geotechnical practices of the highway agencies. A log transformed regression model was developed, representing an exponential expression of the relationship among the variables, whereby small changes in the cost overrun drivers would result in disproportionately large changes in the levels of cost overruns recorded on highway projects. It was inferred that improved budget estimates and appropriate designs that reflect the geologic heterogeneity of the Niger Delta terrain, will counteract the cost overrun propensity of projects, due to effect of poor ground conditions at project sites

The regression modelling of the core geotechnical variables, however explained only 79% of the variance in cost overruns recorded in the highway projects, with 21% of the variation in cost overrun remaining unexplained. The findings of the inductive analysis in chapter 9, had however revealed a multitude of contextual barriers to geotechnical input, which were inferred as accounting for the unexplained variation in the level of cost overrun. As such, other than the core group of geotechnical cost drivers which defined the initial focus of the study, other emergent groups of explanatory themes were discernible: organisational, human and skills related, as well as political and socio-cultural Influence, which directly and indirectly impact on the geotechnical explanations.

Cognitively mapping was further used to visually conceptualise the multiplicity of variables and context, which are directly relevant to explaining why cost overruns experienced by the highway organisations in the Niger Delta are so unusually high. The cognitive mapping thus conceptualised the core geotechnical themes, which interplay within bulbs of organisational catalyst', 'Pressure Emitters', 'Psychological Traps', 'Skills Gaps', 'Dichotomies' and 'Unethical Facilitators', of various scales (as ranked), entrenched within the macro social value system and geo-political climate of highway development in the region. The intricate complexity of this interplay was evident in ties and phase dependent connectivity, between the technical and socially constructs, driving the high level of cost overruns experienced on highway project in the Niger Delta.

11.2 Extent of Achievement of the Study Aim

In achieving objective one to seven, an array of factors predicated on the need for geotechnical input had being identified, as latent pathogens and contextual drivers, contributing to the current state of highway infrastructure delivery in the Niger Delta. The robustness of the findings has thus clarified the mechanism of the build-up of unusually high cost overruns in highway projects, executed in the Niger Delta region of Nigeria. By virtue of the findings, the aim of the study, which is to provide an explanation for the propagation of cost overruns in highway projects, using a geotechnical narrative predicated on the financial risk implications of the heterogeneous geology of the Niger Delta wetland, has been accomplished.

11.3 Main Findings of the Research

The study has highlighted several technical issues in practice, which need to be resolved to align highway project delivery in the Niger Delta, with geotechnical best practices identified from the literature:

- The inconsistency in the phase configuration of highway project development in the Niger Delta, primarily for community projects;
- The lack of adequate geotechnical evaluation for the planning of highway projects;

- The lack of in-house geotechnical presence in some of the highway agencies, throughout the phases of highway development;
- The use of non-differentiated costing platforms in budgetary provision for proposed highway projects at the preliminary phases of highway development;
- The non-adherence of highway designs to the appropriate engineering sections, as recommended by the nationally adopted highway design standard in Nigeria, the TRRL (1993), despite the heterogeneous sub-soil profile of the Niger Delta region;
- The predominant lack of preparation of adequate and comprehensive designs for community highway projects;
- The lack of adequate geotechnical risk containment measures, in contracts awarded by the highway agencies, necessary to lessen the magnitude of geotechnical risk borne by contractors in bidding for highway contracts;
- The primarily subjectively and politically driven mode of contractor selection during the award of highway contracts, which is not based on any form of geotechnical criteria requisite to ensure efficiency of project execution.

All these technical shortcomings, latent in the everyday practices of the highway agencies, revolve around inadequate management of financial risks, due to ground conditions in the Niger Delta. These latent pathogens occur, however, amidst the wide array of socio-cultural issues concomitantly identified. The findings thus highlight the fact, that the high level of cost overrun evidenced in highway project execution in the geologic setting of the Niger Delta, are not purely triggered by technical factors. Non-technical factors, such as: human psychology; the organizational setting; socio-political factors; knowledge gaps; procurement irregularities; also playout to culminate in the unusually high levels of cost overruns. Also the current practice of prioritizing projects according to size or location, implies a preferential management of ground related and other financial risks, which is correspondingly reflected in the disparities in the levels of cost overruns. Consideration thus has to be given to not only the geotechnical factors evident in the development phases, as they relate to ground conditions, but also to the prevailing organizational configuration, the external socio-political climate of the highway agencies, and the psychological interplay between the principal technical and non-technical actors.

11.4 Implications of the Research Findings for the Current State of Highway Development in the Niger Delta Region

The reality of the situation in highway project delivery in the Niger Delta, as deduced from the findings of the case study, depicts a far departure from the theory of good practice, relevant for the cost effective management of highway projects. The findings provide strong empirical evidence on the current state of practice, consequently accounting for the high levels of cost overruns recorded in highway projects executed in the Niger Delta. The study has shown that the various geotechnical issues identified from the study, have to a large extent contributed to increasing the levels of claims and variations, leading to lengthy project delays and abandonment.

Different combinations of ground related issues due to poor geotechnical risk management, have affected project delivery by the highway agencies, for major and community projects. These negative trends, are however, generally more evident in community projects, where pre-contract preparation and geotechnical input is mostly lacking, than in major projects designed by consultants. This interesting finding emanating from this research, explains why percentage cost overruns, are much higher among smaller scale projects when compared to larger ones. A finding which stands in contradiction to the notion, that cost overruns varies directly proportional to project size, as reported in several empirical studies.

The generally poor level of pre-contract preparation by the highway agencies, reinforces local literature evidence on the technical shortcomings in highway project delivery in the Niger Delta. The findings of the study also corroborate the views of earlier technical scholars in the literature on the Niger Delta, such as those offered in the work of Akpokodje (1987,1989); Abam and Okogbue (1993), Oguara, (2002) and Teme (2002). Collectively, these scholars have acknowledged that the geologic setting of the Niger Delta, has high technical and financial undertones, under-scoring the need for adequate geotechnical input in designs based on adequate geotechnical and geologic information. Akpokodje (1987), almost three decades ago, had emphasised the need for a thorough understanding of the geomorphology of the Niger Delta region, to serve as a backdrop to engineering designs of infrastructural projects, in recognition of its peculiar terrain, which is also prone to flooding. It was asserted: "*The need for necessary precautions, commencing with appropriate steps in site investigation and exploration to reveal the presence of the aforementioned poor soil conditions, before the execution of any project cannot be over emphasized*" (Akpokodje, 1987. P 195).

Findings from the case study, suggest that despite Akpokodje's (1987) calls for the adoption of a more comprehensive and geotechnically inclined pre-construction evaluative stage for all highway projects in the Niger Delta, community projects, which are mostly situated in riverine areas, still exhibit an almost complete lack of planning and geotechnical input. This is typified by: (1) the inconsistency of phase configuration; and (2) the use of ad-hoc pre-contract preparation and design processes, by two out of the three highway agencies evaluated. These findings have also revealed the generally low level of technical competence of the highway agencies responsible for highway development in the Niger Delta region, which may be typical of highway development in the wider context of Nigeria. Collectives these failings reinforce the assertion that, low level of in-house pre-contract preparation and geotechnical input are still considered normal practice, despite the calls in the literature for a step change in practice. The study findings clearly have significant implications for the current state of highway development in the Niger Delta, as it shows that the greatest potential for cost savings, lies in maximising the justifiable benefits of adequate geotechnical risk containment in highway projects, via the consistent adoption of best practice from inception to completion.

In an attempt to further understand the barriers to the paradigm shift in practice called for by several scholars, who have researched the geology of the Niger Delta and its developmental implications, the research has uncovered the significant institutional and political barriers to change within the highway organisations. The research shows that the inherently poor levels of geotechnical input in highway projects, is a reflection of the trickle-down effect of non-technical factors, such as human and organizational factors, as well as due to knowledge deficiencies in geotechnical risk management, which inherently trigger the geotechnical pathogens to actively escalate budgeted cost, over the lifespan of projects.

Of particular concern however, are the unethical practices and procurement irregularities evident within the highway agencies, which would inevitably negate any gains achievable, in resolving all other technical issues. The findings show that there are several internal organisational loopholes, which creates a viable ground for such unethical practices, where they do occur, to thrive. The apparent lack of rigorously enforced organisational platform for ensuring transparency in project execution by the highway agencies, creates avenues for unethical practices by consultants, contractors and highway officials alike, to exploit the porosity of the prevailing organisational system to their advantage. The findings have thus revealed several forms of procurement irregularities, implicit in the mode of delivery of highway projects in the Niger Delta, which previous qualitative narratives have not uncovered. These include issues of:

Emergency/politically dictated procurement of highway projects; Unplanned budgetary practices; Heightened security risk to highway officials overseeing highway projects; Subjective award of contracts to unqualified contractors; Hushed and unrealistic bidding timelines; and Multiple contract re-award, without any apparent form of accountability.

The multiplicity of issues uncovered in this study, represent the festering contextual drivers underlying the immense infrastructural backwardness evident in the region, despite its wealth of oil reserves. These findings are thus timely, as the critical issues facing infrastructural development in the Niger Delta, which is topical on the international frontier. Having become a cause for public concern, triggering violent agitation and an armed struggle by communities, currently making headlines in the media. The aftermath of these issues, is evident in the war-front like landscape of the Niger Delta region, following repeated bombings and explosions, reported in numerous media publications. These findings may also explain why the significant budgetary funds that have been allocated to several foiled institutional bodies, set up by successive administrations in Nigeria, to address infrastructural backlog in the Niger Delta, have not ended up producing any meaningful development in the region. But rather the continuing legacy, is the series of delayed and abandoned projects, that have been left in the wake of their collapse.

11.5 Broader Implications/Contributions of the Study

The cost overrun explanation provided is this study, is contextual to the tropical wetland setting of the Niger Delta region of Nigeria. However, it has direct theoretical, academic, practice based and policy implications, which contributes to the wider body of knowledge.

11.5.1 Contributions to Theory: Analytic Generalizability

Yin (2014), prescribed that achieving analytic generalisation, as opposed to statistical generalisation, is the primary purpose of a case study research. Identifying and addressing rival and complementary explanations, as well as explicitly outlining new theories emerging from this case study, is thus the basis on which analytic generalisation is made, necessary to explicitly show the study's contribution, to the body of existing theory on the phenomena of cost overruns in public projects. Several theoretical contributions, are thus implicit in the findings of this research.

A key theoretical contribution from this case study, is that it has shown that the rival explanation of strategic underrepresentation of actual project cost, leading to cost overruns, argued by Flyvbjerg *et al.* (2002), does not play out in the specific context of the Niger Delta. Although political motives, strongly underlie the planning and approval pattern of projects executed in the Niger Delta, the theory of deliberate underestimation, advanced by Flyvbjerg *et al*. (2002) has little explanatory power in the case of highway development in the Niger Delta. The findings show that in reality, no apparent form of Cost Benefit Analysis (CBA), which should mandatorily form the basis of approval in choosing from competing *alternatives*, is even carried out. Therefore, the elaborate machiavellian theories of politico-economic motives and power, underlying the theory of strategic misrepresentation by planners and highway officials posited in developed countries, is not evident in the data, and fundamentally does not connote any significance in explaining cost overruns in the Niger Delta.

Rather, the study findings further reinforce the generalisability of Love *et al.* (2012) latent pathogen theory, from the Australian context of building infrastructure, to highway projects in the Nigerian context. The series of evidence from the analysis has thus provided context specific qualitative explanations, about how the prevailing poor levels of geotechnical input constitute latent pathogens, which have triggered a chain reaction effect, right from the conceptual phase, and contributed to the increasing the levels of claims and variations, at the post-contract phase. This has consequently escalated cost and impacted on project delivery in the Niger Delta, leading to lengthy project delays and abandonments in highway projects. Poor geotechnical risk management by the highway agencies, has created a propensity for highway projects to run over budget, considering the financial risks inherent in the wetland geologic setting of the Niger Delta.

In addition to the presence of latent geotechnical pathogens at the various stages of project planning, an emergent theory from the data, is that project approval and execution for highway projects executed in the Niger Delta have no definite criteria, and are largely determined by the urgency induced from political and community quarters. The theory of: *Pressure induced urgency, due to political and community emitters, which creates psychological traps and a repressive atmosphere for highway officials, leading to an adhoc, preferentially dichotomised and dictatorial type of project planning, with evidence of unethical practices in project execution and governance*, seems to be an emergent strand of theoretical explanation to cost overruns in highway projects. This is suspected as possibly the strongest theoretical explanation holding in the wider context of Nigeria, which complements the presence of geotechnical pathogens triggered by a predominantly low level of technical-know how. The combination of these technical and social vices, in essence leads to a vicious cycle of short funding and delays, a theory earlier forwarded by Morris (1990) in the Indian setting.

To this end, a major theoretical contribution from this research is that, it blurs the boundaries of the dialectical debate in the literature, between the theoretical and technical schools of thought, competing as explanations for cost overruns in highway projects. A stance which had been previously advocated by Ahiagu Dugbai (2015), in stating:

> *"Existing theories on causes of overruns… from an engineering and technical perspective…and from an economic/psychological/strategic perspective are views both critical to holistically dealing with the problem of cost growth, and therefore should be seen as complimenting, rather than opposing sides of the same issue" (p 52).*

The level of technical competence, the socio-psychological manifestations of project actors, as well as the distinct organisational and institutional of settings in highway agencies, matter in providing a holistic understanding of what drives cost overruns in public infrastructure projects. This was an assumption overlooked by Flyvbjerg *et al*. (2002), in globally generalising his rival explanation on cost overrun, contesting and rejecting the validity of technical explanations to cost overruns. The fundamental concern raised by this research in this regard therefore, is the question of the generalisability of knowledge created in similar positivist studies on cost overruns. As such, studies primarily seeking to provide generalizable explanations for the phenomena of cost overruns, are not plausible, and will therefore be subject to rebuttal.

This study, has therefore demonstrated the plausibility of incorporating and linking both strands to the argument on cost overruns (Theoretical and Technical) in highway projects, relevant to provide more comprehensive contextual explanations to cost overruns in public infrastructure projects. The acknowledgement that, various methodologically valid explanations on cost overruns in public projects, can co-exist due to their context specificity, without the need to disprove each other, and without having to generalise beyond the study setting, is a major contribution to knowledge uncovered by this research.

The findings from the case study further reinforces to various extents, several of the existing non-technical theories on cost overrun. Typically, Cantarelli *et al.* (2013) had mapped out an untested hypothetical model, of how both parties to a contract anticipate each other's behaviour in setting price margins, during contractor selection and contract award phase of infrastructure projects, in an intricately psychological game of political and economic motives. Elements of this theory of game signalling between the principal actors in public projects, namely the contractor and client, seem to play out in the scenario of price setting, in the geologic context of the Niger Delta. The poor geotechnical risk allocation mechanism, has led to strategic adversarial behaviour of both the highway agencies and the contractors, with incompetent contractors winning contracts, based on tactically deflated tender figures, and often times abandoning them, leading to multiple contract re-awards.

The findings from this study also reinforces Johansen (2015) uncertainty framework, which shares the characteristics of Gil and Lundriganm (2012; 2013) Relay Race versus Core and Periphery theories, in emphasizing the multiplicity of unforeseeable risks and often competing/clashing interest groups in public projects, as accounting for cost overruns. This is evident in the multiplicity of political and community stakeholders in the Niger Delta region. Political pressure at upper helms of the hierarchy of power dictate to the highway agencies, while community stakeholders at the grass root level, exert their influence via bombings, hostage taking and violent agitations. The issue of high cost overruns in highway projects, thus cannot be divorced from the geo-political dynamics of the Niger Delta, and the agitations for the development of the backward region, which exerts clashing socio-political pressure on the highway officials. Therefore, despite the increased funding for the construction of new roads to open up the swamps in the region, the pressure from the various clashing interest groups, has impacted on the agencies' ability to properly plan for and manage highway projects.

However, irrespective of the case study findings upholding and supporting the validity of a scant number of qualitative narratives, carried out in the setting of developed nations, it has also shown that several others are not adequate to holistically explain the scenario of highway project delivery in the developing world. Typically, in the Netherlands, Cantarelli *et al.* (2010:793) tested the theory of lock as "a form of psychological coping associated with the inability to withdraw from obligations made during the decision-making process". From the findings of this research, the theory of lock-in reported in the Netherlands does not necessarily apply to the Nigerian setting. Cantarelli *et al.* (2012:50) however recognised this and emphasised the need for context based studies, specifically in relation to individual countries, stating that:

> *"With a general tendency in country specific studies towards lower or higher average cost overruns…, it remains difficult to make inferences about individual countries ... This therefore supports the need for further research into country specific cost performance of transport infrastructure projects".*

There are thus several distinguishing features in the narrative offered from this study, which represent its distinct theoretical contributions, unprecedented in previous qualitative narratives explaining cost overruns from the perspective of developed nations. These include:

- *Knowledge and skills gap between the developed and developing world*

  The findings from this research has validated the researchers preconceived notion, of the wide knowledge and skills gap between the developed and developing world, in the management of geotechnical risk, inherent in highway projects. The study has empirically confirmed the observations of two seminal authors: Millard (1993) and Oguara (2002), from past international and local literature, respectively, to the present day settings. Millard (1993), commented on the difficulties experienced by ex-colonial countries in tropical areas, in designing roads suitable for their terrain, and setting up technical organisations to adequately manage funds allocated to highway development. Oguara (2002), speculated that the shortcomings in the technical practices of the highway agencies, were responsible for the underdeveloped state of road network in the Niger Delta. This was in view of the several foiled developmental efforts, whereby Oguara (2002), called for more geotechnical ingenuity in the delivery of highway projects in the region.

  The study has revealed that at present times, there still exists apparent knowledge deficiencies, with respect to geotechnical risk management principles, and current highway design best practices, within the highway agencies in the region. This was evident from the responses of the agencies' in-house design professionals, who exhibited very low levels of familiarity with the basic technical terminology of highway pavement designs and standards. These significant knowledge deficiencies demonstrated the worryingly low levels of awareness amongst in-house civil engineers, of the fundamental tools of their profession, or other internationally recognised best practice design standards.

  The study further revealed the poor level of technical competence and the prevalence of poorly qualified professionals employed by highway agencies in the region. The highway agencies clearly lacked qualified technical manpower, with the requisite qualifications, as a result they were badly under staffed. This is evident, as typically quantity surveyors and civil engineers worked in dual capacities, often interchangeably, within the various departments, with no clear cut definition of professional roles within the highway organisations. Consequently, most professionals serve in multiple capacities. The study further reveals instances of job descriptions not matching the qualifications of staff working on road projects, with completely unrelated (non-construction) professionals working in the capacity of project managers and supervisors. Cases of medical doctors, accountants, marine engineers and even petroleum engineers heading departments in charge of road projects, were cited.

- *Oppressive Demotivating Organisational Climate in Highway Procurement*
  The case study has revealed the ill structured and inconsistent organisational processes and project management practices in the highway agencies, entrenched in a suffocating cocoon of geo-political and communal pressures. The impact of political interference on the in-house professional roles, in the procurement of highway projects, and the cautiousness and demotivation it arouses in professionals in the performance of their duties, is a distinctive major finding from this research, which previous studies have not uncovered. Political authority thus appears to have usurped the professional role of project leadership in the Niger Delta, compared to the dynamics of the developed world, where project governance by delegated professionals, ideally determine the motivation and performance of team members in highway projects. The subjugation of professional obligations and ethics, in deference to political dictates, and its impact on the motivation of highway officials, is a major theoretical finding emerging from this case study.

- *Dichotomous and Preferential Execution of Projects*
  Several forms of preferential treatment of projects are evident in highway project delivery in the Niger Delta, even after the projects have been approved for execution. These include: Planned versus adhoc procurement practices for major versus community projects; Politically motivated selective project management practices; Unequal priority status in the post contract management of upland vs riverine projects. These dichotomous practices stand in sharp contrast to the assumptions of equality in the efforts and approach to managing approved public projects.

11.5.2 Contribution to Academe: Originality of the Research

Research is a systematic and organised effort to investigate a specific problem in the pursuit of a solution (Sekaran, 2007; Grey, 2009). The originality of such solutions however, is a prerequisite in a PhD research, as demonstrative of its academic contribution to the existing body of knowledge. Variants to the form of originality are thus tenable in various fields of study. These are listed by Philips and Pugh (1994) to include geographic, methodological, evidential, paradigmic, cross-disciplinary, field specific originality etc. This PhD research demonstrates originality in its contribution to knowledge, implicit in the empirical approach used to research the problem of cost overruns in highway projects, executed in the setting of a developing nation, and traversing cross-disciplinary realms, with the robust use of multiple methods.

The academic contribution of this research is evident, in the robustness and transdisciplinary nature of the theoretical under-pining used to understand the propagation of cost-overruns and ground related risk in highway projects. This study has used a comprehensive theoretical approach to understanding the propagation of cost growth in highway project estimates, based on an analysis of the geotechnical intricacies in highway development, which lies between the borderline of several fields of knowledge. One can readily identify three of such fields with the necessary scientific principles: Engineering Geology; Highway Engineering, and Quantity Surveying (Figure 1.5).

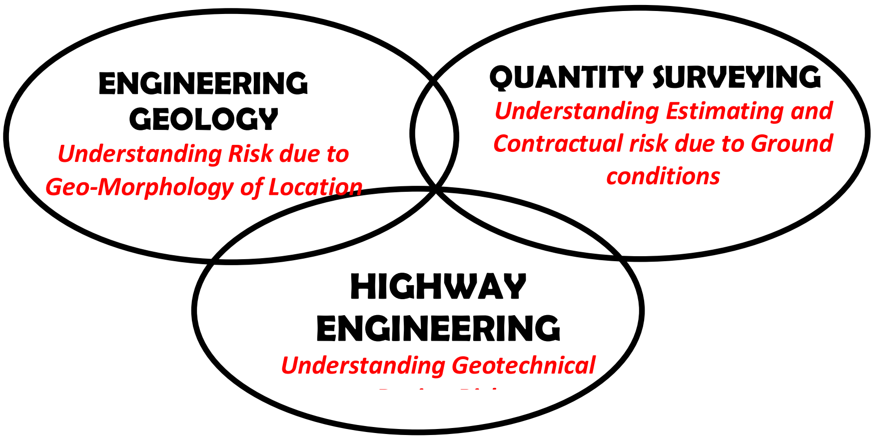


Figure 11.2: Interlocking Fields in this Study's Approach to Explaining Cost Overruns

By combining these different but converging fields of study, geotechnical risks and the associated cost-overrun implications have been captured, in estimates prepared during the budgetary, design and contractual phases. This thus shifts the emphasis of the cost overrun debate from just the more superficial arguments between technical and theoretical schools, to a more in-depth evaluation of a major financial risk variable underlying all forms of transportation infrastructure projects.

Equally distinctive is the fact that the case study setting, has been framed within the lenses of an organisational perspective, as opposed to the more common approach of using only project level characteristics to quantitatively account for cost overruns, as evident in the empirical literature. The distinctiveness of this approach is evident as it adds an in-depth measure of texture and feel of the hierarchical intra-organisational functions and processes in highway agencies, which is unprecedented in previous quantitative studies on cost overrun. The use of cognitive mapping based on empirical data, further tries to visually conceptualise how technical and non-technical variables, within and outside highway organisations, impact on cost overruns experienced on highway projects. The tangent taken by the researcher to explain cost overruns in this study, is therefore demonstrative of its originality, as it is unchartered in the body of scholarly literature, to provide context specific and in-depth geotechnical/geologic explanations to cost overruns, within the broader socio-cultural setting of highway organisations in the developing world.

A further academic contribution of this study is methodological. The methodology used, has established the practicality of adopting a critical realist orientation, as a philosophical lens, to frame a mix method case study investigating the phenomena of cost overruns in highway projects. The mix of methods deployed in this case study, is evident in:

- The use of spatial statistical analysis of geotechnical index data on subgrade soils, as a form of contextual definition of risks inherent at project sites. This represents a novel approach to understanding ground related risks in highway projects. The deployment of this approach was useful as a relevant starting point of the case study, to draw attention to the magnitude of the cost-overrun deferential induced by the geologic heterogeneity of the Niger Delta terrain, due to poor geotechnical practices;

- The geotechnical characterisation of cost overrun drivers in the estimate preparation phases of highway projects, as a narrative form of qualitative analysis, with the reflexive inductive analysis of unanticipated social constructs. This approach charts out a mostly overlooked methodological orientation for carrying out research in the engineering and quantitative disciplines, which often cling to purely positivists methodologies to understand technical issues in construction projects;

- The use of regression analysis, represents an innovative use of a quantitative approach, as a basis of achieving triangulation, necessary to tie and link up the various qualitative and quantitative strands of the technical explanation generated. This approach adopted, served to explicitly define the magnitude of financial risk borne by highway agencies, implied by latent geotechnical pathogens. The use of regression analysis thus moved Love *et al. 's* (2012) latent pathogen theory to a further degree of statistical integrity, higher and above the untested assertions of Flyvbjerg *et al*. (2002).

- The use of cognitive mapping to further represent the complex interconnectivity, between the multiplicity of technical and social constructs, portrays the usefulness of visual conceptualisation to concisely relate linked qualitative data, a fundamental tenet of the hermeneutic circle. The cognitive map provided a snapshot of the contextual organisational, human and institutional barriers accounting for cost growth in highway projects executed in the peculiar geologic context of the region, based on empirical data. This showed the weightiness in the dynamics of forces, simultaneously at play in highway organisations, which inherently trickle down to trigger cost growth on a project specific basis.

This study therefore methodologically demonstrates the logicality of mixing methods: Archival data modelling technique, in tandem with a contextual narrative built from qualitative data, to develop an explanatory quantitative model and weighted cognitive map of cost overrun drivers. The findings therefore serve to fill in a major gap in the existing literature by providing specific contextual backing, which significantly expands the findings from previous empirical research on cost overruns. It has furnished the more holistic picture missing in the disjointed findings of previous empirical studies on cost overruns. This sets the methodological agenda for post-2016 research on cost overruns in construction projects.

The methodological robustness of this study, is further evident against the backdrop of mono-method studies, evident in the bulk of previous empirical cost overrun studies, which either provide qualitative theoretical explanations or quantitatively analyse project data and recorded cost overrun outcomes in projects. Of particular concern is the predominance of artificialised questionnaire survey based on positivist approaches, which can only give pointers in the general direction of where the problem may lie, but cannot adequately explain and provide understanding of the phenomena of cost growth in highway projects. As Ahiagu Dugbai (2014: 40) succinctly puts it: "*Most studies on cost overruns only begin to scratch the surface of this complex phenomena plaguing highway projects, often more generating questions than answers*". The methodological validity of such studies is thus put to question, as such studies may almost completely miss out the contextual drivers that can only be revealed from a qualitative narrative. This study thus reinforces the need for more comprehensive and context based qualitative approaches, to compliment the analysis of project data, as a basis of inferring causality in cost overrun research.

The critical realist stance adopted in this study, has further implications for resolving current paradigmic arguments in the construction management research community, beyond the specific knowledge domain of cost overrun research. This is against the backdrop of the strongly debated arguments in cost overrun research, outlined earlier in the critical analysis of the literature, which showed isolated schools of thought vying for ultimate supremacy in providing generalizable explanations for the propagation of cost growth in public projects. This is analogous of the philosophical and paradigmic debates in the wider construction management research community. As this study demonstrates, critical realism presents itself as a valid philosophical position, relevant to carry out rigorous and methodologically robust research on construction phenomena, which can withstand the critique plaguing the use of mono methods in construction management research. This is considering the dialectical philosophical debate on construction phenomena, as being mostly social constructs, which can be also objectively studied. The robustness of the findings from this study, thus reinforces the call for methodological pluralism advocated by Dainty (2008), who argued that the research methods used by the construction management community should be more adventurous, and seek to incorporate a more diverse mix of methods, outside the confines of positivism traditionally embraced by the industry.

11.5.3 Contribution to Practice

The study has established the fact that the dominant factor accounting for the cost overruns in highway projects executed in the Niger Delta region, is the poor levels of geotechnical risk management, exacerbated by the difficult terrain. The explicit definition of the magnitude of financial risk borne by highway agencies, implied by the lack of adherence to geotechnical best practices, is a motivation requisite to catalyse change in the procurement environment of highway projects across the Niger Delta. This brings to the fore, the need for a geotechnical risk based transformation framework, to urgently address the current issue of unusually high cost overruns recorded on highway projects. More specifically, several tangible deliverables are implicit in the research findings, further underscoring its direct contributions to practice within the geographic setting of the study area:

- A descriptive qualitative snapshot, providing a narrative of the current design, estimating and contractual scenario prevailing in highway development in the Niger Delta, which is unprecedented in the body of scholarly literature.

- A synthesized Geotechnical Best Practice Evaluation Criteria (GBPEC) implicit in the geotechnical characterisation of cost overrun drivers, that can be used in inferring adherence to geotechnical best practices, necessary to minimise cost overruns. This can thus serve in the dual capacity of a risk management tool for highway agencies.

- A geo-spatial multiple regression based model of geotechnical pathogens, that can be developed to serve as a useful input in Reference Class Forecasting/Case Based Reasoning (CBR) models relevant for geotechnical decision making of future highway projects in the Niger Delta.

- A cognitive map of contextual drivers, which draws attention to the weighty issues dragging and slowing down the pace of highway project delivery in the Niger Delta region of Nigeria, and whose resolution is critical for any meaningful progress to be made in the infrastructural development of the backward region.

However, although the findings of this study is considered relevant to address the identified knowledge gaps, in the practice of the highway agencies operating in the developing setting of the Niger Delta region of Nigeria, such practice based geotechnical shortcomings may also be evident in other settings. As the literature reveals, there are still current arguments in the practice of highway organisations, surrounding:

- The use of off-the-shelve historical data for conceptual cost estimating, with several scholars advocating that adequate expenditure should be devoted to carrying out more rigorous and comprehensive desk studies, to enable the use of more deterministic costing methods;
- The justifiable level of expenditure to be allocated to carrying out detailed ground exploration, and whether there is need to incorporate Ground Investigation Reports (GIR) and Differing Site Condition (DSC) clauses in engineering contracts, as a mechanism of geotechnical risk containment;
- The relevance of geotechnical presence, right from project inception and feasibility studies, and not just for design purposes.

This empirical study of highway delivery in the Niger Delta, thus depicts a case in hand showing how these widely contested issues in geotechnical practice and cost estimation, still currently on going to various degrees on highway projects, can have significant financial impact on project completion cost.

The study has further revealed that a multiplicity of contextual sociocultural issues exists within, and external to the organisational setting of highway agencies. The implication of these findings for practice is that, it has drawn attention to how non-technical drivers in projects can have a far reaching impact in determining the success or failure of highway projects, in achieving the financial objective of subverting cost overruns. It is thus clear that tackling the phenomenon of cost growth, leading to overruns in public infrastructure projects, is not as simplistic as previously portrayed in the literature, but is a multi-hydra headed monster, whose tackling should go much deeper than the scientific deployment of technical tools in estimating and risk management.

11.5.4 Contribution to Policy

Achieving value for money is a recurrent theme and a fundamental principle that resonates across all forms of investment decisions. For this principle to be operative in highway investment in the Niger Delta region, would require a change in the existing approach to geotechnical risk management. This is critical to minimising avoidable cost overruns due to adverse ground conditions, This study has provided clients for road projects (highway agencies), and who therefore constitute the primary target audience, with the necessary empirical justification that: Value for public funds expended on highway development may be achieved and justifiably expended, if the appropriate estimating, design and contractual principles that reflect geotechnical best practices, are incorporated into projects, to subvert ground related cost-overruns.

The policy implication of this research work therefore, lies in creating an awareness of the need for the adoption of a more substantiated geotechnical basis, by relevant organisations and institutional authorities, via:

- Establishing differentiated costing platforms during budgeting for highway development, in cognisance of the heterogeneous ground profile of the Niger Delta region;
- Addressing and accounting for the vagaries of varying subsoil profiles in designs for all proposed highway projects by adequate expenditure on ground investigations;
- Enforcing the implementation of all contractual measure, necessary to ensure adequate containment of geotechnical risks in the procurement of highway projects;

- Minimising external political and community interference to maintain a conducive geotechnical platform for relevant professionals to ensure geotechnical input in highway projects;
- Providing adequate technical, human and financial resources, necessary for the highway organisations to adhere to best practice.

There is thus an evident need for a radical re-orientation of the policy objectives of highway infrastructure delivery in the Niger Delta, to focus more on geotechnical perspectives, in other to achieve value for money in highway investments. Effective appraisals and costing of the geotechnical intricacies associated with the wetland terrain of the Niger Delta, is therefore a crucial factor, on which the successful and economic development of highway infrastructure in the region needs to be pivoted. There is therefore considerable potential for achieving value for money, via ensuring adherence to geotechnical best practises, to generate appropriate designs and estimates reflective of ground conditions in the Niger Delta. This will be financially expressed, in terms of a reduced disparity between initial budgetary estimates and final cost figures, for highway projects in the Niger Delta.

However, to achieve this goal, the identified socio-cultural issues, which represent the human, organisational and institutional barriers to geotechnical input, would also need to be tackled conscientiously by relevant highway authorities. This is necessary to create a conducive platform for a highway investment strategy, that is closely linked to the terrain of the Niger Delta, as a mechanism to ensure cost effective delivery of highway infrastructure in the region.

11.6 Recommendations of the Study

The findings from this research call for a step change by the highway agencies, to ensure adequate understanding of the geomorphology of the Niger Delta, based on rigorous geotechnical evaluation, before the design and construction of highways in the region. Such prescriptive measures necessary to entrench geotechnical principles, for the efficient development of road infrastructure, have been identified from best practices in the literature, as a synthesis of solutions, which have direct relevance and applicability to enhance the practises of highway agencies in the Niger Delta. The researcher thus makes relevant referrals to the literature advocating for geotechnical best practices, to serve as technical recommendations necessary to align the practices of the highway agencies, at various phases of project development. The recommendations are derived from the selective documentary analysis of international best practice guidelines for cost estimating, commissioned government reports, highway standards and professional guidelines for managing geotechnical risks, some of which have being discussed in the literature. These include:

- The British Design Manual for Roads and Bridges (DMRB, 2006) guidelines for managing geotechnical risks;
- The Evans and Peck (2008) Report and recommended standards of best practice for cost estimation on highway projects, commissioned by the Australian Federal Government;
- The United States Government Accountability Office (GAO, 2009) best practice estimating guidance;
- The Association of Cost Engineers (AACE, 1997) International recommended professional practice guide to construction cost estimating;
- The Institution of Civil Engineers (ICE; 1991;1999) recommendations for geotechnical Practice
- The Transportation and Road Research Laboratory (TRRL, 1993) Over Seas Road Note 31, for the design of bituminous highways in tropical countries:
- The DFID Project Report R6898: Guidelines on the selection and use of road construction materials in tropical countries.

The fundamental tenet of geotechnical best practice requires that geotechnical input is ensured in highway projects from the earliest point of project planning, feasibility studies and conceptualisation, down to project completion. The recommendations forwarded, are thus chronologically articulated, in response to the geotechnical issues uncovered at the progressive phases of project development by the highway agencies in the Niger Delta region of Nigeria.

11.6.1 Planning Phase

The findings from this study has revealed a non-existent planning/feasibility phase for highway projects in the Niger Delta. Of primary significance at this phase of highway development in the Niger Delta, is the impact of political and communal influences which serve as the basic consideration in planning for road projects to be executed. However, the practice by highway agencies in the developed world shows that the planning/feasibility phase of highway development is considered a crucial phase, and more steeply inclined towards technical and environmental details in mapping out alternative layouts. Typically, In the United States, Chou (2002) explained that this stage of project development is referred to as the investment/corridor planning stage, used to analyse the feasibility of proposed schemes, with high feasibility projects given higher priority, subsequent to which conceptual estimates are prepared. In the Australian context, this phase, referred to as the project identification phase, is also used to map out network and corridor objectives as a basis on which a rapid Benefit Cost Analysis (BCA) is carried out to obtain funding approval.

Highway agencies and relevant authorities in the Niger Delta, thus need to be enlightened about the general objective of geotechnical evaluation, right from the planning phase of highway projects. At the planning phase of highway projects, the researcher recommends the use of terrain mapping supported by a terrain attribute database. As such geographical information systems, can be used to analyse such data, as a basis of generating a geotechnical land classification system for use in the planning of highway routes in the Niger Delta. Such data is also necessary for carrying out desk studies at the preliminary design phase for the approved highway projects in Niger Delta.

Accessibility to such data, is however a primary hurdle that needs to be overcome. This is because, although there are currently various studies on the geology and geotechnical properties of sub soils in the Niger Delta, these are mostly not disseminated. The few available are scattered in privately owned reports and in the scant published literature. This was a problem faced by the researcher during the field work. Also from, the response pattern of the consultants to the highway agencies, the researcher inferred that this may be why only preliminary site reconnaissance are carried out, by visiting the site to identify locations for drilling boreholes, before the detailed ground investigations. Desk studies which should ideally entail studying other geologic information related to the project site and its location were often not carried out. This is not surprising since there is no comprehensive and readily accessible geotechnical data base on the Niger Delta, unlike in developed countries, were such information, as well as a wealth of other relevant documented historical data, are available. Typically, in the UK, such data can be readily accessed at the appropriate regional offices, highways engineering division, or ground engineering division at the Transport and Road Research Laboratory (TRRL) and at the British Geological Survey. As such making readily available technical resources for carrying out desk studies, typical of developed countries, is a necessary first step to ensure adequate geotechnical evaluation.

The Transportation Research Laboratory (TRL), in a technical report prepared under the Department for International Development(DFID), identified several potential sources of information for desk studies that can be assessed by developing countries. More specifically, the researcher proposes that geological field maps, aeromagnetic maps and aerial photographs and topographic maps maintained by the Geological Survey of Nigeria, as well as the use of remote sensing techniques to interpret satellite images for the Niger Delta, can be combined with site specific investigations to produce more detailed and comprehensive geotechnical mapping of subgrade soils in the region. A further technical data needed would be reliable piezometric level data, which should be consistently monitored in order to gauge groundwater levels and movement in the Niger Delta.

To pool together the various sources of geographic, geotechnical and geologic data, for use in engineering and costing applications, necessitates the setting up of a geotechnical/geological information unit specifically for the Niger Delta. Expenditure devoted to this can be justified in the long term by a corresponding reduction in the preliminary design and estimating effort required for highway development. Forming of geological engineering co-operatives can also be formally instituted to provide geotechnical data for engineers, planners, designers and contractors who may require data on soil in the area for use as engineering materials, as well as help in developing a clear vision for new researches. The effective management of information gathering and collation procedures is therefore of critical importance to ensuring adequate geotechnical evaluation for highway development in the Niger Delta.

11.6.2 Design Phase

Subsequent to the planning phase, there is a need for highway agencies in the Niger to consistently ensure geotechnical input in projects, by maintaining in-house geotechnical presence throughout the design and costing phases of smaller scale community project execution. However, the findings have revealed that apart from not maintaining geotechnical presence internally, there are no explicit design and estimating unit for two out of the three highway agencies in the region. On this issue, there is an apparent need to reflect better clarity and definition of professional roles in the organisational structure, with provision made for distinct design and estimating units. Furthermore, the statutory laws establishing the agencies, should stipulate and enforce the basic criteria, for defining the minimum qualifications of staff working in specific technical departments of highway agencies. Ensuring this, is of particular significance, to improving the adequacy of designs and estimates, as well as ensure the efficient post-contract management of geotechnical risks.

Reference in this instance, can be made to the UK, where apart from the having relevant qualified professionals in projects, two key personnel are responsible for the adequate management of geotechnical risk in designs. These personnel are the Designer's Geotechnical Advisor (DGA) and the highway agency's in-house Geotechnical Advisor (GA), both of who have to work closely from the early stage of the project. The geotechnical advisor is employed by the consultant as a professional who works with the in-house geotechnical personnel. The DMRB (2006:22) thus stipulates: "*Each overseeing organization shall have on its staff, or shall appoint, a GA with responsibility for the geotechnical aspects of the work of the Overseeing Organization*". The DGA is also required to be certified, as having the relevant experience appropriate to the project being undertaken, and with the matching qualifications.

Based on the stipulations of the British DRMB (2006), the in-house geotechnical personnel are thus responsible for the procurement and supervision of the consultant specialism in the geotechnical aspects of a project, with a further provision made for independent geotechnical audit by the highway agencies from time to time. Checks of this nature would be particularly useful, for highway agencies in the Niger Delta, as the level of detailed geotechnical investigations carried out by consultants, based on which designs for major roads are prepared, were apparently not verified. On this issue, contradictory responses from the chief consultants, their lower cadre staffs and the highway officials. Reports of unethical professional practices by consultants, were however filtered from the responses as a possibility which needs to be checked.

Explicit provision should be made to rigorously enforce the compliance of geotechnical requirement in projects, within the organisational framework of the highway agencies. Highway agencies in the Niger Delta therefore need to employ geotechnical professionals as part of their in-house project management team, to ensure consistency in the management of geotechnical risks, throughout the sequential phases of project development. As the ICE (1999:9) advocates:

> *"engaging geotechnical presence at the earliest opportunity, will ensure that, appropriate remedial measures or design changes are carried out; accurate records are obtained of the ground actually encountered; a supplementary investigation to mitigate the problems is implemented".*

To ensure that the geotechnical risks in the design of highway projects are identified, and then adequately managed throughout a project, Volume 4 of the British DRMB (2006), further sets out standard procedures for the planning and reporting of geotechnical works in highway projects, necessary to ensure that geotechnical risk is correctly managed by geotechnical personnel. The DMRB (2006) outlines key stages to be followed, as an integral part of geotechnical risk management by highway agencies, in the overall project progression, which the researcher considers adaptable to the Niger Delta:

Key Stage 1: Initial Review of Project and Geotechnical Risks to determine its Geotechnical Classification and thus the requirement for Geotechnical Certification:

This phase is useful to identify potential geotechnical risks, at the conceptual phase. The complexity of the geotechnical requirements of the project is therefore assessed at this stage. Set criteria for classifying geotechnical risks in projects is provided, using geotechnical categories, one to three, with increasing levels of complexity: With one, for projects satisfiable on the basis of routine geotechnical assessments; two, for those requiring detailed quantitative assessments; three, for complex geotechnical risks requiring a high degree of specialization.

Key Stage 2: Preliminary Assessment referred to as a Preliminary Sources Study Report (Desk Study) and preparation of the Ground Investigation Report.

This stage is useful to ensure the procurement of relevant geotechnical information, necessary to undertake an accurate assessment of project risks, for preliminary and detail design purposes. It is thus a pre-requisite that desk studies and preliminary reconnaissance surveys are carried out, to serve as baseline data, necessary to gain background geotechnical information on project sites in the Niger Delta, which should logically precede and not be substituted for detailed ground investigation. This should be a mandatory requirement for all highway projects in the Niger Delta, prior to detailed design preparation and construction of highway projects. To this effect, the British DRMB provides advice on carrying out GI in Note HA 34/87.

Key Stage 3: Geotechnical Design and Construction Certification

At this stage, information on the detailed project design is provided, for the contractor to prepare and carry out construction. However, the study reveals that for community projects executed by the highway agencies in the Niger Delta, detailed designs are mostly not prepared by the in-house professionals. Survey layout plans, rough sketches, and sometimes even verbal instruction are considered sufficient for the award of contracts. Furthermore, the general pattern of the responses from the interviews, showed that most of the agencies' in-house professionals exhibited very low level of familiarity with the basic technical terminology of highway pavement designs and standards.

In view of these findings, the study recommends that highway agencies need to periodically carry out staff development programmes, trainings, workshops and seminars for their technical staff and professionals, to keep abreast with current practices and developments in highway designs. Of particular importance is the need to enforce the adoption of the TRRL (1993) design guide as required by the Federal Ministry of Works, by professionals in state and regional highway agencies. The TRRL (1993) Overseas Road Note 31, which is now widely used in other developing countries, provides guidance on the structural design of roads within tropical regions, and defines the construction material requirements.

Increased networking between the highway agencies in the Niger Delta, as well as with other highway agencies in tropical areas, and in the developed world, would provide an excellent opportunity for highway professionals in the Niger Delta to meet with each other, and those in other tropical regions. The clear benefits derivable, would thus be knowledge transfer from more advanced technical organisations with relevant skills, and relating to the current experiences of geotechnical risk management in similar hydrogeological environments.

Key Stage 4 Geotechnical Feedback

At the final phase, a Geotechnical Feedback Report is prepared by the DGA and the GA, reporting on the general progress of the construction work, and particularly any unexpected ground conditions requiring changes to design, that occurred. The ICE (1999:5) on this note, recommends:

> *"It would be useful if completed projects, both successful and those which have incurred significant claims related to unforeseen site conditions, could be analysed to ascertain their technical and contractual elements. The technical problems could be categorized to establish particular areas of site investigation deficiency, and study of the contractual aspects might highlight the conditions and procedures which are unhelpful to successful construction".*

The entirety of the documentation required for geotechnical risk management, from project inception to completion, based on the stipulations of the DRMB (2006), are thus the: Geotechnical Classification Report; Preliminary Sources Study Report; Ground Investigation Report; Geotechnical Design Report; Geotechnical Feedback Report. It is thus the researcher's belief that highway agencies in the Niger Delta, stand to make positive changes to the delivery of highway infrastructure, if these guidelines deduced from more advanced practices, are adopted. This could constitute a starting point, necessary to resolve most of the current geotechnical shortcomings in the design of highway projects.

11.6.3 Costing Phase

Considering the heterogeneous ground profile of the Niger Delta, the implications of carrying out adequate geotechnical evaluation for highway projects, has far reaching impact beyond the generation of appropriate designs. This is because, it will over the project life span, further improve the accuracy of estimates, particularly during conceptual costing phase of budget preparation. Typically, the DRMB (2006) states:

> *"The properties of engineering soils and rocks vary not only from one geology to another, but within the same geology and it should not be assumed, without full supporting evidence, that the ground conditions are identical".*

This has been shown to have severe implications for the accuracy of conceptual estimates, used in budgeting for highway projects. As the study findings reveal, the method of cost per kilometre averages based on similar past projects, has led to significant disparities between budgeted and final outturn costs.

There is thus an evident need to improve the accuracy of conceptual cost estimates in the Niger Delta, requiring that geotechnically differentiated cost estimates are prepared for proposed highway projects, predicated on adequate information on ground conditions. The GAO (2009) Cost Estimating and Assessment Guide, recommends best practices, for developing and managing capital program costs, and provides comprehensive guidelines for the selecting costing methodologies most suited to the different elements in a Work Breakdown Structure (WBS), in tandem with the level of scope definition. In this vain the GAO (2009:34) stated:

> *"A project cost estimate may comprise separate estimates of differing classifications. Certain portions of the design or work scope may be well defined, and therefore warrant more detailed cost estimating techniques and approaches, while other areas are relatively immature and therefore appropriately estimated using parametric or other less definitive analytical techniques".*

The AACE (1997) equally recommended that the estimate corresponding to the conceptual phase should be expressed at level-1(unit rate) or Level-2 (elemental) rather than on a more generic level-4 cost per length of road length basis, which is a rough order of magnitude estimate type, typically adopted by highway agencies. The GAO (2009:35) guideline in this vain asserted that:

> *"Because it is developed from limited data and in a short time, a rough order of magnitude analysis should never be considered a budget-quality cost estimate".*

Emphasis should therefore be placed by the highway agencies in the Niger Delta, on getting geotechnical information via desk studies, carried out on time, as a basis of getting the project scope defined to the best possible degree at this phase. This should be with applicable contingency allowance provided, depending on the level of confidence in the information gathered. As such at budget preparation stage, geologic mapping and case histories from desk studies in the area can be deployed to characterize geologic conditions. Since pavement cost in highway projects account for the highest percentage of the total cost of road works, it can be discerned that the level of definition of design of the road pavement, should be sufficiently developed, to permit using a level-1/2 approach. Evans and Peck (2008) best practice guidance further showed that getting the conceptual estimate defined to this best possible degree, increases the probability of not exceeding 10-15% and 25-40% range in variations, at 50% and 90% confidence limits respectively.

11.6.4 Contractual Phase

At the contractual phase, appropriate forms of engineering contracts such as the NEC or FIDIC should be used. The inclusion of Ground Investigations Reports is also necessary. This is in view of the findings, which show that highway agencies in the Niger Delta still use the JCT form of contract which is applicable only to building contracts, and do not include Ground Investigation Reports as part of the standard contract documentation provided for tenderers. This poor geotechnical risk containment, has led to adversarial behaviour and the strategic pricing of contracts by inefficient contractors, who often times abandon the projects, leading multiple contract re-awards by the highway agencies. Contract documentation for highway contracts awarded in the Niger need to further incorporate Differing Site Condition clauses, to provide financial relief for contractors in the event of unforeseen ground conditions, to cover for unplanned cost associated with geotechnical intricacies in the heterogeneous terrain of the Niger Delta.

For riverine locations in the Niger Delta region, the geomorphology and other physical attributes of the terrain would compel a construction firm to step up its profit margin, if it is to efficiently execute a project there. The contractor in estimating for the works will have to incorporate these geographic and subsoil factors which directly or indirectly affect the cost of construction works in the swampy and coastal areas in the Niger Delta. As such, the overheads of any efficient construction firms carrying out construction work in riverine areas will likely increase, leading to a corresponding increase in tender figures. In this vain, the lowest bid criterion currently adopted in contractor selection by the highway agencies, will therefore likely stifle the competitive advantage of the more efficient contractors.

Awarding contracts to inefficient contractors, without any form of geotechnical selection criteria, is clearly a gamble which has 'boomeranged' and undermined the long run cost-efficient procurement of highway projects executed in the Niger Delta. Contractor selection criteria, against the background of the difficulties typically associated with construction works in the swamps and coastal zones, is apparently a key success factor for highway projects. Highway construction in the Niger Delta clearly requires a high level of geotechnical experience and expertise by contractors, who should be familiar with the rigours and uncertainties of construction works in the area, for a project to be successfully completed under budget and in time.

During contract execution, geotechnical specialists should also be more closely involved in the supervision of construction. To curtail the high incidents of claims, justified on the basis of unexpected ground conditions, logically requires that monitoring of projects should be carried out by a team, including qualified geotechnical personnel. As such consultants employed to post-contract monitoring of projects and the highway agencies, should ensure that their staff are not only qualified, but jointly and closely monitor progress of work by contractors. To this end, the issue of short staffing reported in the highway agencies, needs to be addressed. Adequately qualified professionals, in sufficient numbers, should be employed to improve staff strength in the post contract management of highway projects. The joint inspection/measurement of works by the agency and the consultants, should therefore constitute the basis for the approval of interim certificate of payment. Ensuring the technical adequacy of staff, responsible for the post-contract management of highway projects in the Niger delta, represents another crucial issue which needs to be addressed to guarantee project success.

11.7 Conclusion

The study, has revealed the prevailing geotechnical risk management practices of the highway agencies in the Niger Delta, based on which broader inferences have drawn by the researcher, in relation to the scholarly literature, and the literature on geotechnical best practice. Several unanticipated social constructs in the organisational and institutional settings of the agencies operating in the Niger Delta have also emerged, as factors impacting on the level of geotechnical input inherent in the practices of the agencies. Recommendations have thus been proffered with a view to achieving best practice in the Niger Delta region, comparable to other more technically advanced highway organisations in developed countries. This is to create a supportive technical organisational platform, to ensure that value for money in investment in highway development is achieved. The study has thus shown that to better manage the risks inherent in the wetland conditions of the Niger Delta, the highway agencies need technical capacity in geotechnical risk management. Geotechnical aspects of highway delivery must therefore be strengthened, and the poor risk perception attitude and culture surrounding the procurement of highway projects, need to be changed, to give geotechnical concerns a higher priority status.

11.8 Study Reflections and Positionality of the Researcher

The researcher started off this study, having concluded a Bachelor's degree in Quantity Surveying, and an MPhil degree in Environmental Management, based on a dissertation work titled 'A bioclimatic study of building design and cost in Nigeria'. The researcher's academic interest has thus been largely defined by cross-disciplinary research via the interface between the financial and technical aspects of construction and the natural environment. As a follow up on the M. Phil dissertation, which basically dealt with the financial and physiological impact of climate on building construction in Nigeria, the researcher was motivated to extend this line of interest to the engineering/geotechnical aspect of the interfaces between the built and the natural environment, for a PhD. This was enabled by a background in environmental geotechnics, sedimentology, and hydro-geology courses, undertook as part of the M. Phil course work.

In furtherance of this line of research, the PhD study was initially focused on developing a mathematical costing model, as an artifact to improve the accuracy of estimates at the conceptual costing phase of highway projects in the Niger Delta, due to its heterogeneous ground profile. The research was thus initially targeted to quantitatively model the significant disparities in cost that arise from design adaptations to suit the peculiar problematic terrain and subsoils of the Niger Delta region of Nigeria, and further develop an engineering geologic mapping based costing prototype, using a Geographic Information System interface.

The methodology proposed at this point was heavily influenced by the researcher's inherently quantitative inclination, as a Quantity Surveyor. This was because the researcher had a narrow view and understanding of the issue of cost overruns, and mostly related it to the limitations in the techniques used in preparing estimates. In common with other built environment professionals, the researcher conception of research was a purely positivist approach. The research focus was however latter redefined to probe wider into the range of geotechnical issues which underlie the unusually high level of cost overruns experienced in completed highway projects. This realignment of the research focus, resulted in a shift in the researcher's positionality from a purely positivist orientation to a mix method paradigm.

The researcher at the start of the research was also narrowly focused on understanding the purely technical shortcomings, due to the perceived discrepancies between the theory of best practice and the practice of the highway agencies, in terms of their approach to the containment of ground related risks in highway projects. As such, only the technical issues principally revolving around subsoil conditions of the Niger Delta region, constituted the primary emphasis of the study. These were presupposed as being the more profound underlying factors that needed to be investigated, to understand the propagation of significant cost overruns in the Niger Delta. With this technical orientation, the potential geotechnical cost drivers were identified from the geotechnical literature. The study was thus limited to statistically validating that poor geotechnical practices were the primary cost overrun drivers contributing significantly to spate of project delays and abandonment in the geologic context of the Niger Delta.

However, as the research evolved, a reflexive adaptation of the research was warranted by the emerging socio-cultural trends in the data, which widened the researcher's pre-conceived technical perspective, to understanding the role that the wider contextual setting of highway organisations played in propagating cost overruns in highway projects. Whilst these additional findings did not necessarily negate the researcher's technical stance, the researcher's personal and professional beliefs and understanding of the phenomena of cost overruns in public projects, significantly widened. As a result, the researchers' positionality shifted from one focused only on technical issues, through the lens of geotechnical risk management, to a wider prospective, of how less tangible theoretical social constructs concomitantly interplay with technical factors in organisations, leading to cost growth.

11. 9 Scope for Further Research

The poor level of Geotechnical Risk Management (GRM) in highway projects, executed in the Niger Delta region of Nigeria, has been identified from this research. Particularly, the adverse non-project specific 'Organisations and People' related variables in the highway agencies, has been shown to speedily diminish, and impede geotechnical best practice. This is typically evident in the low level of technical competence and skills in the design and costing of highway projects, and the deficient institutional arrangements within the highway agencies. This emergent view of geotechnical practice, calls for further research, necessary to develop a risk-based transformation improvement framework, in other to align best practice into highway project delivery in the Niger Delta region. Such transformation framework should therefore be targeted at addressing four fundamental areas of GRM identified in this study:

1. Training to acquire/sensitize an awareness of the value for money benefits of GRM, and the application of such knowledge within transportation projects.
2. Tools, methods and conventions, essential for the highway agencies to practise geotechnical risk management.
3. Rousing the in-house technical professionals to apply GRM
4. Policy direction for non-geotechnical decision makers in the highway agencies, who ultimately determine the amount of resources, such as money and time, to be allocated to geotechnical concerns.

Also implicit in the findings of this research, is the need to tackle the social vices plaguing the procurement system for highway infrastructure in the Niger Delta, which necessitates a major culture shift. This is necessary to create a viable socio-economic platform for the meaningful development of the much needed highway infrastructure in the backward Niger Delta region. The findings from this study has thus opened up a whole 'can of worms', on the critical and fundamental issues plaguing highway development in the Niger Delta, which provides several leads for future research.

However, although the theory generated from this study is mostly limited to explaining the propagation of unusually high cost overruns in the geo-political and socio-cultural setting of highway development in the wetland terrain of the Niger Delta region of Nigeria, there is scope for further research to test the generalisability of theory forwarded in this study to other developing nations. This is against the backdrop of the paucity of organisational studies on highway projects in developing countries, which go beyond the artificiality of questionnaire studies, that mostly sample the general opinions of construction professionals.

The insider perspective of the highway organisations provided in this study, also serves as a lead for carrying out further related empirical research on highway projects, outside the confines of the developing world, to explore the interdisciplinary links between the social and technical risk aspects of construction projects. This research has thus pointed out new directions for further in-depth mix method studies, needed to investigate and get a close feel of the technical dynamics of public infrastructure projects, as products of the social settings prevailing in public agencies. This is against the backdrop of the current renewed emphasis on trans-disciplinary construction management research, to ensure value for money and better management of project risks.

Appendix A: Pilot and Final Drafts of Interviews

Appendix A1: Civil Engineers Initial Interview Guide

1. Does your agency use the Transportation and Road Research laboratory (TRRL) (1993) guidelines which are adopted as the Nigerian Highway design standard (was deleted to assess the level of awareness of the respondents) for the design of your flexible pavements? (YES/NO)
2. If No, is there a recognised national or international standard of design that your agency uses to develop their road designs?
3. What is the approach to designing your road projects: do you prepare designs for individual road projects or do you use standard designs?
4. What are the key variables that are used as a basis for preparing road designs in your agency?
5. What are the standard dimensions and lane width of roadways for road projects executed by your agency?
6. What traffic class and loading are the roads designed for?
7. In the Niger Delta, ground conditions have been recognised as a major factor affecting designs. What are the issues relating to ground conditions of the Niger Delta terrain that are principally reflected in your designs? (Was deleted as it was a repetition of Q4)
8. How does your organisation prepare designs when a road project traverses various soil types?
9. How does your organisation identify the varying subsoil conditions along a road route?
10. What level of site investigation does your organisation carry out?
    - Desk study;
    - Preliminary site reconnaissance;
    - Detailed ground investigations.

11. At what point during the design of projects are the services of geotechnical consultants engaged? (*Moved upwards to be more logical and coherent)*

12. Do you include ground investigation reports as part of your contract documentation? (Deleted as the question was *deemed as being more appropriate for quantity surveyors*)

Appendix A2: Final Interview Civil Engineers Guide **<u>(AA- DIG1-Nov' 14)</u>**

Overview

1. What is your job description, experience and professional qualifications?

2. Please could you describe the organisational structure of your agency and the job description of the functional units responsible for the execution of road projects?

(Q1 and 2 included to gain demographic information, also order of questions was reshuffled to achieve a more logical flow)

Design Unit

3. Do you prepare your road designs within the internal structure of your organisation or are your road designs prepared by external consultants?

4. What is the approach to designing your road projects: do you prepare designs for individual road projects or do you use standard designs?

5. What are the standard dimensions and lane width of roadways for road projects executed by your agency?

6. What traffic class and loading are the roads designed for?

7. What are the key variables that are used as a basis for preparing road designs in your agency?

8. Do you use the Transportation and Road Research laboratory (TRRL, 1993) Overseas Road Note guideline, for the design of your flexible pavements? (YES/NO)

9. If no, is there a recognised national or international standard of design that your agency uses to develop their road designs? (*Included to further explore the level of awareness of the respondents*)

10. How does your organisation prepare designs when a road project traverses various soil types?

11. How does your organisation identify the varying subsoil conditions along a road route?

12. If yes, at what point during project development are the services of a geotechnical professional deployed and what is their role in the project development?

13. What level of site investigation does your organisation carry out?
    - Desk study;
    - Preliminary site reconnaissance;
    - Detailed ground investigations.

Please could you further explain your response?

Appendix A3: Initial Draft Quantity Surveyors Interview Guide

1. What are the phases of highway development that road projects have to go through before construction? Please could you give any time scales? *(Redrafted to using more appropriate terminologies)*
2. What are the functions of different units in your agency responsible for highway projects and how are funds budgeted for proposed schemes?
3. How are road costs estimated in your agency at the preliminary phase?
4. What is the level of accuracy achieved based on your initial project estimates?
5. What factors based on your working experience typically cause projects to run over budget?
6. Whereby road projects traverse various soil types how does your organisation reflect this in the initial and detailed estimates? *(Redrafted to using more appropriate terminologies)*
7. Do you think the ground conditions encountered at project site is a major cost factor that can affect the ability of your projects to be carried out within budget? *(Redrafted to using more appropriate terminologies)*
8. What contractual provision is made in the event that different soil conditions are encountered after contract award?
9. Are there any failed or abandoned projects that occurred on the grounds of unexpected ground conditions?
10. If yes, what was the magnitude of financial undertone involved?

Appendix A4: Quantity Surveyors Final Interview Guide (AA- DIG1-Nov' 14)

1. What is your job description, experience and professional qualifications?
2. Please could you describe the organisational structure of your agency and the job description of the functional units responsible for the design, costing and execution of road projects? *(Q1 and Q2 included to build up demographic information)*
3. Please could you describe the various phases of project development from the budgetary phase to the commissioning of projects by your organisation?
4. How are road costs estimated in your agency at the preliminary phase of road projects?
5. What level of accuracy is achieved based on your initial project estimates? Do the final cost of construction of your projects normally within the initial budgeted funds?
6. What factors based on your working experience typically cause projects to run over budget?
7. Has your agency experienced a significant number of abandoned or delayed projects due to ground conditions?
8. Whereby road projects traverse various soil types how does your organisation reflect this in the initial and detailed estimates?
9. What procurement system is adopted in the award of road contracts: Traditional or Design and Build? *(Included)*
10. What conditions of contract is used by your agency**?** *(Included as a lead-in question)*
11. What contractual provision is made in the event that different soil conditions are encountered after contract award?
12. Do you include ground investigation reports as part of your contract documentation?
13. Do you think the level of site detail provided for ground conditions affects project delivery in terms of the level of claims, delays, cost overruns occurring for your road projects? *(Included to further explore the issue*)
14. Are there any failed or abandoned projects that have occurred on the grounds of unexpected ground conditions?
15. If yes, could you give a few isolated instances and the magnitude of financial undertone involved?

Appendix A5: Road Contractors Initial Draft Interview Questions

1. What is the basic documentation that are usually used in the award of road contracts executed by your firm?
2. Are ground Investigation reports included as part of this documentation for road contracts in the Niger Delta?
3. Do you think that the nature of the ground at the site of any road project is a major risk factor for road contracts executed by your firm in the Niger delta?
4. How does your firm assess the nature of the soils prevailing at road sites when tendering for contracts?
5. How do you compute your rates to reflect the risk of encountering poor soil conditions?
6. Does the inclusion or exclusion of ground investigation reports affect the bid values submitted during tender?

Appendix A6: Final Road Contractors Interview Guide

1. What forms of procurement have been used in the projects handled by your organisation? (*Included based on observations from pilot respondents*)

2. What is the basic documentation that is provided as a basis of bidding for road contracts and how adequate is it in terms of information required for preparing your bid estimates? *Question further clarified to better relay meaning.*

3. Is ground Investigation reports included as part of this documentation for road contracts awarded to your organisation? Yes/ No

   If no, does your firm carryout Ground Investigations before bidding for contracts. *(Deleted as the question was noted during the piloting phase as too obvious and was also a repetition of Q6*)

4. Do you think that the nature of the ground at the site of any road project is a major risk factor for road contracts in the Niger delta?

5. How does your firm assess the nature of the soils prevailing at road sites when tendering for contracts?

6. What are the specific technical ground related risk factors you have encountered during contract execution? *(Added from response pattern in piloting)*

7. Has your firm ever opted out of bidding for jobs on the basis of risk perceived due to ground conditions? *Added based on comments from pilot phase as to the possibility of this scenario occurring.*

8. How do you compute your rates to reflect the risk of encountering poor soil conditions?

9. Does the inclusion or exclusion of ground investigation reports affect the bid values submitted during tender?

10. What are your pricing strategies in bidding for highway contracts executed in upland as compared to riverine areas? *Added based on comments from the piloting phase.*

Appendix A7: Initial Draft of Consultants Interview Guide (AA-FIG1- Feb' 15)

1. Please could you give a brief introduction to your professional background, experience and qualifications?

Designs

2. What are the major variables that have the most significant impact on road designs prepared by your firm?

-

3. What are the standard dimensions and lane width of roadways for state road projects?

4. What traffic class and loading are the roads designed for?

5. Do you use the Transportation and Road Research laboratory (TRRL, 1993) Overseas Road Note 31 guideline, which is currently adopted as the Nigerian Highway design standard, for the design of flexible pavements? (YES/NO)

6. If no, is there a recognised national or international standard of design that your organisation uses to develop road designs?

Soils

7. In the Niger Delta, ground conditions have been recognised as a major factor affecting designs. What are the issues relating to ground conditions of the Niger Delta terrain that are principally reflected in your designs?

8. How does your organisation prepare designs and cost estimates when a road project traverses various soil types?

9. How does your organisation identify the varying subsoil conditions along a road route?

10. At what phase of project development are the services of geotechnical professional in your firm deployed and what is their role in the project development?

11. Does your organisation carryout ground investigation prior to the design of roads? Yes/No

12. If yes, what level of site investigation your organisation carries out before the design of road projects?
    - Desk study;
    - Preliminary site reconnaissance;
    - Detailed ground investigations. (Deleted as too obvious)

13. Please could you further explain your response (Deleted, as merged in 12)

Appendix A8: Final Consultants Interview Guide (AA-FIG1- Feb' 15)

1. Please could you give a brief introduction to your professional background, experience and qualifications?

Designs

2. What are the major variables that have the most significant impact on road designs prepared by your firm?

▪

3. What are the standard dimensions and lane width of roadways for state road projects?

4. What traffic class and loading are the roads designed for?

5. Do you use the Transportation and Road Research laboratory (TRRL, 1993) Overseas Road Note 31 guideline, which is currently adopted as the Nigerian Highway design standard, for the design of flexible pavements? (YES/NO)

6. If no, is there a recognised national or international standard of design that your organisation uses to develop road designs?

Soils

7. In the Niger Delta, ground conditions have been recognised as a major factor affecting designs. What are the issues relating to ground conditions of the Niger Delta terrain that are principally reflected in your designs?

8. How does your organisation prepare designs and cost estimates when a road project traverses various soil types?

9. How does your organisation identify the varying subsoil conditions along a road route?

10. At what phase of project development are the services of geotechnical professional in your firm deployed and what is their role in the project development?

11. Does your organisation carryout ground investigation prior to the design of roads? Yes/No

12. If yes, please could you describe the procedures of site investigation your organisation carries out before the design of road projects?

Appendix B: Organisation Management Consent/Agreement Letter (AA-OMC1-Nov'14)

Research Title: Explaining Cost overruns in Highway Projects

Researcher: xxx (PhD candidate, University of Salford, School of Built Environment)

The project investigates the financial implications of differing ground conditions that are typically encountered in the Niger Delta Region of Nigeria as a basis for which improvement in the existing approach to road cost estimation can be predicated. It is therefore hoped that your organisation could benefit from the study to be able to generate more accurate cost forecasts during the planning and contractual phase of road works.

In order to meet the objectives of the study named above, the researcher needs to collect information required to carry out the research. The researcher therefore seeks your permission to access past road project information as well as to recruit delegates who could provide useful information on the basis of designs and estimation in your agency. The anonymity of delegated respondents and the organisation would be maintained within the research. The researcher wishes to emphasize that the information provided by your organisation could determine the ultimate outcome of the research. Study findings would be communicated back to your organisation.

Your requested contribution to the study is based on your granting access to your project records and delegating the appropriate personnel. Signing this form acknowledges your permission. Thanks for your kind consideration of my request.

-------------------------------- **-------------------**

Management Signature **Date**

Appendix C: Consent Form

Improving the Accuracy of Conceptual Estimates in the Costing of Bituminous Paved Highway Routes in the Niger Delta

Having taken the time to read the information sheet provided, please tick the relevant boxes as part of your consent to take part in the study.

	Yes	No
Taking Part		
I have read and understood the project information sheet dated DD/MM/YYYY.	☐	☐
I have been given the opportunity to ask questions about the project.	☐	☐
I agree to take part in the project. Taking part in the project will include being interviewed and recorded (audio).	☐	☐
I understand that the interview transcripts would be made available to me to ascertain its accuracy.	☐	☐
I understand that my taking part is voluntary; I can withdraw from the study at any time and I do not have to give any reasons for why I no longer want to take part.	☐	☐
Use of the information I provide for this project only		
I understand my personal details such as phone number and address will not be revealed to people outside the project.	☐	☐
I understand that my words may be quoted in publications, reports, web pages, and other research outputs.	☐	☐

*Please choose **one** of the following two options:*
I would like my real name used in the above ☐
I would **not** like my real name to be used in the above. ☐

______________________	______________________	________
Name of participant [printed]	Signature	Date
______________________	______________________	________
Researcher	[printed] Signature	Date

Appendix D: Participant Invitation/information Sheet

Explaining Cost Overruns in Highway Projects: A Geo-Spatial Regression Modelling and Cognitive Mapping of Latent Pathogens and Contextual Drivers

Invitation

You are invited to be part of an academic research study. The above named project is carried out as part of a PhD research programme at the University of Salford, United Kingdom by Amadi Alolote Ibim under the School of built environment. Below is a brief outline of the research for your perusal to inform you on the purpose of the research. You are urged to read the information provided below as basis on which you can decide to partake in the study.

Project Details

The project investigates the financial implication of differing ground conditions that are typically encountered in the Niger Delta Region of Nigeria. The Niger delta is one of the largest wetlands in Africa and like all deltas is crisscrossed by a myriad of streams interwoven with patches of relatively dry lands. This gives rise to a complex and heterogeneous set of sub-soils. Highway routes in the region typically span across various soil types with differing engineering properties with should ideally imply a corresponding variation in the design of road sections and resultant cost. The study against this background investigates the practice of highway agencies in Rivers State as case studies in comparison to the theoretical requirements of good practice in estimating. The researcher embarks on this study due to the significant impact that ground conditions, which is considered to be the primary variable shaping the cost profile of road works in the Niger delta, has on the accuracy of preliminary cost estimates. The potential outcome of the study would be the development of an approach to costing that could be used to improve the costing of bituminous pavements traversing different soil types in the region. It is therefore hoped that highway agencies could benefit from the study to be able to generate more accurate cost forecast during the planning phase of road works.

Your Role in the Study

To embark on this study therefore, the researcher requires access to individuals within the highway agencies in Rivers State which has been chosen as a typical instance of the various soil types that are typically encountered in the Niger Delta. Also the researcher would seek expert opinions from highly experienced consultants to gain their perspectives on the technical details of how the problematic terrain of the Niger delta region affects the costs of pavement construction for road works.

The researcher kindly solicits your cooperation to be participants in this study as highly valued inputs for the successful conduct of the research. The researcher wishes to expressly state that the anonymity of respondents would be maintained at all times. Information disclosed in the course of the interview would be treated with the utmost level of confidentiality as part of the ethical requirements of conducting research at the University of Salford. Information sought would be used for purely analytical purposes as part of this academic exercise which would be subsequently published. There would be no reference to names or any personal details of the participants in any research publication arising from the study.

The researcher also wishes to inform potential participants that participation in the research is purely voluntary and that at any point during or after the conduct of the interviews participants are free to withdraw from the study. Under such circumstance the researcher is thus ethically bound not to use such information as may have been provided. No undue influence should therefore be perceived as a basis for participating in the study as participant's willingness to be part of the study is strongly advocated for.

The researcher would thus appreciate if a convenient time can be arranged for the conduct of telephone interviews which would last for an approximate duration of thirty minutes. The researcher also wishes to inform the respondents that the interview conversation would be audio recorded for the purpose of the research. The taped conversations would be securely kept and destroyed after it has served its purpose of analysis. Taped interview conversation would be transcribed and made available for your viewing. As such all necessary measures to safeguard any information received and its accuracy would be taken.

Thanks for taking time to read this information. Any potential queries regarding the study should be directed to

- Amadi Alolote
- PhD candidate
- School of Built Environment
- University of Salford
- a.i.amadi@edu.salford.ac.uk
- Tel No: 07466762469

Appendix E: Ethical Approval

Academic Audit and Governance Committee

College of Science and Technology Research Ethics Panel
(CST)

MEMORANDUM

To **Amadi Alolote (and Prof David Eaton)**

cc: **Professor Hisham Elkadi, Head of School of SOBE**

From **Nathalie Audren Howarth, College Research Support Officer**

Date **12/01/2015**

Subject: **Approval of your Project by CST**

Project Title: **Improving the Accuracy of Estimates in the Costing of Bituminous Paved Highway Routes in the Niger Delta**

REP Reference: **CST 14/66**

Following your responses to the Panel's queries, based on the information you provided, I can confirm that they have no objections on ethical grounds to your project.

If there are any changes to the project and/or its methodology, please inform the Panel as soon as possible.

Regards,

References

AACE. (1997). Cost Estimate Classification System. The Association for the Advancement of Cost Engineering, Recommended Practice No. 17R-97:

Abam, T. K. S., Osadebe, C. C and Omange, G. N. (2005). Influence of geology on pavement performance: A case study of Shagamu-Benin City Road, southwestern Nigeria. *Global Journal of Geological Sciences*, 3 (1), 17-24.

Abandoned Projects Audit Commission (2014). Report of the Abandoned Projects Audit Commission set up by President Goodluck Jonathan in 2011.

Abd El-Razek, M.E., Bassioni, H.A and Mobarak. A.M. (2008). Causes of delay in building construction projects in Egypt. *Journal of Construction Engineering and Managemen*t, 200, 831–841.

Adeege, O.O. (1995). *Effective Reduction in the Cost of Structures*. Minna: Rinka Publishing House.

Adegbemi, O. B., Afees, S and Olasunkanmi, O. I. (2012). 'Infrastructure and economic growth in Nigeria: A Multivariate Approach. *Research Journal of Business and Accounting*, 78-85.

Adesunloye, M.O. (1987). Investigating the problem soils of Nigeria. *9th regional conference on soil mechanics and foundation Engineering for Africa,* 1 A.A. Balkema,103-112.

Africa Check Facts Sheet. (2014) [online] Available at https://africacheck.org/factsheets/factsheet-nigerias. Accessed 23/07/2015

Africa check Home Page. (2014). Transportation in the Niger Delta [online]. Available at <www.igbofocus.com>. Accessed 20/04/2014

African Development Bank. (2013). Developing Africa's Infrastructure for Enhanced Competitiveness. *World Economic Forum,* The Africa Competitiveness Report.

African Infrastructure Country Diagnostic. (2008). Unit Costs of Infrastructure Projects in Sub-Saharan Africa, Africon

Agbebaku, C. A. (2003), "Law and Development in Nigeria: The Impact of the Niger Delta Development Commission (NDDC) on Development Efforts". In F. E. Iyoha, S. O. J. Ojo and P. O. Oviasuyi (eds), Women, Youth Restiveness and Development in the Niger Delta Region, Ekpoma: Institute for Governance and Development, 152 – 163.

Agbola, T. and Olurin, T. A. (2003), "Land use and Landover Change in the Niger Delta", excerpts from a Research Report presented to the Centre for Democracy and Development.

Ahiaga-Dagbui D.D, Smith S.D, Love P.E.D, Ackermann F (2015) Spotlight on construction cost overrun research: superficial, replicative and stagnated, In *Proceedings of the 31st Annual ARCOM Conference*, Raiden A and Aboagye-Nimo E (Eds), Association of Researchers in Construction Management 7-9th Sept, 2015 Lincoln, UK

Ahiaga-Dagbui , D. D and S.D. (2014). Rethinking construction cost overruns: cognition, learning and estimation. *Journal of Financial Management of Property and Construction*, 19(1), 38 - 54

Aibinu, A.A. and Odeyinka, A. (2006). Construction delays and their causative factors in Nigeria. *Journal of Construction Engineering Management*, ASCE, (132) 7, 667-677.

Aigbedion, I. (2007). Geophysical investigation of road failure using electromagnetic profiles along Opoji, Uwenlenbo and Illeh in Ekpoma-Nigeria. *Middle-East Journal of scientific Research*, 2 (3-4).111-115

Aisuebeogun, A. (1995). The Port Harcourt region; land form characteristics of the environment. *Journal of Geographic Thought*. (1) 10 – 14

Aiyetan, A.O. (2010). Influences on construction project delivery time. A PhD thesis submitted to the Nelson Mandela Metropolitan University

Ajayi, L. A. (1987). Thoughts on road failures in Nigeria. *The Nigerian. Engineer*, 22 (1), 10-17.

Ajibade, A. and Odeyinka, H. (2006) Construction Delays and their Causative factors in Nigeria. *Journal of Construction and Engineering Management*. 132(7), 667- 677

Akinola, R.S. (2003). Resolving The Niger Delta Crises Through Polycentric Governance System, *Workshop in Political Theory and Policy Analysis*. Department of Public Administration, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.

Akintoye, A. and Fitzgerald, E. (2000) A survey of current cost estimating practices, *Construction Management and Economics*, 18(2), 161-72.

Akinyemi, E. O. (1983). Towards a developed national transportation system in Nigeria: technological challenges and mechanisms for progress. In, Ibiejugba, J. and Adeniyi, J. (eds.) Technological Developments and Nigerian Industries, 1, 190-210.

Akoa, B.B. (2011). Cost Overruns and Time Delays in Highway and Bridge Projects in Developing Countries- Experiences from Cameroon. An unpublished Master's thesis submitted to Michigan State University

Akpan, E.O.P., Amade, B., Okangba, S.E, and. Ekweozor, C.O. (2014) Constructability Practice and Project Delivery Processes in The Nigerian Construction Industry. *Journal of Building Performance,* 5(1). 10-18.

Akpokodje, E.G. (1987b) The engineering-geological characteristics and classification of the major superficial soils of the Niger Delta. *Engineering Geology* 23(4),193-211.

Akpokodje, E.G. (1989). Preliminary Studies on the Geotechnical Characteristics of the Niger Delta Subsoil. *Engineering Geology*, 26, 247 – 257.

Akpokodje, E.G (1987a). Engineering geology of the Niger-delta. *9th regional conf. for Africa on soil mechanics and foundation engineering*. A.A. Balkema/Rotterdam/Boston. 751-760.

Al-Amodi, O.S.B., Asi, I. M., Al-Abdul Wahab, H. I., and Khan, Z. A. (2002). bearing ratio correlations. Journal of Materials in Civil Engineering ASCE. 512-523. Clegg Hammer-California

Alavi, S.A. and Tavares, P.E. (2009). Highway project cost estimating and management. The State of Montana Department of Transportation. Final Report

Albatal, A.H., Kotb, A.S and Mohammad, H.H. (2010) Effect of Inadequate Site Investigation on the Cost of Road Construction (Case Study). An un published PhD thesis. Construction and Building Department, Faculty of Engineering, Arab Academy for Science, Technology & Maritime Transport, Cairo, Egypt.

Alhalaby, N.M.H. and Whyte, I. L. (1994) The impact of ground risks in construction on project finance. Risk and reliability in ground engineering: The Institution of Civil Engineers conference. Thomas Telford, 54-67.

Allahaim, F. D and Liu, L. (2013). Understanding Major Causes Cost Overrun for Infrastructure Projects; A Typology Approach. *Annual Conference of the Australasian Universities Building Educators Association* (AUBEA)The University of New South Wales, Australia

Allal, M and Edmund, G.A. (1997). Manual for the planning of Labour intensive road construction. ILO Publication. Geneva.

Al-Sudairi, A. A. (2007). Evaluating the effect of construction process characteristics to the applicability of lean principles. *Construction Innovation*, 7(1). 99-121.

Al-Tabtabai, H., Alex, A., and Tantash, M., (1999) "Preliminary Cost Estimation of Highway Construction Using Neural Networks," Cost Engineering, Association for the Advancement of Cost Engineering, Morgantown, 41(3), 19-24.

Al-Tabtabai1, H. (1998) A framework for developing an expert analysis and forecasting system for construction projects. *Expert Systems with Applications* 14(2) 259–273

Altshuler, A. and D. Luberoff. (2003). Mega-Projects: The Changing Politics of Urban Public Investment. Brookings Institution, Washington DC

Amade, B. (2012) "Partnering Mechanisms and the Procurement of Building Construction Projects Delivery" *International Journal of Advanced Scientific and Technical Research*. 6(2) 596-620.

Amadi, A. (2009). A Bioclimatic Approach to Shelter Design in Nigeria. An unpublished Masters Dissertation submitted to the Rivers State University of Science and Technology. Port Harcourt. Institute and Geo-Sciences and Space Technology.

Amasuomo, O.M. (2014). Procurement of Functional Rural Primary School Buildings through the Application of Appropriate Technology for Building Materials and Construction. *Academic Journal of Interdisciplinary Studies*, MCSER Publishing, Rome: Italy 3(1) 45-53.

American Association of State Highway Transport Officials. (1993). Guide for Design of Pavement Structures. Highway and Transportation Officials, Washington, DC.

American Society of Civil Engineers. (1990). Construction Risks and Liability Sharing, Volume 2. *American Society of Civil Engineers*, Washington, DC.

An, S., Kim, G, and Kang, K. (2007). A case-based reasoning cost estimating model using experience by analytic hierarchy process. *Journal of Building and Environment*. 42(7), 2573–2579.

Andawei, M. (2015). Risk factor rating of construction projects in the Niger Delta region. *Journal of Engineering Manufacturing and Technology*.1-10.

Anderson, S., Molenaar, K., and Schexnayder, C. (2006). "Guidance for cost estimation and management for highway projects during planning, programming, and preconstruction." Final Report 574, National Cooperative Highway Research Program (NCHRP), Washington, DC.

Anon, G. (1999). "LRN Supply Chain Re-Engineering Workshop." Logistics Focus, May, 7 (4), 43-44.

Anyanwu, J.C; Oaikhena, H., Oyefusi, A. and Dimowo, F.A. (1997). The Structure of the Nigerian Economy (1960-1977) Onitsha, Nigeria: Joanne Educational Publishers Ltd

Arain F. M. and Pheng L. S., (2005.) "How design consultants perceive causes of variation orders for institutional buildings in Singapore," Architectural Engineering and Design Management, 1(3),181-196.

Arumala, J. O. and Akpokodje, E. G. (1987). Soil Properties and Pavement Performance in the Niger Delta. *Quarterly Journal of Engineering Geology and Hydrogeology*, 20, 287-296.

Ashton, P. (1998). A definitive framework model for effective site and ground investigative procedure. Unpublished MSc. Dissertation, School of the Environment, University of Brighton.

Ashton, P and Gidado, K (2001) Risk associated with inadequate site investigation procedures under design and build procurement systems. In: Akintoye, A (Ed.), *17th Annual ARCOM Conference 2001, University of Salford. Association of Researchers in Construction Management*, 1, 961-9

Ashton, P. and Gidado, K. (2002). The Identification of uncertainty and risks associated with inadequate ground investigation procedures relative to project complexity. *18th annual conference of the Association of Researchers in Construction Management, UK.*

Ashworth, A, and Hogg, K. (2007). "Willis's Practice and Procedure for Quantity Surveyor", Blackwell Publishing Ltd, Oxford, UK.

Asmar, S.M., Mounir, El Awad, S., Hanna, F., Gary C, and Whited, M. (2011). New approach to developing conceptual cost estimates for highway projects. American Society of Civil Engineers.

Association for the Advancement of Cost Engineering (1997) Recommended Practice No. 17R-97.

Association of Geotechnical and Geo-Environmental Specialists. (2003). Ground Report: A Client's Guide to Desk Studies.

Atkinson, G.M. (1993). Costs that could have been saved by desk studies: Case histories. *Canadian Journal of Civil Engineering*, 40(5): 411-426.

Attala, M., and Hegazy, T. (2003). Predicting Cost Deviation in Reconstruction Projects: Artificial Neural Networks Versus Regression. *Journal of Construction Engineering and Management*, 129 (4), 405-411.

Ayeni J.O. (1997). *Principles of Tendering and Estimating*. Ogbolapa limited. Lagos

Ayodele, E.O. and Alabi, O. M. (2011). Abandonment of Construction Projects in Nigeria: Causes and Effects; *Journal of Emerging Trends in Economics and Management Sciences* (JETEMS), 2 (2), 142-145.

Baccarini, D. (1996). The concept of project complexity- A Review. *International Journal of Project Management,* 14 (4), 201-204.

Baccarini, D. (2004). Accuracy in estimating project cost construction contingency - a statistical analysis, Cobra 2004: RICS International Construction Conference, Responding to Change, 7-8 September. Headingley Stadium, U.K.

Barret, P. S and Sutrisna, M. (2009). Methodological strategies to gain insights into informality and emergence in construction project case studies. Construction Management and Economics, 27(10), 935-948.

Bayelsa State Home Page. (2015). Map of Bayelsa State [online]. Available at <www.bipa.gov.ng/en/index.php/ Bayelsa-state> Accessed 10/06/2015

Bazley, P. (2007). Qualitative Data Analysis with NVivo. SAGE publications, London

BBC (2012). New ECB building in Frankfurt goes over budget. [0nline]. Available at <http://www.bbc.co.uk/news/world-europe> accessed 22/04/2016.

Bell, F. G. (2007). *Engineering Geology* (2nd Ed). Oxford, UK: Elsevier Ltd.

Belli, P., Anderson, J., Barnum, H., Dixon J., and Tan, J. (2001). Economic Analysis of Investment Operations: Analytical Tools and Practical Applications, World Bank Institute.

Birley, G and Moreland, N. (1998). *A practical guide to academic Research*. London: Kogan Page Limited.

Blaikie, N. (2007). *Approaches to social enquiry. Polity Press*, Cambridge, UK.

Blaok, D. (1970). *Qualitative Paradigm Relativism*. Social and Behavioural Research. Chicago, University of Chicago Press.

Bley, A. F. S. (1990). Improved Conceptual Estimating Performance Using a Knowledge-Based Approach, An unpublished PhD Dissertation. The University of Texas at Austin.

Bontekoe, R. (1996). *Dimensions of the Hermeneutic Circle*. Atlantic Highlands, NJ: Humanities Press.

Bordat, C., B. G. McCullouch, S. Labi, and K. C. Sinha. (2004). An Analysis of Cost Overruns and Time Delays of INDOT Projects. Publication FHWA/IN/JTRP-2004/07. Joint Transportation Research Program, Indiana Department of Transportation

Bowles, J.E. (1997). *Foundation Analysis and Design*. McGraw-Hill.

Bresnen, M. Goussevskaia, A. and Swan, J. (2005). Editorial: Managing projects as complex social settings. *Building Research & Information*, 33 (6), 487-493

Brinberg, D and McGrath, J. (1985). *Validity and the research process*. New Bury, Park. CA: Sage

Brook, M. (2004). Estimating and tendering for construction work, 3rd ed. Boston: Butterworth Heinemann.

Brown. S. F., Brunton, J.M, and Stock, A. F. (1985). The analytical design of bituminous pavements. *Proceedings of the. Institution of Civil. Engineers*, 2 (79),1-31.

Brunes, F and Lind, H. (2014). Explaining cost overruns in infrastructural projects: A new framework with applications to Sweden. Working Paper 01 Section for Building and Real Estate Economics, School of Architecture and the Built Environment, Royal Institute of Technology.

Bruzelius, N., Flyvbjerg, B. and Rothengatter, W. (2002). Big decisions, big risks. improving accountability in mega projects. *Transport Policy*, 9(2), 143-154.

Bryman, A. (1989). *Research Methods and Organization Studies*. Contemporary Social Research. Uwin Hyman Ltd

Bryman, A. and Bell, E. (2003) *Business Research Methods*. Oxford University Press, Oxford.

Building Research Establishment. Site investigation for low-rise building: desk studies. Building Research Digest, 1987, No. 318.

CDM Regulations. (1994). Health and Safety: The Construction (Design and Management) Regulations, No.3140 Statutory Instrument. HMSO.

Campbell, A.E (2009). Federal Road Management for Sub-Saharan African Nations: A Nigerian Case Study. An unpublished Master's thesis. Department of Civil Engineering University of Waterloo, Ontario, Canada.

Campbell, R. (2002). A Hundred Years of Phenomenology: Perspectives on a philosophical tradition, Ashgate Publishing Ltd, England, 73-87.

Canning, D. and Fay, M. (1993). 'The Effects of Transportation Networks on Economic Growth,' http://academiccommons.columbia.edu/catalog/ac:99886

Cantarelli, C. C., Chorus, C. G., and Cunningham, S. W. (2013). Explaining Cost Overruns of Large-Scale Transportation Infrastructure Projects using a Signalling Game. Transportmetrica A: Transport Science, 9(3): 239–258.

Cantarelli, C. C., Molin, E. J. E., van Wee, B., and Flyvbjerg, B. (2012). Characteristics of cost overruns for Dutch transport infrastructure projects and the importance of the decision to build and project phases. *Transport Policy*, 22: 49–56.

Cantarelli, C.C., Flyvbjerg, B., Molin, E.J.E and Van Wee, B. (2010). Cost Overruns in Large-scale Transportation Infrastructure Projects: Explanations and Their Theoretical Embeddedness. *EJTIR* 10(1), March, 5-18.

Cantarelli, C.C., Flyvbjerg, B., Molin, E.J.E and Van Wee, B. (2010). "Lock-in and Its Influence on the Project Performance of Large-Scale Transportation Infrastructure Projects. Investigating the Way in Which Lock-in Can Emerge and Affect Cost Overruns," *Environment, Planning and Design*, 37 (5): 792-807.

Carter, B. (2000). *Realism and Racism: Concepts of race in sociological research*. Critical Realism Interventions Series. London: Routledge.

Cathie (2000). Evaluating the cost-effectiveness of Ground investigations. *Site Investigation and Geotechnics*, SUT, London, 77-91.

CBN, (2014). Statistics on Road Failures. Research Department Occasional Paper Series, Central Bank of Nigeria, Abuja, Nigeria.

Central Bank of Nigeria. (2003). Highway Maintenance in Nigeria: Lessons from Other Countries. Research Department Occasional Paper Series, Central Bank of Nigeria, Abuja, Nigeria.

Chan, A. P. C. and. Yeong, C.M. (1995). "A comparison of strategies for reducing variations," *Construction Management and Economics*, 13 (6), 467–473,

Chan, A.P.C., Scott, D. and Lam, E.W.M. (2002). Framework of Success Criteria for Design/Build Projects. *Journal of Construction Engineering and Management,* 130,153-155.

Chan, E. H. W. and Au, M. C. Y. (2007). Building contractors‟ behavioural pattern in pricing weather risks. *International Journal of Project Management*, 25(6), 615-626.

Chang, A. Shing-Tao. (2002). 'Reasons for cost and schedule increase for engineering design projects'. *Journal of Management Engineering*, ASCE, 18(1), 29-36.

Chao-hui Wu , , Ting-ya Hsieh, Wen-lon Cheng. (2005). Statistical analysis of causes for design change in highway construction on Taiwan. *International. Journal of Project Management,* 23(7), 554–563.

Chapman, C. and Ward, S. (1997). *Managing project risk and uncertainty: A constructively simple approach to decision making*. John Wiley & Sons, Ltd.

Chapman, C. and Ward, S. (2002). *Managing project risk and uncertainty: A constructively simple approach to decision making.* John Wiley & Sons.

Charles W. Schwartz and Regis L. Carvalho. (2007). Final Report Volume 2: Evaluation of Mechanistic-Empirical Design Procedure MDSHA Project No. SP0077B41 UMD FRS No. 430572. Maryland State Highway Administration

Chen D and Burrell P. (2001). Case-based reasoning system and artificial neural networks: a review. *Neural Computing and Applications,* 10(4), 264–76.

Chou, J. (2009). Web-based CBR system applied to early cost budgeting for pavement maintenance project. *Expert Systems with Applications,* (36), 2947–2960.

Chou, J. (2005). Item-level quantity-based preliminary cost estimating system for highway earthwork, landscape, subgrade treatments, base, surface courses, pavement and traffic control. Doctoral dissertation presented to the faculty of the graduate school of the University of Texas at Austin

Chou, J. (2010). Cost simulation in an item-based project involving construction engineering and management. *International Journal of Project Management* 29 (11) 706–717.

Chou, J., and O'Connor, J. T. (2007). "Internet-based preliminary highway construction cost estimating database." Journal of Automation and Construction., 17(1),65–74.

Chukwu, O. (2014). The menace of unbaiting project failures, delays and abandonment in the Niger Delta. *Journal of Development and Economic Policy*.123-129.

CIOB. (1997). *Code of Estimating Practice*, 6th Edition, The Chartered Institute of Building, London; Longman,

CIOB. (2010). *Current Methods of Procurement*. The Chartered Institute of Building. Blackwell Publishing

Clark, R.G. (1998). Costs that could have been saved by a Desk Study: A case History. Construction Research Communications.

Clayton, C.R.I., Matthew, M.C and Simon, N.E. (1996). *Site investigation*. Blackwell Science, Oxford

Clayton, C.R.I. (1995). *Site Investigation*. Granada. London

Clayton, C.R.I. (2001). Managing geotechnical risk: Time for a Change. *Proceedings ICE. Geotechnical Engineering.* Paper 149. 3-11 Thomas Telford.

Clayton, C.R.I. Simons, N. E and Matthews, M.C. (1982). Site investigation. a handbook for engineers Department of Civil Engineering, University of Surrey, Granada.

Code of practice for site investigations. (1999). BS5930. British Standards Institution

Coduto, D.P. (2007). *Geotechnical Engineering: Principles and Practices*, Prentice Hall,

Collop, A. (2013). Pavement design in the UK and future developments. Nottingham Transportation Engineering Centre.

Colorado Dept. of Transportation. (2000). "Long range cost estimation research project." CDOT-DTD-R-2000-7, Denver.

Connor, H and Gibson, N. (2003). A Step-by-Step Guide to Qualitative Data Analysis. Pimatiziw Journal of Aboriginal and Indigenous Community Health 1(1) 63-91.

Constitution of the Federal Republic of Nigeria. (1999). Distribution of allocation: Federal, States, and Local Government Areas.

Corder, G. W and Foreman, D. I. (2009). *Nonparametric Statistics for Non-Statisticians*. Hoboken: John Wiley & Sons. 99–105.

AACE, (1997). Cost Estimate Classification System. AACE Recommended Practice No. 17R-97:

Cottrell, D. S. (2006). Contractor process improvement for enhancing construction productivity. *Journal of Construction Engineering and Management*, 132(2).189-196.

Craig, R.F. (2006). *Soil mechanics*. E&FN Spon, New York. pp 447.

Crawle, M. J. (2014). *Statistics: An Introduction Using R*. Second Edition. John Wiley & Sons Inc.

Creedy, D., Skitmore, M., Johnny, K and Wong, W. (2010). Evaluation of Risk Factors Leading to Cost Overrun in Delivery of Highway Construction Projects. *Journal of Construction Engineering and Management.* 528- 538.

Creedy. G.D. (2006). Risk Factors leading to cost overruns in the delivery of highway construction projects. An unpublished PHD thesis submitted to the Queensland University of Technology.

Cresswell, J.W. and Clark, V.L.P. (2011). *Designing and Conducting Mixed Methods Research*. 2nd ed. Thousand oaks, CA; Sage

Cresswell, J.W. (2003). Research Design: *Qualitative, Quantitative and Mixed Methods* Approaches. 2nd ed. Thousand oaks, CA; Sage

Crotty, M. (1998). The foundation of social research: *Meanings and perspectives in the research process*. London: Sage.

Crowley, L and Hancher, D. (1995). Risk assessment of competitive procurement. *Journal of Construction Engineering and Management*, 121, 241–248.

Dainty, A.R.J. (2007). A review and critique of construction management research methods. In Hughes, W. (ed.) *Proceedings of Construction Management and Economics 25th Anniversary Conference, University of Reading*, 16–18 July,143 -151.

Dainty, A.R.J. (2008) Methodological pluralism in construction management research. In *Advanced methods in the Built Environment*, A. Knight and L. Ruddock Eds, West Sussex, Wiley-Blackwell: 75-84

Dapiriteye, A.I. (2007). *Least Cost Modelling for the construction of roads in the Niger Delta. A tool for Route selection.* Pierce hall.

David-West, S.H. (2014). “Economic Development of Nigeria and the Challenge of Road Infrastructure Improvement,” The Nigerian Institution of Civil Engineers (NICE). *The 11th National Civil Engineering conference proceedings*. 32- 39.

Department of Energy. (2011). cost estimating Guide 413.3B, Program and Project Management for the Acquisition of Capital Assets, U.S. Department of Energy Washington, D.C.

Department of Infrastructure, Planning and Natural Resources. (2003). Roads and Salinity. Click Media, Australia: Penrith

Department of the Environment, Transport and the Regions. (2014). Cost Overruns in Highway projects [online]. Available at <nationalarchives.gov.uk> accessed 13/06/15

Descombe, M, (2007). *The Good Research Guide for small scale social Projects*. McGraw Hill, England

Design Manual for Roads and Bridges. (2008.) Managing geotechnical risk. Volume 4 section 1 Part 2 hd 22/08

Dlakwa M. M. and Culpin, M. F. (1990). *Reasons for overrun in public sector construction projects in Nigeria.* Lagos: Butterworth-Heinemann Ltd.

Dobson, P. (2002) 'Critical realism and information systems research: Why bother with philosophy?'[online]. Available at: http://informationr.net/ir/7-2/paper124. Accessed 20/08/2015

Donnell, K. E. (2005). Identification of Potential Strategies, Methods, and Tools for Improving Cost Estimating Practices for Highway. An unpublished Masters dissertation. The Office of Graduate Studies of Texas A and M University

Dul, J. & Hak, T. (2008) *Case Study Methodology in Business Research*, Oxford, Elsevier Ltd.

Durotoye, B. (1983). Geomorphology and quaternary deposits of Nigeria. In "*Tropical soils of Nigeria in engineering practice*", Edited by Ola, S.A., A.A. Balkema/Rotterdam/Boston, 1-15.

Duverlie, P and Castelain, J. M. (1999). Cost estimation during design step: Parametric method versus case based reasoning method. *International Journal of Advanced Manufacturing Technology*, 15(12), 895–906.

Eden, C., Williams, T and Ackermann, F. (2005). Analysing project cost overruns: comparing the ''measured mile'' analysis and system dynamics modelling. *International Journal of Project Management,* 23, 135–139.

Eflis, C. I. (1979). Pavement Engineering in Developing Countries. Transportation and Road Research Laboratory (TRRL) Department of the Environment Department of Transport Supplementary Report 537.

Egan, J. (1998). Rethinking construction: the report of the Construction Task Force. London, Department of the Environment, Transport and the Regions.

Eisenhardt, K. M and Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, 50(1), 25-32.

EJCDC (2016). Conditions of Contract. The Engineers Joint Contract Documents Committee.

Ekeocha, N and Egesi, N. (2014). Evaluation of Subgrade Soils using California Bearing Ratio (CBR) in Parts of Rivers State Journal of Applied Science and Environmental Management,18 (2) 185-187.

El-Kholy, A. M. (2015). Predicting Cost Overrun in Construction Projects. *International Journal of Construction Engineering and Management*. 4(4), 95-105.

Emsley, M.W, David J. L., Roy D, Anthony, H. and Rickson. (2002). Data modelling and the application of a neural network approach to the prediction of total construction costs. Manchester Centre for Civil and Construction Engineering,

Emujakporue, O. G. (2012). Geophysical investigation of the causes of highway failures in Niger Delta sedimentary basin (A Case Study of the Eastern part of East- West Road), Nigeria. *Scientia Africana,* 11 (1).143-152

Esenwa, M. (2008). Asphalt Concrete Pavement: Innovative Partnership for better Roads, Training Note and Guide. Canada.

European Union. (2011). Infrastructure Development: Abandoned, Incomplete and Substandard Projects Sponsored by Federal, State, and Local Governments; Oil Companies and International Organizations since 2000. Report on Public Services, Good Governance and Development in Niger Delta Communities

Evans, T and Peck, P. (2008). Best Practice Cost Estimation for Publicly Funded Road and Rail Construction. Department of Infrastructure, Transport, Regional Development and Local Government. Australia.

Faridi, A.S and El-Sayegh, S.M. (2006). Significant factors causing delay in the UAE construction industry. *Journal Construction Management and Economics.*24(11) 1167-1176.

Farrell, P. (2011). *Writing a Built Environment Dissertation: Practical Guidance and Examples*. Wiley-Blackwell. Chichester.

Fashaye, M.T. (1992). "Construction in Nigeria" The cost of development in the Niger Delta. *Journal of the Nigerian Building and Civil Engineers.* 12(2), 12-18.

Fatokun, O.1. and Bolarinwa, A.I. (2009). Problem soils of Nigeria in road failure investigation. Technical Dept. Nigeria Building and Road Research Institute, (NBRRI), Report No. 13, 30.

Fatokun, O.1. and Bolarinwa, A.I. (2011). Geotechnical characterisation of some major problem soils of Nigeria in road failure investigation. A paper presented at the *National Engineering Conference of Nigeria Society of Engineers (NSE).* Port Harcourt

Federal Acquisition Regulation. (2005). Solicitation Provisions and Contract Clauses. FAC 2005-89-1.Part 52 [online]. Available at <https://www.acquisition.gov/?q=browse/far/52> accessed24/02/2016

Federal Bureau of Statistics. (2013). Federal Account Allocation [online]. Available at <http://www.nigerianstat.gov.ng/> accessed 10-09-2015.

Federal Highway Administration. (2006). American Association of State Highway and Transportation Officials(AASHTO), and National Cooperative Highway Research Program(NCHRP).

Federal Highway Administration. (1976). Occurrence and Distribution Survey of Expansive materials in the United States by Physiographic regions. Report No. FHWA-7682.Office of Research and Development, Washington D.C.

Federal Ministry of Works. (2013). Highway Manual part 1, Paper No. 541. Nigeria. Pavement and materials [online]. Available at <www.works.gov.ng> accessed 20/09/2014.

Federal Ministry of Works. (2006). Compendium report on road infrastructure and related development in Nigeria [online]. Available at <http://www.works.gov.ng/> accessed 13/06/2014.

Federal Road Maintenance Agency. (2007). Medium-term strategy for road sector maintenance management: The Nigeria solution, Nigeria.

Fellows, R. and Liu, A. (2008). *Research Methods for Construction*, 3rd eds, Chichester, Wiley-Blackwell

Fellows, R. (2010). New research paradigms in the built environment. *Construction Innovation: Information, Process, Management*, 10(1),5-13.

Fellows, R. F. and Liu, A. (2015). *Research Methods for Construction*, 4th Edition. Wiley.

FHWA. (2000). Soils and Foundations Workshop, NHI Course No. 132012, Federal Highway Administration, Washington, D.C.

FIDIC. (2005). “MDB Harmonised Conditions of Contract for Construction—General Conditions,”.

Flyvbjerg, B. (2007). ‘Cost overruns and demand shortfalls in urban rail and other infrastructure’, *Transportation Planning and Technology*, 3(1), 9-30

Flyvbjerg, B. (2008). “Curbing optimism and strategic misrepresentation in planning: Reference class forecasting in practice,” *European Planning Studies*, 16(1), 1-21.

Flyvbjerg, B., Garbuio, M and D. Lovall. (2009). “Delusion and deception in large infrastructure projects: Two models for explaining and preventing executive disaster,” *California Management Review*, 51(2) 170–193,

Flyvbjerg, B., Bruzelius, N., and Rothengatter, W. (2003). *Megaprojects and Risk: An Anatomy of Ambition*, Cambridge University Press, Cambridge.

Flyvbjerg, B., Skamris Holm, M.K. and Buhl, S.L. (2002). ‘Underestimating cost in public works. Error or Lie?’, *Journal of the American Planning Association*, 68(3), 279–295.

Flyvbjerg, B., Skamris Holm, M.K., and Buhl, S.L. (2003b). ‘How Common and How Large Are Cost Overruns in Transport Infrastructure Projects?’, *Transport Reviews*, 23(1), 71-88

Flyvbjerg, B., Skamris Holm, M.K., and Buhl, S.L. (2004). ‘What Causes Cost Overrun in Transport. *Fourth Transportation Specialty Conference of the Canadian Society for Civil Engineering* Montréal, Québec, Canada

Franks, J. (1994). *Building Procurement Systems.* Second Edition, CIOB, Ascot, UK.

Frazer, E and Lacey, N. (1993). The Politics of Community: A Feminist Critique of the Liberal-Communitarian Debate. *The Cambridge Law Journal,* 53(3), 619-621.

Fwa, T. F. (1990). Shape Characteristics of Pavement Performance Curves*. Journal of Transportation Engineering*, 116 (5), 692-697.

Gajendran, T. (2011). Investigating informality in construction: philosophy, paradigm and practice’, *Australasian Journal of Construction Economics and Building*, 11 (2), 84-98.

Ganuza, J. (2003). Competition and Cost Overruns in Procurement. Barcelona Economics. Working Paper No107.

Garza, J and Rouhana, K (1995). Neural network versus parameter-based application. *Cost Engineering*,37(2),14–8.

Geddes, S. (1985). *Estimating for Building and Civil Engineering Works*, 8ed, London: Butterworth

Geographical Alliance of Iowa "The Human and Physical Characteristics of Nigeria". Geographical Alliance of Iowa. University of Northern Iowa. Retrieved 2007-08-13. Available at http://www.uni.edu/gai/Nigeria/Background/Standard.

George, E and Atuboyedia, T. J. (2007). Determination of California Bearing Ratio (CBR) Using Light-Weight Dynamic Cone Penetrometer. 14th ARC SMGE, Yaounde, 26-28 November

Georgia Dept. of Transportation. (2007). “Planning level cost estimation study.” ⟨http://www.dot.ga.gov/informationcenter/programs/studies/Pages/CostEstimationStudy.aspx

Gil, N and Lundriganm, C. (2012). The Leadership and governance of megaprojects, Centre for Infrastructure Development (CID), The University of Manchester. Report No.3/2012

Goddey, W. (2011). Infrastructure Development in the Niger Delta. A thesis presented to the department of public administration and local government, faculty of the social sciences, university of Nigeria, Nsukka in partial requirement for the award of doctor of philosophy degree (Ph.D.) in public administration

Government Accountability Office. (2009). Cost Estimating and Assessment Guide, GAO-09-3SP. Washington, D.C.,

Government Accountability Office. (2009). Cost Estimating and Assessment Guide, Best Practices for Developing and Managing Capital Program Costs, GAO-09-3SP, United States

Graham, B. and Thomas, K. (2008). Building Knowledge: Developing a Grounded Theory of Knowledge Management for Construction. *The Electronic Journal of Business Research Methods*. 6(2).115 – 122.

Gransberg, D.D and Gad, G.M. (2014). Geotechnical Requirements in Design-Build Selection Process. Paper presented at the Transportation Research Board (TRB) National Academies Annual Meeting, Washington.

Gransberg, D.D. and S.P. Senadheera. (1998). Design-Build Contract Award Methods for Transportation Projects. *Journal of Transportation Engineering*, ASCE,125, (6), 565-567.

Greene, J.C and Caracelli. (1997). *Advances in mixed method evaluation: The challenges and benefits of integrating diverse paradigms. New directions for evaluations*.74San Francisco: Jossey Bass.

Green Book (2013). Appraisal and Evaluation in Central Government. HM Treasury. London

Grey, D. (2009). *Doing research in the Real World*. SAGE Publications, London.

Grix, J. (2001). Demystifying Postgraduate Research: From MA to PhD. University of Birmingham Press, Birmingham.

Groff, R .(2004). Critical Realism: Post-positivism and the Possibility of Knowledge. *Routledge Studies in Critical Realism*. London: Routledge.

Grove, J. B. (1998). Consultant's Report on Review of General Conditions of Contract for Construction Works, The Government of the Hong Kong SAR

Guba, E. G., and Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin and Y. S. Lincoln (Eds.) *Handbook of qualitative research*,105-117, London: Sage.

Haas, R., Hudson, W. R., and Zaniewski, J. (1994). *Modern Pavement Management*, 2nd ed., Krieger Publishing Company, Malabar, Florida.

Hall, P. (1980). *Great Planning Disasters.* Penguin Books, Harmondsworth.

Halwatura R. U. and. Ranasinghe N. P. N. P. (2013). Causes of Variation Orders in Road Construction Projects in Sri Lanka. *International Scholarly Research Notices*. pp 36- 42

Hammersley, M. and Gomm, R. (2005). Recent radical criticism of the interview in qualitative inquiry. In Holborn, M. and Haralambos, M. (eds) *Developments in Sociology*, 20, Ormskirk, Causeway Press.

Hanachor, M.E. (2012). Community Development Project Abandonment in Nigeria: Causes and Effects. *Journal of Education and Practice* 3 (6).

Harrison, S. (1981) Estimating and tendering – some aspects of theory and practice, Estimating information service, The Chartered Institute of Building, ISSN 0308 8073, No.41. 1981.

Harriss, C. (1998). Why research without theory is not research. A reply to Seymour, Crook and Rooke. *Construction Management and Economics*, 16, 113–116.

Hartmann, A., Dorée, A. and Martin, L. (2010): A Constructivist Approach for Teaching Research Methodology in Construction Management.· *International Journal of Construction Education and Research,* 6, 253-270.

Hedrick, T.E., Bickman, L. and Rog, D.G. (1993). A*pplied Research Design: A practical guide.* Newsbury park, C A: Sage.

Hendrickson, C. (1998). *Project Management for Construction Fundamental Concepts for Owners, Engineers, Architects and Builders*, Prentice Hall

Heron, J. (1996). *Co-operative Inquiry: Research into the Human Condition*. London: Sage.

Heymans, C. and Pycroft, C. (2005). "Drivers of Change in Nigeria: Towards restructuring the political economy", DFID Nigeria.

Hickman, L and Alexander, T. A. (1998). An authoritative collection of Dewey's writings. In *The Essential Dewey*, 2nd eds. Bloomington: Indiana University Press.

Hickson, D.J., Butler, R.J., Cray, D., Mallory, G.R and Wilson, D. (1986). *Top Decisions: Strategic Decision Making in Organisations*. Oxford: Blackwell.

Highways Agency. (2001). Delivering Best Value Solutions and Services—Highways Agency Procurement Strategy. Report of the Highways Agency, London, England,

Hinze, J and Gregory, S. (1991). Analysis of WSDOT Construction Cost Overruns. United States Department of Transportation, Federal Highway Administration. Report No. WA-RD 218.1.

Holden, M.T and Lynch, P. (2004). Choosing the Appropriate Methodology: Understanding Research. *Marketing Review*. 4(4), 397- 406.

Holt, G.D., Olomolaiye, P.O. and Harris, F.C. (1995). A review of contractor selection practice in the U.K. construction industry. *Building and Environment*, 30(4), 553–61.

Holtz, R. D., and Kovacs, W. D. (1981). *An Introduction to Geotechnical Engineering*, Prentice-Hall, Inc., Englewood Cliff.

Huang, Y. H. (1993). *Pavement Analysis and Design*, by Prentice-Hall, Inc., New Jersey,

Huang, Y. H. (2004). *Pavement Analysis and Design*, 2nd edition, Pearson Prentice Hall, New Jersey,

Huberman, A. M and Miles, M.B. (1985). Assessing Local Causality in qualitative research. In D.N. Berg and K.K. Smith Eds. *Exploring Clinical Methods for Social Research*. pp 351-381. New York: Sage.

Ibiba, S. I. (2012). *Niger Delta: Constraints and Pathways to Development*. Cambridge Scholars Publishing

IDOT. (1995). Subgrade Inputs for Local Pavements, Design Procedures No. 95-11, Illinois Department of Transportation, Springfield, IL.

Ighodaro, C. A. (2009). Transport Infrastructure and Economic Growth in Nigeria. *Journal of Research in National Development*, 7 No 2.

Ihuah, P. W and Benebo, A. M. (2014). An assessment of the causes and effects of abandonment of Development projects on real property values in Nigeria. *International Journal of Research in Applied, Natural and Social Sciences*. 2(5), 25-36.

Iloeje, N.P. (1982). *A New Geography of Nigeria*. Fifth Edition. Ikeja: Longman Nigeria Plc.

Indian Roads Congress. (2001). Ministry of Road Transport & Highways Manual for Construction and Supervision of Flexible Works. New Delhi

Indian Standard Method of Test for Soils (1979), Part 16 Laboratory Determination of CBR, First Revision, Bureau of Indian Standards

Infrastructure Risk Group. (2013). Managing Cost Risk & Uncertain. In Infrastructure Projects Leading Practice and Improvement. The Institute of Risk Management, London

Institute of Geosciences and Space Technology. (1996). Geotechnical classification of Niger delta soils Rivers State University of Science and Technology, Port Harcourt, Nigeria

Institution of Civil Engineers. (1991). Inadequate site investigation. A report by the Ground Board. Thomas Telford.

Institution of Civil Engineers. (2001). Managing geotechnical risk: improving productivity in UK building and construction, Thomas Telford,

Institution of Civil Engineers. (1999). Inadequate site and ground investigations leading to construction delays and additional costs. Thomas Telford.

International Railway Journal. (2015). Sweden's Hallandsås Tunnel Project Finally Completed[online] Available at <http://www.railjournal.com> Accessed 20/02/2016.

Isaksson. T. (2002). Model for the estimation of time and cost based on risk evaluation applied on tunnel projects. An unpublished PhD Thesis. Division of Soil and Rock Mechanics Royal Institute of Technology Stockholm, Sweden

Isirimah, N.O. (2004). *Characteristics of the Histosols of the Niger Delta Wetlands*. Owerri: Wontain Books.

Jacob, M. (2012). Cost of Road construction in Developing Countries. Report 897. Federal Emergency Road Management Agency. Nigeria.

Jah, M.K., Schonely, K.C., Jong, C and E. Kim. (2006). *Intelligent road designs. Advances in Transport*. 19.WIT press UK

Jike, V. T. (2004). Environmental degradation, social disequilibrium, and The dilemma of sustainable development in the Niger-Delta Region of Nigeria. Sage Publications

Jing sheng, S.J. (2001). Construction Delays Computation Method. *Journal of Construction and Engineering Management*, 127(1), 60-65.

Johansen, A. (2015). Project Uncertainty Management: A New Approach– The 'Lost Opportunities' Practical uncertainty management seen from a project joint perspective. A Thesis submitted for the Award of a Doctor of Philosophy, Norwegian University of Science and Technology, Faculty of Engineering Science and Technology, Department of Production and Quality Engineering. Trondheim.

John H. Enemugwem. (2009). The Development of the Niger Delta of Nigeria, *Journal of Sustainable Development in Africa*. 10(4), 1960 – 1966.

Joseph L. Gastwirth, Yulia R. Gel and Weiwen Miao. (2009). The Impact of Levene's Test of Equality of Variances on Statistical Theory and Practice. *Statistical Science*. 24(3), 343–360

Joseph, U.N. (2012). Project delays in the Niger Delta region of Nigeria: Significant causes effects and solutions. An unpublished masters Dissertation submitted to the school of engineering and built environment. University of Witwatersrand, Johannesburg.

Jui-Sheng Chou, B.S. (2005). Item-Level Quantity-Based Preliminary Cost Estimating System for Highway Earthwork, Landscape, Subgrade Treatments, Base, Surface Courses, Pavement and Traffic Control. PhD Dissertation, The University of Texas, Austin.

Kahneman, D and Tversky, A. (1979a) Prospect theory: An analysis of decisions under risk. *Econometrica*, 47, 313–327.

Kahneman, D and Tversky, A. (1979b) Intuitive prediction: Biases and corrective procedures, in: S. Makridakis & S. C. Wheelwright (Eds) *Studies in the Management Sciences: Forecasting*, 12-18, Amsterdam: North Holland.

Kahneman, D. (1994) New challenges to the rationality assumption, *Journal of Institutional and Theoretical Economics*, 150, 18–36.

Kain, F, N. (1990). Deception in Dallas: Strategic Misrepresentation in Rail Transit Promotion and Evaluation. *Journal of the American Planning Association*. 56 (2). pp 184-196.

Kaliba, C., Muya, M. and Mumba, K. (2008). Cost escalation and schedule delays in road construction in Zambia. International Journal of Project Management, 27(5), 522-531.

Kalu, U., Ogbonna, E., Mbonu, F and Aniagolu, H. (2014). Does Transportation Sector Have Any Impact On Economic Development? A Time Series Assessment with Nigeria in Focus. *International Journal of Economics, Commerce and Management.* United Kingdom, 2 (8), 31-38.

Kartam, N.A. and Kartam, S.A. (2001). Risk and its management in the Kuwaiti construction industry: a contractor's perspective, *International Journal of Project Management*, 19(6), 325–335

Ketokivi, M. and Mantere, S. (2010). Two strategies for inductive reasoning in organisational research. *Academy of Management Review*.35: 315-33

Kholif, W., Hosny, H., and Sanad, A. (2013). Analysis of Time and Cost Overruns in Educational Building Projects in Egypt. *International Journal of Engineering and Technical Research*, 10(1), 232- 239.

Kim, G., An, S and Kang, K. (2004). Comparison of construction cost estimating models based on regression analysis, neural networks, and case-based reasoning. *Building and Environment*. 39 (10), 1235–1242.

King, N. (2004). Interviews in Qualitative Research. The Modern Language Journal, 2011, Vol.95(4), pp.670-671

King, A. (2008). Using Software to analyse Qualitative data. In *Advanced methods in the Built Environment*, A. Knight and L. Ruddock Eds, West Sussex, Wiley-Blackwell: 75-84

Kolodner J. L. (1992). An introduction to case-based reasoning. *Artificial Intelligence Review*; 6, 3–34.

Kwakye, A. A. (1994). Understanding Tendering and Estimating, Gower, London

Latham, M. (1994). Constructing The Team. Final Report of the Government / Industry Review of Procurement and Contractual Arrangement in the UK Construction Industry. H M S O Publications, July.

Lawrence, H. (2006). *Statistics with STATA. C.* Thomson Books.

Lawson, C. (2003). Critical Issues in *'Economics as Realist Social Theory'. Critical Realism in Economics: Discussion and Debate.* S. Fleetwood, ed. London and NY, Routledge: 209-258.

Lee, K and Kim, K. (2015). Collar Option Model for Managing the Cost Overrun Caused by Change Orders. [online]. Available at www.mdpi.com/journal/sustainability accessed 13/01/2016.

Le-Hoai, L; Lee, Y. D and Lee J. Y. (2008). "Delay and Cost Overruns in Vietnam Large Construction Projects: A Comparison with Other Selected Countries", KSCE *Journal of Civil Engineering*, 12 (6), 367-377

Lincolin, Y and Guba, E. (2003). *Paragdmatic Controversies, Contradictions and Emerging Confluences. Handbook of Qualitative Research*. Thousand oaks, CA Sage163- 188.

Lincolin, Y and Guba, E. (1985). *Naturalistic Inquiry*: London: Sage.

Lipscomb, M. (2011). Critical realism and realist pragmatism in mixed methods: Problematics of event identity and abductive inference (Evolving paradigms in mixed methods research) In: *American Educational Research Association Annual Meeting*, New Orleans, Louisiana, USA, 8th - 12th April.

Littlejohn, G S., Cole. K and Mellors, T W. (1994). Without site investigation ground is a hazard. *Proceedings of the ICE - Civil Engineering*, 102 (2) , 72 –78.

Livneh, M. and Goldberg, Y. (2001). Quality Assessment during Road Formation and Foundation Construction: Use of Falling-Weight Deflectometer and Light Drop Weight, Transportation Research Record 1755, TRB, National Research Council, Washington, D.C., 69-77.

Long, N.D., Ogunlana, S., Quang, T., and Lam, K.C. (2004). 'Large construction projects in developing countries: a case study Vietnam'*, International Journal of Project Management*, 22, 553-561.

Love, P.E.D., Edwards, D.J, and Irani, Z. (2012) Moving Beyond Optimism Bias and Strategic Misrepresentation: An Explanation for Social Infrastructure Overruns. IEEE Transactions on Engineering Management 59(4):560-571

Love P. E. D., Edwards, D. J., Smith, J. and Walker, D. H. T. (2009). "Congruence or divergence? A path model of rework in building and civil engineering projects," *ASCE Journal of Performance in Construction Facilities*, 23(6), 480–488.

Love, P.E.D. (2015). Understanding the Landscape of Overruns in Transport Infrastructure Projects. *Environment and Planning and Design*, 42, 490-509.

Love, P.E.D., Sing, C., Carey, B and Kim, J. (2015). Projects Estimating Construction Contingency: Accommodating the Potential for Cost Overruns in Road Construction. *Infrastructure and Systems,* 21(2).

Lowe, D., Emsley, M., and Harding, A. (2006)." Predicting Construction Cost Using Multiple Regression Techniques." *Journal of Construction Engineering Management*. 132(7), 750–758.

Lundman, P. (2011). Cost Management for Underground Infrastructure Projects: A Case Study on Cost Increase and its Causes, Luleå University of Technology, Luleå.

Lundrigan, C and Gil, N. (2013). Megaprojects: An Evolving Hybrid Meta-Organisation. Centre for Infrastructure Development, The University of Manchester. Working Paper 14/1

Mac-Barango, D.O. (2006). Locational variations in elemental cost of Structures due to climatic and environmental influences in Nigeria. *Journal of the National Institute of Quantity Surveyors*. 54 (2) 18-21

Mackie, P. and Preston, J. (1998). Twenty-one sources of error and bias in transport project appraisal. *Transport Policy,* 5(1), 1-7.

Mahamid, I. (2011). 'Early cost estimating for road construction projects using multiple regression techniques', *Australian Journal of Construction Economics and Building*, 11 (4) 87-101

Mahamid, I and Bruland, A. (2010). Critical Infrastructure Development: Preliminary Cost Estimating models for Road Construction Activities (4592). *FIG Congress,* Sydney, Australia.

Maher ML, Balachandran B. (1993); Multimedia approach to case-based structure design. *Journal of Computing in Civil Engineering* 8(3):359–76.

Majid, I.A. (2006). Causes and effect of delays in Aceh construction industry. MSc diss. University of Technology Malaysia.

Mansfield, N.R., Ugwu, O.O. and Doranl, T. (1994). Causes of delay and cost overruns in Nigerian construction projects. *International Journal of Project Management*, 12(4), 254-260.

Masterman, J. W. E. (2002). "*An Introduction to Building Procurement Systems*, 2nd ed.", Spon Press, London,

Mazouz S and Zerouala M, S. (2001). The integration of environmental variables in the process of architectural design: the contribution of expert systems. *Energy and Buildings*, 33(7):699–710.

Memon, A. H and Rahman, I. A. (2013). Analysis of Cost Overrun Factors for Small Scale Construction Projects in Malaysia Using PLS-SEM Method. *Modern Applied Science*; 7(8), 74-88.

Memon, A., Abdul Rahman, I., and Abdul Aziz, A. (2011), Preliminary Study on Causative Factors Leading to construction Cost Overrun. *International journal of Sustainable Construction Engineering and Technology*, 2 (1), 57-71.

Mendenhall, W and Terry S. (2003). *A Second Course in Statistics Regression Analysis*. New Jersey: Pearson Education, Inc.,

Merewitz, L. (1973b). Cost overruns in public works. In W. Niskanen, A. C. Hansen, R. H. Havemann, R. Turvey, & R. Zeckhauser (Eds.), *Benefit Cost and Policy Analysis,* 277-295, Chicago: Aldine.

Mertens, D.M. (1998). *Research Methods in education and psychology: Integrating Diversity with quantitative and Qualitative Approaches*. Thousand Oaks, CA; Sage.

Michael, D. (2006). *Value and Risk Management: A Guide to Best Practice*. Wiley-Blackwell. London

Miles, J and Shelvin, M. (2001). *Applying Regression and Correlation*. London:

Millard, R.S. (1993). Road Building in the tropics: State of the art review. Transportation research Laboratory, Department of transport.

Mingers, J. (1997). *Multi-paradigm methodology, in Mingers, J. and Gill, A. (eds) Multimethodology: The Theory and Practice of Combining Management Science Methodologies*, Wiley, Chichester, 1–20.

Ministry of Road Transport & Highways. (2001). Manual for Construction and Supervision of Flexible Works. Indian Roads Congress, New Delhi.

Mohamed, K and Abubakar, D. (2012). Causes of Delay in the Nigerian Construction Industry. *Interdisciplinary Journal of Contemporary Research in Business*. 4(2).123-129.

Molenaar, K.R. and D.D. Gransberg. (2001). Design-builder Selection for Small Highway Projects. *Journal of Management in Engineering*, 17(4), 214–223.

Molenaar, K.R., Diekmann, K.E. and Ashley, D.B. (2006). A Guide to Risk Assessment and Allocation. for Highway Construction Management, Report # FHWA-PL-06-032, Federal Highway Administration, U.S. Department of Transportation, American Association of Stare Highway Transportation Officials, and the National Cooperative Highway Research Program, Washington, DC.

Momoh, I. O, Akintorinwa, O. and Olonrunfemi, M. O. (2008). Geophysical investigation of Highway Failure- A case study from the basement complex terrain of Southwestern, Nigeria*. Journal of Applied Sciences Research*, 4(6): 637-648.

Moore, A. W. (1905). Pragmatism and its Critics. *The Philosophical Review*. 14(3). 322-343.

Morris, S. (1990). “Cost and Time Overruns in Public Sector Projects”. *Economic and Political Weekly*, 47,154 to 168. Indian Institute of Management, Ahmedabad

Morris, S. (2003). “Public Investment in India: Delays and Cost Overruns”, India Infrastructure Report.

Morse, J. M. and Richards, L. (2002). *Readme First for a User's guide to Qualitative Methods*, California, Sage Publications.

Nachmais, C.F. and Nachmais, D. (1992). *Research Methods in Social Sciences*. Britain: Edward Arnold

National Aeronautics and Space Administration. (2013). Analytic Method for Probabilistic Cost and Schedule Risk Analysis. Final Report Number: NNH12PV48D. Office of Program Analysis and Evaluation.

National Audit Office (1994). Getting Value for Money from Construction Projects through Design. London

National Audit Office. (2004). Getting Value for Money from Construction Projects through Design. London

National Audit Office. (1989). Quality control of road and bridge construction. HMSO, London.

National Bureau of Statistics. (2015). Nigerian Construction Sector Summary Report: 2010-2012. [online]. Available at <nigerianstat.gov.ng/> accessed 09/08/2015.

National Economic Development Office. (1983). Faster Building for Industry. London: HMSO. National Economic Development Office.

National Economic Development Office. (1988). Faster building for commerce. NEDO, London, National Highway Cooperative Research Program. (2004). " Procedures for cost estimation and management for highway projects during planning, programming, and preconstruction."

National Space Research and Development Agency. (.2013) Federal Ministry of Science and Technology and technology Nigeria

National Transport Policy for Nigeria. (2013). Draft Document, Transport Sector Reform Committee (2004). Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures, Draft Report, Transportation Research Board, National Research Council, Washington, D.C.

NBRRI. (1998). The design and construction of roads best suited to the Nigerian environment.

Nigerian Building and Road Research Institute, Report No. 13(30).

NHCRP. (2006). Procedures Guide for Right-of-Way Cost Estimation and Cost Management. National Cooperative Highway Research Program (NCHRP) Synthesis Report 625. Transportation Research Board.

NDES. (1997). Environmental and Socio Economic Characteristics of the Niger Delta Region. Niger Delta Environmental Survey Report.

NDRDMP. (2001) Niger Delta Regional Development Master Plan.

NDRMP. (2006). The Niger Delta Region, Land and People. The Niger Delta Regional Development Plan Chapter 1. Federal Republic of Nigeria

New Civil Engineer. (2011). Ground Rules [online]. Available at <https://www.newcivilengineer.com/> accessed 20/03/2016.

Newcombe, D.A., and Birgisson, B. (1999). "Measuring In-situ Mechanical Properties of Pavement Subgrade Soils," NCHRP Synthesis 278, Transportation Research Board, Washington, D.C.

Ngah, S. A. and Youdeowei, P.O. (2013). Salinity depths in coastal aquifers of Niger Delta, Southern Nigeria. *Archives of Applied Science Research*, 5 (2),222-233.

Ngerebara, O.D., Abam T. K. S and Nelson K. (2014). Geotechnical soil characterization of Akanfa–Gbaran Road, Bayelsa State, Nigeria*. International Journal of Scientific and Research Publications*, 4(4), 22-31.

Ngo, T.H.D. (2012). The Steps to Follow in a Multiple Regression Analysis. Statistics and Data Analysis, SAS Global Forum.

Niazi, A., Dai, J.S., Balabani, S., Seneviratne, L. (2006). Product cost estimation: technique classification and methodology review. *Journal of Manufacturing Science and Engineering, Transactions of the ASME* 128, 563–575.

Nicholas Hytiris, Robert Stott & Kenneth McInnes. (2014). *World Transactions on Engineering and Technology Education* WIETE. Glasgow, Scotland, United Kingdom 12(3)

Nicholson, J., Elms, D. G. and Williman, A. (1976). A variational approach to optimal route location, *Highway Engineer*. 23, 22-25

Nigel J. Smith, Tony Merna, Paul Jobling. (2006). *Managing Risk in Construction Projects,* Second Edition, Blackwell Publishing. UK

Niger Delta Development Commission (2006). Projects Report

Niger Delta Development Commission. (2013). About NDDC [Online]. Available at: http://www.nddc.gov.ng/ [Accessed 19 August 2014]

Niger Delta Home Page. (2014). Transportation in the Niger Delta [online]. Available at <www.nig.maps.com> accessed 17/03/2014.

Niger Delta Home Page. (2015). Development in the Niger Delta [online]. Available at <http://www.waado.org> accessed 23/06/2015

Niger Delta Home Page. (2015). Map of the Niger Delta [online]. Available at <www.mapsofworld.com › Nigeria Map> Accessed 10/06/2015

Niger-Delta Development Commission Establishment Act. (2000). Act No 6. Laws of the Federation of Nigeria.

Nijkamp, P. & Ubbels, B. (1999). How reliable are estimates of infrastructure costs? A comparative analysis. *International Journal of Transport Economics*, 26(1), 23-53.

NIST/SEMATECH.(2012). E-Handbook of Statistical Methods, Engineering statistics[0n line] available at <http://www.itl.nist.gov/div898/handbook> accessed 15/05/12.

Njoku, I and Ikeji, U. (2012). The Impact of the Quality of Transport Infrastructure on the Nigerian Economy. *Journal of Economics and Sustainable Development.* 3(10), 174 – 180.

Nune, I. (2013). *Critical Realist Activity Theory: An Engagement with Critical Realism and Cultural-historical Activity Theory*. Routledge

Nwankwala, H.O and Oborie, E. (2014). Geo-technical Investigation and Characterization of Sub-soils in Yenagoa, Bayelsa State, Central Niger Delta, Nigeria. *Civil and Environmental Research*. 6(7), 234-240.

O'Brien, J. J. (1998). *Construction Change Orders*, McGraw-Hill, New York, USA,

O'Toole, D. (2006). Differing Site conditions - who bears the risk? Technical Report retrieved from donald.otoole@troutmansanders.com.

O'Connor, H. and Gibson, N. (2003). A Step-by-Step Guide to Qualitative Data Analysis. Pimatiziwin: A *Journal of Aboriginal and Indigenous Community Health*. pp 64-90

Odeck, J. (2004). "Cost overruns in road construction: What are their sizes and determinants?" *Journal of Transport Policy* (11)43–53.

Ogbonna, D.N., Chilaka, S.N., Gobo, A.E. and Amangabara, G.T. (2008). Effect of waste disposal practices and perennial flooding in Port Harcourt Metropolis, Journal of Research in Bioscience, 4(3),103-110.

Oguara, T. M. (2002). Sustainable Development of High Infrastructure in the Niger Delta Region. *Proceedings of the Nigerian Society of Engineers (NSE) Conference*. 4-10.

Ogunlana, S. O. (1989). Accuracy in Design Cost Estimating. A Doctoral Thesis submitted at Loughborough University of Technology.

Okagbue, C. O. and Uma, K. O. (1988). The Impact of Geology on the Performance of a bituminous surfaced Pavement: A Case Study from south-eastern Nigeria. Journal of African Earth Sciences, 7(1), 257-264.

Okecha, S. A. (2003), "Flames of Sabotage: The Tragedy of Youth Restiveness in the Niger Delta", Nigeria. *Journal of Peace, Conflict and Development*.

Okogbue, C. O. and Aghamelu, O. P. (2011). Geotechnical assessment of road failures in the Abakaliki area, South-eastern Nigeria. *International Journal of Civil and Environmental Engineering*, 2, 12-24.

Okon, U.M. (2009). THE Niger Delta Development Commission's Approach to Infrastructure and Socio-Economic Development of the Niger Delta Region of Nigeria A master's thesis report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg.

Okpala, D.C. and Aniekwu, A.N. (1988). Cause of high cost of construction in Nigeria. *Journal of Construction Engineering and Management*, ASCE, 114 (2) 223-34.

Oladapo, M. I., Olonrunfemi, M. O. and Ojo, J. S. (2008). Geophysical investigation of road failures in the Basement Complex Areas of South-western, Nigeria. *Research Journal of Applied Sciences* 3(2), 103-112.

Oladinrin, T., Olatunji, S and Hamza, B. (2013). Effect of Selected Procurement Systems On Building Project Performance in Nigeria. *International Journal of Sustainable Construction Engineering & Technology*, 4(1),32-37.

Olawale, Y.A. (2010). "Cost and Time Control Practice of Construction Projects in the UK: The Pursuit of effective management control" University of the West of England.

Olowosulu, A. T., (2005). A framework for Mechanistic-empirical pavement design for tropical climates. Journal of Civil Engineering, The *Nigerian Institution of Civil Engineers*, 5(1), 44-54.

Olubomehin O. O. (2012). 'The Nigerian Motor Transporters since the 1920s. *'International Journal of Humanities and Social Sciences*, 2(12), 230-237.

Olujide, O, and Amadise, S. O. (2009). Active Soils of the Niger Delta in Road Pavement Design and Construction. *Journal of Geotechnical and Geological Engineering*, 27(1), 81-88.

Omange, G.N., Nnama, S.K. and Aitsebaomo, F.O. (1988). Engineering characteristics of subgrade soils of Nigeria and application to economic pavement design. *Proceedings of the conference, Ten year of building and road research*, NBRRI. 135-179.

Omotosho, O. and Ogboin, A.S. (2009). Active Soils of the Niger Delta in Road Pavement Design and Construction. In *Geotechnical and Geologic Engineering,* 27:81. Springer: Netherlands.

Oni, S. I. (2004): "Development of Urban Transportation". In Perspectives on Urban Transportation presented at the Colloquium on Thirty Years of Social Services and Management in Nigeria, Benin City, Nigeria

Oni, S. I. and Okanlawon, k. R. (2008). Nigeria's transport infrastructural development: An integral part of the national economic empowerment and development strategy (NEEDS). *Nigerian Journal of Earth Sciences*. University of Lagos, Lagos.

Onokala, P. C. (2012). 'Transport Systems in Nigeria', Lead Paper presented at *the International conference of the Nigerian Institute of Transport Technology*. NIIT), Zaria. 53-69

Osemenan I. (1987): Project abandonment. New Watch Magazine, 1(15).

Osland, O and Strand, A. (2010). The Politics and Institutions of Project Approval - a Critical-Constructive Comment on the Theory of Strategic Misrepresentation*, EJTIR* 10(1), 2010, 77-88.

Ossai, S.U. (2012). Nigeria: The Challenge of abandoned Projects in the Niger Delta. *Journal of Public policy and Development*, 2(3), 34-45.

Otoko, G and Pedro, P. (2014) Cement Stabilization of Laterite and Chikoko Soils Using Waste Rubber Fibre. *International Journal of Engineering Sciences and Research Technology*,130- 136.

Otoko, G and Precious, R. (2014). Stabilization of Nigerian deltaic clay (chikoko) with groundnut shell ash. International Journal of Engineering and Technology Research 2(6),1 – 11.

Otoko, G.R. (2013). A Review of the Stabilization of Problematic Soils. *International Journal of Engineering and Technology Research* 2(5),1 – 6.

Oviasuyi, P. O. and Uwadiae, J. (2010). The Dilemma of Niger-Delta Region as Oil Producing States of Nigeria. *Journal of Peace, Conflict and Development*, 16(5), 54- 67.

Oxford Dictionary. (2014). Definition of Philosophy [online]. Available at <http://www.oxfordreference.com> Accessed 13/03/2014.

Panas, A. and Pantouvakis, J. P. (2010). Evaluating Research Methodology in Construction Productivity Studies. *The Built & Human Environment Review*, 3(1), 63-85.

Pasuma, L.J, R.S. Epps, P. Farrington and A.D Robinson. (1989). Construction in the Niger Delta; Depositional and Engineering Properties of Sediments in Rivers State. Lagos: *Journal of the institute of British Quantity Surveyors*.

Paul, T., Chow, F. and Kjekstad, O. (2002). "*Hidden Aspects of urban planning surface and underground development*", Thomas Telford Publishing, London.

Peacock, W. S. and Whyte, I. L. (1992). Site Investigation and Risk Analysis. Paper presented at *The Institution of Civil Engineers Symposium*, (May), 74-81.

Perera, B., Dhanasinghe, I and Rameezdeen, R. (2009). Risk management in road construction: The case of Sri Lanka. *International Journal of Strategic Property Management*, 13(2), 87-102.

Perry, C. (1998). Processes of a case study methodology for postgraduate research in marketing. *European Journal of Marketing*, 32 (9/10), 785- 802.

Phaobunjong, K. (2002). Parametric Cost Estimating Model for Conceptual Cost Estimating of Building Construction Projects. An unpublished PhD Dissertation. Faculty of the Graduate School, The University of Texas, Austin

Phillips, E, M and Pughs, D.S. (2000). *How to Get a PhD: A Handbook for Students and Their Supervisors*, 2nd Ed. Open Press, Buckingham, PA.

Phillips, L.W. (1981). Assessing measurement error in Key Informant Report: A methodological note on organisational analysis in marketing. *American Journal of Sociology*, 79 (3). 686 -704.

Pickrell, D. H. (1992). A desire named streetcar: fantasy and fact in rail transit planning. Journal of the American Planning Association, 58 (2).158-177.

PMI Standards Committee. (1996). *A Guide to The Project Management Body of Knowledge*. Project Management Institute, Newtown Square.

Powell, W D., J F Potter., H C Mayhew, and M E. Nunn. (1984). The structural design of bituminous roads. TRRL Laboratory Report LR 1132. Transport and Road Research Laboratory, Crowthorne.

PPAC. (2012). Report on NDDC projects. Presidential Projects Assessment Committee.

Proverbs, D. and Gameson, R. (2008). Case study research. In Knight, a. & Ruddock, I. (Eds.) *Advanced Research Methods in The Built Environment*. Chichester, Wiley-Blackwell.

Raftery, J., McGeorge, D. and Walters, M. (1997). Breaking up methodological monopolies: A multi paradigm approach to construction management research. *Construction Management and Economics*, 15(3), 291–297.

Rahman, I. A., Memon, A. H. and Ahmad K, T. A. (2013). Relationship between Factors of Construction Resources Affecting Project Cost. *Modern Applied Science and Economics* 28 (5), 509-526.

Rahman, M and Kumaraswamy, M. (2001). Revamping risk management in Hong Kong construction industry. In John Kelly & Kirsty Hunter (Eds.) *Proceedings of the RICS Foundation - Construction & Building research Conference* (COBRA), 3-5 Sept. 2001, Glasgow Caledonian University, Glasgow, the UK, 1, 61-73.

Rao, M and Ranade, H V. (2013). Risk based cost estimation of capital intensive road projects using Monte-Carlo simulation. *International Public Works Conference*, Darwin, Northern Territory, Australia

Reilly, J., Sangrey, D., Gabriel, M, Prill, W., and Shilbayay, S. (2004). Using Risk-based Evaluation – The Success of CEVP. www.wsdot.wa.gov/projects/cevp/default.htm

Reilly, J.J, McBride, M., Dye, D. and Mansfield, C. (1994). Guideline procedure "Cost Estimate Validation Process (CEVP)", Washington State Department of Transportation, Available at: http://www.wsdot.wa.gov/projects/projectmgmt/riskassessment.

Riesbeck C, Schank., R and: Lawrence, N.J. (1989). *Inside Case-Based Reasoning*. Hillsdale, Erlbaum Associate Publishers.

RMW Home page. (2014). Map of Rivers State [online]. Available at <www.waado.org/nigerdelta/nigeria> accessed 12/09/2014

Roberts. G. M, (1999). A model of road transport investment in developing countries. Transportation and Road Research Laboratory, UK.

Robson, C. (1993). *Real World Research: A Resource for Social Scientists and Practitioner-Researchers*. Oxford; Blackwell

Romero, V. S. and J. M. Stolz, (2009). Cost Estimating for Underground Transit: Too Dangerous to "Guesstimate". San Francisco, CA

Rooke, J. and Kagioglou, M. (2007). 'Criteria for evaluating research: the unique adequacy requirement of methods'. *Construction Management and Economics*, 25(9):979-987.

Rooke, J. A., Koskela, K. and Kagioglou, M. (2009). Informality in organization and research: a review and a proposal. *Construction Management and Economics*, 27(10), 913-922.

Rooke, J., Seymour, D. and Crook, D. (1997). Preserving methodological consistency: A reply to Raftery, McGeorge and Walters. *Construction Management and Economics*, 15, 491–494.

Runeson, G. (1997). The role of theory in construction management research: Comment. *Construction Management and Economics*, 15(1), 299–302.

Runeson, G. and Skitmore. M. (2008). Scientific Theories. In *Advanced methods in the Built Environment*, A. Knight and L. Ruddock Eds, West Sussex, Wiley-Blackwell: 75-84.

Cateret, R. (2015). A review of the effects of salinity on road pavements and bituminous surfacing. A PhD Thesis submitted to the university of New castle, Australia

Rys L. G. and Wood. I. R. (1986). A question of priority - product before procurement in site investigation practice. Site investigation practice. Engineering Geology 2, 349-355.Geological Society, London,

Sabol, L. (2008). Challenges in Cost Estimating with Building Information Modelling. Design and Construction Strategies. Washington, DC. 202- 222

Sala-i-Martin, X. and Subramanian, A. (2003). Addressing the Natural Resource Curse: An Illustration from Nigeria", IMF Working Paper WP/03/159, 24.

Salem, O., AbouRizk, S and Ariaratnam, S. (2003). Risk-based life-cycle costing of infrastructure rehabilitation and construction alternatives. *Journal of Infrastructure Systems* 9, 6–15.

Sanders, S., and Maxwell, R., Glagola, C. (1992). "Preliminary Estimating Models for Infrastructure Projects," Cost Engineering, Association for the Advancement of Cost Engineering International, Morgantown, 34(8), 7-13.

Saunders, M., Lewis, P and Thornhill, A. (2009). *Research Methods for Business Students*. Fifth edition. Pearson Education Limited; Prentice Hall.

Schexnayder, C.J., Weber, L.S and Fiori, C. (2003) Project Cost Estimating: A Synthesis of Highway Practice. American Association of State Highway and Transportation Officials (AASHTO)

Schwandt, T. (2001). Hermeneutic circle. In Dictionary of qualitative inquiry (112-118). Thousand Oaks, CA: Sage Publication.

Sekaran, U. (2007). *Research Methods for Business,* 3rd edition, John Wiley.

Sekeran, U. (1992). *Research Methods for Business*: *A Skill Building Approach*, 2nd Ed. New York: Wiley.

Semen, P. M. (2006). A Generalized Approach to Soil Strength Prediction with Machine Learning Methods, US Army Corps of Engineers, Engineer Research and Development Centre.

Seymour, D. and Rooke, J. (1995). The culture of the industry and the culture of research. *Construction Management and Economics*, 13(6), 511–523.

Seymour, D., Crook, J. and Rooke, J. (1998). The role of theory in construction management: Reply to Runeson. *Construction Management and Economics*, 16, 109–112.

Seymour, D., Rooke, J. and Crook, J. (1997). The role of theory in construction management: A call for debate. *Construction Management and Economics*, 15(1),117–119.

Shahin, Md., Khokon, ZH., Sobhan, MA., and Ahmed, TU. (2015). Salt Tolerance Limit of Bituminous Pavement. *International Journal of Civil Engineering* 2(4).

Shanmugam, M., Zainudeen, M. N and Amaratunga R.D.G. (2006). Research Institute for the Built and Human Environment, University of Salford.

Sharma, S and Goyal, P, D. (2014). Cost Overrun Assessment Model in Fuzzy Environment. *American Journal of Engineering Research,* 3(7), 44-53.

Short, K.C. and Stauble, A. J., (1967). Outline of Geology of the Niger Delta. American Association Petroleum Geology Bull 51 5 761-779.

Singh, H. (2010). Delays and Cost Overruns in Infrastructure Projects: An Enquiry into Extents, Causes and Remedies. *Economic & Political Weekly*, 14(21)

Skamris, M. K. and Flyvbjerg, B. (1997). Inaccuracy of Traffic forecasts and cost estimates on large transport projects. *Transport Policy*, 4(3), 141-146.

Slaughter, R. (1995). *The Foresight Principle*. Adamantine. London.

Smith, A. and Mason, K. (1997). Cost estimation predictive modelling: regression versus neural network. The Engineering Economist. 42(2), 137-161.

Smith, R. (1992). Owner's Guide to Saving Money by Risk Allocation, American Consulting Engineers Council.

Smith, R. C. (1986). *Estimating and Tendering for Building Work*, Longman: London.

Sodikov, J. (2005). Cost estimation of highway projects in developing countries: artificial neural network approach. *Journal of the Eastern Asia Society for Transportation Studies*, 6, 1036 - 1047.

Sonugaa, O.A and David, O. (2002). Particular barriers and issues associated with projects in a developing and emerging economy. Case study of some abandoned water and irrigation projects in Nigeria. *International Journal of Project Management,* 20 (2002) 611–616

Sowers, G. (1993). "Human Factors in Civil and Geotechnical Engineering Failures. *Journal of Geotechnical. Engineering*, 2, 238-256.

Steenbrink, R. A. (1994). *Optimization of Transport Networks*, John Wiley & Sons, New York

Steven M, T. and Oberlender, G. (2003). Predicting accuracy of early cost estimates using factor Analysis and multivariate regression. *Journal of Construction Engineering and Management. American Society of Civil Engineers* (ASCE). 198 -204

Strauss, A. and Corbin, J. (1998). *Basics of Qualitative Research*. Second Edition. SAGE Publications, California.

Stuart D. Anderson, Keith Robert Molenaar, Cliff J. Schexnayder. (2007). Guidance for Cost Estimation and Management for Highway Projects During planning, programming and preconstruction. National cooperative highway research program (NCHRP) Report.574

Sunjka, B.P. and Jacob, U. (2013). Significant causes and effects of project delays in the Niger Delta region, Nigeria. *SAIIE25 Proceedings*, 9th – 11th of July 2013, Stellenbosch, South Africa. 641-649.

Sweis, G., Sweis, R., Abu Hammad, A. and Shboul, A. (2008) 'Delays in construction projects: The case of Jordan'. *International Journal of Project Management,* 26 (6), 665-74

Tah, J.H.M., Thorpe, A. and McCaffer, R. (1994) A survey of indirect cost estimating in practice. *Construction Management and Economics,* 12(31), 31-36.

Tan, F and Makwasha T. (2010). 'Best practice' cost estimation in land transport infrastructure projects. 'Best practice' cost estimation in land transport infrastructure projects. Australasian Transport Research Forum Proceedings Canberra, Australia http://www.patrec.org/atrf.aspx

Tashakari, A and Teddlie, C. (1998). *Hand Book of Mixed Methods in Social and Behavioural Research*. Thousand oaks. CA; Sage.

Teme, S.C. (2002). The physical environment, Engineering and water resources in Rivers state. Ministry of environment and water Resources (RSMEMR) Interim Guidelines and standards, 1-23.

Thayer, H. S. (1952). *The Logic of Pragmatism: An Examination of John Dewey's Logic*. New York: Humanities Press.

Theyes H.L. (1996). Overview of South African Mechanistic Pavement Deign Method. *Conference proceedings of the annual meeting of the Transportation Research Board*.

Thomas E U and Toakley, R.A. (1999). Risk management in the conceptual phase of a project. *International Journal of Project Management.* 17(3), 161-169.

Thompson, P.A. and Perry, J.G. (1992). Engineering Construction Risks. Thomas Telford, London.

Timm, D. and Newcomb D. (2006). Perpetual pavement design for flexible pavements in the US. *International Journal of Pavement Engineering*, 7(2),111–119.

Tolla, P and Valkeisenmäki A. (2012). Ground Investigation for Road Projects NVF TC34 P. Finnish Traffic Agency

Toor, S and Ogunlana, S. (2008). Problems causing delays in major construction projects in Thailand *Construction Management and Economics*, 26(4), 395-408.

Touran, A. (1993). "Probabilistic Cost Estimating with Subjective Correlations," *Journal of Construction Engineering and Management, American Society of Civil Engineers,* 119(1), 58-71.

Transport and Road Research Laboratory. (1978). Terrain evaluation for highway engineering and transport planning. A technique with particular value for developing countries. Department of Transport, TRRL Report SR 448. Crowthorne

Transport and Road Research Laboratory. (1993). A guide to the structural design of bitumen surfaced roads in tropical and sub-tropical countries. Department of the Environment Department of Transport, Road Note 31.

TRL. (1998). Department for International Development Project Report Guidelines on the selection and use of road construction materials by Transport Research Laboratory

Trost, S., M., and Oberlender, G., D. (2003). Predicting the Accuracy of Early Cost Estimates Using Factor Analysis and multivariate Regression. *Journal of construction Engineering and Management*, 129 (2), 198-204.

TRRL. (2010). Guidance Notes on Road Pavement Drainage Design. Road Note 6. RD/GN/035, The Transportation and Road Research Laboratory.

Tumi, S., Omran, A and Pakir, A. (2009). Causes of Delay in Construction Industry in Libya. Proceedings *The International Conference on Economics and Administration*, Romania ICEA – FAA Bucharest.

Turochy, R. E., Lester A. H., Lacy, L. A. and Robert S. D. (2001). Highway project cost estimating methods used in the planning stage of project development. Technical Assistance Report. Virginia Transportation Research Council.

Tyrrell A. P. (1983). An investigation of the extra costs arising on highway contracts. Transport and Road Research Laboratory, Crowthorne, SR 814.

Ubani, E.C. and Ononuju, C.N. (2013). A study of failure and abandonment of public sector-driven civil engineering projects in Nigeria: An empirical review. *American Journal of Scientific and Industrial Research.*

Ubani, E.C. (2015). Analysis of Factors Responsible for Project Cost Underestimation in Nigeria. International Journal of Economics, Commerce and Management. 3(2), 1-12.

Uff J. F. and Clayton. R. I. (1986). Recommendations for the procurement of ground investigation. Construction Industry Research and Information Association, London, SP 45.

Ugbe, F.C. (2011). Basic Engineering Geological Properties of Lateritic Soils from Western Niger Delta. *Research Journal of Environmental and Earth Sciences,* 3(5): 571-577

UNDP. (2006) Niger Delta Human Development Report. United Nations Development Programme.

United States Department of Transportation. (2002). Subsurface Investigations: Geotechnical Site Characterization Publication No. FHWA NHI-01-031 Federal Highway Administration NHI Course No. 132031 Reference Manual

United States Department of Transportation. (2006). Geotechnical Aspects of Pavements. Federal Highway Administration. FHWA NHI-05-037.

USIP. (2011). Conflict in the Niger Delta: More Than a Local Affair. United States Institute of Peace Special Report. Centres of Innovation, Washington.

Unoanwanaile, M. O. (2009). The Niger Delta Development Commission's approach to infrastructure and socio-economic development of the Niger Delta region of Nigeria Johannesburg. An unpublished Masters dissertation. Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg.

Vanguard. (2016). Akwa Ibom communities angry with NDDC over abandoned projects. available [Online], Available at [accessed 11/04/2016]. <www.vanguardngr.com › News> [accessed 11/04/2016].

Vanguard Press Release. (2015). 90-yr-old woman leads protest over abandoned road in Bayelsa[online]. Available at <http://www.vanguardngr.com> Accessed 2014/06.

Venmans A.A.M. (2006). Integral design of motorways on soft soil on the basis of whole life costs. *Proceedings of the 16th ICSMGE,* Osaka. Balkema, Rotterdam.

Venmans A.A.M. (2013). Building with the Subsurface for realizing cost-efficient infrastructure. *Proceedings of the 18th International Conference on Soil Mechanics and Geotechnical Engineering*, Paris.

Vidalis, S. M. and Najafi F.T. (2002). Cost and Time Overruns in Highway Construction. *Proceedings of the 4th Transportation Specification. Conference of the Canadian Society for Civil Engineering*, 2799–2808, Montreal, Quebec, Canada.

Vishta, R. (2007) Comments on IRC Draft Flexible Macadam Specifications published in Indian Highways, 35, No. 8.

Wachs, M. (1987). Forecasts in urban transportation planning: uses, methods and dilemmas. *Climatic Change*, 11, 61-80.

Wachs, M. (1989). "When planners lie with numbers". *Journal of the American Planning Association*, 55, 476-479

Walker, D.H.T. (1997). Choosing an appropriate research methodology. *Construction Management and Economics*, 15, 149-159.

Wall, D.M., (1997). Distributions and correlations in Monte-Carlo simulation. *Construction Management and Economics*, 15, 241–258.

Walton, J. R., and Stevens, J. D. (1997). “Improving conceptual estimating methods using historical cost data.” Transportation Research Record 1575, Transportation Research Board, Washington, DC, 127–131.

Watson I. (1995). CBR case-based cost estimation, case based reasoning: prospects for application. IEE Colloquium 1-5.

Wenhua, L and Yuwen L. (1999). “Study on Forecasting Method of Construction Cost Based on Artificial Neural Network”. *Chinese Journal of Management Science*, 4(1) 29-34.

Whitman, R.V. (2000). “Evaluating calculated risk in geotechnical engineering”, ASCE, 110, No 2, Feb, pp145-188.

Willoughby, C. (2005). Transport and the millennium development goals in Africa. A report commissioned by the Africa Union UN Economic Commission for Africa with the collaboration of African Development Bank World Bank European Union.

Winkler, J. T. (1987). The fly on the wall of the inner sanctum: observing company directors at work in Moyser and Wagstaffe.

Winter M.G., Matheson, G.D. and McMillan, P. (1998). Advances in site investigation practice. Transport research Laboratory, Scotland

Wong, J. (2010). What lies Beneath? An Over View of Claims relating to unforeseen Ground Conditions. *Institute of Civil Engineers*.

Wong, J. T. Y. and Hui, E. C. M. (2006) Construction project risks: further considerations for constructors‟ pricing in Hong Kong. *Construction Management and Engineering*, 24, 425-438.

World Bank. (2015). Roads and Highways: Construction and Maintenance, retrieved from World Bank Website http://www.worldbank.org/transport/roads/con&main.htm. 09/04/2015

Yin, R. K. (2003a). *Applications of Case Study Research*, 2nd edition, London, SAGE Publications.

Yin, R. K. (2003b). *Case Study Research: Design and Methods*, 3rd edition, London, SAGE Publications.

Yin, R. K. (2009). *Case Study Research: Design and Methods* (4th Ed.). Thousand Oaks, CA: Sage.

Yin, R. K. (2014). *Case Study Research: Design and Methods* (5th Ed.). Los Angeles: Sage

Yin, R.K. (1994). *Case Study Research: Design and Methods*.3rd ed. Applied Social research method series, Vol. 5. Thousand oaks, CA; Sage

Youdeowei P.O. and H.O. Nwankwala. (2010). “Assessment of some geo-environmental problems associated with road construction in Eastern Niger Delta,” *African Journal of Environmental Pollution And. Health* 8(1): 1-7.

Youdeowei P.O. and H.O. Nwankwala. (2013). “Suitability of soils as bearing media at a freshwater swamp terrain in the Niger Delta,” *Journal of Geologic Mineral Resource*, 5(3) 58-64.

Youdeowei, P.O. (2013). Engineering Assessment of South-Eastern Niger Delta Soils Utilized for Highway Pavement. *Journal of Earth Science Research*, 1(3), 106-112.

Z.C. Moh and S.M. Woo. (1986). Geotechnical considerations in the planning and design of highways in mountainous terrain. *Proceedings on the South- East Asian Congress on Roads, Highways and Bridges*. Institute for international research. Kualar Lumpur

Zumraw, M. (2013). Pavement Design for Roads on Expansive Clay Subgrades. *University of Khartoum Engineering Journal*. 3(1) 52-58.

Zwaing, J.O. (2014). Probabilistic Estimating of Engineering Costs, An Unpublished Master's Thesis submitted to the Faculty: Civil Engineering and Geosciences, University: Delft University of Technology