An Interpretivist Approach for the Development of a Behavioural Framework to Support the Adoption of Waste Minimisation Behaviour of Contractors: The Case Study of Jordan

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Dedication

I would like to dedicate this thesis to my beloved father, Dr Hassan Alhawamdeh, who passed away shortly after my VIVA was completed. As much as I was sad about his death, my condolences is that he was so happy and proud of me for completing my PhD. He was my first teacher in life, my best friend and a wonderful caring father. God have mercy on his soul.

Declaration

I declare that this thesis is my own work and has not been submitted in support of an application for another degree or qualification at this or any other education institution. To the best of my knowledge and belief, the thesis contains no materials previously published or written by another person, except where due acknowledgement is made.

Signature: …………………………………...

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Abbreviations

BF	Behavioural Framework
BIM	Building Information Modelling
BMRA	Building Materials Reuse Association
BRE	Building Research Establishment
BREEAM	Building Research Establishment Environmental Assessment Method
CIWM	Chartered Institution of Wastes Management
CW	Construction Waste
CWDCS	Construction Waste Disposal Charging Scheme
CWM	Construction Waste Minimisation
DEFRA	Department for Environment, Food and Rural Affairs
DFID	Department for International Development
EEA	European Environment Agency
EPA	United States Environmental Protection Agency
GCC	Gulf Cooperation Countries
GDP	Gross Domestic Product
GIZ	German Corporation for International Cooperation
ISO	International Organisation for Standardisation
ISWA	International Solid Waste Association
JCCA	Jordanian Construction Contractor Association
JOD	Jordanian dinar
KSAAEM	KSA Award for Environmental Management
LEED	Leadership in Energy and Environmental Design
LWTs	Low-waste Technologies
MMC	Modern Methods of Construction
NDRC	National Development and Reform Commission of China
RFID	Radio Frequency Identification
SC	Sustainable Construction
SCT	Social Cognitive Theory
SEM	Structural Equation Modelling
SIS	Stepwise Incentive System
SWANA	Solid Waste Association of North America
SWMP	Site Waste Management Plans

TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UNEP	United Nations Environment Programme
UNSD	United Nations Statistics Division
WDI	World Development Indicators
WMP	Waste Management Plans
WRAP	Waste & Resources Action Programme
WRI	World Resources Institute

Definition of Key Terms

Construction Waste	Waste which originates during the construction stage of a project
Construction Waste Minimsation	Comprises the 3Rs of waste minimisation i.e. reduction, reuse recycling)
Sustainable Construction	Construction process which incorporates the basic themes of sustainable development i.e. envirominal, financial and social sustainablety
Behavioural Framework	A decision-making tool which includes a set of integrated factors influencing the behaviour of Jordanian contractors towards consstruction waste minimisation
Low waste technologies	Construction technologies that optimise resource consumption which results in waste minimisation and increased value for a project's stakeholders
Behaviour	Actions and mannerisms made by the individual in conjunction with themselves or their environment, in relation to construction waste mimnimisation
Attitude	The degree to which a person has a favourable or unfavourable evaluation of construction waste mimnimisation behaviour

Publications

The following papers have been published and are based upon the work conducted in this thesis:

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Abstract

In recent decades, with the rapid development of urbanisation and the acceleration of construction, renovation and demolition activities worldwide, enormous volumes of construction waste (CW) have been generated at a colossal rate. CW accounts for approximately 36% of the total solid waste received at landfill sites around the world, and therefore, presents a significant challenge to the sustainability of the construction industry, the country's economy at large, and environmental sustainability worldwide. For Jordan, this issue is pertinent since the construction industry is still suffering from insufficient sustainability practices characterised by poor production, sub-standard performance and a wasteful culture. Therefore, construction waste minimisation (CWM) has become a pressing issue due to the scarcity of resources and a subsequent unsteady energy supply, which are two serious challenges facing Jordan today. This is, in addition to the poor economic situation in Jordan with CW considered a major financial burden on government spending having to deal with CW and its associated issues.

Different approaches and techniques have been established over the years by many researchers and practitioners worldwide, who have sought to determine optimal methods to support CWM. More recently, increasing attention has been placed on addressing the role of human factors in CWM, as the majority of the causes underlying CW are directly or indirectly affected by the behaviour of those working in the construction industry. The behaviour of contractors is a crucial element in the implementation of successful CWM measures, as many studies have emphasised their impact on the generation and minimisation of waste in construction projects.

However, a critical appraisal of the CW literature showed that adopting CWM behaviour depends on many factors that contribute to its success or failure, and each of these factors can exert a different level of influence. Accordingly, in reviewing existing behavioural adoption literature to aid the exploration and understanding of the potential factors influencing the behaviour of contractors towards CWM, it has been observed that nearly all adoption theories and frameworks have attracted strong criticism from researchers for being too simplistic and inadequate in successfully predicting CWM behaviour. Further, critics argue that the current behaviour adoption theories and frameworks have been established in developed countries and lack empirical evidence as to their applicability in the Middle-East region, particularly in Jordan; CWM behaviour is perceived and valued differently by different cultures. Consequently, this thesis describes the development of a behavioural framework (BF) that aims to address this research gap.

The Delphi technique, incorporating a series of semi-structured interviews, was chosen as the primary research investigative method, for the discovery and building of the BF. Twelve respondents (the experts' panel), with extensive knowledge of, and experience in, the Jordanian construction industry participated in two rounds of the Delphi study. They were able to offer a well-informed look at the current and potential status of the adoption of CWM behaviour among Jordanian contractors. The results of the Delphi study were then triangulated with the findings of the literature review in order to form the and develop the BF. Following this, a validation workshop was used, involving seven construction professionals, to validate and refine the BF so as to be of value to the Jordan context. The resulting BF consists of four constituent variables that work together to explain and predict CWM behaviour. These are: personal, technological, social and organisational variables; each of these variables include several factors influencing the behaviour of Jordanian contractors towards CWM. In total, 10 factors, which includes 31 subfactors, are identified and included in the framework. The BF advances a more holistic understanding of CWM behaviour, which will support the adoption of waste minimisation in Jordanian construction projects.

Chapter 1

Introduction

1.1 Chapter overview

This chapter provides an introduction to this study including its justification, aim and objectives, methodology outline and structure. It begins by presenting a background to the study and illustrates the problem of construction waste (CW), as well as the inherent need for construction waste minimisation (CWM) practices, particularly, with a focus on the Jordanian construction industry. Further, key behaviour adoption theories and frameworks, used in understanding CWM behaviour, are briefly described and then their ineptness is identified, highlighting the gap in the literature as well as the motivation for this study. Following this, a methodological design is introduced in order to achieve the research aim and objectives.

1.2 Research background and rationale

Waste is a colossal problem in the world of construction and is considered to be one of the major contributors to the total waste production, generating around 36% of the total solid waste worldwide which equates to 2.5-3.5 billion tonnes each year (International Solid Waste Association [ISWA], 2015). The enormous generation of CW presents a significant challenge to the sustainability of the construction industry, the country's economy at large and environmental sustainability worldwide. A number of significant environmental, economic and social problems (the 3 pillars of sustainability) are a result of CW:

- **Diminishing landfill space**: Many countries worldwide are rapidly running out of landfill areas for dumping waste, especially in developing countries, yet the need for landfill space is ever growing. For instance, figures published by the UK government revealed that construction and demolition waste is around 130 million tonnes of waste per annum which is responsible for almost two thirds of the total landfill waste (Department for Environment, Food and Rural Affairs [DEFRA], 2020). In the EU, over 800 million tonnes of construction and demolition waste is generated every year (Deloitte, 2017), accounting for around 25 - 30% of all waste generated (European Commission, 2018). The figure is more than 1.5 billion tonnes in China (Huang et al., 2018), with only 5% being recycled (National Development and Reform Commission of China [NDRC], 2014). In the USA, the volume of CW increased to 569 million tonnes each year in 2017 (United States Environmental Protection Agency [EPA], 2019). It is a similar story in the Middle-East region; inevitably the figures are lower but relative to the region's size and economic situation, they are still significant. The construction industry in the Gulf Cooperation Countries (GCC) generate around 66 million tonnes of waste every year, accounting for around 55% of all waste generated (McElroy, 2012, 2016). Most of the collected waste in these countries is disposed of in landfills and waste dumpsites on the outskirts of the cities (Ouda et al., 2018). In Kuwait, approximately 16 million tonnes/year of CW is produced and around 66-84% of this waste is disposed of in landfill (Albeeshi et al., 2017; Puri-Mirza, 2020). The UAE is no exception and is ranked as one of the largest producers of waste (per capita) worldwide where construction and demolition waste account for 70% of total waste generated (Al-Hajj & Hamani, 2011; Swain, 2018).

- **High consumption levels of raw material resources**: The generation of CW also contributes to the depletion of the world's natural resources including non-renewable sources of energy, as well as resources that are in danger of depletion, such as metal, timber and crushed stone (United Nations Environment Programme [UNEP], 2015b). Construction activities consume around 35% of the world's resources, including 12% of water, 25% of steel and more than 50% of crushed rock, gravel and sand. These are all used globally each year for construction (UNEP, 2015b, 2019a, 2019b, 2019c). Additionally, the construction sector accounts for 36% of global final energy use, including embodied energy (UNEP, 2019a).

- **Pollution and contamination**: These are other significant problems attributed to increased volumes of CW worldwide. Existing research suggests that construction activities is a major contributor to environmental pollution having an impact on air, water and soil contamination and resulting in adverse effects on flora and fauna (Ding et al., 2016; Ferronato et al., 2017). Globally, 33% of CW is still openly dumped in forests, open lands or waterways and this figure can increase to 93% in lower-income countries, since open dumping is a prevalent waste disposal practice causing soil and water contamination (World Bank, 2018). Additionally, CW often contains solvents and volatile organic compounds which affect human health and create fire hazards (Butera et al., 2014). Furthermore, CW leads to serious air pollution, as 11% of the generated waste is treated through incineration worldwide (World Bank, 2018), in addition to 11% of the total carbon dioxide (CO_2) emissions resulting from the associated energy usage of construction activities (UNEP, 2019a).

- **Financial losses**: Waste increases the total cost of construction projects; around 15% (by value) of materials delivered to construction sites are wasted (Waste & Resources Action Programme [WRAP], n.d.). The true cost of CW is not only reflected in material purchasing costs, but also the cost of storage, transport, disposal, the cost of the time spent managing and handling the waste and the loss of income from not salvaging waste materials (Mahpour & Mortaheb, 2018; Hao et al., 2019). According to Osmani (2011), the true cost of waste in construction projects is estimated to be around 20 times the cost of the disposal of waste. Further, CW increases the tender price which affects the competitiveness of obtaining new projects (Ann et al., 2013). From a country's economic perspective, CW is of grave concern and a challenging issue faced by many economies around the world. Globally, 205 billion dollars was spent in 2010 on solid waste related challenges and this figure could rise to an estimated 375 billion dollars per year by 2025 (Asnap, 2012). In low- and middle-income countries, solid waste management comprises of more than 20% of municipal budgets and around 50% of the local governments' investments (World Bank, 2018). Therefore, managing CW and its related problems affect the financial sustainability of governments as funding must be balanced with the provision of other essential services such as healthcare, education and housing (ISWA, 2017).

For Jordan, this issue arises at a time when the built environment is failing to meet the increasing demands on scarce resources (Royal Scientific Society of Jordan, 2013). Jordan imports 97% of its energy needs (The Ministry of Energy & Mineral Resources, 2017), and is ranked as the fifth most water-scarce country in the world (World Resources Institute [WRI], 2020). Additionally, the increase in pollution resulting from CW is particularly problematic in Jordan, given that waste landfilling and illegal dumping are commonly pursued disposal practices (UNEP, 2015a; Aldayyat et al., 2019). Around 90% of the total generated waste in construction sites is disposed of in landfill sites in Jordan (Batayneh et al., 2007). According to the Waste Atlas Partnership (2014), Jordan has two large landfill sites which are ranked among the "World's 50 Biggest Dumpsites", posing a serious threat to human health and the environment.

Waste is also a key contributor for cost overruns in the Jordanian construction industry as the percentage of wastage materials (by value) accounts for 15 to 21% in construction projects (Bekr, 2014). Building material prices are very high given Jordan's limited and costly supply of natural resources, and the ever-increasing price of importing raw materials from neighbouring countries (Royal Scientific Society of Jordan, 2013; Bekr, 2014). Such a situation has also placed a major burden on the government especially given the poor economy of Jordan. The escalating price of imported fossil energy in Jordan amounts to 4.6 billion Jordanian dinar (JOD) per year (Ministry of Energy and Mineral Resources, 2017) with the construction industry being a major contributor to national energy consumption levels (Tewfik & Ali, 2014; El Hanandeh, 2015). Further, the environmental degradation cost is a major burden for the Jordanian government, as each year, large amounts of money are spent dealing with the environmental problems resulting from CW and its associated issues. According to The German Corporation for International Cooperation (GIZ, 2014), the environmental degradation cost was estimated to be around 393 million JOD in 2006, which is a significant figure in relation to Jordan's Gross Domestic Product (GDP).

Different approaches and techniques have been established over the years to deal with CW worldwide, notably after World War II. The majority of the regulations in developed nations were established to encourage waste minimisation due to the large quantities of waste left after the war (Nixon, 1978). In addition, the rapid development of urbanisation and the acceleration of construction, renovation and demolition activities in recent decades, have resulted in enormous volumes of construction and demolition waste increasing at an exponential rate (Yeheyis et al., 2013). Therefore, growing attention has been placed on the need to address such issues by both researchers and practitioners in the construction industry. This has been met with many studies, beginning from the 1980s onwards, which have sought to determine optimal methods to reduce waste, by minimising the associated adverse impact of construction and the demolition of structures (Hu, 2011).

However, waste minimisation in the construction industry has not always been successfully controlled due to several reasons, including illegal dumping, lack of governmental supervision, the behaviour of those working in the construction industry and the lack of interest from project stakeholders towards CWM (discussed in section 2.4.3). These problems are paramount in Jordan, as the construction industry is still suffering from insufficient sustainability practices characterised by poor production, sub-standard performance and a wasteful culture (Tewfik & Ali, 2014; Aldayyat et al., 2019). Therefore, with the growing need and awareness of the importance of CWM as a means to address the global sustainability agenda, waste minimisation is becoming an important function of construction project management and an integral part of every project delivery process, especially in developed nations.

1.3 Research justification

Waste is identified as a significant sustainability issue in the construction industry. It is generated throughout the entire project lifecycle, which includes the design, construction and demolition stages. Every stage has their specific related waste-causes and sources (see section 2.3.3). However, waste generation is usually upmost in the construction stage since it includes a wide range of activities that may contribute to waste generation. The construction stage and its associated waste are classified into site clearance, material use, material handling, material non-use, human error, on-site management and planning, on-site operation, transportation and finally, residual waste (Wang et al., 2008; Al-Hajj & Hamani, 2011; Nagapan et al., 2012b, d; Saez et al., 2013; Najafpoor et al., 2014; Bakshan et al., 2015; Al-Rifai & Amoudi, 2016; Ajayi et al., 2017a; Kolaventi et al., 2020).

Consequently, numerous researchers have attempted to identify the most effective CWM approaches related to the construction stage. Although a number of authors acknowledge the importance of design-out practices in terms of their benefits towards CWM (Ekanayake & Ofori, 2004; Osmani et al., 2008; Ajayi & Oyedele, 2018a), the amount of waste generation can still be significant, if it is poorly executed during the construction process. Conversely, if on-site practices are effectively implemented, it could minimise any waste that originates directly from the construction stage and indirectly from the design stage and, therefore, mistakes and errors made during design can be corrected and avoided (Lopez et al., 2010; Love et al., 2011, 2012). With regards to the demolition stage, there are certain methods that can potentially salvage waste generated from demolition, however, the problem with this type of waste is that it is unavoidable, and there is a strong chance of producing significant amounts of it (Zhang et al., 2012; Wu, et al., 2014; Akinade et al., 2015, 2017; Chen & Lu, 2017; Yu et al., 2020). Therefore, there are more opportunities to avoid waste and reduce at the origin during the construction stage, whereas demolition waste can be treated separately for reuse and recycling. Thus, the construction stage is a significant stage in relation to CWM.

Different types of waste can be generated during the construction stage (see section 2.3.2), including physical (solid material) and non-physical (time and cost) waste (Nagapan et al., 2011, 2012c). Existing literature suggested that more attention should be placed on improving the minimisation of solid material waste in construction projects (e.g., Lau et al., 2008; Oko John & Emmanuel Itodo, 2013; Ding & Xiao, 2014; ISWA, 2015; Saidu & Shakantu, 2016; Hossain et al., 2017; Huang et al., 2018; Wu et al., 2019; Villoria-Sáez et al., 2020). This is because of the huge amount of solid waste worldwide which is generated by the construction industry, posing serious problems for the three pillars of sustainability, at the project as well as national level (as explained in section 1.2). Therefore, solid material waste in construction projects is identified to be the most critical due to its impact on the environment as well as the delivery and cost-overrun of projects. Accordingly, minimising solid waste is an essential aspect in construction sites and, therefore, the well-known waste management hierarchy (see section 2.4.1) focused on the 3Rs of waste minimisation (i.e., reduction, reuse & recycling) for addressing CW generation. Waste reduction (i.e., prevention) is the optimal situation of CW management as source reduction usually results in the least environmental and economic costs because it requires no collecting or processing of waste. However, when CW prevention is not possible, reuse and recycling are the next best practical options that protect the environment, alongside resource and energy consumption as well as reducing the quantity of disposed waste to landfill. This is in addition to the reduction of further costs, including landfill charges and the transportation of disposal, which can be significant in some projects (Yuan, 2011; Wang et al., 2010; Ding et al., 2015; Ajayi et al., 2014, 2017a)

Over the years, different CWM approaches have been established to address the issue of CW during the construction stage, including on-site waste minimisation practices, technological approaches and legislation (see section 2.4.3). More recently, increasing attention has been placed on addressing the behavioural cause of CW, as many researchers have noted that human factors have a major effect on the generation and minimisation of waste in construction projects (Osmani et al., 2006; Kulatunga et al., 2006; Begum et al., 2009; Al-Sari et al., 2012; Udawatta et al., 2015; Bakshan et al., 2017; Wu et al., 2017; J. Li et al., 2018a; Liu et al., 2019; Luangcharoenrat et al., 2019). Their studies revealed that the most common causes of CW generation are directly or indirectly affected by the behaviour of those working in the construction industry and, consequently, negative behaviour towards CWM could lead to significant waste generation. Kulatunga et al. (2006) have argued that CW occurs onsite for a number of reasons, most of which can be prevented, particularly, by changing attitudes. Therefore, according to the aforementioned studies, it is important to focus on the behaviour cause of CW generation with regards to achieving effective CWM. This is particularly important with regards to the behaviour of contractors, from management to labourer level, as they are directly involved in construction activities on-site (i.e., the construction stage).

Despite the growing need, previous studies have not fully addressed the role of the ‘human factor’ in CWM. Various studies have proved that understanding the behaviour of contractors in minimising waste is most challenging and complex, as adopting positive CWM behaviour depends on many factors that contribute to its success or failure. According to the literature, prospective and targeted employees may exhibit negative behaviour towards CWM for several reasons, such as: insufficient relevant knowledge and lack of experience in construction, lack of awareness and understanding of the negative effects of CW, absence of senior management support, lack of interest and motivation towards CWM, technical difficulties and lack of rules and regulations concerning CW (see section 2.4.3.5). Supporting this stance, Osmani et al. (2006) noted various factors that have been found to impact the perception of architects and contractors regarding waste minimisation and, more importantly, each of these factors has different levels of influence in differing contexts. Therefore, it is important to identify and understand the factors influencing the behaviour of contractors with regard to achieving effective CWM.

For that reason, as Morris et al. (2012) have recommended, a review of existing well-known behavioural adoption theories and frameworks is needed in order to understand the human behaviour in a certain context (see section 3.3). This will provide a body of literature that may aid the researcher's attempt to explore and understand the potential factors influencing the behaviour of contractors towards CWM. The most popular behavioural theories include: the Technology Acceptance Model (TAM) proposed by Davis (1985); Social Cognitive Theory (SCT) by Bandura, (1986); the Theory of Reasoned Action (TRA) suggested by Fishbein and Ajzen (1975), and the Theory of Planned Behaviour (TPB) proposed by Ajzen (1985, 1991). These theories have been utilised in various disciplines, including construction, and have been proven to be valid and reliable in the prediction of human social behaviour (Lee et al., 2003; King & He, 2006; Nabavi, 2012; Otieno et al., 2016; Hagger, 2019). However, despite the numerous attempts to provide accurate predictions of human behaviour, nearly all of these have attracted strong criticism from researchers for being too simplistic and inadequate in successfully predicting behaviour (e.g., Venkatesh & Davis, 2000; Bagozzi, 2007; Turner, 2010; Sniehotta et al., 2014; Montaño & Kasprzyk, 2015; Botetzagias et al., 2015; Ajibade, 2018; Schunk & DiBenedetto, 2020). Additionally, in reviewing the existing behavioural adoption literature with regards to construction (see section 3.4), it has been observed that the existing behaviour adoption theories and frameworks all have their relative benefits and limitations in successfully predicting the factors impeding the adoption of CWM behaviour. This is in addition to the fact that such adoption theories and frameworks have been established in developed countries, which strongly reflect the attitudes, values and beliefs of those environments, and may be inappropriate for other countries as it differs from one culture to another (Humphreys, 1996; Hong & Chiu, 2001; Wu et al., 2017; Liu et al., 2019). Therefore, existing CWM behaviour adoption frameworks may be inappropriate and are less open to generalisation in relation to the Middle-East region and hence, Jordan. Consequently, there is a need for a behavioural framework (BF) that will address the weaknesses of existing theories and frameworks (to be discussed in sections 3.3.5 & 3.4) in order to enhance the explanatory power in the prediction of CWM behaviour. This will aid in identifying and understanding of the factors influencing the behaviour of Jordanian contractors towards CWM, especially since a critical appraisal of existing literature reveals that scant studies are currently available in CWM behaviour in the Middle-East region, and particularly in Jordan.

1.4 Research gap and contribution

Prior to proceeding with research gab, it is important to define the term “framework” in order to understand the contribution of this study to the enhancement of CWM behaviour. A framework can be defined as a set of concepts (elements/variables) used to solve a problem in a specific domain; and considered as a conceptual structure that enables different business objects to be framed and treated homogeneously (Paim & Flexa, 2011). In other words, it is a model of how a theory makes logical sense of the relationships amongst the several factors that have been identified as important to the problem (Sekaran, 2000).

This study attempts to bridge the gap in the CW literature through the development of a BF that will support the adoption of waste minimisation in Jordanian construction projects. The BF will advance a more holistic understanding of the factors influencing the behaviour of contractors towards CWM, especially since there is a lack of extensive and empirical research dedicated to investigate CWM behaviour in Jordan, where the circumstances and culture are different from other countries. The need for a BF is also necessitated because to date, the construction industry in Jordan is still suffering from insufficient sustainability practices characterised by poor production, sub-standard performance and a wasteful culture. The theoretical basis of the BF will be developed using best practice with regards to existing behavioural adoption theories and frameworks to enhance the explanatory power in the prediction of CWM behaviour. Further, the process for producing the BF will be useful references for other studies which attempt to understand CW and its related issues in other socio-economic contexts.

1.5 Aim and objectives

The aim of this research is:

> *To develop a behavioural framework (BF) to support the adoption of waste minimisation behaviour by contractors in Jordanian construction projects.*

Based on the research aim, five research objectives have been established as outlined below:

1. To gain extensive knowledge and understanding of the need for waste minimisation and its related adoption issues in the construction industry.

2. To explore existing behavioural theories and frameworks and their effective application in a CWM context.

3. To investigate and identify the factors influencing the behaviour of Jordanian contractors towards waste minimisation during the construction stage.

4. To develop a BF to support the adoption of waste minimisation in the construction stage of projects using Jordan as a case study.

5. To validate the developed BF for effective waste minimisation for contractors in Jordanian construction projects.

1.6 Research methodology

A research methodology is "a system of explicit rules and procedures upon which research is based and for knowledge is to be evaluated" (Fellows & Liu, 2015). Since the research gap and intended contribution of this study has been identified, it is therefore essential to design a rational methodological approach to execute this research and to validate the results (Saunders et al., 2007; Fellows & Liu, 2015).

After careful consideration of the nature of the research problem, a qualitative approach, which is aligned with the interpretive research philosophy, will be adopted as the research methodology for this study. This is because such a paradigm which is governed by the qualitative inquiry of "what" and "how" questions, allows the researcher to investigate in-depth and insightful information and explanations of the Jordanian contractors toward the adoption of CWM (see sections 4.3 & 4.4). The Delphi interview technique is to be used as the primary mode of data collection to meet the study's aim and objectives as it offers a well-informed look at the current and potential status of the adoption of CWM behaviour among Jordanian contractors. Finally, a validation workshop will be employed in this research to validate the results of the Delphi study. Figure 1.1 outlines the stages within the research methodological process which demonstrates a sense of a "sequence" and acts as a guideline for the researcher to monitor the research in order to ensure that the process is on the right track.

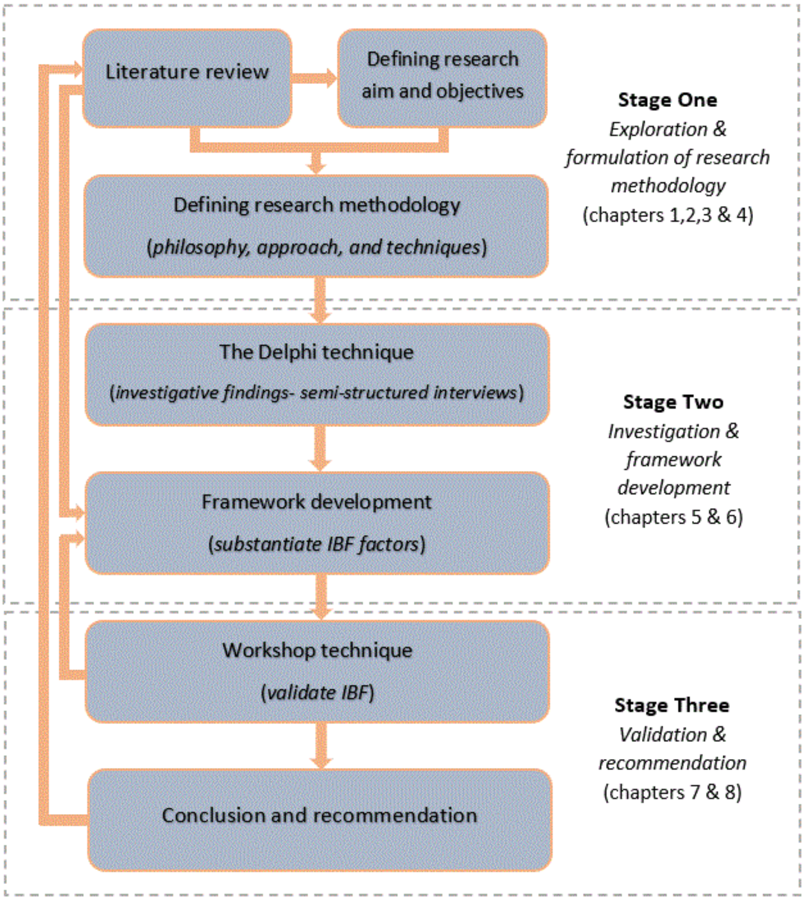

Figure 1.1: Flow diagram of the methodological process of this study

In light of the above figure, the adopted methodological process is divided into three main stages with each stage addressing a particular research objective. Stage One involves a critical and comprehensive review of the existing literature regarding the fundamentals of CW, including types, causes and CWM approaches with a particular focus on CWM behaviour (Objectives 1& 2). Consequently, Stage Two involves the adoption of the Delphi technique as the primary investigatory technique to identify and understand the factors influencing the behaviour of Jordanian contractors towards CWM, and to substantiate the list of factors found in the literature review (Objectives 3& 4). Finally, Stage Three involves a workshop technique with the objective of validating the set of data which was identified in Stage Two as this enables the researcher to assure that the BF is of value to the Jordanian construction industry. In addition, this stage summarises and synthesises the entire research findings, acknowledges limitations and the novelty of the research as well as providing recommendations for future research studies. (Objectives 5).

1.7 Research structure

This research will be divided into eight chapters as follows:

Chapter 1*:* This presents the research problem, justification, aim and objectives and outlines the research methodology. Finally, this chapter ends with a summary of the PhD thesis structure.

Chapter 2*:* This presents the fundamentals of the CW subject, its definition, origins, causes and its minimisation methods and need. Finally, it goes on to discuss the current uptake of CWM in the Jordanian construction industry.

Chapter 3*:* This discusses the behaviour of contractors towards waste minimisation during the construction stage. It reviews the application of the extant behaviour adoption theories and frameworks, as well as the ineptness and practical limitations in their explanatory power.

Chapter 4*:* This discusses the research methodological design adopted in this research by establishing the research's philosophy, approach, strategy (techniques) and the research validation method.

Chapter 5*:* This presents the research's primary findings gathered through the Delphi technique formulation with discussion of the results. This is to identify and understand the factors influencing the behaviour of Jordanian contractors toward CWM.

Chapter 6*:* This discusses the development of the BF based on the tabulation of the key findings of the Delphi study (Chapter 5) with the findings of the literature review (Chapters 2 & 3).

Chapter 7*:* This presents the results of the framework's validation through a workshop technique. This is to validate and refine the BF so as to be of value to the Jordanian construction industry

Chapter 8*:* This summarises and synthesises the entire research findings, acknowledges the originality of the research and discusses the limitations of this study in order to propose a list of recommendations for future work.

1.8 Chapter summary

This chapter provided an overview of this thesis by introducing the research's aim and objectives, justifying the research area, providing a summary of the research methodology and the contribution of the research to advancing knowledge. The following chapter will provide an in-depth discussion with regards to the nature of CW in order to establish the principles of, and the need for, CWM.

Chapter 2

Waste in the Construction Industry

2.1 Chapter overview

Chapter 1 laid the overall foundation and purpose of this thesis. It clarified that many countries worldwide are facing significant problems resulting from CW and its associated negative impact with respect to the three pillars of sustainability (environment, economic and social). This was mainly attributed to the lack of effective waste minimisation practices throughout the construction project's lifecycle. This chapter considers the nature of CW and how it can be minimised, with particular focus on behaviour and its impact on CW generation and minimisation. It begins by discussing the effect of waste on construction sustainability followed by a description of the fundamentals of CW: its definition, origins, causes, and its minimisation methods and needs. Finally, presents the prevailing situation in Jordan with regards to CW with the aim of identifying gaps in the knowledge and confirming the research objectives as discussed in Chapter 1.

2.2 Sustainable construction

Sustainable construction (SC) refers to the construction process which incorporates the basic themes of sustainable development. H. Li et al. (2018) defined SC as a "subset of sustainable development that aim to eliminate the negative impact on the built environment while enhancing the social health and economic development of the community as a whole". A similar definition was posited by the International Organisation for Standardisation (ISO, 2015), stating "sustainable construction brings about the required performance in built facilities with the least unfavourable environmental impacts, while encouraging economic, social and cultural improvement at a local, regional and global level".

Sustainable development in the construction industry is one of growing interest around the world. According to H. Li et al. (2018), SC supports social wellbeing in addition to environmental protection and economic prosperity and in order to satisfy a sustainable development in construction, it is important to attain the right balance between these pillars of sustainability (see Figure 2.1). Confirming this, Gan et al. (2015) revealed that the key drivers for attaining SC in the built environment includes cost-effective construction projects, creating a healthy built environment using resource-efficiency and promoting high standards of living for people, as a result of better performance and quality of built facilities over their full lifecycle.

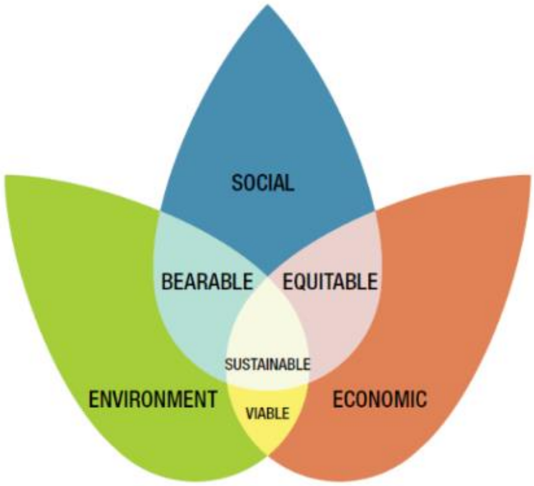

Figure 2.1: Sustainable development - interaction of social, environmental and economic pillars of sustainability

The construction industry faces serious challenges affecting the successful achievement of SC. According to Ramanathan et al. (2012), achieving project completion on time and within the estimated cost are basic requirements for attaining SC. Both issues are major considerations affecting the performance of the construction industry in both developed and developing countries. However, it has been shown that the trend of a cost overrun is more severe in developing countries, as sometimes it exceeds 100% of the estimated budget of the construction project (Memon et al., 2010). Imposing negative impacts on the environment is also considered a significant problem inhibiting the effective implementation of SC. Gan et al. (2015) revealed that the construction industry is considered to be the most environmental-unfriendly human activity due to the excessive consumption of natural resources and the production of a great deal of pollutants.

CW is considered a serious and chronic problem affecting the successful achievement of SC. A number of authors (e.g., Nagapan et al., 2012a; Osmani, 2012; Yeheyis et al., 2013; Wu et al., 2016; Ding et al., 2016, 2018; Islam et al., 2019; Wang et al., 2019) and environmental protection agencies such as in the UK (DEFRA, 2020), in the USA (EPA, 2019) and internationally (ISWA, 2015), have raised concerns over the generation of high volumes of CW and have listed CWM among the top priorities for attaining SC. This is because of the major impact which CW exerts on the three pillars of sustainability at the project as well as the national level (explained in section 2.4.2). According to Bakshan et al. (2015), waste generation over a building’s lifecycle - through design, construction or demolition - triggers a number of environmental, financial and social problems. Therefore, it is important to understand the fundamentals of CW and demystify the issues concerning its minimisation, as it would be an important step along the road to achieve the environmental, financial and social sustainability for construction projects.

2.3 Construction waste

As previously discussed in Chapter 1, CW is becoming an important issue in many countries around the world due to the massive volumes generated every year. Although the issue of CW is widely known around the world, it is still important that it is clearly identified in order to gain a comprehensive understanding of the principles of, and the need for, CWM.

2.3.1 Construction waste definition

According to the United Nations Statistics Division (UNSD, 2016), waste is described as "materials that are not prime products (that is, products produced for the market) for which the generator has no further use in terms of his/ her own purposes of production, transformation or consumption, and of which he/ she wants to dispose… waste may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities… residuals recycled or reused at the place of generation are excluded".

Waste in construction is identified in different ways in the literature. For instance, Skoyles and Skoyles (1987) defined it as "a material which needs to be transported elsewhere, due to damage, excess, or non-use or which cannot be used specifically due to non-compliance with the specifications, or which is a by-product of the construction process". This definition, however, focuses on waste which arises during the construction process. Shen et al. (2004) went further by providing a more comprehensive definition including waste that could arise from other stages and phases. They stated that "waste from construction can be in the form of building debris, rubble, earth, concrete, steel, timber, and mixed site clearance materials, arising from various construction activities including land excavation or formation, civil and building construction, site clearance, demolition activities, roadwork, and building renovation… waste is often the mixture of inert and organic materials". Notably, these definitions refer only to material waste, whereas other authors (e.g., Ekanayake & Ofori, 2000; Alwi et al., 2002) defined waste in construction projects in terms of material, labour and machinery waste which results in time, cost and quality losses. Based on these definitions, it can be noted that there are different types of waste in construction projects and therefore, for the purpose of this study, it is important to identify its components to know which type is going to be focused upon and why. These are discussed in the following subsection.

2.3.2 Construction waste classification

Various types of wastes are generated throughout the construction project. The amount and classification of these wastes depend on different issues, such as the nature and the stage of the construction project, and the methods of construction. Many categorisation models have been applied to classify the types of waste in construction projects, however there is no universal classification system as waste can be classified in many ways, see Table 2.1.

Table 2.1: Classifications of waste in construction projects

Type of waste	Type of classification	Reference
- Material - Time - Cost	Physical and non-physical waste	Nagapan et al. (2011, 2012c).
- Design - Construction - Demolition	By their origin	Shen et al. (2004), Kozlovská and Spišáková (2013), Polat et al. (2017).
- Labour - Material - Machinery	By their cost	Ekanayake and Ofori (2000), Alwi et al. (2002), Yahya and Boussabaine (2006), Bølviken et al. (2014).
- Transportation - Inventory - Motion - Waiting - Over-production - Over-processing - Defects	By their added value	Ohno (1988), Koskela et al. (2013) Bølviken et al. (2014).

Table 2.1 details the most common classifications of waste in the construction projects. However, numerous studies in the construction literature focus on solid material waste, and have listed it among the top priorities in relation to CWM (e.g. Lau et al., 2008; Wang et al., 2008; Llatas, 2011; Al-Hajj & Hamani, 2011; Oko John & Emmanuel Itodo, 2013; Ding & Xiao, 2014; Sáez et al., 2015; Saidu & Shakantu, 2016; Al-Rifai & Amoudi, 2016; Hossain et al., 2017; Arshad et al., 2017; Huang et al., 2018; Mulenga, 2018; Menegaki & Damigos, 2018; Liang et al., 2019; Wu et al., 2019; Bakchan & Faust, 2019; Villoria-Sáez et al., 2020). Additionally, a number of governmental and private institutions such as in the UK (WRAP,

DEFRA, CIWM), in the USA (EPA, SWANA), in the European Union (EEA) and internationally (ISWA, UNEP) have raised concerns over the generation of high volumes of material waste in construction projects. This is because of the significant impact of such type of waste on the three pillars of a SC (full details in section 2.4.2). Therefore, this study focuses on solid material waste, irrespective of the type of wastes in construction projects, and the terms CW and CWM will be used throughout this thesis to refer to solid material of generated waste in construction sites.

In a typical classification, solid waste from construction projects is often a mixture of inert and non-inert materials. The inert materials are the components that scarcely participate in chemical reactions under common circumstances, such as concrete, bricks, ceramics, plaster, asphalt, aggregate, rock or rubble and soil. The non-inert materials are readily engaged in chemical reactions, such as ferrous and non-ferrous metal, timber, plastic, glass, paper, cardboard, wallboard and other organic materials (Zhang et al., 2012; UNEP, 2015a; Wu et al., 2017). The first step towards CWM is the identification of the problem as well as its causes and effects. Therefore, to minimise waste in construction projects, it is very important to identify the origins and causes of CW first, so that CWM methods can be effectively implemented.

2.3.3 Origins and causes of construction waste

Both terms, “origins of waste” and “causes of waste”, are often used synonymously. However, for the purpose of this study, it is important to clarify the difference between these terms. In this context, the term ‘origins’ refers to the stage or level of activities that generate CW, whilst the term ‘causes’ refers to the reasons why CW is generated within the stage or level of activities.

CW is generated throughout the entire project lifecycle i.e., during the design, construction and demolition stages. The literature reveals a large number of past studies which have been conducted to identify origins based on the project stage or level activities. For instance, Gavilan and Bernold (1994) grouped the origins of CW according to the following: design, procurement, materials handling, operation, residual and others. This has also been reported by a number of other studies (Serpell & Labra, 2003; Ekanayake & Ofori, 2000, 2004). Osmani et al. (2008) added four clusters into these six groupings, including contractual, transportation, on-site management and planning, and material storage. Keys et al. (2000) adopted a slightly different categorisation system, their study classified the origins of CW under the headings of manufacture, supplier, procurement, designer, logistics, client, contractor and site management.

Notably, Keys' classification suggested that the origins of CW are not only associated with project activities but also with the project stakeholders. Another categorisation was proposed by Tam et al. (2007a), who included the demolition stage in their grouping of waste origins namely design, procurement, material handling, construction/renovation and demolition.

Causes of CW are mainly associated with two stages of a construction project: the design and construction stages (see Table 2.2). Various issues that cause CW are highlighted in the literature, and they have different levels of significance and impact on CW generation. A number of researchers have come to this conclusion in their studies. For instance, Nagapan et al. (2012b, c) traced the most significant sources of CW to errors and mistakes in design and during construction. Their study indicated that mistakes during construction have a strong positive correlation with rework and, thus, increase waste generation. Confirming this, Al-Hajj and Hamani (2011) revealed that excessive off-cuts resulting from rework and variations are considered as one of the main waste generators in construction projects.

Luangcharoenrat et al. (2019) conducted a structured questionnaire survey among Thai contractors to identify causes of CW generation. Their results showed that the main causes are design and documentation, human resources, construction methods and planning, and material and procurement. Some studies emphasised that improper materials procurement is a practice that leads to a great deal of CW (Ajayi et al., 2017b; Kolaventi et al., 2020), while other studies showed that material handling and control are dominant issues that contribute significantly to waste generation on construction sites (Oko & Emmanuel, 2013). Furthermore, poor weather and environmental disasters such as earthquakes, hurricanes, tornadoes and floodwater can sometimes also be significant with regard to waste generation in construction projects. (Karunasena, & Amaratunga, 2016; Domingo & Luo, 2017). Table 2.2 categorised and itemised common causes of CW generation which are identified in past studies.

Table 2.2: Common causes of waste generation in construction projects

Group	Causes of CW	Reference
Design	- Errors in contract documents - Blueprint errors - Detailing errors - Design changes - Complexities in design - Poor coordination and communication (late information, last minute client requirements, slow drawing revision and distribution) - Unclear/unsuitable specification	Nagapan et al. (2012c), Ajayi and Oyedele (2018a), Nursin et al. (2018), Akinade et al. (2018), Osmani (2008, 2013), Banihashemi et al. (2018), Polat et al. (2017), Al-Hajj and Hamani (2011).
Procurement	- Shipping errors/ suppliers' error - Ordering errors - Late/incorrect timing of deliveries - Leftovers due to over estimation - Packaging materials - Incorrect quantity estimation - Use of low-quality materials	Nagapan et al. (2011), Mahamid and Elbadawi (2014), Ajayi and Oyedele (2018b), Ajayi et al. (2017b), Kolaventi et al. (2020), Ajayi (2020), Kern et al. (2015).
Handling of materials	- Improper storage/deterioration - Improper handling (off-site and on-site) - Materials supplied in loose form	Mahamid and Elbadawi (2014), Nagapan et al. (2011), Oko and Emmanuel (2013), Najafpoor et al. (2014).
On-site operations	- Rework due to errors - Improper project planning - Equipment malfunctions - Use of incorrect material - Poor workmanship - Leftovers from cutting and shaping/ materials off-cuts - Poor site conditions - Poor supervision - Lack of waste minimisation plans	Udawatta et al. (2015), Al-Hajj and Hamani (2011) Bekr (2014), Al-Rifai and Amoudi (2016), Osmani et al. (2006), Arshad et al. (2017), Polat et al. (2017), Oko and Emmanuel (2013), Kolaventi et al. (2020), Muhwezi et al. (2012), Patil and Pataskar (2013).
Others	- Poor weather conditions - Environmental disasters - Accidents - Theft and vandalism	Bekr (2014), Karunasena and Amaratunga (2016), Domingo and Luo (2017), Muhwezi et al. (2012), Vasconcelos and Junior (2015).

In light of the above table, it can be noted that there are no causes that generate waste at the demolition stage; the whole structure will be turned to waste once its torn down and is often considered as non-avoidable waste. Therefore, this research concentrates on waste generated during the construction stage only, and does not extend to demolition as there are more opportunities to avoid waste and reduce at the origin, whereas demolition waste can be managed separately for reuse and recycling. According to several studies (e.g., Zhang et al., 2012; Wu et al., 2014; Akinade et al., 2015, 2017; Chen & Lu, 2017; Yu et al., 2020), there are certain methods that can potentially salvage waste generated from demolition (e.g., deconstruction), however, the problem with this type of waste is that it is unavoidable and there is a strong chance of producing significant amount of it. Wu et al. (2014) and Akinade et al. (2015) indicated that the majority of waste which results from the demolition of structures is unrecoverable and eventually sent to landfills. Thus, the construction stage is a significant stage in relation to CWM.

This research also does not extend to waste that originates during the design stage, as waste generation is usually upmost in the construction stage since it includes a wide range of activities that may contribute to waste generation. According to numerous studies (e.g. Tam et al., 2007b; Wang et al., 2008; Al-Hajj & Hamani, 2011; Nagapan et al., 2012b,d; Saez et al., 2013; Najafpoor et al., 2014; Mahayuddin & Zaharuddin, 2013; Bakshan et al., 2015; Gulghane & Khandve, 2015; Sasidharani & Jayanthi, 2015; Li et al., 2016; Al-Rifai & Amoudi, 2016; Ajayi et al., 2017a; Arshad et al., 2017; Kolaventi et al., 2020), CW is generated throughout the construction stage where there is site clearance, onsite operation, material use, material handling, material non-use, human error, on-site management and planning, transportation, and finally residual waste. Therefore, even with an effective project design, there are still strong chances of producing huge amount of waste, if it is poorly executed during the construction process. Conversely, if on-site practices are effectively implemented, it could minimise any waste that originates directly from the construction stage and indirectly from other stages and phases of the project. Accordingly, mistakes and errors made during the design stage can be corrected and avoided in the construction stage (Lopez et al., 2010; Love et al., 2011, 2012).

As this study focuses on the construction stage it is, therefore, important to identify the construction stakeholders involved in such a stage. In construction projects, a contractor is the main stakeholder that is engaged in construction work, with a responsibly of managing, constructing and completing the project as drawn by the designer. Contractors include employees of different disciplines, each of which has a specific related job duties and responsibilities and these are typically: lead manager, project manager, site managers, site supervisors, and labours. This is in addition to sub-contractors and any individual self-employed worker. Lead and project managers (also referred to as senior management) oversee all phases of the construction process, from planning to administrative needs, while site managers oversee on-site operations, such as materials, personnel, and the construction budget. The difference between site supervisors and site managers is that the latter are a step above and have a wider scope of responsibility, whereas the former are mainly responsible for ensuring compliance with construction safety regulations in addition to monitoring the work progress of on-site workers and sub-contractors. Labourers (also referred to as on-site workers) include both skilled and unskilled labours, and the difference between the two is that the job requirement of the latter requires no specific education level or specialised experience, whereas the former requires additional skills or education.

It is important to note that CW generation is not only a technical issue but also a behavioural one, therefore, the next subsection discusses how the behaviour of personal involved in the construction industry, particularly contractors, can largely influence waste generation and why it is timely that this research focuses on this issue among other causes. Notably, in the following debate, the terms “attitude” and “behaviour” are used synonymously by researchers in their studies, referring to causes of CW generation. However, for the purpose of this study, the difference between the two terms is discussed in section 3.2.

2.3.3.1 Behavioural cause of construction waste

Human factors are integrated with every stage and phase in construction projects, unlike the other technical causes which are related to a specific phase (see Figure 2.2). This is because most common causes of CW generation are directly or indirectly affected by the behaviour of those working in the construction industry and by changing perceptions and attitudes; most of these causes can be prevented (e.g., Osmani et al., 2006; Kulatunga et al., 2006; Begum et al., 2009; Al-Sari et al., 2012; Udawatta et al., 2015; Ikau et al., 2016; Bakshan et al., 2017; Wu et al., 2017; J. Li et al., 2018a; Yuan et al.,2018; Liu et al., 2019; Luangcharoenrat et al., 2019)

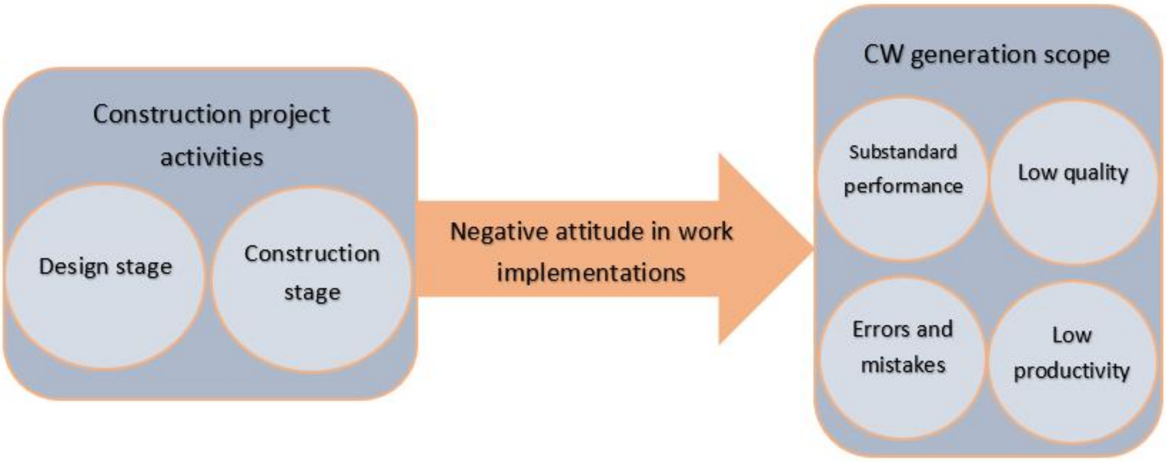

Figure 2.2: The effect of human factors on waste generation in construction projects

Al-Sari et al. (2012) highlighted that due to the labour-intensive nature of construction activities, the levels of waste generation are largely influenced by the behaviour of contractors. For instance, Wang et al. (2008) revealed that CW generation during on-site activities such as on-site management, operating machines, materials ordering and material handling, is mainly attributed to contractors' behaviour. Similarly, Fapohunda and Stephenson (2011) concluded that CW is mainly caused by a failure to use resources properly and effectively by construction operatives, such as cutting materials and materials protection. Liu et al. (2019) revealed that the extent to which reduction, reuse and recycling of CW can be attained, depends highly on motivational influences on the attitude of contractors, from management level to labourers. Furthermore, Kulatunga et al. (2006) argued that the effective implementation of CWM measures is largely affected by the attitude and perception of contractors.

However, such behaviour of contractors is influenced by a number of important factors as discussed in section 3.4. For instance, Poon et al. (2001) revealed that project managers may have little motivation towards performing on-site waste sorting, because it is perceived time and labour demanding. This was confirmed by Yuan et al. (2018) who provided relevant evidence exploring contractors' attitudes to waste. They add that a lack of managerial support and commitment being devoted to CW management activities, such as the availability of adequate resources, manpower and time, often results in difficulties for project stakeholders in minimising CW. Other studies concluded that lack of awareness and knowledge of contractors are major waste generation causes in construction sites. For example, Al-Hajj and Hamani (2011) stated that one of the main causes contributing to CW generation was lack of environmental awareness. Luangcharoenrat et al. (2019) noted that poor experience and lack of skills in assigned tasks will affect the quality of work often causing rework and repairs, which will result in huge CW generation. Furthermore, Lu and Yuan (2010) suggested that poor knowledge of CWM measures can lead to a great deal of CW generation. This can also result in poor perception among construction operatives by considering CW generation as an inevitable matter (Teo & Loosemore, 2001).

In light of the above discussions, it can be noted that human factors can have a major effect on waste generation and minimisation in construction projects. Therefore, this study focuses on the behavioural approaches when addressing CWM, as according to Udawatta et al. (2015) behavioural approaches require improvement to minimise waste generation in construction projects. Since the nature of waste has been clarified and its related causes have been identified, it is therefore important to discuss how it could be minimised with the aim of identifying gaps in the knowledge and confirming the research objectives.

2.4 Construction waste minimisation

In recent decades, with the rapid urban development, vast construction, renovation and demolition activities can be found across the world causing the amount of waste to increase at a high rate. The increasing awareness of such issues by both researchers and practitioners in the construction industry, has led to the development of CWM as an important function of construction project management. In addition, a large body of literature has emerged dedicated to its study (Yeheyis et al., 2013; Ding et al., 2015). However, CWM has not always been successfully controlled due to several reasons, including a lack of awareness and poor knowledge of the CW issue, illegal dumping, lack of governmental supervision, and the lack of interest from construction stakeholders towards waste minimisation (discussed in section 2.4.3). This shows that more work is required to achieve an acceptable standard in CWM. The subsequent sections discuss the principles of, and the need for, CWM, and highlight key findings of previous studies that relate to waste minimisation approaches which have been utilised in construction projects. This is to gain methodological insights for this study and also to identify key drivers as well as challenges facing waste minimisation in the construction industry.

2.4.1 Waste hierarchy

The hierarchy of waste management is a well-known guide used in the evaluation of practices from the most favourable option to the least favourable one, for addressing waste generation in construction projects (see Figure 2.3). It represents the best practicable options that protect the environment alongside resource and energy consumption within the chain of priorities for waste management, starting from the optimal situation of waste reduction (also referred to as prevention) and extending up to waste disposal which is the end-of-pipe solution. The waste hierarchy comprises the 3Rs of waste minimisation (i.e., reduction, reuse & recycling), followed by recovery of energy (e.g., incineration) and final disposal.

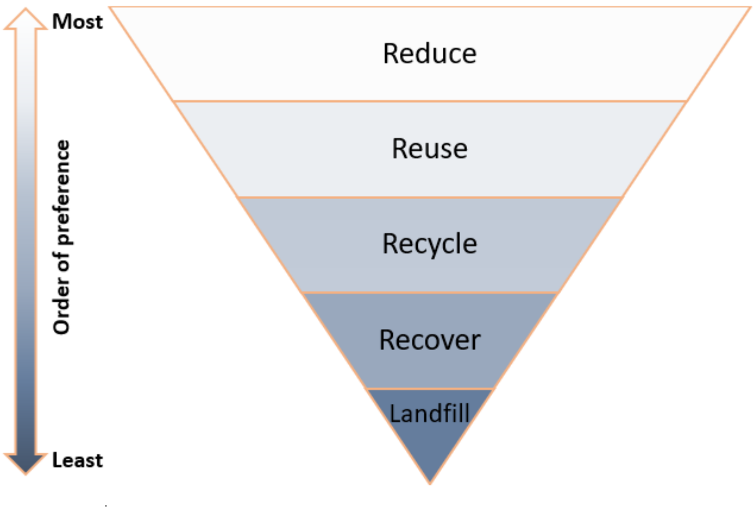

Figure 2.3: Waste hierarchy (Council Directive 2008/98/EC, 2008)

Reducing CW is the paramount goal of the hierarchy, as source reduction usually results in the least environmental and economic costs because it requires no collecting or processing of waste, which in turn helps to reduce the cost of higher charges for waste transportation, recycling and disposal. Therefore, CW management must primarily aim to prevent waste generation from the start. However, when waste prevention is not possible, the reuse of CW is the next most desirable option as suggested by the hierarchy. This step often requires collection but relatively little or no processing. Failing the above, recycling is most often the more preferred option than energy recovery in the hierarchy of waste management. However, both activities generally require collection and processing, thus, requiring additional energy and resources to reduce CW levels. CW disposal is the last resort in the waste management hierarchy and only considered once all other possibilities have been explored due to its negative environmental impact.

Notably, the terms CW management and CWM have sometimes been used interchangeably in the literature. However, some studies have defined clear differences between the two. For instance, the Council Directive 2008/98/EC (2008) has referred to CWM (or CW reduction) as the process of eliminating waste at the source, while it defined CW management as the process which comprises all the five options in the waste hierarchy including source reduction. Other sources (e.g., Ismam & Ismail, 2014; Saadi et al., 2016) have adopted different perspectives separating the process of CW reduction from CW management, referring to CW management as the process involved in dealing with waste once it has arisen. However, the scope of this study on CWM focuses on the 3Rs of waste minimisation during the construction stage, based on their significant resulting benefits in relation to construction projects as well as local communities, and for the purpose of this study, the term CWM will involve these three activities.

Many governments worldwide have established a number of CW management plans and strategies following the guidelines of the waste hierarchical approach in order to effectively manage CW (see section 2.4.3.3). However, several barriers and challenges often face the successful implementation of these plans and strategies. For example, recycling, reuse and recovery targets seem rather unrealistic in some cases due to several challenges, including insufficient infrastructure, lack of interest and engagement with programs, strategies' system vagueness, weak strategic planning and the lack of a specific legislative framework (see Table 2.7).

2.4.2 The need for construction waste minimisation

In recent decades, there has been a growing need and awareness of the importance of CWM as a means to address the global sustainability agenda, as well as a step towards environmental friendliness and economic benefits. According to Ekanayake and Ofori (2000), the effects of CW can be classified into two levels: the project level and the national level. At the project level, CW impacts stakeholder's profits, and reputation as well as the project's performance and productivity. At the national level, CW causes national and even global environmental problems as well as a financial load on governments; dealing with CW and its related problems. The subsequent sections discuss the effects of CW on the environmental, financial, and social aspects of SC and why there is an inherent need for CWM for both construction industries and governments.

2.4.2.1 Environmental issues

CW creates a number of major environment problems, such as diminished landfill areas due to increasing quantities of the disposed waste; consumption of a large volume of raw material resources; pollution and contamination resulting in serious health problems; and added energy consumption for transportation of waste and manufacturing new materials instead of those which are wasted (Nagapan et al., 2012a; Marzouk & Azab, 2014; Ding et al., 2016, 2018;

Ibrahim, 2016; Ferronato et al., 2017; Wang et al., 2018; Wang et al., 2019). Therefore, CWM is becoming ever more essential to protect the natural ecosystems and public health

Construction and demolition waste accounts for approximately 36% of the total waste received at landfill sites around the world, equating to 2.5-3.5 billion tonnes each year (ISWA, 2015). Many countries are reporting that they are rapidly running out of landfill areas for waste, especially in developing cities. For instance, figures published by the UK government revealed that the construction industry in the UK generates around 130 million tonnes/year of CW which is responsible for almost two thirds of the total landfill waste (DEFRA, 2020). Over 800 million tonnes of construction and demolition waste are generated every year in the EU (Deloitte, (2017), accounting for around 25% - 30% of all waste generated (European Commission, 2018). The figure is more than 1.5 billion tonnes in China (Huang et al., 2018), with only 5% being recycled (NDRC, 2014). In the USA, the volume of waste generated by the construction industry increased to 569 million tonnes in 2017 (EPA, 2019).

It is a similar story in the Middle-East region; inevitably the figures are lower but relative to the region's size and economic situation, they are still significant. The Gulf Cooperation Countries (GCC) generate around 120 million tonnes of general solid waste every year; the construction industry is responsible for around 55% (McElroy, 2012, Bhatia, 2016). Most of the collected waste in these countries is disposed of in landfills and waste dumpsites on the outskirts of the cities (Ouda et al., 2018). In Kuwait, approximately 16 million tonnes/year of CW is produced and around 66-84% of this waste is disposed of in landfill (Albeeshi et al., 2017; Puri-Mirza, 2020). The UAE is no exception and is ranked as one of the largest producers of waste (per capita) worldwide, where construction and demolition waste account for 70% of total solid waste generated (Al-Hajj & Hamani, 2011; Swain, 2018). In Abu Dhabi alone, 4.55 million tonnes of waste were generated by the construction industry with 67.8% sent to dumpsites and landfills (Hittini & Shibeika, 2019).

The generation of waste also contributes to the depletion of raw materials. This is because the construction industry consumes a huge amount of building materials most of which are from non-renewable sources such as metals and timber (UNEP, 2015b). Therefore, waste in construction projects means more consumption of these non-renewable resources. According to the UNEP (2015b, 2019a, 2019b, 2019c), buildings construction consumes around 35% of the world's resources including 12% of fresh water (including embodied water), 25% of steel, and more than 50% of crushed rock, gravel and sand. These all are used globally each year for construction. Additionally, the built environment accounts for 36% of the global final energy use each year, including embodied energy which is the energy used for all processes which are associated with projects construction, starting from the mining and processing of natural resources to manufacturing, transport and utilisation of building materials and finally, waste recycling and the disposal stage (UNEP, 2019a)

Pollution and contamination are additional significant problems resulting from CW. CW is a major contributor to environmental pollution having an impact on air, water and soil contamination, and resulting in adverse effects on flora and fauna (Ding et al., 2016; Ferronato et al., 2017). According to the World Bank (2018), 33% of CW is still openly dumped globally in forests, open land or waterways which in turn may cause soil and water contamination. This is because building construction materials are mostly processed materials and, therefore, often contain solvents and volatile organic compounds which affect human health and create fire hazards (Butera et al., 2014). Notably, open dumping (i.e., illegal dumping) is a prevalent waste disposal practice in lower-income countries equating for 93%, where there is a huge shortage of designated landfills, resulting in serious environmental impact (World Bank, 2018). However, CW disposal not only contaminates water and soil fertility but also leads to serious air pollution, as 11% of the generated waste is treated through incineration worldwide (World Bank, 2018). Additionally, the increasing volumes of CW and its associated energy usage create energy-related carbon dioxide (CO_2) emissions which contribute to climate change (Ibrahim, 2016). According to the UNEP (2019a), buildings construction accounts for 11% of energy and process-related CO_2 emissions each year.

The realisation of the impacts from CW on the environment has led both governments and decision makers in construction to develop various minimisation approaches, governmental legislations and good practice in order to protect the environment (see section 2.4.3). However, despite the recognised effort for enhancing environmental sustainability, the amount of CW generation is still substantially high and is considered a chronic and ongoing problem. This can be attributed to several major issues including lack of interest in CWM (Jaillon et al., 2009; Simpson, 2012); poor perception of the environmental problems which are caused by CW, (Al-Hajj & Hamani, 2011); and an absence of strict governmental policies and regulations, or reinforcing their existing ones (Votyakova, 2018). In confirmation of this, Lu et al. (2015) and Li et al. (2020) noted that managers are mostly concerned with time and money objectives in construction projects and that is why some managers would rather pay the charges and fees of CW disposal rather than investing money in CWM because sometimes it is perceived as being cheaper and less time consuming.

2.4.2.2 Economic issues

While CW affects the environment, it is also a key contributor to cost overruns in construction projects. Numerous studies in the construction literature have revealed that waste prevention results in financial benefits within the construction industry (Yuan et al., 2011; Saidu & Shakantu, 2016). According to WRAP (n.d.), around 15% (by value) of materials delivered to construction sites are wasted. However, the cost of material purchasing is only one part contributing to the total cost of CW as there is the cost of collecting, transporting and disposing as well as the time spent on managing and handling such waste (Mahpour & Mortaheb, 2018; Hao et al., 2019). Indeed, Osmani (2011) indicated that in construction projects, the true cost of waste is around 20 times the cost of waste disposal. Financial losses of CW generation can also result in increased tender prices of construction projects and, therefore, will raise the cost for clients as well as affect the competitiveness of contractors in obtaining future projects (Ann et al., 2013). However, when CW generation is unavoidable, on-site sorting, reuse and recycling of CW can also contribute to cost reduction in construction projects. This is because such waste minimisation practises reduce the quantity of disposed waste to landfill, which can be significant in some projects, and therefore reduce CW disposal cost including landfill charges and the transportation of disposal (Hao et al., 2008; Yuan, 2011; Wang et al., 2010; Ding et al., 2015; Ajayi et al., 2014, 2017a). For instance, landfill tax costs the construction industry in the UK over 200 million pounds each year (Osmani, 2012), resulting in significant profit losses for projects stakeholders.

Therefore, it is very important for the construction industry to improve its performance in this competitive age by adopting effective CWM practices. This will benefit both clients and contractors by achieving efficient construction in terms of reduced costs and time. For that reason, many stakeholders in the construction industry including clients, designers and contractors, are placing an increased effort in waste minimisation towards obtaining its optimum value (Osmani, 2011; Hussin et al., 2013; Yeheyis et al., 2013). However, project stakeholders sometimes are not incentivised in taking effective actions to minimise CW due to a lack of awareness and knowledge of the financial benefits (cost saving) of CWM (Udawatta et al., 2015; Bakshan et al., 2017). Additionally, the widespread perception by projects stakeholders that CWM is an activity that contributes to additional project expenses, creates a lack of interest towards adopting effective measures to minimise waste (Manowong, 2012).

From the country’s economic perspective, CW is of grave concern and a challenging issue facing many economies worldwide. Managing CW and its related problems require substantial investments from municipal governments, including physical infrastructure and long-term operations. This involves eliminating the damage that results from landfill emissions, removing the openly dumped waste to its specified dumping landfill, constructing new landfills to accommodate increased waste quantities and coverage of operational expenditures for labour, fuel and the servicing of equipment. This is in addition to enforcing rules and regulations for controlling waste disposal and subsequent monitoring, as well as developing waste management plans and strategies (Hussin et al., 2013; Marzouk & Azab, 2014). Globally, 205 billion dollars was spent in 2010 on solid waste related challenges and this figure could rise to an estimated 375 billion dollars per year by 2025 (Asnap, 2012). This situation, however, is more critical in low- and middle-income countries where financing solid waste management systems is one of their greatest concerns, since it comprises of more than 20% of municipal budgets and can be much higher in certain cases. Furthermore, it is estimated that local governments in such countries provide about 50% of their investments for solid waste services and management (World Bank, 2018). Potentially, this results in a major impact on the financial sustainability of local governments as funding must be balanced with the provision of other essential services such as healthcare, education and housing (ISWA, 2017; World Bank, 2018).

2.4.2.3 Social issues

While it is recognised that waste generation plays a key role in the environmental and economic sustainability of construction, it is clear that the social benefits of SC are strongly correlated with the minimisation of CW. Adopting SC through waste minimisation outlines the creation and management of a healthy built environment based on resource efficient and ecological principles (Hussin et al., 2013; Gan et al., 2015). This will result in achieving significant advantages of social sustainability for both society and the construction industry. In terms of a society perspective, SC enhances the environmental performance through minimising pollution, salvaging natural resources, reducing the overall energy use and enhancing city landscapes by reducing open dumping (see section 2.4.2.1). Additionally, SC enhances the economic performance of governments through reducing costs of dealing with CW and its related problems (Section 2.4.2.2) Therefore, adopting SC through carrying out essential sustainability practices (e.g., CWM), will help improve the quality of life and increase the standard of living in local communities.

From the construction industry perspective, the social benefits of adopting SC are reflected through responding to the needs of people over the project's lifecycle, providing high satisfaction for customers and working closely with clients, suppliers, employees and local communities (Azis et al., 2012; Hussin et al., 2013; Almahmoud & Doloi, 2018). In other words, social sustainability in construction is best achieved by attaining satisfaction from the project stakeholders through conducting sustainable practices (e.g., CWM), which require the collaboration of all parties involved in the construction process. In recent decades, the shift in the construction industry from the traditional paradigm towards sustainable development has received close global attention as a result of the significant impact of CW on the environment and society (Nagapan et al., 2012a). Therefore, it is important to integrate the three pillars of sustainability throughout the construction projects life cycle, with every stakeholder having a responsibility for carrying out sustainability practices including CWM (Gan et al., 2015).

2.4.3 Construction waste minimisation approaches

Over the years, different approaches have been established to address waste minimisation throughout the stages of the construction project. For instance, design-out practices including proper design and documentation, CW estimation modelling, low waste procurement management and collaborative design process, were identified as the most common waste minimisation approaches during the design stage (Alhawamdeh & Lee, 2019). On-site waste collection, reusing and recycling are considered significant waste minimisation approaches that are recommended by several authors during the construction stage (Huang et al., 2018; Ng et al., 2018). For the demolition of structures, Zhang et al. (2012) suggested that deconstruction or sequential demolition technology are effective approaches during demolition activities which can salvage large portions of materials for reusing and recycling.

However, this research study is focusing on waste minimisation during the construction stage, as explained in section 2.3.3. Therefore, there is a real need to undertake a comprehensive review of common waste minimisation approaches adopted during the construction process. This is to gain a profound insight into the impact of such methods and highlight any barriers encountered in their application. Additionally, it will identify research trends and gaps that will support the critical need for improvement and the potential impact of this stage. The following subsections categorise common CWM approaches identified in past studies under four main groups namely: on-site waste minimisation practices, technological approaches, legislation and behavioural approaches.

2.4.3.1 On-site waste minimisation practices

On-site waste minimisation practices are very important approaches due to their huge impact. These practices usually include two types of waste minimisation measures. The first type of measures are waste management practices which are employed after waste is generated (i.e., waste collecting, sorting and reusing). The second type are source reduction measures which through their effective implementation, enhance the performance of the construction process and, thus, minimisation occurs in CW generation. Table 2.3 highlights common waste minimisation practices utilised in construction sites.

Table 2.3: CWM- on-site waste minimisation practises

CWM category	Type of practice	Reference
On-site waste minimisation practices	Waste collecting and sorting	Hao et al. (2008), Wang et al. (2010), Yuan et al. (2011), Lu and Yuan (2012), Yuan et al. (2013), Ding et al. (2016).
	Waste reuse	Jin et al. (2017), Ajayi et al. (2017a), Wu et al. (2016), Huang et al. (2018).
	On-site planning and management: - On-site supervision - On-site planning and scheduling - Quality management - On-site communication - Maintenance of equipment and machinery	Wang et al. (2008), Hoonakker et al. (2010), Chin-Keng (2011), Mäki and Kerosuo (2015), Udawatta et al. (2015), Ajayi et al. (2017a, b), Ajayi and Oyedele (2018b), Mohideen and Ramachandran (2014).
	On-site material management: - Material procurement - Material delivery - Material storage - Material handling	Al-Hajj and Hamani (2011), Madhavi et al. (2013), Patil and Pataskar (2013), JerutoKeitany and Richu (2014), Gulghane and Khandve (2015), Ding et al. (2016), Koriom et al. (2019).

Waste collection and sorting are important approaches in on-site waste management as they are preliminary steps for achieving reuse, recycling and safe waste disposal. On-site collection and sorting have a large impact on the quantity of recycled and reused waste as the more the wasted materials are collected and sorted the more waste there is to be recycled and reused (Yuan et al., 2011). Additionally, reusing and recycling could be largely influenced by how well the different components of CW are properly segregated (Ding et al., 2016). On-site sorting is often adopted to minimise waste disposal. As Lu and Tam (2013) have argued, if CW is unavoidably generated on construction sites, arranging on-site sorting is advisable for contractors. The benefits of conducting on-site sorting of CW typically include: reducing the cost of waste disposal, increasing the rates of reuse and recycling, prolonging the lifespan of landfills designed for receiving waste, and reducing the pollution resulting from the huge amount of disposable waste (Hao et al., 2008; Ding et al., 2015; Wang et al., 2010).

Although the sorting procedure of CW can be carried out on-site or by hiring a specialised company, a number of studies highlighted the benefits of on-site sorting since it requires less effort, results in better segregation and avoids the transport of refuse to sorting and recycling facilities (Lu, & Yuan, 2012). Nonetheless, there are number of critical issues constraining on-site collection and sorting including, lack of on-site space, sorting cost (cost of transportation, equipment, and labour), waste separability and the market for recyclables (Hao et al., 2008; Wang et al., 2010; Yuan et al., 2013; Ajayi et al., 2015). Additionally, the contractors' attitude is regarded as one of the most critical issues, as according to Yuan et al. (2013), project stakeholders' attitude and management effort are perceived as being of major importance in on-site collection and sorting practices.

Reuse is also considered one of the important waste minimisation practices on construction sites. In the general situation, reuse is more desirable than recycling as reusing CW will avoid the cost of recycling and its associated energy usage (Wu et al., 2016). Reusing and salvaging waste materials reduces the quantity of disposed waste to landfill, which can be significant in some projects. This will protect the environment, and reduce further costs for both clients and contractors through reducing the cost of purchasing new materials, and avoiding the disposal and transport costs of waste materials (Yuan et al., 2011; Ajayi et al., 2017a, 2014). However, the practice of reusing CW is still in its infancy and there are key barriers to implementation such as non-compliance of specifications of the salvaged materials, lack of knowledge and experience of reusing waste, and lack of awareness of the short- and long-term advantages of reusing CW (Park & Tucker, 2017; Jin et al., 2017; Huang et al., 2018).

Site supervision is one of the vital on-site management measures that ensures time, safety, quality and cost effectiveness of construction operations (Ajayi et al., 2017a, b). Site supervisors are mainly concerned with the planning, organising, monitoring and controlling of each phase of the construction process. In addition, they ensure communication of instructions and taking action whenever necessary to deal with identified problems (Wang et al., 2008; Mäki & Kerosuo, 2015). Therefore, negligence of supervision in construction sites can disrupt the effective implementation of construction activities which would increase the chances of waste generation. However, lack of skills and experience of site supervisors affects the quality of supervision as according to Alwi et al. (2001), the success of supervision is more likely to be dependent on the experience rather than merely the number of supervisors involved in a project. Adequate on-site planning and scheduling is also an essential issue in CWM as efficient planning of construction activities ensures proper allocation of time, money, material and human resources (Ajayi, et al., 2017b). This will help avoid errors, minimise wasted resources, enhance the work performance and increase the productivity of work. Additionally, with effective construction planning, the consequences of unforeseen situations can be easily controlled or even avoided (Mäki, & Kerosuo, 2015). However, Udawatta et al. (2015) pointed out the importance of devoting adequate time for the on-site planning process to achieve successful outcomes.

Quality management (quality planning, assurance & control) is another on-site measure that provides a major contribution to CWM. It is a proactive measure to produce high quality work through eliminating defects at the source which reduces rework and ensures that the quality of the final work is controlled (Chin-Keng, 2011). This can be achieved by identifying all the issues that might have an impact on the quality of work including the role of people and the quality of materials (Hoonakker et al., 2010; Ajayi, & Oyedele, 2018b). Therefore, obtaining high quality in construction work is heavily reliant on the utilisation of standardised materials, stakeholders' behaviour and the proficiency of workmanship (high experience and skills), which all have a direct effect on waste generation. One significant barrier against quality implementation in construction projects is that some contractors reduce their costs in order to obtain new tenders in a competitive bidding process. As a result, they may try to reduce allotted resources towards safety or quality management in order to maintain a healthy profit margin for the work (Hoonakker et al., 2010).

Furthermore, researchers have highlighted the importance of collaboration and clear communication between the different parties involved in the construction process (Hoonakker et al., 2010). Typically, the construction industry consists of three primary participants: the customer (i.e., owner of the project), the consultant (i.e., designers & architects), and the general contractor (including sub-contractors). Even though a common project goal is a shared completion of the project plan, the participants differ in their objectives of the construction process. For instance, the typical owner would like their desired project to be completed in the shortest time possible. The consultant is hired by the owner to provide their service concerning the design of the project; however, most often their relationship with the contractors is unclear.

The contractor attempts to complete the project as drawn by the designer seeking the most efficient way possible in order to increase their profit (Hoonakker et al., 2010).

Therefore, effective collaboration and communication between the different parties involved in the project will lead to more engagement in CWM by enhancing the work performance, increasing the productivity, reducing conflicts among parties and reducing post-variations and rework (Wang et al., 2008; Udawatta et al., 2015). One more typical on-site management measure is regular maintenance of construction equipment and machinery which can significantly contribute to CWM. Such a measure helps sustain the continuous and reliable operation of equipment and machinery in construction sites and, as a result, minimises equipment downtime, avoids interruptions and rework, increases productivity, improves quality and reduces the cost (Bashiri et al., 2011; Mohideen, & Ramachandran, 2014). Therefore, equipment and machinery maintenance are absolutely essential to maintain a trouble-free working environment and reduce the chance of CW generation.

Finally, researchers have emphasised the significance of on-site material management towards CWM. This is because ineffective material management is evident in many construction projects and causes considerable waste of time, money and materials (JerutoKeitany & Richu, 2014). Material management is described as a coordinating function responsible for planning and controlling materials flow in a construction project (see Figure 2.4). This ensures that the right quality and quantity of material are appropriately selected, effectively delivered and safely handled on site in a timely manner and at a proper reasonable cost (Madhavi et al., 2013; Gulghane & Khandve, 2015). According to Nagapan et al. (2011), the management of procuring materials is a critical step and needs to be effectively planned and executed to avoid shortages or surpluses in the materials' inventory in construction sites. While shortages in the supply and flow of construction materials are often cited as major causes of project delay, productivity degradation and financial losses (Nagapan et al., 2011), excessive stocks are also subject to damage, deterioration, theft and vandalism and poor weather conditions (Muhwezi et al., 2012). Ajayi et al. (2017b) revealed that Just-In-Time delivery affects the maintenance of a consistent flow of materials for production, thus affecting the time scale of construction activities. Additionally, improper storage of construction materials can cause material damage and loss which has a direct impact on CW generation (Najafpoor et al., 2014). Furthermore, Koriom et al. (2019) emphasised the importance of efficient material handling, as this practice encompasses all aspects of movements and distribution of raw materials, work in process, or finished goods on and off construction sites.

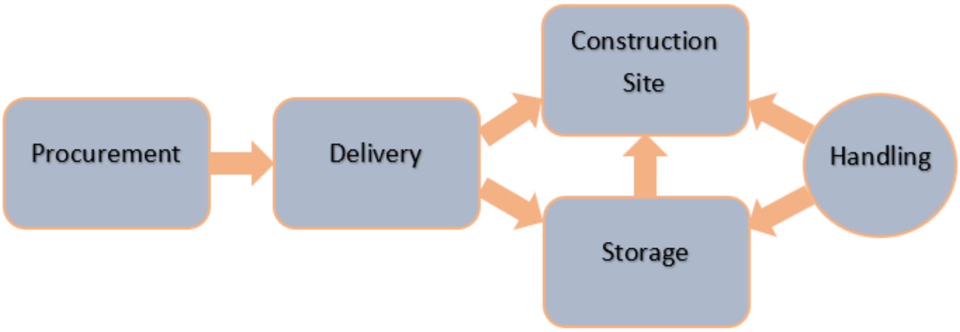

Figure 2.4: A typical material management process in construction projects

Therefore, effective material management in construction projects ensures material safety and protection, increases work productivity, avoids schedule delays and enhances the overall project performance. However, Gulghane and Khandve (2015) argued that there is a lack of tools and techniques currently utilised in construction projects to overcome human error in material management. Their study suggested that manual material management practice procedures are unsatisfactory as they are labour intensive, inaccurate and error prone. Moreover, increasing awareness about the significance of every aspect of material management is almost essential as it helps trace the origins and causes of any failures (Al-Hajj & Hamani, 2011; Patil & Pataskar, 2013).

2.4.3.2 Technological approaches

Low-waste technologies (LWTs) are not new to the building industry and are considered one of the important approaches in CWM. Utilising LWTs in the construction process optimises resource consumption which results in waste minimisation and increased value for a project's stakeholders (Jaillon et al., 2009; Zhang et al., 2012). Table 2.4 illustrates common LWTs that are available to support implementation in construction projects.

Table 2.4: CWM- technological approaches

CWM category	Type of LWTs	Reference
Technological approaches	Soft technologies (i.e., information and communication technologies)	Adriaanse et al. (2010), Nikakhtar et al. (2015), Gulghane and Khandve (2015), Liu et al. (2015), Martínez-Rojas et al. (2016), Won and Cheng (2017).
	Hard technologies (i.e., innovative construction tools and equipment)	Zhang et al. (2012), Tam et al. (2015), Pan et al. (2018), Martin and Perry (2019).
	Modern methods of construction (MMC)	Lu and Yuan (2011), Zhang et al. (2012), Mesároš and Mandičák (2015), Rahman (2014), Tam et al. (2015), Martin and Perry (2019).

Information and communication technologies, which are sometimes referred to as soft technologies, aid project managers to improve the processes and work performance during construction activities, thereby minimising CW generation (Martínez-Rojas et al., 2016). Such LWTs improve collaboration, coordination and data exchange including data sharing, digital representation, and storage among the stakeholders involved in the construction process (Zhang et al., 2012; Martínez-Rojas et al., 2016; Won & Cheng, 2017). For instance, Building Information Modelling (BIM) is a widely embraced information and communication technology that is used in architecture, construction and engineering. It contains a wealth of information, such as material resources and geometry which can be integrated with the project's schedule which, in turn, provides improved planning to help ensure Just-In-Time arrival of materials, equipment and labour (Won & Cheng, 2017). Another example is Radio Frequency Identification technology (RFID) that is being adequately used on-site to manage construction materials easier and faster which, in turn, will overcome human error and the potential of CW generation (Grau et al., 2012; Gulghane & Khandve, 2015).

Hard technologies, such as innovative construction tools and equipment, are becoming more widely used by contractors in construction sites. Such LWTs contribute to CWM through increasing the productivity and quality of work, providing a tidier and safer working environment, improving work performance, and reducing construction process duration and costs (Tam et al., 2015; Pan, et al., 2018). One common example is Machinery Sprayed Plaster, as the main difference between traditional cement mortar and mechanised plaster is that the former is applied and trowelled smooth by hand, whilst the latter is mixed and applied mechanically. Therefore, utilising such a tool can provide high productivity of work, low labour demand, a tidier work space and less waste generation (Tam et al., 2015).

Modern methods of construction (MMC) is another typical approach of LWTs and have a very broad application in the construction industry, especially in developed countries (Mesároš & Mandičák, 2015). MMC are construction techniques that incorporate innovative designs and technological implementations which have a strong capability to minimise CW generation (see Figure 2.5). This type of LWT ensures an efficient management process, increases the precision of construction within a shorter time, optimises usage of resources, reduces the environmental impact and increases construction sustainability (Zhang et al., 2012; Tam et al., 2015; Mesároš & Mandičák, 2015). For instance, an innovative formwork system such as Prefabricated Steel Formwork is one of the most commonly used methods in construction activities. It can provide higher stiffness and is more durable than traditional timber formwork since it can be erected repetitively as well as maintain a coherent concrete surface. This will aid in reducing the additional allocation of materials and labour in dealing with step joints and poorly cast surfaces. In addition, it will increase the precision and quality of the construction component which leads to reduced possibilities of CW generation. (Tam et al., 2015).

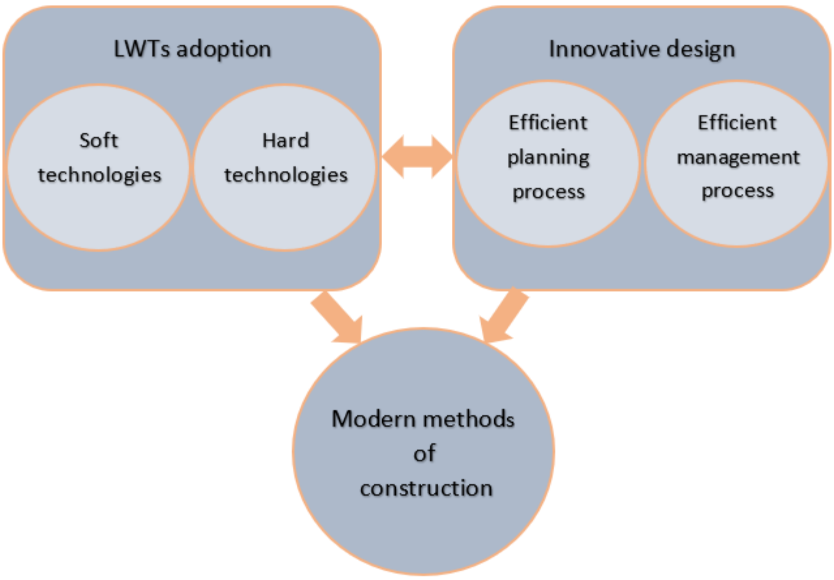

Figure 2.5: Criteria of modern methods of construction (MMC)

In general, LWTs facilitate quicker construction and produce better quality work leading to a decrease in waste generation. In addition, there would be cost savings if construction materials can be reused or if mass production is required (Jaillon et al., 2009; Tam et al., 2015). However, there are limitations and barriers with regard to the implementation of LWTs such as: higher LWT's appliance design and investment costs, market limitations, limited fabrication facilities, unstandardised construction materials, lack of qualified equipment operators, lack of knowledge and familiarity with the LWTs and their implementation, insufficient government support and, finally, the culture of the construction industry as some contractors tend to use more familiar conventional methods (Jaillon et al., 2009; Zhang et al., 2012; Rahman, 2014; Abarca-Guerrero et al., 2017). Additionally, LWTs occasionally do not meet the general functional requirements as set for the construction project due to their incompatibility with the project's nature (Jaillon et al., 2009). Furthermore, there is often negative behaviour towards the implementation of LWTs, as construction costs remain the most governing issue for project stakeholders when choosing a construction method (Abarca-Guerrero et al., 2017).

2.4.3.3 Legislation

Government regulations and policies play a critical role in CWM by developing and fostering the regulatory environment. However, CWM legislation can exert a different level of influence: some are compulsory and some are total or partial voluntary. Table 2.5 highlights the common polices and regulations issued to support CWM.

Table 2.5: CWM- regulatory measures

CWM category	Type of regulation	Reference
Legislation	Landfill disposal charges	Lu and Tam (2013), Ann et al. (2013), Poon et al. (2013), J. Li et al. (2018b), Hao et al. (2019), Li et al. (2020).
	Illegal dumping penalties and supervision	Lu and Tam (2013), European Commission (2016), Rahim et al. (2017), Wee et al. (2017), J. Li et al. (2018b).
	Waste management schemes	Tam (2008), Solís-Guzmán et al. (2009), Zaman and Lehmann (2011), European Commission (2016), Yukalang et al. (2017), DEFRA (2020).
	Sustainable development strategies	Augenbroe et al. (1998), Warnock (2006), European Commission (2012, 2014), Yukalang et al. (2017).

Over the past years, local governments have been paying increased attention to the promotion of CWM through establishing and further reinforcing landfill charges. It is considered as one of the most typical legislative measures implemented by many local governments worldwide, due to the increasing amount of CW being disposed to landfill sites (Lu & Tam, 2013). Landfill charges play a critical role in promoting economic incentives for contractors to minimise waste, as well as encourage reuse and recycling as cost savings prevail as the primary motivating factor (Yuan et al., 2011; Hao et al., 2019). For instance, a landfill tax came into force in the UK in 1996 and has encouraged recycling and recovery and this is now, in many cases, cheaper than sending CW to landfill (European Commission, 2016). In Hong Kong, a significant minimisation of CW was achieved in the first three years (2006–2008) of the CW Disposal Charging Scheme (CWDCS) implementation (Ann et al., 2013).

However, landfill charges have not always exerted a strong influence towards motivating project stakeholders to minimise CW, as in many cases waste is being disposed of with little or no attempt at early recovery (J. Li et al., 2018b). The most likely reason is that some project stakeholders are reluctant performers with a laissez-faire attitude to CWM as according to Ann et al. (2013), lack of involvement in CWM results from sub-contractors being reluctant to change. Li et al. (2020) revealed that there is a negative correlation between stakeholders' perceptions of cost reduction and their willingness to pay for CW collection, sorting and recycling. Another reason is that sometimes project managers would rather pay the charges of CW disposal than invest time and money in CWM, because the former is perceived as being much cheaper (J. Li et al., 2018b; Li et al., 2020). Confirming this, a study by Poon et al. (2013) revealed that at times the cost of landfill charges is not high enough to raise the awareness about waste minimisation on construction sites. Moreover, some contractors tend to increase their tender prices in order to absorb the extra cost for landfill charges (Ann et al., 2013).

Monitoring CW disposal and imposing penalties for illegal dumping is another key legislative measure toward controlling CW generation. Imposing financial penalties significantly promotes economic incentives for project stakeholders towards minimising CW (Yuan et al., 2011). Many local governments are establishing strict measures for monitoring CW disposal further reinforcing their existing ones to discourage illegal dumping of CW. For instance, in the UK, local councils and environmental regulatory bodies have a responsibility towards controlling the illegal disposal of waste. They carry out a huge a number of inspections of waste sites and have issued guidance for environmental offences. However, in the year 2013/2014 there were almost 18% of open dumping incidents from construction and demolition waste in the UK which indicated that further attention and effort should be placed on such issues (European Commission, 2016).

Local governments worldwide are continuing to examine effective monitoring measures and enforce strict punishment to prevent the practice of illegal dumping of CW (Lu & Tam, 2013; Rahim et al., 2017). However, implementation efforts are challenged by some difficulties including limited financing, low staff technical capacity and ambiguity in the policies' guidelines (Wee et al., 2017; World bank, 2018). Additionally, both strict regulations and looser regulations can lead to illegal dumping practices (J. Li et al., 2018b). For instance, higher landfill charges may trigger objections or uncooperative behaviour, such as illegal dumping, from related construction stakeholders because this policy will affect their financial interests. On the other hand, charge levels which are too low will not provide sufficient motivation for construction stakeholders to minimise CW.

Waste management schemes have been developed by many local governments worldwide as they are ultimately responsible for any related waste management strategies and waste prevention plans. Additionally, some of these plans provide specific targets to be met for waste reduction, reuse and recycling. For instance, Waste Management Plans (WMP) have been developed by UK governmental bodies within England, Scotland, Wales and Northern Ireland, which are responsible for any related waste management issues (European Commission, 2016). One of the targets of WMP is for the UK to recover at least 70% of non-hazardous construction and demolition waste by 2020, which it is currently meeting (DEFRA, 2020). In 2019, the Ministry of Ecology and Environment decided to address the issue of enormous amount of solid waste generation in Chinese cities by introducing the concept of a 'zero waste city' (Lu, 2020). This concept includes 100% recycling of solid waste and 100% recovery of all resources from waste materials. In the UAE, the Centre of Waste Management, Tadweer, has been established by the government of Abu Dhabi in 2008. It is responsible for the implementation of solid waste management policies and strategies across the Emirate. In the first half of 2019 Tadweer has managed to collect 1.2 million tonnes of solid waste (including CW), and this was a relatively large figure considering the country's size and population (Gulf news, 2019).

Furthermore, several governments initiated sustainable development strategies to coordinate participatory processes of thought and action in order to achieve economic, environmental and social SC objectives in a balanced and integrative manner. For instance, the "Construction 2020 Strategy" has been established in the EU in order to support the construction sector in its adaptation to key upcoming challenges, as well as to promote sustainable competitiveness in the sector. One of its main objectives is to improve resource efficiency, protect the environment and improve business opportunities (European Commission, 2012, 2014). Another example is the USA where a number of national sustainability initiatives have been established such as "Buildings for the 21st Century" and "Resource conservation strategies", in order to create a new generation of buildings that are energy efficient, high quality, affordable and environmentally sustainable. These strategies hold tremendous potential and have attained successful outcomes over the past years (Augenbroe et al., 1998; EPA, 2016). In 2016, Dubai launched the Dubai 3D Printing Strategy which adopted an emerging technology to help produce SC. This initiative has a vision to transform the Emirate as a 'leading hub of 3D printing technology' by 2030 and dictates that 25% of the buildings in the Emirate will be constructed using the technology by that year. The first project that was in line with such a strategy was "Apis Cor" which was completed in 2019 and the significant benefit from such project is to achieve increased efficiency including time, cost and waste reduction (Arabian Industry, 2020).

Nonetheless, not all of the waste management schemes and sustainability strategies were successful, as the impact on minimising CW (i.e., diverting from landfill, minimising resources consumption and reducing illegal dumping) was often minimal. For instance, DEFRA repealed the Site Waste Management Plans (SWMP) policy in 2013 after five years of implementation due to its inefficiency (European Commission, 2016). Additionally, in New Zealand, the “Building Act” and the “Resource Management Act” made few concessions to environmental sustainability (Warnock, 2006). A number of key issues were identified to constrain the full successful implementation of such schemes and strategies, including insufficient infrastructure, weak strategic planning, lack of interest and engagement with programs, staff capacity, information systems and strategies' system vagueness (Zaman & Lehmann 2011; Yukalang et al., 2017). Additionally, many construction organisations only seek to invest in waste minimisation to be legally compliant and, therefore, produce minimum performance outcomes (Simpson, 2012).

2.4.3.4 Behavioural approaches

As previously explained in section 2.3.3.1, the role of human factors has gained more attention from researchers in recent years. This is because behaviour is critical to the successful attainment of desired CWM outcomes. Hence, several behavioural approaches have been addressed to minimise waste in the construction industry. Table 2.6 demonstrates the common behavioural approaches.

Table 2.6: CWM- behavioural approaches

CWM category	Type of approach	Reference
Behavioural approaches	Training and education of: - CW causes and minimisation techniques - Environmental impacts and cost reduction	Wang et al. (2008), Begum et al. (2009), Al-Hajj and Hamani (2011), Al-Sari et al. (2012), Ling and Nguyen (2013), Bakshan et al. (2017), J. Li et al. (2018a).
	A Reward scheme motivation	Kulatunga et al. (2006), Tam and Tam (2008), Mills et al. (2012), Yuan (2013), Mahpour and Mortaheb (2018).
	Waste management support	Rodriguez-Melo and Mansouri (2011), Tan et al. (2011), Akadiri and Fadiya (2013), Nagapan et al. (2012a), Bakshan et al. (2015).

The awareness of CW causes and minimisation techniques are significant issues in tackling CWM behaviour, and it can be addressed by providing adequate relevant training and education (J. Li et al., 2018a). Training on source-reduction procedures, reuse of materials and the underlying factors that can generate CW, can highly improve the level of knowledge and skills of CWM among contractors which in turn, would effectively improve CWM growth and performance (Al-Hajj & Hamani, 2011; Yuan, 2013; Abarca-Guerrero et al., 2017). Indeed, Luangcharoenrat et al. (2019) noted that poor implementation of CWM due to lack of experience and skills in assigned tasks, will cause rework and repairs. Further, increasing awareness of financial incentives (cost saving) is seen to be a most influential method of motivating stakeholders in taking effective action to minimise CW, as project stakeholders are mostly concerned with cost saving objectives (Udawatta et al., 2015; Bakshan et al., 2017). Moreover, environmental awareness which is a qualitative variable that influences the willingness of various construction stakeholders to minimise waste, can also be raised by highlighting the importance of CWM through providing relevant education (Wang et al., 2008; Al-Sari et al., 2012; Yuan, 2013).

A number of training schemes have been initiated by governmental bodies as well as and private organisations with the aim of enhancing awareness in the construction industry towards sustainable development. For instance, ISWA has made a key contribution in knowledge build-up, action and awareness raising in waste minimisation and recycling (ISWA, 2017). In the UK, a number of institutions such as WRAP, CIRIA and the Building Research Establishment (BRE), have been promoting SC through guiding the construction industry towards waste minimisation with the support of their workshops, publications, best practice examples and guidance. It was evident that such institutions have helped businesses and individuals to develop sustainable practice and use resources in an efficient way (Akadiri & Fadiya, 2013). For instance, BRE has established the ‘Site Sustainability Manager Training scheme’, which provides training and education that will equip site managers with the required knowledge for delivering the most sustainable development. Such scheme ensures that a construction site will not only be managed in an environmentally efficient manner but also gives the client and the site management team confidence that the project’s design requirements are achieved. However, despite the importance of education and training about CW issues, there is still a significant absence of the provision of such training by decision makers in the construction industry, especially in developing countries (Ling, & Nguyen, 2013; Mahdi, & Ali, 2019; Mahamid, 2020). The reason behind this can be mainly attributed to a lack of motivation and reluctance to change which are seen as key barriers constraining the implementation of such an approach (Ling & Nguyen, 2013). Additionally, there is a general lack of management support in investment of time and money for providing the necessary training and educational courses about CWM (Al-Hajj & Hamani, 2011; Lu et al., 2015).

A reward scheme is an effective performance-dependent approach that can motivate construction stakeholders, including both organisations and employees, to change their behaviour and increase their participation in waste minimisation (Osmani et al., 2008; Liu et al., 2019). Several reward schemes, which can be a financial reward or non-financial recognition, have been established by many governmental bodies and non-profit institutions for the promotion of SC. For instance, the Building Research Establishment Environmental Assessment Method (BREEAM) was established in 1990 in the UK and is the world's longest established method of assessing, rating and certifying the sustainability of buildings, including energy use and material waste. In more than 50 countries across the world, around 550,000 projects have been BREEAM-certified and over 2,250,000 projects are registered for certification (Giles, 2017). In addition, the KSA Award for Environmental Management (KSAAEM) was established in Saudi Arabia in 2015. It is a financial award as well as an honorary recognition of outstanding achievements in environment and sustainable development. So far, it has been awarded to many individuals and organizations in recognition of their substantial contributions to the environment (Ksaaem, 2018).

Within the construction industry, an organisational strategy of rewarding construction employees is foreseen to raise their willingness and motivation to be more engaged in CWM activities (Kulatunga et al., 2006; Wang et al., 2014). Conversely, negative behaviour towards CWM might exist among some employees, particularly construction operatives, thinking that it is not worthwhile unless it is tied to personal financial benefits (Yuan, 2013). The reward scheme can be in the form of bonuses, merit-related salary reviews, and recognition of individual/ team excellence rather than the length/ duration of service. For instance, the Stepwise Incentive System (SIS) scheme is used to measure the cost saved in purchasing materials and controlling CW generation (Tam & Tam, 2008). The key importance of such a scheme is that it exploits employees' awareness of CWM by rewarding staff involved in projects who are producing lower CW levels. Tam and Tam's (2008) study showed that the effectiveness of SIS can result in CW being reduced by up to 23%.

It is noteworthy that incentive-based (e.g., rewards) and penalty-based (e.g., fines & charges) approaches are both important measures affecting CWM behaviour. However, a study conducted by Mahpour and Mortaheb (2018) provided evidence for the preference of incentivising over penalising construction employees in order to increase their motivation for minimising CW.

Finally, waste management support refers to schemes which are provided to construction stakeholders in order for them to obtain financial and environmental benefits from their projects. A number of non-profit organisations are supporting the construction industry through the provision of guidance, solutions and services that facilitate better waste management. For instance, in 2011, WRAP managed to help more than 600 construction companies succeed in halving their waste to landfill, which in turn, positively influenced construction to the value of more than 38 billion pounds (WRAP, 2011). In the USA, the Building Materials Reuse Association (BMRA) is a non-profit organisation which provides guidance and services to facilitate the reuse of used or surplus building materials through an online directory website (EPA, 2019). It can be noted that both reward schemes and waste management support schemes are significant in terms of their resulting benefits in CWM. However, several barriers may stand in the way for such behavioural approaches such as: lack of interest of project stakeholders; employee belief that waste generation is outside of their control; it is not a cost-effective practice; it takes more time to undertake; and focus should be on delivering quality construction (while ignoring the issue of waste minimisation) (Jaillon et al., 2009; Ajayi et al., 2015, 2016; Jin et al., 2017; Wu et al., 2017). Additionally, the absence of a rewarding system can exist (within organisations) when project managers do not perceive any short-term benefit from CWM, as sometimes the financial returns gained from minimising CW are too small (Wang et al., 2014).

2.4.3.5 A summary of construction waste minimisation approaches

From the discussions presented in sections 2.4.3.1 through to 2.4.3.4, the common CWM approaches and the key barriers affecting their implementation level are summarised in Table 2.7.

Table 2.7: A summary of the common CWM approaches and their key barriers

CWM approach	Barrier	Reference
Waste collecting and sorting	- Lack of on-site space - Increased sorting cost - Poor waste separability - Poor market for recyclables - Poor attitude and management effort of contractors	Hao et al. (2008), Wang et al. (2010), Yuan et al. (2013), Ajayi et al. (2015).
Waste reuse	- Non-compliance of specifications, - Lack of knowledge and experience of reusing waste - Lack of awareness of the short- and long-term advantages reusing waste.	Park and Tucker (2017), Jin et al. (2017), Huang et al. (2018).
On-site planning and management: `	- Lack of skills and experience of site supervisors - Insufficient time and money allocation for the on-site planning and quality management processes - Poor material quality - lack of experience and skills - Lack of interest from project stakeholders	Alwi et al. (2001), Udawatta et al. (2015), Hoonakker et al. (2010), Ajayi and Oyedele (2018b).
On-site material management:	- Lack of tools and techniques for managing construction materials - Lack of awareness about the causes of failures in construction material management	Al-Hajj and Hamani (2011), Patil and Pataskar (2013), Gulghane and Khandve (2015).
LWTs	- Higher LWTs appliance design and investment cost - Market limitations - Limited fabrication facilities - Lack of knowledge and familiarity with the LWTs and their implementations - Insufficient government support - The governing culture of the construction industry - Incompatibility with the requirements of the construction project - Negative behaviour towards the acceptance of LWTs	Jaillon et al. (2009), Zhang et al. (2012), Rahman (2014), Abarca-Guerrero et al. (2017).
Landfill disposal charges	- Reluctance to change - Low disposal charges - Increasing tender prices for absorbing the cost of landfill charges	Ann et al. (2013), Poon et al. (2013), J. Li et al. (2018b), Li et al. (2020).
Illegal dumping penalties and supervision	- Limited government financing, - Low staff technical capacity - Ambiguity in the policies' guidelines - Lack of moderation in policies	Wee et al. (2017), J. Li et al., (2018b).
Waste management schemes and sustainable development strategies	- Insufficient infrastructure - Weak strategic planning - Lack of interest and engagement with programs - Minimum legal compliance - Poor staff capacity managing the schemes - Poor information systems - Strategies' system vagueness	Zaman and Lehmann (2011), Simpson (2012) Yukalang et al. (2017).
Training and education	- Lack of motivation - Reluctance to change, - Lack of management support	Al-Hajj and Hamani (2011), Ling, and Nguyen (2013), Lu et al. (2015).
Reward scheme and waste minimisation good practices	- Lack of interest of project stakeholders - Belief that CW is inevitable - Belief that CWM is not cost and time effective - Interest in delivering quality over CWM - Absence of a rewarding system, especially when the financial returns from CWM are perceived as small	Jaillon et al. (2009), Wang et al. (2014), Ajayi et al. (2016), Jin et al. (2017), Wu et al. (2017).

2.5 Construction waste in Jordan

The Hashemite Kingdom of Jordan is a relatively-small country in western Asia (see Figure 2.6), with an area of 88,780 km2 and a population of 10 million (World Development Indicators [WDI], 2019a,b). It has one of the smallest economies in the Middle-East region. A number of key sectors contribute to the Jordanian GDP, such as manufacturing, transport, tourism, hospitality and the construction sector, with the latter being one of the most critical components of Jordan’s economy (The Economic Policy Council, 2016). The Jordanian construction industry is ever growing with the highest annual growth rates (16%) after agriculture. In addition, Jordan’s construction sector is one of the largest employers in the economy; during the period (2015-2018) it was the 6th largest employer in Jordan (Department of Statistics, 2020).

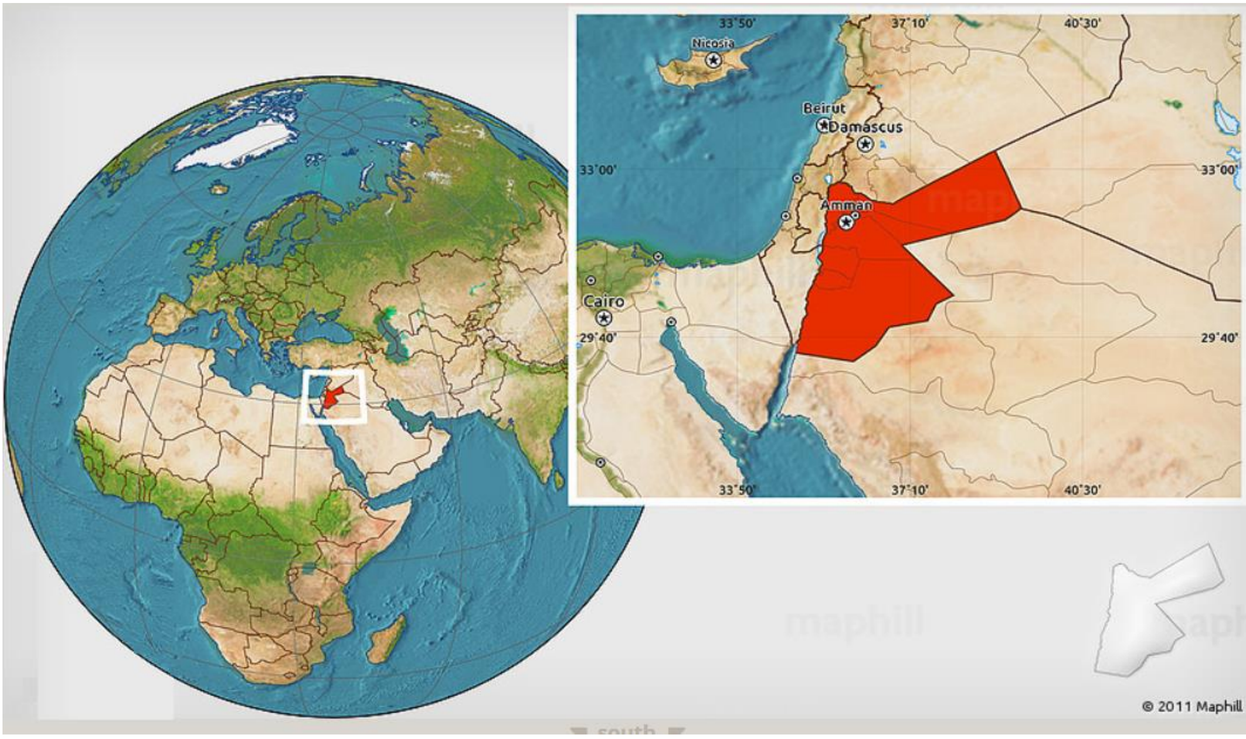

Figure 2.6: Map of Jordan (maphill maps)

Jordan’s construction industry can be categorised into two main categories, namely, small and medium size companies and large size companies (Al-Rifai & Amoudi, 2016). The first type of company is usually managed by one person, is mostly a family business and their main interest is to obtain maximum profit from the investment within a shorter time period. Most often, this type of company plays the role of client and contractor and sometimes that of the designer, with little or no concern about the issue of CW. Companies falling under the second type of category are usually multimillion-dollar investments, where the management is primarily concerned with cost and quality objectives. Accordingly, the lack of interest from construction stakeholders in addition to the rapid development in the construction sector, has resulted in the fast growth of CW generation in Jordan.

Despite undertaking an extensive review of the CW literature, it was observed there is a lack of statistics and data provided by both private and governmental bodies in Jordan concerning the quantity of CW generation. However, according to a number of previous studies targeting the CW subject in Jordan (Batayneh et al., 2007; Bekr, 2014; Alshboul & Abu Ghazaleh, 2014; El Hanandeh, 2015; Al-Rifai & Amoudi, 2016), and based on the extensive working experience of the researcher in the Jordanian construction industry, it was noted that CW is a colossal problem and the amount of CW generation is ever increasing. According to GIZ (2014), around 2.6 million m^3/year of CW is produced in the capital Amman. Inevitably, this figure is relatively small compared to other economies, but relative to Jordan's size and economic situation, it is significant. Further, a study conducted by Batayneh et al. (2007) indicated that 90% of the total waste generated in construction sites is disposed with little or no attempt for recovery.

Various causes contribute to waste generation in Jordanian construction projects. However, few studies have investigated this issue. Al-Rifai and Amoudi (2016) conducted a qualitative survey investigating the main causes contributing to CW in Jordanian projects; they categorised these causes into two main groups: management related and workforce related. With regard to the first category, they revealed that a lack of quality management in construction processes can result in high waste generation. As for the second category, the lack of skilled workers and workforce errors contributes to a huge amount of CW generation. Batayneh et al. (2007) revealed that post-variation orders as well as damages resulting from the mishandling of materials and weather conditions, are both common causes of waste generation in the Jordanian construction industry. Additionally, their study suggested that the modernisation of buildings in Jordan and/or partial demolition for their maintenance, generate a large amount of CW. Further, Bekr (2014) investigated 60 possible causes of CW through a quantitative survey which included clients, contractors and consultants. The results indicated that frequent design changes from clients; poor documentation of contracts; rework due to workers mistakes; poor storage of materials; and poor strategy of waste minimisation ranked as the most significant causes of waste in Jordanian construction sites. The behavioural of construction stakeholders also plays a vital role in CW generation as there is a general lack of interest, from construction clients and contractors, towards CWM in Jordan, and this especially applies to small and medium construction companies as their main interest is to maximise profits (Al-Rifai & Amoudi, 2016).

2.5.1 The need for construction waste minimisation in Jordan

There is a growing concern about SC from both the government and project stakeholders in Jordan. Enhancing environmental management has become a pressing issue due to the scarcity of resources and a subsequent unsteady energy supply: two serious challenges facing Jordan today (Royal Scientific Society of Jordan, 2013). Jordan is a small country with poor resources; it imports 97% of its energy needs (The Ministry of Energy & Mineral Resources, 2017), and is ranked as the fifth most water-scarce country in the world (WRI, 2020). Therefore, the issue of CW arises at a time when the built environment is failing to meet the increasing demands on limited resources and the inefficient use of them (Royal Scientific Society of Jordan, 2013). In this regard, CWM can be a pillar of progress by committing construction projects to responsibility towards the environment and to the efficient use of resources over their life cycle.

The increase in pollution resulting from CW is another significant problem in Jordan. This is because waste disposal is the preferred waste management method in most construction projects, as according to Batayneh et al. (2007), 90% of the total generated CW is disposed of in landfills. The Waste Atlas Partnership (2014) highlighted that Jordan has two large landfill sites, which are ranked among the ‘World’s 50 Biggest Dumpsites’, posing a serious threat to human health and the environment. Further, open dumping and burning of CW are commonly pursued illegal disposal practices which continues to be an on-going problem in Jordan (UNEP, 2015a; Aldayyat et al., 2019). Such practices are approaching significant epidemic proportions, resulting in foul odours and air and water pollution, which are dangerously affecting the surroundings.

Waste is also a key reason for cost overruns in the Jordanian construction industry, as the percentage of wastage materials (by value) accounts for 15 - 21% (Bekr, 2014). This is because building material prices are very high given Jordan’s limited and costly supply of natural resources, and the ever-increasing price of importing raw materials from neighbouring countries (Royal Scientific Society of Jordan, 2013; Bekr, 2014). For instance, the escalating price of imported fossil energy in Jordan amounts to 4.6 billion JOD per year (Ministry of Energy and Mineral Resources, 2017), with the construction industry being a major contributor to national energy consumption levels (Tewfik & Ali, 2014; El Hanandeh, 2015). Such an issue has also placed a heavy financial load on government spending including investing in energy production, refining, transport and distribution; this is especially significant given the poor economy of Jordan (Ali & Al Nsairat, 2009; Department for International Development [DFID], 2016). In 2017, the public private partnership investment in energy was estimated at around 2.7 billion dollars which is around 1.95 billion JOD (WDI, 2017). Furthermore, the environmental degradation cost is a major burden for the Jordanian government, as each year, large amounts of money are spent dealing with environmental problems. This includes waste production, illegal dumping and energy CO_2 emissions. In 2006, the environmental degradation cost was estimated to be around 393 million JOD, which is a significant figure in relation to Jordan's GDP (GIZ, 2014).

Following the Arab Spring in 2011, regional instability and the Syrian conflict have had a major impact on Jordan. The border closure with Syria has disrupted transit routes of regional trading resulting in significant shortage of some imports and as a consequence, increased prices of various products (SNAP, 2014). A study by Bekr (2014) showed that for the period 2010 to 2012 the price of almost every variety of construction material increased by 11.5% to 15.2%. Additionally, attacks on pipelines in Egypt have disrupted the supply of fuel to Jordan, which the country has obtained since 2002 at below market rates due to a diplomatic agreement between both countries. The attacks forced Jordan to purchase oil at international market prices which has led to a huge jump in local energy consumption costs (Luck, 2016).

Accordingly, the promotion of SC practices, including waste minimisation, contributes to a lower and more efficient use of energy, water and other resources, as well as a reduced environmental impact. Additionally, CWM can largely contribute to cost savings in construction projects which, in turn, will enhance the economic performance of the Jordanian construction industry. Therefore, there is a need for waste minimisation which would strongly support the necessity for carrying out this research in order to attain SC (Royal Scientific Society of Jordan, 2013; Bekr, 2014; GIZ, 2014; Tewfik & Ali, 2014; El Hanandeh, 2015; UNEP, 2015a; Aldayyat et al., 2019). The next section provides an overview of current waste minimisation practices in Jordan. This is to investigate their implementation levels and barriers, and to identify research gaps for attaining effective CWM.

2.5.2 The current uptake of construction waste minimisation in Jordan

Generally, the construction industry in Jordan is still suffering from insufficient sustainability practices characterised by poor production, sub-standard performance and a wasteful culture (Tewfik & Ali, 2014; Aldayyat et al., 2019). The participation of Jordanian construction stakeholders in waste minimisation is still limited and very modestly explored. Additionally, there is a lack of a comprehensive waste management plan and/or regulatory framework that provides an effective system for collection, recycling, treatment and safe disposal of solid waste in Jordan (GIZ, 2014). In the past two decades, there has been a number of initiatives from both the construction industry and governmental bodies towards the promotion of SC and green building practices in Jordan. This was as a result of increasing demands on scarce resources and the poor economic situation of Jordan (explained in section 2.5.1). Such initiatives also arose as a response to the dramatic shift towards modern building systems in Jordan to cope with the modernised style of living (Ali & Al Nsairat, 2009; Hanandeh, 2015).

The National Solid Waste Management Strategy (2015-2034) was established in Jordan in 2015. It aims at shifting from an old, inefficient, costly and environmentally unsustainable solid waste management system towards a modern and integrated one, based on the 3Rs approach. Such a strategy promotes recycling practices through the establishment of pilot separate collection systems for recyclables, formulating relevant technical regulations and legislative frameworks required and enhancing public awareness through educational programs (European Commission, 2017). However, the vast majority of solid waste management activities in Jordan are considered pilot projects, and small-scale interventions, as the recycling of solid waste remains untapped accounting for only 6 % - 10% (GIZ, 2014). This is due to three reasons. The first is the poor, insufficient government-run strategy for promoting solid waste management practices, as the majority of existing recycling and waste collection activities are informal and are limited to private corporations as well as individuals (GIZ, 2014; Aldayyat et al., 2019). For instance, steel and metal waste are collected and sold as scrap at 20% of their original purchase price (Al-Rifai & Amoudi, 2016). On the other hand, formal waste collection activities are only carried out at the dumpsite level by private companies (hired by the authorities) which are mainly concerned about the market prices, in terms of collecting and sorting the various recyclable materials (UNEP, 2015c, Aldayyat et al., 2019).

The second issue is the current solid waste management legislative framework which reports several gaps and deficiencies. This includes the lack of ability to establish a sustainable materials recovery system which needs to be evaluated and adjusted to the context of reaching the goals of Jordan's 'National Solid Waste Management Strategy' (Aldayyat et al., 2019). Additionally, there is poor capability in the local municipalities in providing adequate services for waste collection and disposal (UNDP, 2015c).

Finally, the third reason is that the awareness of, and willingness for, waste reuse and recycling in the local community as well as in organisations (including the construction sector) in Jordan is still poor with a minimum of initiatives prevalent to support its widespread implementation (GIZ, 2014; UNEP, 2015a, c; European Commission, 2017). The government has the responsibility to educate the public on how to manage solid waste, pointing out its importance through more effective approaches, as they are most likely to positively change behaviour of Jordanians but have yet to do so.

In the past few years, the concept of “green building” has become widely known in the construction industry in Jordan. It is used to refer to buildings characterised by increased energy efficiency, reduced water and material consumption, and the improvement of health and the environment (Royal Scientific Society of Jordan, 2013; Tewfik & Ali, 2014). Green building concepts can be applied to projects under construction as well as to completed ones through retrofitting. In 2013, the “Jordan Green Building Guide” was issued by the Jordan National Building Council with references from international leading sustainability rating systems such as LEED, BREEAM, and Green Globes (Tewfik & Ali, 2014; Matarneh, 2017). It involves comprehensive technical standards and criteria divided into seven chapters namely: green building management, site sustainability, water efficiency requirements, energy efficiency requirements, healthy indoors environment, materials, and resources. Following this, an incentive program for the adoption of green buildings was launched in 2015 based on the Jordan Green Building Guide rating system. Buildings that adopt such a rating system will be entitled to an increase in the ‘Floor Area Ratio’. A number of key green buildings exist in the capital Amman, such as the King Hussein Business Park, the World Health Organisation Regional Office Building and The Middle East Insurance Company. However, green building practices are still not widely implemented in Jordan's construction projects as the number of buildings that are certified by Jordan's green building rating system and/ or other rating systems, are very few. The most likely reason is that all the green building guidelines in Jordan are attached to a voluntary rating system and are lacking compulsory requirements (Matarneh, 2017). Additionally, there is a lack of interest from many clients and contractors who hold poor perceptions toward the economic viability and the environmental benefits from the adoption of green building practices. Most of the construction projects in Jordan are considered small to medium-size projects, with the majority being commercial residential buildings (apartment buildings), and therefore, the main interest in such projects is maximising profit (Al-Rifai & Amoudi, 2016).

With regards to policies and regulations, there is a lack of specific regulations and/ or instructions for local municipalities to control CW in Jordan. Nonetheless, they are required to regulate, monitor and enforce solid waste management, including construction and demolition waste. This mandate is generally stipulated in several policies and regulations issued by a number of governmental bodies listed in Table 2.8. For every project within a municipality’s territory, whether it involves excavation (i.e., the commencement of a project) or renovation, a permit needs to be granted against security for the proper handling and disposal of construction and demolition waste in designated disposal sites. However, considerable quantities of construction and demolition waste still end up being dumped illegally (GIZ, 2014).

Table 2.8: Policies and regulations addressing solid waste management in Jordan

Policies and regulations	Objective	Issuing authority
Environmental Protection Law No. 52/2006	"Sets the direct responsibilities for the Ministry of Environment and sets overarching principles for environmental protection"	Ministry of Environment
Solid Waste Management Regulation No. 27/2005	"Sets general requirements in terms of manpower, equipment, monitoring, container management, separation of hazardous wastes, documentation, and final treatment or disposal control"	Ministry of Environment
Municipalities No. 1/1978	"Sets the different types of nuisances and municipal control measures, including the municipal responsibilities for waste collection, transport, treatment, and disposal, and the attached fee system"	Municipalities
Buildings and Zoning Regulation No. 67/1979	"Sets permit requirements for excavations and renovations, to control C&D waste illegal dumping"	The Ministry of Municipal Affairs
Municipalities Law No. 13/2011	"Sets municipal responsibilities including municipal cleaning, waste collection, and disposal"	The Ministry of Municipal Affairs

In conclusion, from the author's experience in the construction industry and based on existing studies discussed throughout section 2.5, it is evident that the current situation of CWM is very poor in Jordan. The above discussions reveal gaps in CW legislations; the participation of construction stakeholders in waste minimisation; the lack of provision of a comprehensive waste management plan; the capabilities of municipalities in controlling CW; and public awareness. These all contribute to the overall inefficiencies of poor CWM in Jordan. Moreover, scant studies are available which have investigated the behavioural cause of CW in the Jordanian construction industry and, therefore, there is a need for this research.

2.6 Conclusion

The aim of this chapter was to provide a background to CW and to demonstrate the principles of, and the need for, its minimisation. Furthermore, the current uptake of CWM has been discussed in many developed countries as to garner best practice and challenges in CWM for potential application in the Jordanian construction industry. Accordingly, a number of key issues have been identified.

First, solid materials waste was identified as most critical due to its impact on the three pillars of sustainability at the project, as well as, the national level. (see Section 2.4.2). Second, the construction stage was identified as the most critical stage in terms of CWM. This is because effective implementation of on-site practices can minimise any waste that originates directly from the construction stage and indirectly from the design stage. Additionally, waste generation can be avoided and reduced at the origin during the construction stage, whereas demolition waste is often considered as non-avoidable waste (see section 2.3.3). Third, human factors were identified as a major part in waste generation and minimisation in construction projects, as common causes of CW are directly or indirectly affected by the behaviour of the personnel involved in the construction industry (see section 2.3.3.1). Fourth, CW has increasingly become a pressing issue in Jordan due to the scarcity of resources, subsequent, unsteady energy supply and the poor economic situation in Jordan with CW considered a financial burden on government spending (see section 2.5.1). Fifth, it was noted that the construction industry in Jordan is still suffering from insufficient sustainability practices, characterised by poor production, sub-standard performance and a wasteful culture. It has also been predicted that the absence of efficient waste management plans will become increasingly problematic for Jordan (see sections 2.5.2). Sixth, the current status CWM in Jordan is very limited and modestly explored. More important, there are few studies currently available in Jordan regarding CWM behaviour (see sections 2.5.1 & 2.5.2). The following chapter will investigate CWM behaviour and behavioural adoption theories and frameworks, in order to demystify and understand the factors affecting such a behaviour, particularly amongst contractors, to improve the prevailing situation.

Chapter 3

Construction Waste Minimisation Behaviour

3.1 Chapter overview

Having defined the problem and justified the need for this research in Chapter 1, Chapter 2 identified the need to address behavioural approaches that support waste minimisation in the construction industry. This led to a need for a wider focus on understanding how behaviour in the construction industry, particularly by contractors, impacts upon CWM. This chapter reviews extant behaviour adoption theories and frameworks that could be used to identify and understand the factors influencing contractors' behaviour towards CWM. The analysis and application of these theories and frameworks are reviewed and, additionally, the ineptness and practical limitations in their explanatory power is made profoundly clear. Thus, the gap left by previous research efforts is affirmed and utilized to build a theoretical base for this study in order to address the unique nature of this research investigation.

3.2 Stakeholders' behaviour towards construction waste minimisation

The terms "attitude" and "behaviour" are sometimes used synonymously in the literature (e.g., Kulatunga et al., 2006; Begum et al., 2009; Al-Sari et al., 2012). However, some studies have identified clear differences between the two, separating attitude from behaviour, and referring to attitude as a factor that affects CWM behaviour (e.g., Wu et al., 2017; J. Li et al., 2018; Liu et al., 2019). Thus, it is important to clarify the difference between these terms as, in the context of this research, behaviour refers to the computed response of the individual to various stimuli or inputs, whether internal (self-concept) or external (surrounding environment), conscious or subconscious, overt or covert, and voluntary or involuntary (Elizabeth & Lynn, 2014). Put simply, it is the actions and mannerisms made by the individual in conjunction with themselves or their environment, in relation to CWM. As for "attitude", it refers to the degree to which a person has a favourable or unfavourable evaluation of behaviour; it is considered as a mediating variable which will influence ultimate CWM behaviour (Ajzen, 1991). According to social psychology studies, attitude reflects the individual's mental and neutral state of readiness, organised through experience, exerting a directive or dynamic influence on his/ her response to all objects and situations with which it is related (Davies et al., 2002). For the purpose of this study, since the researcher seeks to identify and understand the factors influencing the behaviour of contractors towards CWM, the term CWM behaviour will comprise attitudes of contractors as well as other potential factors affecting the adoption of CWM.

Achieving CWM requires effective action from all those engaged in construction, including governmental bodies, clients, designers, contractors and suppliers. This is confirmed by Shen et al. (2007) and Abidin (2010) who revealed that participation and commitment of project stakeholders can have a major influence on the goals of SC. However, an extensive review of the literature on CWM approaches (section 2.4.3) reveals that the global status regarding CWM is not promising. This is because the perceptions and attitudes of construction stakeholders towards CWM are often different depending on several factors (section 3.4.1). For instance, the realisation of the significant impacts of CW on the environment is seen to be very important in order to ensure environmental sustainability in construction projects. This is because many construction stakeholders do not place high importance on environmental issues when it comes to CWM. One example is demonstrated by Serpell et al. (2013), who revealed that small and medium-size contractors are mostly focused solely on the economic element, with little or no interest and/ or awareness of the environmental and social aspects of construction sustainability, such as waste minimisation. On the other hand, Serpell et al.'s study indicated that large-size contractors are often concerned with the three pillars of SC as a consequence of client demand for sustainable projects and/ or higher awareness of such contractors towards construction sustainability. Indeed, Begum et al. (2009) revealed that environmentally positive attitudes and responsible behaviours are critical in understanding how to resolve issues surrounding CW management.

However, awareness of the environmental impact of CW has not always exerted a strong influence on CWM. Mahpour and Mortaheb (2018) provided a rationale for this, claiming that financial incentives and cost saving devices are more conducive to driving CWM. This was confirmed by a number of studies (e.g. Jia et al., 2017; Hao et al., 2019; Liu et al., 2019) who revealed that economic performance has been critical in promoting waste management measures in construction projects. This is because cost saving is the first priority when considering whether to adopt waste management measures, or not. Confirming this, Al-Hajj and Hamani (2011) revealed that maximising profit and cost savings are considered to be the most important benefits for motivating contractors towards CWM. However, project stakeholders sometimes are not incentivised to take effective action to minimise CW due to a lack of awareness and knowledge of the financial benefits (cost saving) of CWM. According to Udawatta et al. (2015) and Bakshan et al. (2017), awareness of cost savings and understanding the economic growth of construction projects can have a significant influence towards motivating project stakeholders, including clients, designers and contractors, in minimising CW. For instance, Abidin (2010) noted that project stakeholders, even in large projects, are mostly reluctant to implement SC practices because of their time and cost concerns and the lack of knowledge and awareness of sustainable practices. Further, Manowong (2012) revealed that the widespread perception by project stakeholders that CWM is an activity that contributes to additional project expenses, creates a lack of interest towards effective measures to minimise waste. Consideration of social sustainability, which ensures a better quality of life, is also an essential issue pertaining to waste minimisation in construction projects. The project stakeholders' awareness and effort with regards to waste minimisation are largely associated with attaining social benefits of SC, including the avoidance of creating new and undesirable landfill sites, stemming from potential environmental health risks associated with CW and its disposal, and reducing the cost of construction (Hussin et al., 2013).

Consequently, according to the above discussions, there has been increased attention and effort worldwide focused on CWM behaviour in recent years. However, such behaviour has not always been successfully controlled due to the factors affecting it (see section 2.4.3). With regards to the case of Jordan, although there are few studies currently available in Jordan concerning the subject of CWM and its related behaviour, it was observed that the construction industry is still suffering from poor and insufficient sustainability practices particularly by contractors (as discussed in section 2.5), based on the following: First, from the author's experience in the construction industry and based on existing studies, it was seen that the current situation of CWM is very poor in Jordan and the amount of CW generation is ever increasing. This was mainly attributed to the gaps in CW legislations (GIZ, 2014; Aldayyat et al., 2019); the participation of Jordanian construction contractors in waste minimisation is still limited and very modestly explored (Tewfik & Ali, 2014; Aldayyat et al., 2019); and the practise of illegal dumping and waste disposal with little or no attempt for recovery (GIZ, 2014; UNEP, 2015a). Second, there is a general lack of interest from construction clients and contractors towards CWM, and this especially applies to small and medium construction companies as their main interest is to maximise profits (Al-Rifai & Amoudi, 2016). Finally, compared to the global current situation of CWM and its related issues and particularly in neighbouring countries, where they share a similar construction culture to Jordan, it is evident that the behavioural cause of CW (particularly by contractors) is a significant issue that needs to be investigated in Jordanian construction projects.

It is therefore, important to understand CWM behaviour, particularly by contractors (as explained in section 2.3.3), in order to achieve holistic and integrative CWM. The following discussion begins by reviewing existing behaviour adoption theories and frameworks that may aid the attempt to explore and understand the factors influencing the behaviour of contractors towards CWM. Indeed, Black et al. (2001) suggested that variables/ factors found in behavioural adoption theories and frameworks are the starting point for any study in order to build up a theoretical base for the fieldwork investigation. According to these theories and frameworks, CWM behaviour is viewed as a consequence of a set of perceptions and attitudes which have different levels of influence in differing contexts.

3.3 Behavioural adoption theories and frameworks

'Behaviour theories and frameworks' are theories in psychology that try to predict human behaviour towards a certain subject through investigating the factors that influence individual behavioural choices (Morris et al., 2012). They have been utilised in various disciplines, such as technology adoption, construction, education, health, environmental sustainability and many others. According to these theories, the adoption of CWM behaviour is determined by an individual's beliefs and perceptions towards such an issue. The most popular theories include: The Technology Acceptance Model (TAM; Davis, 1985), Social Cognitive Theory (SCT; Bandura, 1986), Theory of Reasoned Action (TRA; Fishbein & Ajzen, 1975); and the Theory of Planned Behaviour (TPB; Ajzen, 1985). These are discussed in more detail in the following subsections.

3.3.1 Technology Acceptance Model (TAM)

TAM is one of the most recognised behaviour adoption theories, developed by Davis in 1985 (see Figure 3.1). It is an information systems theory that seeks to provide a basis for understanding the impact of external factors on users' attitudes and the level of their intentions regarding the acceptance and usage of a technology (Davis, 1985). TAM is considered one of the most influential extensions of the TRA (see section 3.3.3).

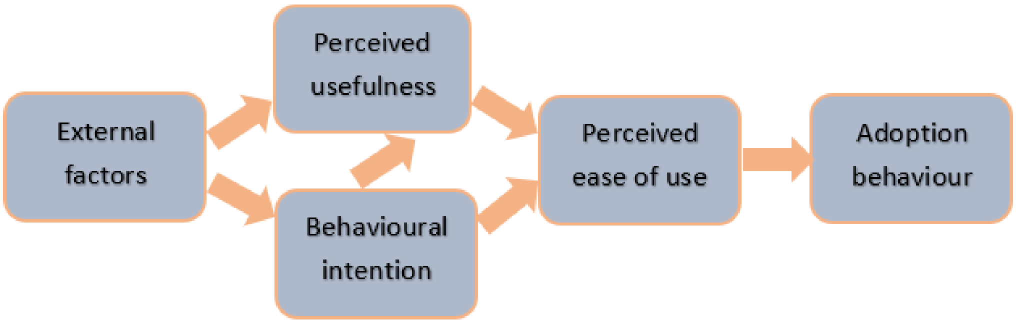

Figure 3.1: Technology Acceptance Model (TAM; Davis, 1985)

TAM suggests that when a new technology is presented to users, there are two main factors that influence their decisions and attitudes about how and when they will use it. These are: the technology's "perceived usefulness" and "perceived ease of use". Perceived usefulness is defined by Davis as "the degree to which an individual believes that using a particular system would enhance his/ her job performance", while perceived ease of use refers to "the degree to which an individual believes that using a particular system would be free from [increased] effort". According to the theory's author, both factors have the capability to determine the actual use (adoption behaviour) of a technology. The TAM has been extensively used in predicting the adoption behaviour of information systems and technological devices, and has proved to be valid and reliable for describing technologies' acceptance (Lee et al., 2003; King & He, 2006). In the field of construction, TAM was used in predicting the application of several LWTs such as BIM (Sanchís Pedregosa et al., 2020), mobile computing technology (Son et al., 2012) and 3D building models (Sepasgozaar et al., 2017).

3.3.2 Social Cognitive Theory (SCT)

SCT was proposed by Bandura in 1986 (see Figure 3.2). The theory describes the unique way in which an individual acquires, maintains and performs behaviour under the social environment where he/ she observes a model performing a behaviour and the consequences of that behaviour. Observing a behaviour can also encourage individuals to engage in behaviour they have already learned (Bandura, 1986).

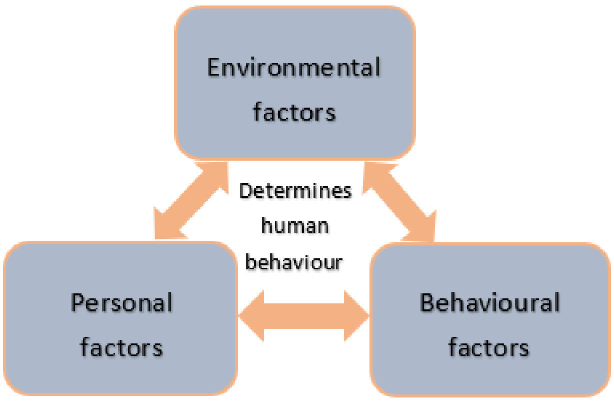

Figure 3.2: Social Cognitive Theory (SCT; Bandura, 1986)

In SCT, human behaviour is extensively motivated and regulated by the ongoing exercise of self-influence. The major self-regulative mechanism operates through the interaction of three determinants. These include personal, environmental and behavioural factors. The first factor refers to the individual's self-efficacy towards the behaviour, while the second factor refers to aspects of the setting or environment that affects the individual's ability to successfully complete the behaviour. Finally, the third factor refers to the response individuals receive after they perform the behaviour (Bandura, 1986). In the interactionist perspective of SCT, effective self-reaction can be achieved by self-monitoring of one's behaviour, its determinants, and its effects - judgment of one's behaviour in relation to personal standards and environmental circumstances. In other words, social factors affect the operation of the self-regulative mechanism, where an individual's knowledge acquisition can be directly related to observing others within the context of social interactions, experiences and external media influences (Bandura, 2001). SCT has accumulated an impressive research record in diverse contexts and been proven to be very effective in the prediction of human social behaviours (Schunk, 2012; Nabavi, 2012; Schunk & DiBenedetto, 2020). Furthermore, SCT is an evolving theory that is open to change based on a reasonable view of the social implications and its effects on people's behaviour (Schunk & DiBenedetto, 2020).

3.3.3 Theory of Reasoned Action (TRA)

TRA was developed by Fishbein and Ajzen in 1975 (see Figure 3.3) and has been tested and used widely. It has been recognised as one of the most effective theories in explaining the relationship between human behaviour, and intention to adopt that behaviour (Hagger, 2019). The theory states that an individual's decision to engage in a particular behaviour depends on his/ her intention towards performing that behaviour. The stronger the intentions the individual holds will also increase the likelihood for the behaviour to be performed (Fishbein & Ajzen, 1975).

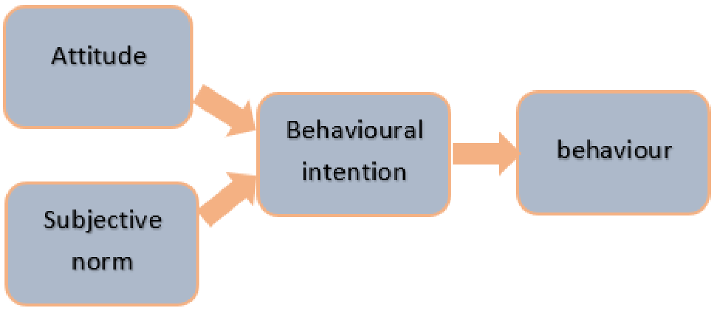

Figure 3.3: Theory of Reasoned Action (TRA; Fishbein and Ajzen, 1975)

According to TRA, the intention to perform a certain behaviour is determined by subjective norms and attitudes towards behaviours. The attitude towards behaviour is defined as the degree to which a person has a favourable or unfavourable evaluation of behaviour, while subjective norm refers to the perceived social pressure to perform or not perform the behaviour (Fishbein and Ajzen, 1975). In TRA, there are two main conditions that can affect the relationship between behavioural intention and behaviour. The first condition is that there must be stability of intentions between the time of measurement and the performance of the behaviour. This means that intention must remain the same between the time that it is made and the time that the behaviour is performed. The second condition is the degree to which carrying out the intention is under the volitional control of the individual; the individual always has control over whether or not to perform the behaviour (Wahab, 2018). Although numerous instances were identified in which researchers overstepped the boundary conditions initially proposed for the model, the predictive utility remained strong across conditions (Ajzen, 1991). This was confirmed by Otieno et al. (2016) who revealed that practical and useful results were obtained using the TRA framework through identifying where and how to target strategies for changing behaviour.

3.3.4 Theory of Planned Behaviour (TPB)

TPB was proposed by Ajzen in 1985 as an extension to the TRA. It is one of the most widely recognised and influential theories in behaviour adoption frameworks (Conner, 2020). This theory covers a person's non-volitional behaviour by understanding how deliberative behaviour can be predicted and changed, because behaviour can be deliberative and planned (Ajzen, 1991; Figure 3.4).

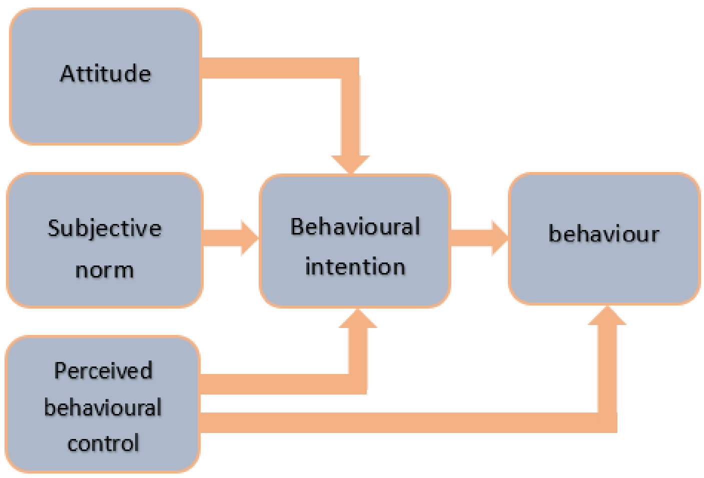

Figure 3.4: Theory of Planned Behaviour (TPB; Ajzen, 1985)

TPB asserts that an individual's behaviour is driven by both behavioural intentions and perceived behavioural control, while behavioural intention is a function of three determinants which are: attitude towards behaviour, subjective norm and perceived behavioural control. Whilst attitude towards behaviour and subjective norm are defined earlier in section 3.3.3, perceived behavioural control is the third antecedent of intention in this theory which refers to the perceived ease or difficulty of performing the behaviour (Ajzen, 1991). TPB has long dominated attempts to predict behaviour and much work has been carried out on the basis of this theory in different fields (e.g., healthcare, education, marketing, finance and construction). Furthermore, several critical reviews, theoretical frameworks and meta-analyses have been published, by both the theory's author and others in different domains and situations, to predict the planned behaviour as well as the actual behaviour; significant benefits were gained from the TPB application (Teo & Loosemore, 2001; Ajzen, 2011; Montaño & Kasprzyk, 2015; Paul et al., 2016; Mak et al., 2019). In a construction context, the explanatory power of TPB has already been proven to be very effective in predicting CWM behaviour and the factors affecting it (Wu et al., 2017; Li et al., 2018; Mak et al., 2019).

3.3.5 Critique of the behavioural adoption theories and frameworks

There have been numerous attempts to analyse the adoption of TAM, SCT, TRA and TPB in terms of their effective understanding in subject-related behaviour, nearly all of which, however, have received different levels of criticism from researchers for their inadequacy in predicting behaviour towards a certain subject in complex situations. Their studies argue that although such theories and frameworks are undoubtedly valuable, their implementation often has certain constraints. The following discussions illustrate a comprehensive critique, highlighting the limitations to the adoption of these theories and frameworks.

- **TAM**

  Various opinions and arguments have been posed by authors concerning the exact variables influencing the acceptance of a technology (Venkatesh & Davis, 2000; Lee et al., 2003; Bagozzi, 2007; Venkatesh & Bala, 2008; Chuttur, 2009; Marangunić, & Granić, 2015; Otieno et al., 2016; Olushola & Abiola, 2017; Ajibade, 2018). Their studies criticised the TAM for its simplicity which ignores the importance of subjective norms (e.g., such as social influence and voluntariness) and organisational factors (e.g., job requirements and facilitating conditions) which have been found to have a significant effect on the usage behaviour of a technology. For instance, Ajibade (2018) argued that the organisation's policies and rules can largely impact the acceptance of a technology through promoting it in a mandatory setting. Venkatesh and Davis's (2000) study revealed that the TAM variables, such as perceived ease of use and perceived usefulness, were given very little support in the explanation of technology's usage. Thus, they incorporated other variables such as job requirements, voluntariness and subjected norms which were found to have provided better explanatory power. This was confirmed by Venkatesh and Bala (2008) who added that factors contributing to the acceptance of an IT are likely to vary with the facilitating conditions, social influence, target users and context. Further, Bagozzi (2007) noted that social processes are essential in the prediction and implementation of a new technology. Therefore, researchers have extended the TAM by adding more construct variables in order to define uncovered measures in the main construct of the theory (Marangunić, & Granić, 2015).

- **SCT**

SCT is known to be more concerned with the social influence on the individual's behaviour including social interactions, others' experiences and external media influences (Bandura, 1986). However, a number of studies (e.g., Compeau & Higgins, 1995; Nabi, & Clark, 2008; Turner, 2010; Nabavi, 2012; Young et al., 2014; Schunk & DiBenedetto, 2020) argue that Bandura's theory is based on the assumption that behaviour is primarily influenced by the surrounding environment which is not always the case, because people move through life and their behavioural patterns can change drastically with little change in their environment. Additionally, Turner (2010) added that the extent to which social factors play into the actual behaviour and whether one is more influential than another, is not quite clear in SCT. Although the theory's principles are intended to be generic and applicable across different contexts, some theoretical adaptation may be needed. Schunk and DiBenedetto (2020) indicated that SCT was developed before the advent of contemporary technology, as the basic social cognitive principles were developed and tested largely in face-to-face settings without advanced technology such as online media. Further, Nabi, and Clark (2008) and Young et al. (2014) stated that SCT does not focus on emotion or motivation (perceived usefulness), other than through reference to past experience.

- **TRA**

Various studies argue that the simple construct of the TRA limits its power of analysis towards predicting behaviour (Bagozzi et al., 1989; Kippax & Crawford, 1993; Han et al., 2010; Montaño & Kasprzyk, 2015; Paul et al., 2016; Hagger, 2019). For instance, TRA neglects the perceived behavioural control factor when predicting behaviour and assumes that individuals have full volitional control of themselves (Montaño & Kasprzyk, 2015; Paul et al., 2016). In other words, TRA focuses on behaviours that people decisively enact, and it is limited in terms of being able to predict behaviours that require access to certain opportunities, skills, conditions and/ or resources. Indeed, Han et al. (2010) revealed that the inclusion of perceived behavioural control enhances the prediction of behavioural intentions and behaviours. They elaborated that the influence of perceived behavioural control on a certain behaviour is most important when the behaviour presents some problem with respect to control. Further, Bagozzi et al. (1989) emphasised that a strong intention is not always followed by the performance of the behaviour. In fact, behaviours and attitudes may not always be linked with intentions, particularly when the behaviour does not require much cognitive effort.

- **TPB**

  Although there has been considerable support for the TPB, a number of studies have criticised the theory for ignoring the importance of additional significant variables which should be incorporated to enhance its explanatory power in predicting behaviour (Mathieson, 1991; Davies et al., 2002; Tonglet et al., 2004; Kaiser, 2006; Bortoleto et al., 2012; Sniehotta et al., 2014; Montaño & Kasprzyk, 2015; Botetzagias et al., 2015; Wu et al., 2017; Conner, 2020). According to Montaño and Kasprzyk (2015), TPB does not provide an acceptable explanation for human behaviour and, thus, needs to be changed or extended. Various studies noted that TPB neglected moral considerations as sometimes moral norms can have a larger impact than attitude on intention to perform the behaviour (Bortoleto et al., 2012; Botetzagias et al., 2015; Wan et al., 2017). Moreover, many have argued that TPB ignores the importance of the technological factors (e.g., ease of use and perceived usefulness), as such factors can better predict the attitude toward the adoption of a technology (Mathieson, 1991; Sniehotta et al., 2014).

In conclusion, TAM, SCT, TRA and TPB are the most applicable and practical theories and frameworks available to support the prediction of human behaviour. Nonetheless, their limitations in terms of their inadequacy and simple construct have weakened their explanatory power and efficiency. The main argument of the critics is that such behavioural adoption theories and frameworks ignore the importance of additional variables/ factors which were found to have a significance towards the successful prediction of human behaviour. The next section demonstrates and discusses the application of the aforementioned theories and frameworks in a construction context. This is to provide a body of literature for understanding the factors influencing contractors' behaviour towards CWM, with the aim of identifying gaps and practical limitations in the prediction of such a behaviour.

3.4 Behaviour adoption theories and frameworks in a construction context

Various studies have analysed the use of the behavioural adoption theories and frameworks in the understanding of contractors' behaviour and their work performance in the construction industry. This section discusses a number of key studies which have investigated such issues, followed by a presentation of their ineptness and practical limitations in order to affirm the gap left by previous research efforts.

In a study of which the aspects of the technology adoption were considered to be mandatory, Lee et al. (2012) proposed a conceptual BIM acceptance model to understand the key factors affecting the adoption of such technology by facility managers in Korean construction projects. The proposed model was constructed by integrating the TAM and TPB variables. The study's result showed that among thirteen factors hypothesised to have direct or indirect effects on BIM acceptance, five were identified as key influential factors affecting the adoption of BIM. These factors are "self-efficacy", "compatibility", "belief in the benefits", "collaboration environment" and "facilitating conditions". This seemed to offer a valid extension to TAM's authors' higher-level views as they revealed that the measurement items for BIM acceptance can be examined to ensure reliability and validity. Additionally, hypothesis testing can be conducted to explore the relationships between the key factors which may lead to a higher acceptance of BIM. However, the findings of this study were limited to the identification of social factors as the authors investigated BIM acceptance behaviour in a mandatory environment.

In Australia, Sepasgozaar et al. (2017) looked into the ability of TAM to assess the introduction of a 3D building using laser scanner technologies. They applied TAM utilising two of its main elements: "usefulness' and "ease of use" each measured by a range of factors. The findings showed that a lack of knowledge with regard to the scanner applications and the presence of low-skilled workers represented the main barriers to the application of such technology. Moreover, their study revealed that by modifying a generic framework, key constructs were addressed, such as scanner performance expectancy, effort expectancy, organisation self-efficacy and user efficacy. This pattern, however, does not match the usual components shown in the TAM framework since new constructs have been identified and addressed that fall under organisational factors. These are: implementation facilitating support and maintenance support.

Lorente et al. (2014) examined the usefulness of SCT in the effective understanding of the factors affecting contractors' engagement and performance in the Spanish construction industry. A comprehensive questionnaire was collected from 228 construction workers from different small and medium-sized construction companies. The results suggest that personal resources (i.e., self-efficacy, mental and emotional competences) play a predictive role in the perception of job resources (i.e., job control and supervisor social support), which in turn leads to work engagement and self-rated performance. Lorente et al.'s study extended the motivational process of SCT by including additional personal resources (i.e., mental and emotional competences) as a predictive role. Their study has proved that boosting the positive beliefs of construction workers regarding their competences will result in a better perception of their performance.

Teo and Loosemore (2001) employed TPB as a theoretical basis to explore the influence of contractor behaviour on CWM. However, they did not collect empirical data to testify the relationship between employees' attitudes and their waste minimisation behaviour. Zhu and Li (2012) and J. Li et al. (2018a) tried to fill the gap by carrying out a survey among Chinese contractor employees and established a quantitative TPB model of their CWM behaviour using Structural Equation Modelling (SEM). The model revealed significant findings on the basis of high reliability and validity, and showed that the validated model demonstrated that the awareness and attitude from construction workers exert the greatest influence on behavioural intention toward CWM. This was also confirmed by Shurrab et al. (2019) who revealed that the perceived benefits of SC can highly affect the CWM behaviour of Emirates' contractors. Nonetheless, their behavioural intention was unable to predict behaviour, while perceived behavioural control has a significant effect on behaviour.

In a comparative analysis study between China and the USA, Liu et al. (2019) applied the TPB to improve decision-making for CWM among workers in China. The results indicated that the lack of management support and benefit-driven effect are significant issues which contribute to the generation of waste in the Chinese construction industry. Additionally, Chinese construction workers had poorer minimisation technologies and knowledge than American construction workers which made it very difficult for them to implement CWM. The pattern also supports the findings of Yuan (2013) and J. Li et al. (2018a) who found that construction-related knowledge, environmental benefits and social benefits can motivate construction stakeholders towards minimising waste. However, Liu et al.'s study was limited as it failed to consider the role of project managers based on the premise that project managers hold significant influence in decision-making regarding CWM. Furthermore, it seems that their study failed to consider the technological factors which can help to explain the lack of utilisation of waste minimisation technologies in the Chinese construction industry.

Finally, in Wu et al.'s (2017) study, a theoretical model was initially established based on TRA and TPB to investigate the determinants of contractor's CWM behaviour in China. The conclusions reached in this study was that economic viability followed by governmental supervision were the two significant issues influencing Chinese contractors to make CWM decisions. The construct of project constraints was an insignificant determinant regarding contractor's adoption of CWM behaviour in this instance. However, this study was limited to the identification of cultural differences in the Chinese construction industry. Different cities may have different CWM requirements, thus the responses from the respondents may differ significantly.

Drawing on the information provided in the aforementioned discussions based on the extensive review of the relevant literature, the key weaknesses regarding the behavioural adoption theories and frameworks for CWM are presented below:

- There is a lack of studies which have utilised TAM and SCT behavioural adoption theories and frameworks to address CWM issues despite being proven effective in the prediction of human behaviours in other fields. With regards to TAM, the majority of the studies in the literature focused on explaining the acceptance of technologies in the subjects of education, marketing and finance (King, & He, 2006; Marangunić & Granić, 2015) but there was scant application in construction. The most likely reason is that the construction industry is frequently reported as a low-technology industry, lagging behind other industries in terms of implementing innovative technologies i.e., LWTs (Becerik-Gerber & Kensek, 2010; Sepasgozar & Bernold, 2013). In respect of the SCT framework, "health" and "education" were the major focus in terms of predicting human social behaviours (Schunk & DiBenedetto, 2020).

- There is a lack of variety of regions, especially in the Middle East, with regard to the studies conducted using behavioural adoption theories and frameworks for the predication of CWM behaviour. Based on this review, the majority of studies that utilised these four theories have been conducted in developed counties, such as the United States, Europe and in China, and therefore authors (e.g., Humphreys, 1996; Hong et al., 2001; Wu et al., 2017; Liu et al., 2019) have argued that the results of these studies are less open to generalisation in other cultural contexts, such as in the Middle-East region. Accordingly, the adoption of these theories and frameworks may be inappropriate for developing countries, as it differs from one culture to another because of different prevailing factors. Wu et al. (2017) noted that the adoption of a certain behaviour is perceived and valued differently by different cultures.

- Much of the literature analysing the adoption of CWM behaviour is based on theoretical findings and there is little published work with empirical findings. Sniehotta et al. (2014) suggested that psychological theories should define their range of intended applications which should be empirically substantiated, rather than implicitly making untenable claims explaining all behaviour.

- It should be noted that TAM's ability to explain attitudes towards using a particular technology is better than in other theories and frameworks (i.e., TRA, TPB & SCT). The most likely reason, as explained by Mathieson (1991) is that the two components (perceived usefulness and perceived ease of use) of TAM have received more empirical support than the other theories and such factors can better predict attitudes toward the adoption of a technology. Moreover, TAM has the ability to consistently explain a significant amount of the variance in usage intention and behaviour.

- In general, researchers seem to favour TPB over other theoretical frameworks (i.e., SCT & TRA). The most likely reason is that the scope of TPB is more comprehensive as it synthesises the factors both these frameworks consider, such as attitudes and subjective norms. Additionally, it considers the control of individuals over their behaviour which is found to be an influential factor in predicting behaviour (Zhu & Li, 2012). Moreover, the TPB application can effectively demonstrate the effect of each factor in relation to others. For instance, significant findings were found using SEM which provided more insight into the significance of a particular factor (Renzi & Klobas, 2008; J. Li et al., 2018a).

In conclusion, the application of these theories and frameworks in the context of construction confirmed what was reported by the critics in section 3.3.5, in terms of their inadequate and simple construct which lacked additional important factors for the effective prediction of CWM behaviour (discussed in section 3.3.5). For instance, the findings of Lee et al.'s (2012) study revealed that TAM neglects the effect of social pressure while Lorente et al. (2014) indicated that incorporating organisational factors, such as the provision of requisite opportunities and resources, is extremely significant in predicting engagement in work. With regard to Liu et al.'s (2019) study, their application of TPB failed to consider the technological factors which can significantly help to explain the lack of utilisation of waste minimisation technologies in the Chinese construction industry. Thus, based on the findings of these studies, there is a need for the development of a BF, that addresses such weaknesses of existing theories and frameworks, in order to enhance the explanatory power in the prediction of CWM behaviour. Such a framework will support the adoption of waste minimisation in Jordanian construction projects by identifying and understanding the factors influencing the behaviour of contractors towards CWM.

3.4.1 Factors influencing the behaviour of contractors towards waste minimisation

In reviewing the existing literature, various factors have been found to impact on the behaviour of contractors towards CWM, such as those identified in the previous section. However, the question remains as to which factors have the most influence on the adoption of CWM behaviour. Therefore, the forthcoming discussion presents the important factors influencing the behaviour of contractors towards CWM. According to the CW literature in sections 2.4.3 and 3.4, these factors are considered to be the most common behavioural factors which occur on construction sites.

- **Knowledge**

  Behaviour-related knowledge means “knowing how to enact the intended behaviour, to determine responsibility for the intended act and to evaluate the perceived effectiveness of the behavioural act” (Davies et al., 2002; J. Li et al., 2018a). It reflects one's ability to perform a specific behaviour, recognising that their expectations of positive outcomes of a behaviour will be meaningless if there is any doubt as to capability (Compeau et al., 1999). Various physiological-related studies have found that there is a significant correlation between behaviour and related knowledge (Teo & Loosemore, 2001; Davies et al., 2002; Fabrigar et al., 2006; Funke, 2017).

  In a CW context, J. Li et al. (2018a) revealed that construction-related knowledge and experience of contractors are amongst the most important issues, influencing their behaviour towards CWM. Extensive knowledge and experience of construction help to raise the perceptions and understanding of contractors in the causes and types of CW. It also helps raise their consciousness of the longer term social and ethical implications of their activities in the project (Teo & Loosemore, 2001; Wang et al., 2008; Al-Hajj & Hamani, 2011; Yuan, 2013; Abarca-Guerrero et al., 2017; J. Li et al., 2018a; Luangcharoenrat et al., 2019). Further, awareness of the importance of using LWTs, in terms of its resulting benefits as well as familiarity and skills in applying these technologies in construction projects, influence the willingness of clients and contractors towards their adoption (Sepasgozaar et al., 2017). Moreover, knowledge and awareness of financial incentives (cost saving) help to motivate project stakeholders in taking effective action towards CWM (Udawatta et al., 2015; Bakshan et al., 2017), as they are mostly concerned with cost saving objectives (Mahpour & Mortaheb, 2018; Liu et al., 2019). Therefore, extensive knowledge and awareness from contractors on the positive outcomes of CWM, through educating managers, supervisors and workers on the issue of CW and highlighting their importance in terms of environmental sustainability, profit maximisation and quality control (knowledge-based constructs), can significantly result in effective CWM (a behavioural construct).

- **Personal norms**

  Personal norms reflect an individual's internalised morals and is a relatively important predictor of behaviour. It reflects the individual's beliefs and ethics regarding how he/ she should behave and what actions are right or wrong (Bortoleto et al., 2012). Personal norms are derived from social norms but are heterogeneous across individuals. They are learned and modified through social constructs. Thus, the consequences of violating or upholding social norms are tied to one's self-concept (Davies et al., 2002; Kaiser, 2006; Bortoleto et al., 2012; Wan et al., 2017). For instance, previous social-psychological studies (e.g., Schwartz, 1977 & Stern et al., 1995) have found that the anticipated feeling of regret has an important effect on decision-making. Indeed, as noted by Stern et al. (1995), the role of anticipated regret is of particular interest in the domain of company regulation violations as if some employees expect negative consequences when performing a violation action, they may decline to do so.

  In a CW context, Teo and Loosemore (2001) suggested that the lack of implementation of CWM measures, which can result in negative outcomes, can morally motivate individuals toward minimising CW. Furthermore, several authors (e.g. Wang & Yuan 2011; Yuan & Wang, 2017; J. Li et al., 2018a; Corsini et al., 2018; Mak et al., 2019) argue that work performance, in terms of personal perception and judgment, desire for decision objectives and consequences of decision making, can be perceived as a form of moral behaviour (personal obligation) since the benefits of performing such behaviour (e.g. cost and time saving, increased productivity, reduced waste, reduced environmental impact) are shared within the work environment and community (in addition to the person involved), hence, is a key motivation factor for minimising CW.

- **Perceived usefulness**

  Perceived usefulness (realised or expected) is defined as the perceived likely positive consequences of the behaviour (Bandura, 1986). It has three dimensions which are: perceived usefulness for the community, organisation, and the person involved.

  - **Perceived community usefulness:** This refers to the degree to which an individual believes that performing a particular behaviour would reap benefits for the local community (Shurrab et al., 2019). Therefore, with the growing awareness and understanding of the positive shared benefits of subject-related behaviour in any aspect of a person's life (e.g., study, work, daily life activities, etc.), his/ her willingness and interest in adopting that behaviour may increase. In a CW context, Begum et al. (2009)

showed that environmentally positive attitudes and responsible behaviours are critical in understanding how to resolve issues surrounding CW management. Yuan et al. (2018) revealed that benefits can be gained from the adoption of CWM behaviour, such as attaining a sustainable environment and enhancing quality of life, and, as a result, project managers are sometimes more inclined to pay more attention to waste minimisation. Further, Serpell et al.'s (2013) study indicated that only large-sized contractors are often concerned with the three pillars of sustainability in construction projects.

- **Perceived organisation's usefulness:** This refers to the degree to which an individual believes that performing a certain behaviour would enhance his or her job performance, and is viewed as an advantage for the organisation through a better and more efficient way of performing certain tasks (Davis, 1989). Compeau et al. (1999) noted that organisational-related outcome expectations have a strong relationship with behaviour, since it is often difficult for individuals to separate the anticipated consequences of the behaviour from their expectations of performance attainments. In a CW context, various studies (Udawatta et al., 2015; Jia et al., 2017; Park & Tucker, 2017; Hao et al., 2019; Liu et al., 2019) have revealed that economic performance has been critical in promoting waste management measures in construction projects. This is because cost saving is the first priority when considering whether or not to adopt waste management measures. Al-Hajj and Hamani (2011) revealed that maximising the profit and cost savings are the most important benefits for motivating contractors towards CWM

- **Perceived personal usefulness:** This refers to expectations of change in image or status, or of expectations of benefits for behaviour and the outcome of the behaviour (Bandura, 1989; Compeau et al., 1999). Therefore, with growing awareness and understanding of employees regarding the personal benefits they could gain by performing a related behaviour, their motivation, desire and interest will be positively influenced towards adopting that behaviour. In a CW context, Osmani et al. (2006) claimed that there was a consensus among both architects and contractors that financial reward was one of the key incentives to drive waste minimisation, and there was also a need to reward all project stakeholders for good waste minimisation performance. Mahpour and Mortaheb (2018) suggested that incentivising construction employees (savings from CWM is to be shared among them) is more efficient and promotes ethics compared to penalising in CWM.

- **System ease of use**

  Perceived ease of use (effort expectancy and complexity) is defined as "the degree to which the prospective user expects the potential system (e.g., LWTs) to be free of effort" (Davis et al., 1989; Luque-Martínez et al., 2007). Previous innovation studies (e.g., Davis et al., 1989; Davis, 1993; Rogers, 1995; Venkatesh & Davis, 2000) have found that there is a strong correlation between the ease of use of a technology and the likelihood of its adoption. Rogers (1995) noted that new ideas that are simpler to understand are adopted faster than those requiring the adopter to develop new skills and understanding.

  In a CW context, the implementation attributes, including ease of use of LWTs, are critical measurements for their adoption in construction (Sepasgozar & Bernold, 2013). The reason is that the process of utilising certain LWTs requires familiarity, skilled experts and/ or can be difficult to understand. Additionally, setup requirements and the operational aspect of such technologies can be challenging and require additional work to be carried out (Son et al., 2012; Lee et al., 2015; Hong et al., 2016; Sepasgozaar et al., 2016, 2017; Liu et al., 2018; Yang et al., 2018). For instance, Son et al. (2012) found that the successful implementation of mobile computing devices in construction projects is largely influenced by determinants such as technological complexity and training. Furthermore, Liu et al. (2018) revealed that the adoption of smart construction (i.e., LWTs) depends heavily on operators' perceptions regarding the system's ease of use. This includes the ease with which the employee can become skilled in its use, the mental effort required, its controllability, clarity and how easy it is to understand its capabilities.

- **Descriptive norms**

  Descriptive norms refer to the typical patterns of behaviour, generally accompanied by the expectation that people will behave according to a particular pattern, as determined by beliefs about the extent to which how important others require him/ her to perform a behaviour (Rivis & Sheeran, 2003). In other words, being influenced by surrounding persons (socio-cultural environment) coupled with the willingness to follow a trend is very influential in behaving in a related matter. Hence, the behaviour in this context is considered voluntary. In a CW context, a number of authors (e.g., Lorente et al., 2014; J. Li et al., 2018a; Liu et al., 2018; Yuan et al., 2018) emphasised that the CWM behaviour of contractors can be largely influenced by social norms. For instance, J. Li et al. (2018a) contended that the social pressure on workers to contribute to CWM activities is dictated largely by managers' willingness to commit organisational resources to it. Similarly, Liu et al. (2018) revealed that LWTs adoption can be enhanced through social pressure from project managers. They suggested that general managers can create a moderate, healthy and continuous level of pressure among his/ her project teams in the organisation which, in turn, influences the uptake of such technologies. Furthermore, Yuan et al. (2018) indicated that societal concern about environmental protection can exert strong pressure on contractors towards CWM.

- **Injunctive norms**

  Injunctive norms refer to the prescriptive (or proscriptive) rules specifying behaviour that persons ought (or ought not) to engage in (Kitts & Chiang, 2008). Hence, the behaviour in this context is considered mandatory. In many cases, a subjective norm has a stronger effect in mandatory settings than voluntary settings towards achieving certain targets, since the former has a stronger impact on behaviour (Venkatesh & Davis, 2000). In a CW context, it is generally recognised that the regulatory environment plays a crucial role in promoting CWM practices by enforcing policies for the whole industry (Udawatta et al., 2015; Wu et al., 2017; Yuan et al., 2018; Liu et al., 2018; 2019). For instance, Yuan et al. (2011) and Hao et al. (2019) noted that landfill charges play a critical role in promoting economic incentives that can significantly affect contractors' willingness to minimise CW. Additionally, Liu et al. (2019) and Yuan et al. (2011) indicated that the CWM behaviour of contractors is mostly driven by compulsory laws and regulations with a punishment mechanism, such as imposing financial penalties for illegal dumping. However, Wu et al. (2017) emphasised the significant role of governmental supervision to ensure that laws are enforced promoting better implementation of CWM.

- **Project constraints**

  According to Atkinson (1999), a project's budget, deadlines and scope are significant determinants which can constraint the quality of work. The project constraints' triangle is used to analyse the success of a project delivering the required scope within the established budget and schedule with reasonable quality. However, there should be a balanced trading between constraints. For example, changes in one constraint necessitate changes in others to compensate or quality will suffer (Atkinson, 1999). In a CW context, CWM behaviour depends to some degree on such non-motivational issues as the availability of requisite opportunities and resources, such as time and money (Fapohunda & Stephenson, 2011; Lorente et al., 2014; Udawatta et al., 2015; Abarca-Guerrero et al., 2017; Yuan et al., 2018). According to Abarca-Guerrero et al. (2017), project managers are mostly concerned with cost and time when selecting construction methods and often neglect CWM. Indeed, Manowong (2012) noted that clients and contractors often perceive CW as less important than profit maximisation, and view CWM as an activity which contributes to additional project expenses. Furthermore, Simpson (2012) indicated that many construction organisations only seek to invest in waste minimisation resources to the extent that they produce minimum performance outcomes such as legal compliance. Therefore, Madhavi et al. (2013) suggested that in order to monitor and control CW generation it is often necessary to dedicate time and money resources.

- **Facilitating conditions**

  Facilitating conditions refer to the provision of requisite opportunities and resources by organisations in order to support employees in the implementation of work towards achieving the organisational targets (Ajzen, 1985; Thompson et al., 2003). The more resources and opportunities individuals believe they possess, the fewer obstacles they anticipate and, thus, the greater ease of performing the behaviour (Ajzen, 1991). In a CW context, a study by Yuan et al. (2018) found that intention in conjunction with appropriate opportunities and resources enable the attainment of a behavioural goal in CWM. Wang et al. (2008) suggested that training schemes should be provided for all levels of employees with the objective of improving the environment. This is also asserted by Al-Hajj and Hamani (2011) who recommended the design of specific training and educational programs for different groups of staff. However, they noted that employees' participation can only be effective with genuine support. Furthermore, Lee et al. (2012) conducted a study regarding the adoption of LWTs with the result revealing that facilitating conditions such as the availability of technical assistance, can either restrict or optimise the usage of such technologies.

- **System compatibility**

  Perceived compatibility is defined as "the degree to which an innovation is perceived as being consistent with existing needs, values, past experiences and the technological infrastructure of potential adopters" (Rogers, 1995). An innovation might be perceived as technically or financially superior in accomplishing a given task, but it may not be adopted if a potential adopter views it as irrelevant to their needs (Rogers, 1995; Karahanna et al., 2006). Considerable research has reported on the important impact of compatibility on the decision of technology acceptance of potential users (Karahanna et al., 2006).

  In a CW context, the compatibility construct which fits between a particular LWT and the work environment, current methods of construction and overall objectives, will have a significant influence on both user behaviour and an organisation's intention to adopt that technology (Lee et al., 2012; Sepasgozar & Bernold., 2013; Lee & Yu, 2016; Sepasgozaar et al., 2017; Shirowzhan et al., 2020). For instance, Sepasgozaar et al. (2017) suggested that there are important aspects that should be considered when adopting LWTs in construction projects, in order to ensure the effective and successful adoption of such technologies. These aspects are: how can the outcomes of these technologies be integrated with other building components; and to what extent can these technologies incorporate services and reinforcements in the work implementation and how they will produce better, faster and perhaps lower-cost buildings in the long term. Further, Lee et al. (2012) revealed that one of the most important issues affecting the adoption of BIM in construction activities is the suitability of the potential adopter's work environment.

3.4.2 A Summary of the factors influencing the behaviour of contractors towards waste minimisation

From the discussions presented in the previous section, the most common factors affecting the behaviour of contractors towards CWM are summarised and classified in Table 3.1 below.

Table 3.1: Common factors influencing the behaviour of contractors towards CWM

Factors	Description	Reference
Construction-related knowledge	Knowledge helps to raise the construction workforces' perception and understanding in the CW subject, additionally it helps raise their consciousness of the longer term social and ethical implications of their activities in the project.	Wang et al. (2008), Al-Hajj and Hamani (2011), Yuan (2013), J. Li et al. (2018a) Bakshan et al. (2017).
Personal norms	CWM behaviour can be perceived as a form of moral behaviour since the benefits of such behaviour are shared within the society in addition to the person involved, hence, is a key motivation factor for minimising waste.	Wang and Yuan (2011), Corsini et al. (2018), Mak et al. (2019).
Perceived usefulness	CWM behaviour can be affected by the degree to which an individual believes that minimising CW would reap benefits for the local community, organisation and the person involved.	Osmani et al. (2006) Park and Tucker (2017), Yuan et al. (2018), Hao et al. (2019).
System ease of use	There is a strong correlation between the ease of use of LWTs and the likelihood of their adoption. technologies that are simpler to understand are adopted faster than those requiring the adopter to develop new skills and understanding.	Son et al. (2012), Hong et al. (2016), Sepasgozaar et al. (2016; 2017).
Descriptive norms	Being influenced by surrounding persons, coupled with the willingness to follow the trend, have a significant effect on the individual's behaviour toward CWM.	Lorente et al. (2014) Liu et al. (2018), Yuan et al. (2018).
Injunctive norms	The regulatory environment plays a crucial role in promoting CWM practices by enforcing policies for the whole industry	Yuan et al., (2011, 2018) Liu et al. (2018; 2019).
Project constraints	CWM behaviour depends to some degree on non-motivational factors such as availability of requisite opportunities and resources (e.g., time, money).	Simpson (2012), Lorente et al. (2014), Abarca-Guerrero et al. (2017).
Facilitating conditions	Intention in conjunction with appropriate opportunities and resources enable attainment of a behavioural goal in CWM.	Wang et al. (2008), Lee et al. (2012).
System compatibility	The fit between a particular technology adoption and the work environment, current methods of construction and overall objectives, can have a significant influence on both user behavioural and organisation intention to adopt that technology	Lee and Yu (2016), Sepasgozaar et al. (2017), Shirowzhan et al. (2020).

3.5 Conclusion

Through an extensive review of the relevant literature on CWM frameworks and theories adoption, this chapter has facilitated an understanding of the factors influencing the behaviour of contractors towards CWM. It was notable that these adoption theories and frameworks all have their relative benefits and limitations explaining CWM behaviour. Additionally, the list of factors identified in the literature review lack empirical evidence of their applicability in the Middle-East region, including Jordan. As a result, a theoretical basis was built for this study for developing a BF that addresses the weaknesses of existing theories and frameworks in order to enhance the explanatory power in the prediction of CWM behaviour. Such a framework will support the adoption of waste minimisation in Jordanian construction projects through exploring and understanding the factors influencing contractors' behaviour towards waste minimisation in the Jordanian context. Accordingly, a suitable research approach with effective techniques and methods will be selected in order to achieve the research aim and objectives. The research methodology adopted in this study will be discussed and justified in the following chapter.

Chapter 4

Research Methodology

4.1 Chapter overview

The preceding chapters established the research domain and presented a literature review highlighting the necessity for this research to be conducted, essentially describing the "what" and "why" focus of this work. The chapter incorporates a discussion on, and justification for, the methodological approach to be adopted for the purpose of achieving the research aim and objectives. Nevertheless, in order for the research methodology and study area to be suitably aligned, it is necessary to enhance the understanding of the different elements that constitute the research methodology as well as how they interact. Hence, a research philosophy must be developed that directs and motivates the core research approach and techniques. Research approaches focus on how concepts are formulated and their logical relationships, while on the other hand, research techniques are concerned with the processes involved in collecting and manipulating data. Lastly, it is important to establish the validation dimension of the research methodology to ensure that the analytical outcomes are reliable and consistent. This chapter follows this guidance providing sections that summarise the types of research philosophy, approach, strategy (techniques) and validation used. Additionally, it describes the choices made in the research along with in-depth justifications for such choices.

4.2 Research methodology overview

At the core of any research project is the methodology, which combines the rationale underlying the research and the outcomes to be discussed. According to Fellows and Liu (2015), a research methodology is "the principles and procedures of logical thought processes which are applied to a scientific investigation". Although researchers can choose from various different research methodologies, it is recommended that the methodology they choose can be applied in and has relevance for the field of study (Easterby-Smith et al., 2002). Moreover, as indicated by Morgan and Smircich (1980), the suitability of a research methodology "...derives from the nature of the phenomena to be explored". Thus, for the research aim to be achieved, it is necessary for a systematic process to be implemented, and one way that this can be effectively accomplished is by adhering to the "onion" model for research methodology (see Figure 4.1) developed by Saunders et al. (2007). Such model proposes that there are six primary layers (onions) in a research methodology whose relationships overlap, which are philosophy, approach, strategy, choices, time horizon, and techniques and procedures. A detailed discussion is presented on these elements in the following sections.

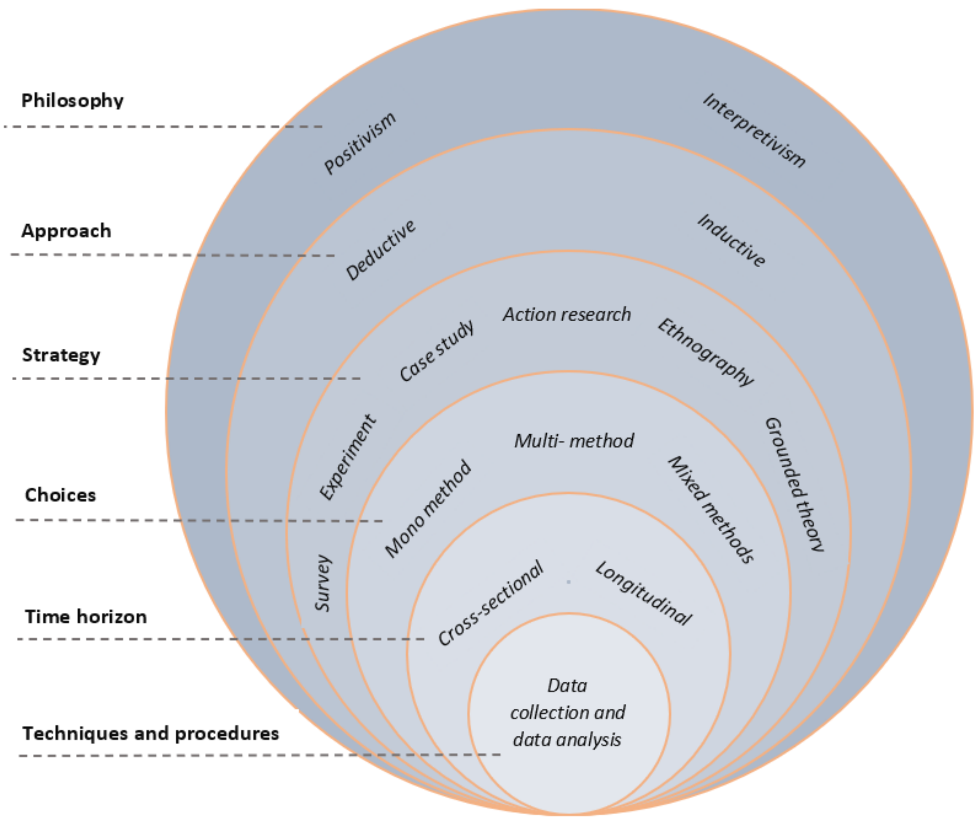

Figure 4.1: The onion research methodology model (Saunders et al., 2007)

4.3 Research philosophy

The research philosophy is reliant on the thinking of the researcher as well as assumptions about the development of knowledge, which subsequently impacts the manner in which the research is conducted (Saunders et al., 2009). Nevertheless, knowledge of the philosophical viewpoint of a specific research will ensure that the researcher is heading in the correct direction and can also diminish the threat of ambiguity and potential for error. It was affirmed by Easterby-Smith et al. (2002) whom acknowledged research philosophies lay the foundation for effectively designed research, and the lack of adherence to philosophical matters can have a negative impact on research quality. As stated by Easterby-Smith et al. (2002), in the context of social science research, two primary research philosophies are employed: interpretivism and positivism. Within these two philosophies there are a number of assumptions/ beliefs (Creswell & Poth, 2016), which include ontology (the essence of reality), epistemology (what knowledge comprises and the process of justifying knowledge claims), axiology (the role that values play in research), and methodology (the research process). Such assumptions are defined as being attributes of research philosophy, and the interlinking of these assumptions facilitates the process of clarifying the research design (research approach and techniques) employed for collecting and analysing the data, which subsequently enables valuable contributions to be made to the relevant literature in a suitable manner (Easterby-Smith et al., 2008; Saunders et al., 2009), see Figure 4.2.

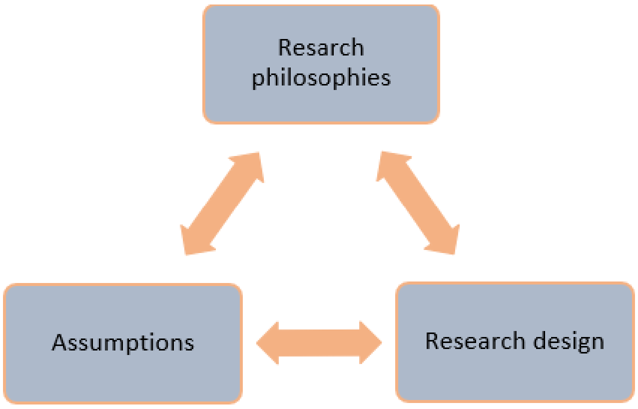

Figure 4.2: Interconnection between philosophical assumptions and research design

Positivism research philosophy has been defined as "an epistemological position that advocates the application of methods of the natural sciences to the study of social reality and beyond" (Bryman, 2016). Easterby-Smith et al. (2002, 2008) suggest that through objective methods, the properties of the social world should be measured, rather than being inferred subjectively through reflection, sensation, or intuition. The aim of the positivist is to develop overall laws and theories that describe the relations within phenomena. It is contended by positivists that there are sufficient similarities between humans and objects, meaning that the same approach can be adopted for studying them and therefore only one path exists that facilitates a scientific comprehension of the world (Bryman, 2003). Therefore, it is suggested by positivist research philosophies that quantitative and experimental techniques should be employed for the purpose of testing hypothetical-deductive generalisations.

Interpretivism has been defined as "a school of thought that focuses on the way that people make sense of the world, especially through sharing their experiences with others via the medium of language" (Easterby-Smith et al., 2008). Hence, it is suggested by interpretative research philosophies that qualitative and naturalistic approaches should be utilised in an inductive and holistic manner with the aim of understanding and explaining a phenomenon, instead of searching for external factors or fundamental laws. In Table 4.1, the different attributes of interpretivism and positivism research philosophies are displayed. Nonetheless, certain research studies are conducive to both philosophical approaches as they could be positivistic, interpretivist, or a combination of the two according to the aims and basis of the research (Easterby-Smith et al., 2002).

Table 4.1: Contrasting implications of positivism and interpretivism (Easterby-Smith et al., 2002)

Measuring item	Positivism	Interpretivism
The observer	Must have independence	Is an element of what is being observed
Human interest	Should have no relevance	Is the key driver behind the science
Explanations	Must show causation	Objective is to enhance the overall comprehension of the situation
Research progress through	Hypotheses and deduction	Collecting rich data, which enables ideas to be derived
Concepts	Operationalisation is necessary for the purpose of measurement	Perspectives of stakeholders should be incorporated
Units of analysis	Should be broken down into basic terms	Can incorporate the complex nature of the "whole" situation
Generalization through	Statistical probability	Theoretical abstraction
Sampling requires	Random selection of large numbers	Limited number of cases selected for particular reasons

In this study, as the aim and objectives require the researcher to attempt to derive conclusions based on the responses of Jordanian contractors with respect to the factors influencing their behaviour CWM, it is clear that this research falls mainly within the interpretivist philosophy paradigm. This is due to the fact that this study's nature necessitates the researcher to comprehend, investigate and obtain Jordanian contractors' opinions, viewpoints and perspectives regarding the implementation of CWM behaviours. Indeed, as noted by Mason (1996) and Easterby-Smith et al. (2002), study of humans as social beings can only be effectively undertaken through the adoption of the interpretivist paradigm as it concentrates on the ways in which people rationalise the world, especially through sharing their experiences with others via the medium of language, and form meaning and social reality. Conversely, criticisms are directed towards positivism when implemented in social science research as it is contended that it is not possible to treat people as objects and theories which leads to definite laws, as people are influenced by perceptions and feelings (Choy, 2014). Having considered the philosophical stance which will be employed for this study, the next section addresses the issue of which research approach is applicable, as recommended by Collis and Hussey (2013).

4.4 Research approach

According to past researchers, the concept "research approach" can be defined as the strategy employed for the purpose of organising research activities incorporating the techniques used for collecting and analysing data to achieve the aim of the research (Easterby-Smith et al., 2002). The strategy of research is categorised under two frequently utilised research approaches, which are inductive and deductive research; hence, a critical aspect of any research work is the determination of a suitable research approach (Collis & Hussey, 2013). The following subsections presents a discussion on the attributes of these approaches, and will also justify the strategy adopted in this research.

4.4.1 Deductive research approach

Deductive research denotes the process of testing a theory. It commences with a theory that has already been established, continues with the formulation of a hypothesis, and then aims to identify whether the theory is applicable to particular instances. Similarly, in this approach, the research is informed by the theory from the beginning and the hypotheses determines the specific evidence that the researcher should be seeking; data is subsequently gathered for either confirming or falsifying the hypotheses (Hyde, 2000), see Figure 4.3.

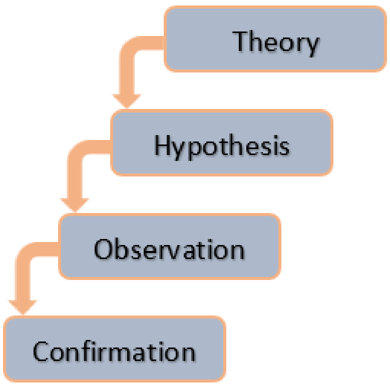

Figure 4.3: Deductive research approach

Deductive research approaches are linked with quantitative techniques for collecting and analysing data, and are favoured by researchers who intend to adopt a positivistic perspective. This is based on the strong academic tradition whereby significant trust is placed in statistics that denote ideas or opinions (Hyde, 2000). Collis and Hussey (2013) state that in the field of natural sciences, in situations where researchers are aiming to identify the causal linkages among the concepts of a hypothesis, and intend to measure on the basis of statistical measures – “how much” and “how often” – the most frequently used approach is deductive research. Thus, researchers are able to anticipate phenomena, forecast the likelihood that they will occur and, thus, enable them to be controlled. Consequently, the conclusion can be drawn that deductive reasoning involves the testing of a theory and ranges from the general (theory) to the specific (observation). Furthermore, it is an approach that seems to act as a way of verifying something instead of making new discoveries. In Table 4.2, the quantitative research approach's strengths and weaknesses are summarised.

Table 4.2: Summary of the strengths and weakness of the deductive research approach

	Strengths	Reference	Weakness	Reference
Deductive (Quantitative) research	It permits replication and comparison.	Hyde (2000), Easterby-Smith et al. (2002).	Humans are regarded as objects (statistics) instead of based on their beliefs and perceptions.	Queirós et al. (2017), Choy (2014).
	The observer is independent from the subject being investigated.	Easterby-Smith et al. (2002).	Insufficient resources for large-scale research.	Choy (2014).
	It facilitates the identification of causal explanations and fundamental laws.	Collis and Hussey (2013).	Lack of depth experience description.	Bryman and Bell (2001).
	Reliability is ensured through critical analysis	Choy (2014).	It lacks strength when utilised in isolation as part of the discovery process, as it enables something to be verified instead of new discoveries to be made	Gable (1994), Collis and Hussey (2013).
	Short time frame for collecting data.	Choy (2014), Queirós et al. (2017).		

4.4.2 Inductive research approach

Inductive research is not driven by hypotheses; rather, it denotes the process of building a theory, which is founded on the analysis of and interaction with empirical data. The researcher searches for patterns that may exist in the data, specifically relationships between the variables, see Figure 4.4 (Mason, 1996; Bryman & Bell, 2001).

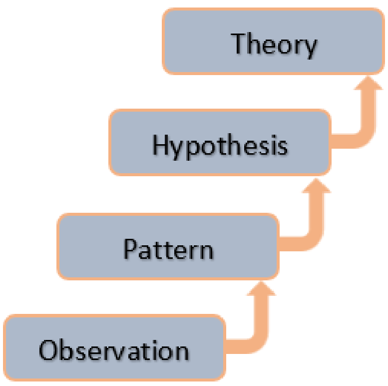

Figure 4.4: Inductive research approach

The inductive research approach is linked to qualitative techniques for collecting and analysing data in order to understand a social or human issue from various different perspectives, and it is favoured by researchers who adopt an interpretivist viewpoint. This type of approach generally places emphasis on words and observations instead of quantifying something for the purpose of expressing a real situation, and tries to explain individuals in natural situations (Mason, 1996; Bryman & Bell, 2001). This is due to the fact that from the perspective of qualitative researchers, meaning cannot be assigned to a phenomenon if the stance of the people who it affects, is not understood, and it should also reflect the daily lives of people, groups, societies and organisations. Indeed Wahyuni (2012) noted, as researchers carry out their investigations within the natural setting of the phenomenon of interest, it is essential to have a direct and in-depth understanding of the research setting through extensive and/ or sustained contact for the purpose of achieving contextual understanding. In Table 4.3, the qualitative research approach's strengths and weaknesses are summarised.

Table 4.3: Summary of the strengths and weakness of the inductive research approach

	Strengths	Reference	Weakness	Reference
Inductive (Qualitative) research	Perceiving social life as a dynamic process instead of being static; i.e., longitudinal	Easterby-Smith et al. (2002).	The process of collecting and analysing data can be lengthier compared with quantitative research	Miles and Huberman (1994).
	Provides rich and in-depth information about the respondent and enables data to be collected in natural settings	Mason, (1996), Bryman and Bell (2001).	Bias can affect interpretation as the perspective of the researcher can be influential	Miles and Huberman (1994), Choy (2014).
	Explains complicated phenomena integrated into local context or exceptional settings	Easterby-Smith et al. (2002, 2008).	It is not possible to generalise conclusions as there are limited subjects and they sometimes have distinctive attributes in comparison to standard respondents.	Choy (2014), Queirós et al. (2017).
	Allow flexibility in research-related processes and offers various alternatives for conducting the research	Wahyuni (2012), Choy (2014).		
	Identifies potential causes of a specific occurrence in a different perspective to that offered by quantitative research	Queirós et al. (2017).		
	Allows the participants to be interpreted in an unstructured manner, respecting anything in the participants' context	Choy (2014).		

Consequently, from Table 4.3, the conclusion can be drawn that inductive reasoning is an approach founded on the formation of theories and ranges from the specific (observation) to the general (theory). Furthermore, it is the optimal approach for discovering, investigating a new field, and has specific benefits in terms of supplementing, validating, explaining, illuminating or reinterpreting quantitative data collected from the same setting.

4.4.3 Justification of the adopted research approach

Collis and Hussey (2013) stated that the selection of a specific research approach rather than others is primarily dependent on the study's goals. Both qualitative and quantitative approaches are focused on investigating phenomena. Nevertheless, the focus of qualitative analysis is predominantly on identifying the variables that influence a specific phenomenon and exploring the environment further (Bryan & Bell, 2001), whereas the main focus of the quantitative approach is investigating the relations between the related variables and the wider consequences (Hyde, 2000). Accordingly, qualitative research has considerable potential to generate novel theories and concepts, whereas the main advantage of quantitative data is in situations where theories and hypotheses have previously been developed and are being examined.

Hence, in the context of this study, the qualitative approach is deemed to be appropriate and relevant. This is due to the fact that this kind of approach allows researchers to investigate and understand the factors influencing the perceptions and attitudes of contractors in terms of the adoption of waste minimisation behaviour within the Jordanian construction industry. As this study is fundamentally concerned with human behaviours, it is only possible to achieve the research objectives by becoming psychologically closer to the research environments, as well as through detailed and insightful investigation and analysis. According to Mason (1996), becoming closer to a phenomenon enhances the researcher's understanding of that phenomenon. The next section presents a discussion on the different types of data gathering and analysis techniques used as part of the qualitative research approach, with a specific focus on justifying the research approach employed in this study.

4.5 Research strategy

From the technical perspective, various different research techniques are utilised for collecting data, and the use of specific research techniques, according to the aim of the research, is defined as a research strategy (Saunders et al., 2009). Such techniques are associated with the research approach and philosophical continuum of any research. For instance, qualitative research techniques include, but are not limited to, literature review, interviews, ethnography and observation, action research, grounded theory, case study(s), Delphi method, and workshop(s) (Mason, 1996; Bryman & Bell, 2001; Easterby-Smith et al., 2002). On the other hand, examples of quantitative research techniques are secondary data (archival data), experiments and survey questionnaires (Hyde, 2000; Collis & Hussey, 2003; Bryman, 2016). The following subsections present a summary of various primary qualitative research techniques, with an explanation of their strength and weaknesses as well as why they are not considered appropriate for this study. Furthermore, the selected research strategy is assessed and justified in terms of its suitability for achieving the study objectives, while a discussion on the characteristics, strengths and weaknesses of each of the selected techniques is presented.

4.5.1 Ethnography and participant observation

Ethnography is a technique for collecting data that has a history stemming from the start of the 18th century through to the early 20th century (Saunders et al., 2009; Bryman, 2016). In this technique, the researcher aspires to become highly familiar with a given group of people through intensive involvement with the individuals in their own cultural setting (social environment), generally for a long time period, and the results are exhibited in a distinctive genre of ethnographic text (Baker, 2006; Watson, 2011). As stated by Baker (2006) and Naidoo (2012), the majority of participant observation studies comprise of the following four stages: developing relationships or familiarisation with the persons, immersion in the field, recording data and observations, and consolidation of the collected information. Hence, it is unlikely that ethnographic research will test a hypothesis, as such studies generally focus on discovering social patterns, with the standard utilisation of unstructured information. Nevertheless, as a result of PhD scheduling, and the limited time available to the researcher to undertake this study, ethnography is deemed not appropriate. This is due to the fact that, as suggested by Bryman (2016), the time required to observe the participants may range from 7 to 10 years to ensure that the researcher is fully immersed within the group being studied so that they can understand and document various attributes of the group.

4.5.2 Action research

Action research is described as the investigation of a social scenario with the aim of enhancing the quality of actions contained within (Costello, 2003; Koshy, 2005). In general, it is an applied investigation aimed at acquiring detailed knowledge and determining solutions to problems that occur in the real world (Hart & Bond, 1995). As stated by Koshy (2005), this approach requires ongoing assessment and re-diagnosis, re-planning and the implementation of actions until a solution is formed. The action research approach is specifically beneficial for answering "how" questions that require control of behavioural events and concentrate on current events (Costello, 2003). Nonetheless, this approach to collecting data does have certain weaknesses; as stated by Karim (2001), the relationship that develops between the researcher and the subject may become too intimate. This can impact the researcher's ability to be objectively detached from the participants and the data, which will potentially jeopardise his/ her position and lead to potential bias. Furthermore, the necessity to generate timely and practical findings from the research pressurises the participants, which could lead to a lack of methodological soundness (Argyris & Schon, 1989). In action research, the process of collecting data can be highly complex, consisting of: forming the problem, developing an action hypothesis, implementation and the diagnostic cycle (Karim, 2001; Costello, 2003). Moreover, in addition to the process being lengthy, it was also suggested by Karim (2001) that action research has rarely been used in the context of construction as a result of the requirement for the researcher to be increasingly and intensely involved in the study. Therefore, the adoption of this technique is not deemed to be suitable for this study.

4.5.3 Grounded theory

Grounded theory denotes the research approach in which a theory is formed based on the data, instead of the collection of data, according to a predetermined theoretical assumption. This technique is specifically beneficial in studies when predicting and explaining behaviour that highlights the development and construction of a theory (Goulding, 2002). In the grounded theory technique, the theory to be formed is founded on the data acquired from a set of observations (Charmaz & Belgrave, 2007; Saunders et al., 2009); nevertheless, even though the data gathering methods related to grounded theory and ethnography have certain commonalities, they are primarily differentiated by their purpose; the aim of grounded theory is the development of theories, while ethnography is focused on the exploration and comprehension of a specific community or culture (Naidoo, 2012). Grounded theory is commonly perceived to exemplify the inductive approach, due to the fact that data gathering commences by forming a preliminary theoretical framework. Nevertheless, it was suggested by Charmaz (2006) that theoretical sampling should be preferred in situations where certain key ideas have been determined. Hence, the utilisation of this approach in this study would lack efficiency, as the theoretical foundation for understanding the factors that influence contractors' CWM behaviours were previously determined in Chapter 3. Furthermore, grounded theory involves a lengthy process in the collection of data, as per the ethnography approach, which is difficult under time limitations of this PhD.

4.5.4 Case study

Yin (2009) stated that a case study comprises of an "…investigation into a contemporary phenomenon within its real-life context …where the boundaries between phenomenon and context are not clearly evident …and in which multiple sources of evidence are used". In other words, research based on a case study can be defined as the process of describing and analysing a phenomenon in an intensive and holistic manner, which may include a programme, an organisation, an individual, a procedure, or a social unit (Gable, 1994). Case studies are essentially qualitative, descriptive, or explanatory, and are focused on producing or modifying a theory; the aim is normally associated with people and the interpretation of a phenomenon from the viewpoint of social actors. Yin (2003, 2009) posited that the case study technique is favourable when attempting to find answers to "how" and "why" questions, when the ability to control events is limited.

Fundamentally, case study research incorporates in-depth and rigorous examination of individual cases and is focused on the complex nature and specific characteristics of the given case. Nonetheless, it can additionally consist of various different cases in which the value of the data is reliant on the number of cases that can be analysed (Merriam, 1988). The benefit of the case study approach is enhanced when the "…investigator has an opportunity to observe and analyse a phenomenon previously inaccessible to scientific investigation". Furthermore, they are beneficial for investigating phenomena that are rapidly changing, as Yin (2009, 2011) claimed that the adaptability of the case study enables the exploration of issues as they emerged during the process of collecting data. Nevertheless, this approach has been significantly criticised; for example, Yin (2003, 2009) suggested that it is not sufficiently rigorous and bias can arise. Grünbaum (2007) stated that this approach is primarily focused on comprehending the context of the specific case, which may lead to a disregard for theoretical influences or empirical generalisation.

Another issue is that the process of conducting and analysing case study research can be relatively time-consuming, and it offers minimal basis for generalising the findings to a wider population from only an individual or limited number of cases (Yin, 2003, 2009, 2011), which can resultantly lead to bias in the collection of data. Thus, due to the various aforementioned reasons, the case study approach is not regarded as being suitable for this study, particularly as this research is specifically focused on obtaining the varied perceptions and perspectives from different participants working on diverse construction projects for the purpose of identifying the best and most precise results for adopting CWM behaviours.

4.5.5 The adopted strategy for this study

The criteria for selecting the research approach to be applied in this study is based on the conditions that were presented and discussed previously in section 4.4.3, where the research in question is formulated on the basis of a "what" and "why" kind of research problem. The next subsections present a combination of methods (i.e., literature review, Delphi interview and workshop), which are deemed suitable for achieving the aim and objectives of this study. The characteristics of all of the selected techniques along with their strengths and weaknesses is discusses and justified.

4.5.5.1 Literature review

An important aspect of all research studies is the literature review due to the fact that it uncovers existing and widely acknowledged facts pertaining to the situation in question (Hart, 2018). Additionally, a literature review allows theories or models that have been previously used by researchers within the discipline to be identified and understood (Yin, 2009). This facilitates the process of identifying an issue in the field that has not been resolved, which will subsequently become the primary concern of the research. Furthermore, it ensures that the researcher does not duplicate the work of past studies and motivates him/ her to concentrate on information sources with greater specialisation (Bryman & Bell, 2001). Moreover, some of the benefits of utilising secondary data collected from a review of the literature includes a reduction in the length of the research process as well as the cost of acquiring knowledge. Nevertheless, a shortcoming of secondary data is that it can be dated, and may not be suitable for the exact requirements of a specific research problem. Also, secondary data in isolation is unable to satisfy the particular demands of specific situations, issues or environments, and it is imperative that primary data is obtained to resolve this deficiency (Randolph, 2009). Hence, it is important that the selection of the literature and data to be examined is made in a careful manner.

In the context of this study, a broad review of primary, secondary and tertiary sources was conducted in the research field, which incorporated books, articles, conference proceedings, reports, PhD theses and websites. The literature review presented in Chapter 2 conveyed a general overview of CW (quantities, types, and causes) as well as the activities targeted at CWM. On the other hand, the studies examined in Chapter 3 offered evidence to describe contractors' behaviour as well as the factors that influence their stance regarding the adoption of CWM. The acquisition of this data enabled the construction of a theoretical foundation for this study, which will be employed for developing the initial BF that can direct Jordanian contractors in effectively implementing CWM.

4.5.5.2 Interview

An interview consists of a meaningful conversation among two or multiple persons (Marshall & Rossman, 2014). It is an open-ended technique focused on discovery with the objective of exploring the perspectives, feelings and viewpoints of the respondent(s) in great depth (Guion et al., 2001). Similarly, according to Boyce and Neale (2006), an interview is a qualitative research method intended to extract a clear understanding of the respondent's viewpoint of the research subject. In this technique, separate in-depth interviews are conducted with a limited number of respondents for the purpose of exploring their viewpoints regarding a specific concept, programme or scenario. The use of interviews provides two primary benefits when collecting data: firstly, it allows the researcher to obtain in-depth and meaningful information regarding a specific field; secondly, fewer participants are required to generate beneficial and pertinent insights (Guion et al., 2001; Queirós et al., 2017). Nonetheless, it is important that the interviewees are selected carefully to prevent bias; furthermore, the process of analysing the data can be time-consuming in terms of transcribing the interviewee's discussions into verbatim (Queirós et al., 2017). Interviews can vary with regard to the a priori structure as well as the flexibility the interviewee is afforded when replying to questions; thus, interviews can be grouped into the following categories:

- **Structured interviews**: This involves the use of questionnaires founded on a pre-established and standardised or uniform group of questions. The person conducting the interview asks each question and then notes the reply on a standardised schedule, generally using pre-coded answers. When asking the questions, they adopt the same voice intonation to ensure that bias does not occur (Boyce & Neale, 2006).

- **Semi-structured interviews**: Neither semi-structured nor unstructured interviews have any form of standardisation. When conducting a semi-structured interview, the researcher prepares a series of themes and questions that will be included. Although the researcher should be prepared with certain-pre-determined questions to ask when interviewing, they must also allow questions to flow naturally based on the information provided by the interviewee. The researcher should not insist upon asking specific questions in a specific order; furthermore, after observing non-verbal behaviours during the interview process, the researcher should immediately record them in their field notes (Mack, 2005; Boyce & Neale, 2006; Marshall & Rossman, 2014).

- **Unstructured interviews**: These types of interviews lack a formal structure. They are generally used by researchers to investigate a general subject of interest in greater detail. In such situations, the researcher does not have a pre-set list of questions to follow, although they should have a clear understanding of the areas that the interview should cover. The interviewee is provided the chance to openly discuss events, behaviours and beliefs with regard to a particular subject, which means that this kind of interaction is often named non-directive. It is alternatively defined as an informal interview as the interview's flow is guided by the perceptions of the interviewee (Easterby-Smith et al., 2002; Boyce & Neale, 2006).

For this study, the semi-structured interview technique will be used as the tool for collecting data in the main research investigation method, as part of the Delphi technique (section 4.5.5.3). This type of interview technique is to be utilised for the purpose of qualitatively exploring the viewpoints and perceptions of the Jordanian contractors regarding the adoption of waste minimisation behaviours in construction projects, and to substantiate the list of factors determined by the review of the literature (see section 3.4). This method is chosen due to its comparative informality in terms of style, as well as the freedom it provides the interviewees to discuss the subject and give their opinions according to their own schedule. Hence, it is believed that the semi-structured interview method would be capable of extracting more useful data compared to structured or unstructured interviews, with regards to the perceptions of Jordanian contractors regarding the factors influencing their behaviour towards CWM.

The procedure that will be followed when performing the semi-structured interviews is the same as the general process used in other interviews: planning, instrument development, data collection, data analysis and dissemination of findings (Boyce & Neale, 2006). Mack (2005) separated the process of conducting the interview into three main steps: interview preparation, performing the interview, and analysis of the interview. Nevertheless, the most wide-ranging separation was suggested by Kvale (1996), who defined seven main stages involved in the process of performing semi-structured interviews, namely thematising, designing, interviewing, transcribing, analysing, verifying, and reporting; a brief summary of each of these stages is provided below along with implementation strategies as with which will be followed as part of this study:

- **Thematising**: This is the initial stage in the interview process in which the researcher provides clarification for the purpose of the interviews and establishes what he/ she aims to discover. After deciding on the overall purpose, the researcher can identify primary data that should be collected through the in-depth interview process based on the determined needs.

- **Designing**: After determining the information that he/ she wants to discover; the researcher must devise a method of achieving this. An integral aspect of this process is the development of an interview guide, which is comprised of a series of questions and probing follow-ups that direct the researcher when conducting the interview. In the preparation of such a guide, the researcher should anticipate and arrange the issues they intend to examine. The interview guide allows the researcher to remain focused on the objectives; ensures that significant matters/ subjects are evaluated; structures and sequences the questions; and maintains consistency when performing interviews with varied respondents. However, a pilot questions are often deemed necessary for the researcher in order to review the extent to which the questions are representative and suitable. further, if warranted by the discussion, the researcher must be prepared to shift their approach or pursue a different approach when conducting the interview by making amendments to the interview schedule.

- **Interviewing**: This is the part of the process in which the interview is performed, and is comprised of three stages: initiating the interview, the main body of the interview, and interview closing. In the initial stage, the researcher and the study are introduced. It is essential that a good rapport is established between interviewer and interviewee, and that the interviewee feels comfortable. During the interview process, the researcher is primarily responsible for listening and observing as he/ she directs the interviewee through a discussion until all of the key issues listed in the interview guide have been covered.

- **Transcribing**: In this stage, the researcher creates a written transcript of the interviews. This incorporates the collation of the researcher's information collecting techniques into a single written form. Hence, the researcher transcribes every question and response verbatim from the interview based on audio recordings and written notes, which can include side notes, observations, feelings and reflections made by the researcher. The main difference between side notes and the respondent's notes is that text is generally highlighted in the former. Finally, the transcribed information is reviewed by the researcher, who determines the aspects that have importance according to the study aims.

- **Analysing**: In this stage, the meaning of the information collected with respect to the study purpose is determined. The researcher studies the information deemed to search for themes, commonalties and patterns for the purpose of making sense of the information. In the event that further questions emerge that need more clarification to serve the study purposes, then an additional in-depth interview is necessary to investigate the matter more extensively.
- **Verifying**: In this step, the collected information is check to ensure that it is credible and valid. A technique defined as "triangulation" is utilised for the purpose of checking and balancing by employing numerous perspectives to interpret an individual set of information. For instance, if the research is focused on the result of a parenting lesson on enhancing the communication between parents and children, the researcher should conduct interviews with parents who participated in the class, the children and spouses/ partners, where applicable. If the responses of all those interviewed are largely analogous, then the evidence would tend to indicate that credibility and validity are ensured. An additional simple method of triangulation is where a peer reads the transcripts to determine whether he/ she derives the same general meaning.

- **Reporting**: In the last stage of the process, the researcher shares the information they have obtained from the interviews with different internal and external stakeholders. The reporting could be in written form, which may include achievements or any needs based on the evaluation of the findings, or it could be delivered orally. Irrespective of the method used for sharing the information, the critical issue is that it must be shared.

4.5.5.3 The Delphi technique

The Delphi technique is described as a forecasting structured method used to elicit and refine the opinions of a specific group, generally comprised of experts (Brown, 1968). It is a process that involves repetition focused on collecting and refining the judgements of experts regarding a specific topic based on the findings of multiple rounds of questions, concentrating on problems, opportunities, solutions or forecasts, with feedback included. The anonymous responses given by the experts are collated and disseminated to the panel subsequent to each round of questioning; essentially, the findings from each round of questions develop the subsequent one. This process is completed after the panel of experts has reached a consensus regarding the specific topic (Skulmoski et al., 2007). Hence, the combined judgment of the experts in the Delphi technique, even though it is comprised of subjective opinions, is regarded as having increased reliability compared to individual statements and therefore, the outcomes have more objectivity (Linstone & Turoff, 1975, 2011; Landeta, 2006). As stated by Rowe and Wright (1999, 2011), the key aspects of the Delphi technique can be listed as: it is a repetitive procedure that comprises a certain number of rounds; the experts' identities remain anonymous; controlled feedback is provided after each round of questions; statistical group response due to the fact that the final reply is comprised of all the opinions.

The Delphi technique has been broadly adopted across the globe in numerous different fields, such as in healthcare, business, IT, education, transportation and engineering. It has been demonstrated to offer benefits in terms of cost and time (Iqbal & Pipon-Young, 2009). Multiple researchers have proposed that when purely acquiring qualitative data, the Delphi technique is the suitable choice (Landeta, 2006; Skulmoski et al., 2007; Rowe & Wright, 1999,2011; Linstone & Turroff, 2011; Kezar & Maxey, 2016). The iterative nature of the Delphi technique enables experts who have diverse perspectives and distinct cognitive abilities to refine their opinions based on the progression of the group's work as the rounds proceed (Skulmoski et al., 2007). Furthermore, the process also affords Delphi experts increased time to deliberate on their ideas prior to finalising them, which enables higher quality responses. As the Delphi experts remain anonymous, they have the freedom to convey their views without feeling pressured to adhere to the opinions of other experts due to the fact that decisions are assessed based on merit instead of the person who proposed the idea (Rowe & Wright, 1999; 2011).

Furthermore, Iqbal and Pipon-Young (2009) noted that as the Delphi technique is flexible and adaptable, it can be implemented in various different situations and to a broad scope of complicated issues that can generally not be analysed using other approaches. For example, the Delphi technique can be employed as a structured procedure that incorporates a combination of qualitative, quantitative or mixed research methods. Not only does this adaptability allow the technique to find answers to research questions, but it also makes it compatible with the capabilities and proficiencies of numerous researchers and participants (Kezar & Maxey, 2016). Hence, according to the multiple and important benefits offered by the Delphi technique, and in line with the aim and objectives of this study, this technique will be selected as a suitable primary research method for investigation, incorporating semi structured interviews as the data collection tool. This is due to the fact that the findings will provide a more informed perspective on the present and potential status of the factors influencing the behaviour of Jordanian contractors towards CVM.

Nevertheless, all research techniques have strengths and weakness. According to Garrod (2008), it is possible that collusion may occur, although Delphi should not accept connived findings and all suggestions of such a possibility should be excluded from the research. Goodman (1987) demonstrated that the use of inadequate methods to summarise and present the responses of the group can make the process of analysing the data less accurate. An additional deficiency is the time factor; for example, Rowe and Wright (2011) suggested that using Delphi can be inefficient when the researcher lacks the time to suitably revise the questions during each subsequent round in order for appropriate and sufficient feedback to be given based on the experts' responses. The aforementioned limitations and shortcomings can cause a Delphi study to have poor design and execution, which will ultimately generate insufficient or false data and, therefore, requires great consideration. The following subsections offer an in-depth explanation of the characteristics, conduct and process of executing the Delphi technique, including the level of consensus, the process of selecting the panel of experts, the design of questions in the Delphi rounds and the method for analysing data.

4.5.5.3.1 Delphi design and consensus

As noted earlier, the Delphi technique utilises a combination of problem solving and expert consultation approaches in an organised way. In Figure 4.6, the series of processes executed in the Delphi technique is demonstrated, which aid in the research questions being answered, at which point information is shared and a level of consensus is achieved (Skulmoski et al., 2007). As stated in previous studies on this subject, a consensus is achieved after a certain number of executed in the Delphi process (Hsu & Sandford, 2007). For example, Rowe and Wright (2011) and Linstone and Turoff (2011) suggested that two or three rounds is adequate for the majority of studies. Whereas Skulmoski et al. (2007) claimed that in many studies, at least three or four rounds of interviews are necessary to reach a consensus. Nevertheless, they advised that in cases where the sample is homogenous, then less than three iterations may be enough for a consensus and theoretical saturation to be reached.

Nonetheless, the degree to which experts agree, which can be defined as a consensus, generally ranges in different studies from 70% as recommended by Hasson et al. (2000) or 80%; furthermore, according to both Giannarou and Zervas (2014) and Heiko (2012), it is important to achieve a response rate in excess of 70%. Different authors (e.g., Hsu & Sandford, 2007; Heiko, 2012; Clibbens et al., 2012) claimed that the degree of consensus can be categorised into three groups: low, medium, and high consensus (see Figure 4.5). Hence, in this Delphi study, a consensus is deemed to have been reached with regard to a statement, when a level of 70% or higher is achieved.

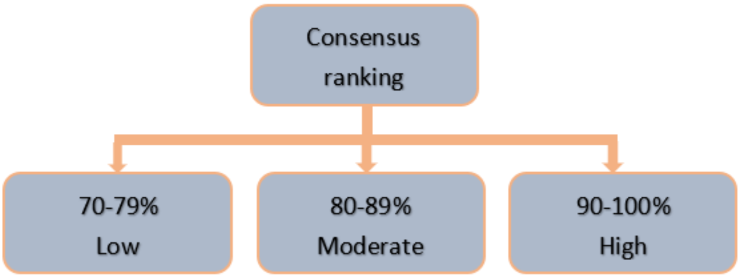

Figure 4.5: Consensus ranking in the Delphi technique

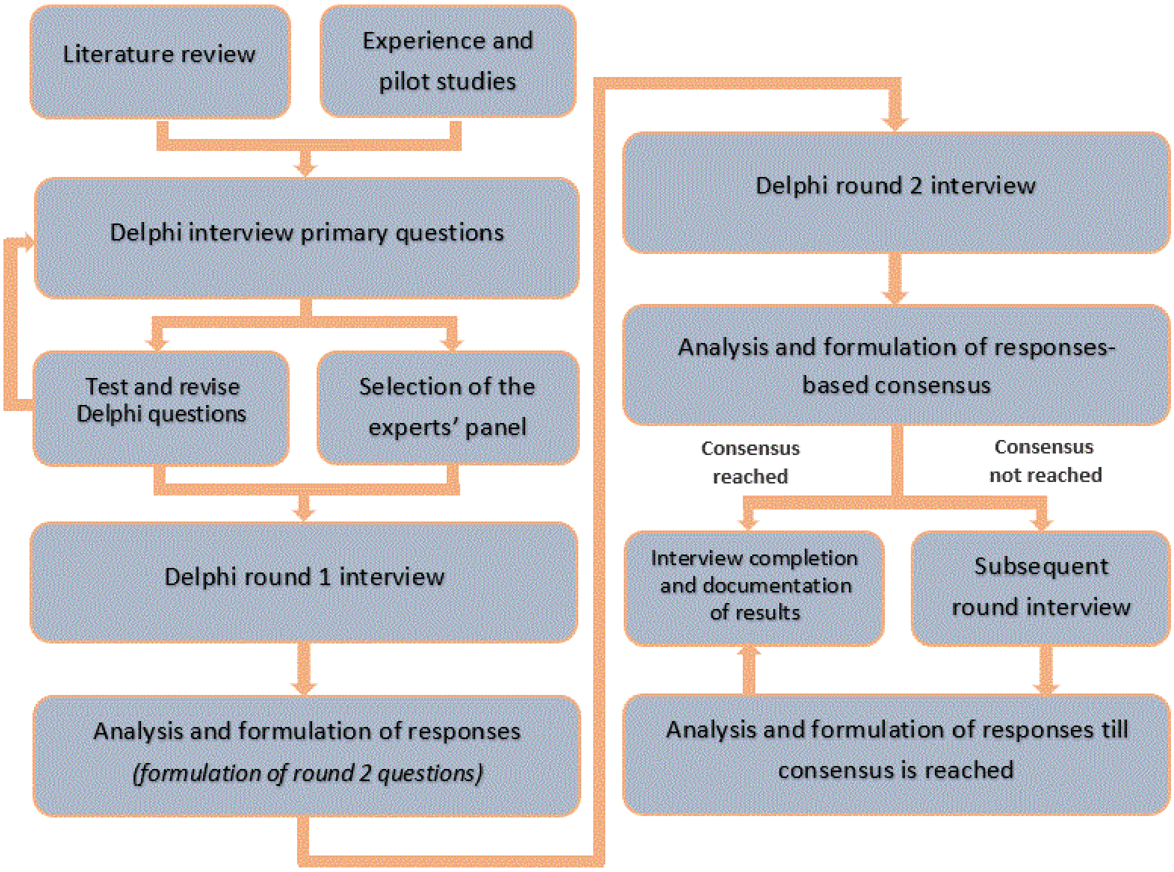

Figure 4.6: The Delphi process in this study

4.5.5.3.2 Panel of experts' selection and sampling technique

When using the Delphi technique, the expert panel (additionally called participants, panellists or respondents) can include any person with pertinent experience and knowledge of a specific subject. Nevertheless, the ideal number and qualifications of the panel of experts are dependent on the setting and objectives of the given study (Oranga & Nordberg, 1993). Likewise, Hasson et al. (2000) observed that the likelihood that a Delphi study will be successful primarily depends on the participants' quality. They indicated that a crucial factor when utilising the Delphi technique is choosing the right experts as they are pivotal for the study's success.

As this study focuses on understanding the behaviour of Jordanian contractors towards CWM, the experts' panel was therefore selected from construction companies who would appear to have the required knowledge and/ or experience in construction. There are four "expertise" criteria that the Delphi participants should satisfy: (I) knowledge and experience of the topic being investigated, (II) the ability and willingness to participate in the Delphi study, (III) sufficient time to participate and (IV) the proficiency to communicate effectively (Adler & Ziglio, 1996). As for the first inclusion criteria, a person is deemed fit for the study if their job description falls under the following:

- Experience of working in the Jordanian construction industry must be greater than five years and the expert must have worked in both private and public projects. This is to ensure that the selected experts had adequate knowledge and experience of the subject in a variety of projects, as each private/ public sector project sometimes requires different construction techniques and standards.

- Experience of working in medium to large-size projects in terms of budget. According to the Ministry of Public Works and Housing of Jordan (2020), medium and large-size projects are defined as those that have a budget exceeding 400,000 JOD. This is to ensure that the selected experts had experience in construction projects which involve technological methods, as most medium to large projects in Jordan depend to some extent on technological construction methods (i.e., LWTs) in addition to the traditional ones. In addition, such sized projects have a greater impact on the production of CW than small projects.

With regards to the rest of the inclusion criteria, the experts must have a sufficient level of interest and involvement in the topic being investigated to increase the commitment and response rate, as the level of participation commitment in a multi-round Delphi can be inferred from the response rates from round to rounds (Keil et al., 2002). Skulmoski et al. (2007) claimed that real experts in a field offer significant insight; however, due to their other commitments, their complete participation may not be guaranteed, which means that well-formulated questions that engage their interest and are to the point can motivate them to participate. Notably, the project type and location were not considered as part of the inclusion criteria. This is because the nature of the built environment is labour intensive and, consequently, waste is generated in all types of projects. Al-Sari et al. (2012) indicated that the labour-intensive nature of construction activities suggests that behavioural impediments are likely to influence waste levels significantly Additionally, Jordan is a small country and the culture, uptake and challenges in the built environment are similar across the different parts of the country.

A purposive sampling technique (Merriam, 1998) or judgement sampling (Mills & Gay, 2019) was followed when contacting panellists for the study to select the most appropriate experts. This sampling technique is one of the most effective techniques for a qualitative research (Patton, 1990), as it allows researchers to freely select information-rich participants to gain an insightful and in-depth understanding of the phenomenon under investigation. However, the group of participants were selected based on critical sampling, which ensures that a comprehensive list of participants with a diversity of experience, knowledge and perceptions, are involved. This sampling technique was used based on Mills and Gay (2019) assertion that it ensures optimum quality of the information provided as well as logical applicability of the finding to other cases. As such, lead manager, project manager, site manager, foremen and labourer were involved in the experts panel interviews. One major source that assisted in reaching out to the research participants was the Jordanian Construction Contractor Association (JCCA) which is a certified construction professional and network including a database of the leading construction companies in Jordan.

The sizes of expert panels in Delphi studies can differ and it is contended that there is no set rule or ideal number of experts necessary to create a panel. In previous studies, the size of the Delphi panel has ranged from the tens to hundreds (Rowe & Wright, 2011). The process of determining the size is dependent on the essence and scope of the research and, to ensure that satisfactory accuracy is achieved in a Delphi study, the minimum size of the panel should be at least between 4 and 7 according to Thangaratinam and Redman (2005). They contended that regardless of the number of experts, it cannot be regarded as one of the standpoints of a statistical sample size due to the fact that the Delphi technique is not targeted at a random sample from a population. This was supported by Skulmoski et al. (2007), who suggested that between 10 and 15 experts is sufficient for a homogenous group. Furthermore, it was observed by Hasson et al. (2000) that researchers believe that the number of experts should be minimised to the greatest extent possible provided that they sufficiently represent the opinions in the field of interest.

4.5.5.3.3 Round 1 design

The first round of the Delphi technique provides the individual experts with relative freedom to elaborate on the areas they perceive to have importance regarding a defined topic. The experts' responses are subsequently collated so that those opinions that are similar can be allocated together. In some cases, the aim of the first round of Delphi is to brainstorm (Schmidt, 1997). As previously mentioned in section 4.5.5.2, semi-structured questions are employed, which allow the respondents to express their views in a manner of their choosing. This approach to questioning is deemed to be appropriate as the direction given to the respondents is minimised, while it also removes the necessity for the researcher to predetermine suitable categories for responses, which allows the formation of groups of similar responses where required subsequent to collecting the data (Marshall & Rossman, 2014).

The process of developing the primary questions of the Delphi should be carefully implemented due to the fact that if a question is not understandable by the experts, their answers may not be suitable and/ or this could be a source of frustration (Skulmoski et al., 2007). The questions in the first round are generally based on an in-depth review of the literature, consultation with associated persons and take the objectives of the Delphi study into account (Iqbal & Pipon-Young, 2009). In the majority of studies, the first-round questions involve a free-flowing and unstructured or semi-structured exploration of the various issues, constraints, difficulties and problems that impact or are impacted by the elements within the study domain (Linstone & Turoff, 2011).

In this Delphi study, the literature review presented in Chapter 2 (section 2.4.3) and in Chapter 3 (section 3.4), offered evidence to describe contractors' behaviour as well as the factors that influence their stance regarding the adoption of CWM. This has enabled the researcher to construct a theoretical foundation for this study, of which the Delphi interview questions are derived from the related literature in line with the objectives of the research. Accordingly, a combination of 11 open-ended questions (see Appendix 2) were formulated and designed to collect the required data based on the list of factors in section 3.4. These questions allow the experts to elaborate on the list of the factors, in addition, it aids in identifying additional factors influencing the behaviour of contractors towards CWM in Jordan. Indeed, as discussed by Cassell and Symon (2004) and Waring and Wainwright (2008), certain codes (i.e., factors influencing CWM behaviour) are generally a priori based on the theoretical stance of the research (i.e., section 3.4), but can be altered or expanded during the process of reading and interpreting the texts.

In certain circumstances, a pilot study is performed with the objective of verifying and modifying the Delphi questions to enhance comprehensibility and to resolve any procedural issues. This makes the questions more valid and reliable while also ensuring their appropriateness and terminology for the purposes of identifying any additional deficiencies and to apply any modifications necessary (Van Teijlingen & Hundley, 2001). This is also recommended by Saunders et al. (2009) and Clibbens et al. (2012), asking an expert, or a group of experts, to comment on the representativeness and suitability of the questions as well as the structure of the research instrument in the initial stage.

The interview schedule was first translated from English into the Arabic language to ensure experts' full understanding of the content. Subsequently, feedback was obtained from a total of four construction professionals working in a construction company in Amman/ Jordan. Notably, these professionals were chosen based on having extensive experience in construction and a strong ability to understand and speak the English language. Their feedback, which was fully taken into consideration and subsequently incorporated in the final interview schedule of the first round, is as follows: (I) some questions were long and needed to be shortened or broken down into more than one question; and (II) some of the Arabic terminologies used in the questions were difficult to understand, overly technical and/ or academic, and should be rephrased in simpler wording. However, the translation of the source-language terms (i.e., English terms) in the target-language text (i.e., Arabic text) proved to be challenging, as the researcher was careful that the translated Arabic language text is enlightening to the reader in that they reflect source image in a genuine and correct manner without losing its credibility. For more certainty, during the interview the researcher made sure to explain any question where necessary in order to receive adequate responses from the experts without any misunderstanding. With regards to translating the results of the interview in to the English language, it was less challenging giving that the researcher is close to the topic being investigated with a clear understanding of its aim and objectives. However, the medium of spoken and written language of the experts' responses concerning Jordanian construction culture raised some concerns in terms of the degree that the researcher believe is now acceptable and reliable reflecting the genuine image of the responses. As expressed by Temple and Young (2004), centring translation and how it is dealt with raises issues of representation that should be of concern to all researchers.

The results of the Round 1 questions will then be analysed according to the research qualitative paradigm. There is no standardised method for analysing qualitative data as researchers often create their own data analysis methods (Saunders et al., 2009). This is due to fact that qualitative data is frequently subjective, rich and is comprised of detailed information generally displayed as words. Hence, when analysing qualitative data, it is often necessary to read a significant volume of transcripts to identify commonalities or distinctions, and then determine themes and develop categories (Wong, 2008). One of the most common and robust methods for the analysis of qualitative data is named Template Analysis and was originally developed by King (2004). This is a kind of textual analysis that concentrates on the textual content for the purpose of describing a phenomenon. The fundamental nature of this this approach to analysis is that the researcher generates a list of code "templates" that represent themes extracted from the textual data.

As stated by Plas et al. (1996), in the coding process, data is broken down, examined, conceptualised, contextualised and categorised in order to produce novel ideas, categories and theories from the phenomenon investigated. According to Ryan and Bernard (2000) "coding is the heart and soul of whole text analysis". Consequently, Template Analysis is utilised for making inferences from data to their context that can be replicated and are valid; to identify the beliefs, values and behaviours, and other aspects of cultural influence. This incorporates the creation of codes based on the identification of important patterns and subsequently extracting meaning from the data and the construction of a logical chain of evidence, Figure 4.7 (King, 2004; Wong, 2008).

However, presenting the results of the first round should be in ranked order; according to the frequency of occurrence of the identified code within the text, as according to Schmidt (1997); it is common for the results of the first round to be ranked and rated. This enables the researcher to create a list, or multiple lists of ranked information, on the basis of which those responsible for making decisions in senior management could apply different criteria when making a decision. Subsequent to analysing and summarising the responses given in the first round, the findings are then presented to the panel of experts for further deliberation and to reach a consensus, in the following round.

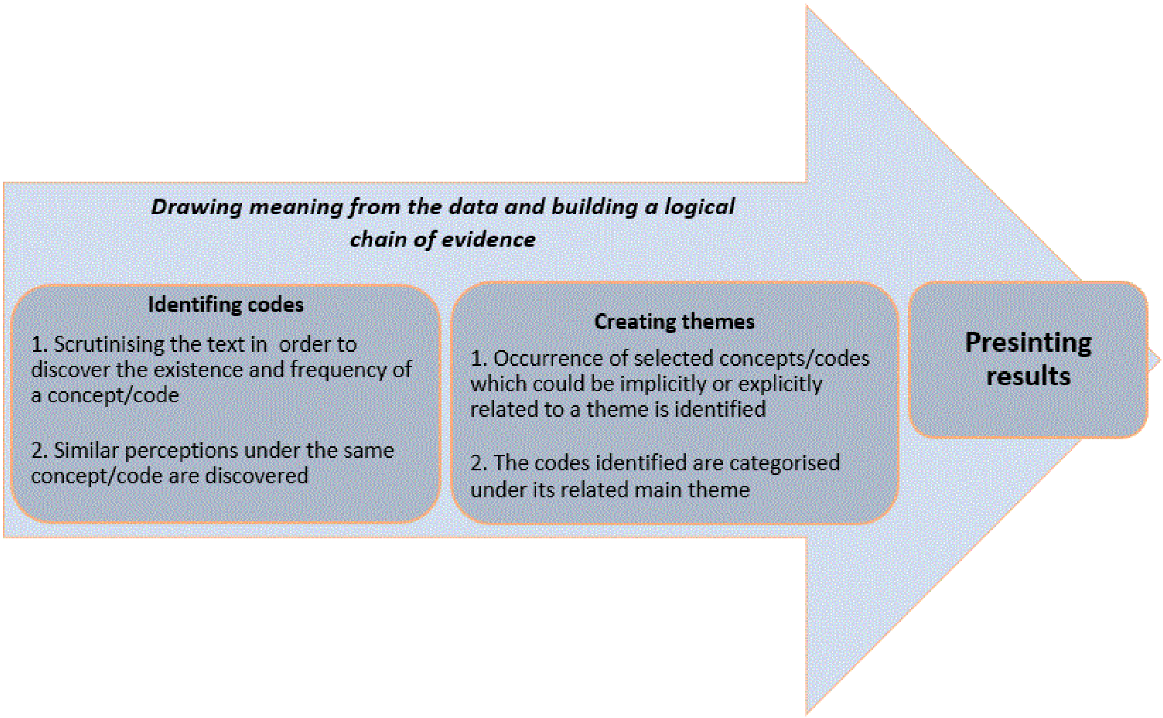

Figure 4. 7: Data analysis process in King's method

4.5.5.3.4 Round 2 and subsequent rounds' design

The responses given in the first round form the basis of the development of the questions for the second round of interview and according to the objectives of the research, the study focus may be directed by the research or the experts' opinions (Skulmoski et al., 2007). Round 2 essentially involves the verification of the pre-established of factors (i.e., codes) analysed in the first round; hence, the number of factors included in the list is often reduced in this round (Schmidt, 1997). Therefore, after the second round and subsequent rounds, the panel of experts has the chance to modify previous estimates based on the feedback provided. This process is repeated until there is consensus in the responses given by the experts for each of the factors. Consequently, from the second round onwards, all questions are also semi-structured as the experts are initially provided with the chance to review their responses given in Round 1 and are additionally given the opportunity to modify or add to their first-round responses (Hsu & Sandford, 2007). The process used to analyse the data in Round 2 and following rounds is frequently similar (Skulmoski et al., 2007).

4.5.5.4 Validation workshop

Validity is related to the degree to which the research findings are reflective of the concept, theory or variable being studied in the social reality. In other words, validity denotes the effectiveness of an instrument (e.g., framework, theory or model) in terms of whether it achieves its measurement purpose (Creswell & Poth, 2016). Research findings alone is not sufficient, as the reliability and validity of the measures must also be ensured. As stated by Creswell and Miller (2000), when regarded as constructs and interpretations of the researcher, research findings can thus be validated by determining the perspective of a different party who may or may not have direct involvement in the study. This is based on the philosophical assumption inherent to qualitative research that reality is a social construct.

Universal standards do not exist in terms of the selection of test processes or criteria to be utilised for validation as they can vary based on the research approach (qualitative or quantitative). In quantitative researches the testing for validity and reliability is a given, which means that it is possible to assess the credibility of such researches (Hammersley, 2008). This was supported by Guba and Lincoln (1989), who argued that the set of criteria for assessing the quality of an investigation is only applicable to investigations founded on the positivist ontology and epistemology. In terms of qualitative studies, consensual criteria for validation do not exist, as these types of studies are criticised for their subjectivity, lack of replicability or generalisability and insufficient transparency (Bryman, 2012). In fact, Hammersley (2008) suggested there are no criteria whatsoever that can be utilised for assessing the quality of an investigation with complete certainty; instead, a knowledge claim can only be assessed based on the likelihood that it is correct. Consequently, it has been argued by researchers that in qualitative studies, it is the opinions and viewpoints of the participants that provide validation instead of the utilisation of quantitative logical instruments and extrapolations, including internal/ external validity and content validity (Rykiel Jr, 1996).

Workshops are specifically appropriate for qualitative assessment and validation processes, where Cohen et al. (2013) and Cresswell and Poth (2016), claimed that workshops are acknowledged to be significantly interactive and experiential methods of collecting data and validating in qualitative studies. Cassell and Symon (2004) considered a workshop to be an effective qualitative technique for providing validation, which involves multiple participants who discuss their experiences, viewpoints, opinions, beliefs and attitudes regarding subjects that are decided by the researcher. Similarly, a workshop was described by Bryman and Bell (2001) as a type of group interview where: there are multiple participants (in addition to the moderator/ facilitator); emphasis is placed on questions pertaining to a relatively strictly defined subject; and the focus is on interacting with the group and the collaborative formation of meanings. It is important to note that no responses are correct or incorrect in a workshop due to the fact that all opinions are considered valid as the objective of conducting a workshop is to identify the most commonly held views and to clarify their meaning for the suggested topic to be validated (Rubin & Missokia, 2006). Therefore, the workshop method will be employed in this research to help with validating the results of the Delphi study for commenting and criticising.

In this study, the workshop schedule incorporates the agenda and questions (see Appendix 5) which is designed to make the participants comfortable with the subject area and focus their attention on the topics to be investigated. Therefore, the workshop schedule is classified into two main themes: firstly, the workshop attendee’s experience of CWM implementation and, secondly, the validation of the BF. The workshop adopted a semi-structured discussion approach to allow the researcher to gather in-depth data from which new concepts may emerge. All feedback, debates and discussion points during the workshops were audio and manually recorded by the researcher. Recordings were transcribed verbatim for analysis. However, it should be noted that transcriptions were time consuming since the researcher had to listen to the tape repeatedly in order to transcribe all accounts and to ensure that nothing important was missed.

The workshop questions were subjected to a pilot testing as recommended by Saunders et al. (2009), an individual or group of professionals can be asked to review the extent to which the questions are representative and suitable. The questions were first translated from English into the Arabic language to ensure participants' full understanding of the content. Subsequently, feedback was obtained from the same four construction professionals who were involved in the pilot testing for the Delphi interview questions in Chapter 5. Their feedback, confirmed the appropriateness and suitability of the workshop questions for achieving the objectives of the study, thus, no changes were required.

The selection process for this workshop participants followed the same inclusion criteria as employed in the Delphi study (see section 5.2.1). This is to provide continuity of discussion to the research in order to confirm and augment the findings from the Delphi study. Following the same procedures in the Delphi study, the researcher used the same lists of employees in leading construction companies as per a list provided by the Jordanian Construction Contractor Association (JCCA). However, the names of the employees who participated in the Delphi study were excluded in order to obtain the viewpoint of another party as well as to increase the accuracy of the results and assess the validity of the proposed framework, as explained above.

With regard to the ideal sample size, Robson and McCartan (2016) advised that there is no definitive answer to this question due to the fact that the sample size can be influenced by a variety of factors, including the participants' accessibility, the resources that the researcher can access, and the practical feasibility of processing the transcripts, specifically with respect to qualitative questions that are open-ended. This is confirmed by Rubin and Missokia (2006) who revealed that the number of people who participate in a workshop can vary. Krueger and Casey (2000) stated that the utilisation of a group of four to six participants, or slightly above, who have analogous backgrounds, attitudes and behavioural patterns is recommended when conducting workshops. The analysis of the workshop results often follows the process of coding, such as in the Template Analysis technique. This include patterns shaped by words, defined as themes or perspectives (Creswell, 2000); therefore, a similar approach to the Delphi study of thematic/ coding analysis (as discussed in section 4.5.5.3.3) is utilised to generate descriptive information as well as to identify patterns in the responses given by the participants during the workshop.

4.6 Conclusion

The aim of this chapter was to discuss and justify the main conceptual and methodological design approaches that are critical for accomplishing this study's aim and objectives. Section 4.2 demonstrated an overview of the research methodology, which directs the logical implementation of this research. Accordingly, inductive research approach is deemed to be suitable for the study in which the qualitative research strategy is selected for the purpose of identifying and understanding the factors influencing the behaviour of Jordanian contractors towards CWM, as well as to validate such factors in the Jordan context. The next chapter will explain the implementation process, data gathering and analysis of the primary investigative method, Delphi technique, for the development of the BF.

Chapter 5

Results of The Delphi Study

5.1 Chapter overview

Following the research methodology discussed in Chapter 4, this chapter presents the process of the Delphi study formulation and a discussion of the results. It begins with a description of the background of the Delphi study which includes the study schedule and selection process of the expert's panel pertaining to this study. Following this, the analysis and findings from two rounds of the Delphi study is presented. Finally, the conclusions and a summary are provided which will feed into the development of the BF.

5.2 Delphi study process and schedule

Conducting high-quality Delphi interviews requires the designing of an interview schedule involving the selection of a qualified panel of interviewees (i.e., panel of experts); developing relevant questions to meet the research aim and objectives; testing them to make sure they can be used to measure the intended purpose; and converting them into an easy format so respondents can understand them and participate effectively (Boyce & Neale, 2006).

The application of the Delphi technique in this study consisted of two rounds of questions which were administered from March, 2019 to June, 2019. Face-to-face semi-structured interviews were conducted with twelve experts in Round 1 and ten experts in Round 2 (two experts did not attend in Round 2). The interview schedule was first translated from English into the Arabic language by the researcher and was then reviewed by the pilot experts for clarity (discussed in section 5.2.2). The reason for this was to support the experts' convenience and full understanding of the content as Arabic is their first language. The interview sessions in both rounds lasted between 45 and 60 minutes. The first-round sessions began with the researcher introducing himself to the interviewee, stating his position, the research aim, objectives and the ethics of the research as well as the provisions made for protecting the interviewee's privacy. This informal beginning gave the interviewee confidence and built-up trust in order to ensure that the interviewee felt able to freely and fully answer the interview questions. During this time, the researcher recorded the interviewees' responses by taking hand-written notes supplemented with a tape-recording, with the interviewees' consent, which would be transcribed afterwards to ensure no findings were missed in the analysis. Further, the researcher explained any question where necessary in order to ensure adequate responses from the interviewees without any prompting and/ or misunderstanding. The following subsections present the selection process of the expert's panel and the design of the questions in both rounds of the Delphi study.

5.2.1 The selection process of the experts' panel

Prior to the interviews, the researcher contacted ten of the leading construction companies in Jordan (in terms of revenue) as per a list provided by the Jordanian Construction Contractor Association (JCCA) in 2019. Each company was asked to nominate a list of their employees working on construction sites whom they believed met the inclusion criteria above. However, it was optional for the company to engage and provide a list of employees; if there was no response, another company would be contacted from the list. Subsequently, the researcher randomly chose five potential participants from the list of various disciplines (i.e., lead manager, project manager, site manager, foremen and labourer) in each of the ten companies. This was to ensure a comprehensive list of participants with a diversity of experience, knowledge and perceptions, as each discipline of employees usually had different roles and responsibilities, which in turn, would ensure optimum quality of the information provided.

A total of 50 potential participants were contacted as the sample population and invited to take part in this Delphi study (see Table 5.2). A letter of invitation was sent out containing an information sheet explaining the purpose and process of this study as well as a consent form and a short questionnaire which included a list of questions to ensure if the potential participants met the aforementioned inclusion criteria (see Appendix 1). A total of 28 participants responded and agreed to participate, equating to a 56% response rate. However, based on the responses received from the short questionnaire, only 12 experts were considered as the correct sample who had completely satisfied the aforementioned inclusion criteria to participate in this Delphi study. During the second round of administering the Delphi study, one project manager and one labourer practitioner expert did not partake, which made a total of ten expert participants. Table 5.1 demonstrates the profiles of the 12 experts who participated in this Delphi study. However, due to issues of confidentiality and anonymity, the experts are not named in this study and are instead given codes (e.g., E1, E2, etc.) to aid identification.

Table 5.1: Profiles of the 12 participating experts in the Delphi study

Name	Education level	Experts discipline group	Position held		Experience (years)
			Round 1 response	Round 2 response	
E1	MSc in Civil engineering	Lead manager	✓	✓	32
E2	BSc in Civil engineering	Project manger	✓	✓	25
E3	MSc in Material engineering	Project manger	✓	×	15
E4	BSc in Architect	Project manger	✓	✓	10
E5	BSc in Civil engineering	Site manager	✓	✓	7
E6	BSc in Structural engineering	Site manager	✓	✓	9
E7	BSc in Quantity surveying	Foremen/supervisor	✓	✓	7
E8	BSc in Quantity surveying	Foremen/supervisor	✓	✓	8
E9	High school	Labourer	✓	✓	12
E10	Industrial Diploma	Labourer	✓	✓	10
E11	Technician Diploma	Labourer	✓	✓	10
E12	High school	Labourer	✓	×	5

Table 5.2: Number of experts participating in each round of the Delphi study

Expert group	Number of invitations	Number of experts in Round 1	Number of experts in Round 2
Lead manager	10	1	1
Project manager	10	3	2
Site manager	10	2	2
Foremen/supervisor	10	2	2
Labourer	10	4	3
Total	50	12	10

5.2.2 Round 1 and 2 questions and analysis

The aim of the first round of the Delphi study is to gather and elicit the opinions of the experts' panel on the factors influencing the behaviour of contractors towards CWM in Jordan. As previously discussed in the methodology chapter in section 4.5.5.3.3, a combination of 11 open-ended questions were formulated and designed to collect the required data based on the list of factors in section 3.4 (see Appendix 2). The first question sought to gain background information about the need for CWM from the perspective of Jordanian contractors, and the remaining ten questions were directly related to the key research investigation. Following the design of the first-round questions, a pilot study was conducted to enhance the validity and reliability of these questions and to make necessary amendments prior to an actual interview, as mentioned in section 4.5.5.3.3.

The data is analysed based on the Template Analysis method as discussed in section 4.5.5.3.3. A number of codes were identified based on their frequency of occurrence in the first-round responses, which were then categorised under main themes. For instance, the responses of the experts in Round 1 were categorised into four main variables (themes), namely: personal, technological, social and organisational. Within each of these variables a number of factors (i.e., codes) were identified, and corresponding subfactors; for example, in the technological variable (theme), two factors (codes) of system ease of use and system compatibility were identified, and within each of these factors there were a number of subfactors.

With regards to second round of the Delphi study, it aims to verify the factors, acquired from the first round, influencing the behaviour of Jordanian contractors towards CWM. According to the section 4.5.5.3.4 in the methodology chapter, the second-round questions are constructed from the results acquired from the first-round responses (see Appendix 3). Accordingly, all the factors that were identified through the discussions of the experts in the first round were then presented to the experts during the second round in rank order, according to the frequency of occurrence (indicating their importance), for reconsideration and validation until consensus is reached. Notably, the minimum percentage that is considered a consensus in this study, as discussed in section 4.5.5.3.1, is 70% of the number of experts in the second round. The results of the second-round will then be used to develop the proposed BF. It should be noted that only two rounds of the study were deemed necessary for the experts' panel to reach a consensus, as discussed in section 5.4.

5.3 Discussion of results from Delphi Round 1 and 2

Findings from the interview data, interestingly, did not appear to contradict the factors within the literature (see section 3.4.1), since all of them were confirmed by the experts' panel. However, there were distinct variations in the level of influence of these factors on the behaviour of Jordanian contractors towards CWM. Additionally, some distinct variations between the perceptions of the experts from different levels of the hierarchy emerged, in particular, between managerial level employees who were mainly involved in the planning and supervision of projects, and the employees who were essentially on the front line and responsible for the implementation of work on construction sites. This section illustrates the analysis and discussion of the two rounds of this Delphi study. It begins by discussing the responses of the experts' panel regarding the need for CWM in Jordan. Following that, it discusses the analysis of the experts' responses with regards to the four main variables (personal, technological, social, and organisational) influencing CWM behaviour of contractors.

5.3.1 The need for construction waste minimisation in Jordan

The opinions of the experts' panel emphasised the need for CWM in the Jordanian construction industry, and highlighted the significant benefits that would be achieved from adopting CWM. Five benefits were identified in the first round, with which all reached full consensus during the second round. Table 5.3 presents these benefits.

Table 5.3: Delphi-study results - the benefits of CWM

CWM advantages	Round 1 (frequency of occurrence)	Round 2 (consensus)
Reducing construction cost	9 experts	100%
Increasing the productivity of the construction process	6 experts	100%
Improving safety at construction site	6 experts	100%
Reducing the environmental pollution	3 experts	100%
Reducing the depletion of the limited natural resources	2 experts	100%

The panel of experts had four clear threads of argument: all experts from management level to labourers indicated that CWM would be very important to the Jordanian construction industry in order to achieve more SC and enhance the performance of the environment. The findings substantiate the literature (see section 2.4.2) regarding the benefits that could be achieved from CWM for the construction industry as well as the local community.

Increasing financial gains was identified as one of the key drivers for CWM based on the frequency of responses from the experts in both rounds. Nine experts (E1, E2, E3, E5, E6, E8, E9, E10 & E12) indicated that source reduction of CW is a direct benefit to the project managers, as waste costs are directly related to profit margins and so any cost saving directly increases profit. They elaborated that a more efficient use of construction materials means reduced purchasing costs and also time and resources used in managing and handling waste contribute additional costs to the construction project. Project manager E3 commented:

"*avoiding waste generation can save a lot of money for clients and contractors. This is because, in addition to the cost of the purchased materials which ends up as waste, there are the expenses of storage, transport, and disposal which will all add extra cost to the project budget and reduce profit*". Expert 4 supported this stance and added that the cost of CW is a very important issue when considering the tender stage. This issue reached full consensus during the second round as there was strong agreement about the importance of such an issue in the Jordanian construction industry. Furthermore, the significance of reducing construction costs was also confirmed from all the experts in section 5.3.2.3 as a strong motivational issue for contractors towards CWM.

Likewise, project performance is strongly linked to the performance of CWM as revealed by the opinion of six experts (E1, E2, E4, E6, E7 & E11). They indicated that avoiding waste generation in construction projects will increase work productivity and efficiency through saving time and costs associated with waste. Additionally, effective on-site sorting, collecting and reuse of generated waste can reduce further costs for managers and enhance the performance of work on construction sites by ensuring a safer and tidier workplace. Expert E6 stated: "*...construction waste is one of the main causes of project delays. It's a barrier which holds back the progress of the project*". Experts E7 and E10 focused on the generation of CW as one of the major issues that impacts quality of construction projects during the finishing stage. During the second round, all experts expressed full agreement with the benefits of such issue. This was also reflected in section 5.3.2.3, as both project managers and site managers emphasised the strong link between financial benefits and enhanced project performance.

With regard to safety, experts E4, E5, E7, E8, E10 & E11 expressed great concern about the danger of waste on the wellbeing of workers on construction sites. They indicated that the hazard of sharp and heavy materials in construction debris can result in injuries and accidents which are common problems in construction sites in Jordan. Experts E5 and E8 added that CW usually contains hazardous materials and harmful substances and, therefore, the exposure to such waste is very dangerous for the on-site workers. Supervisor E8 stated: *"construction waste contains a lot of harmful things such as nails, glass, small parts of steel, asbestos, and many other things, and from my experience, I have seen at least one or two accidents happen in each site I have entered, I think it's a problem that needs more reconsideration".* During the second round, all experts agreed with the importance of CWM with regards to such issue, as labourer E9 suggested that minimising CW can largely avoid on-site accidents and obstructions.

Environmental sustainability targets such as reducing pollution and the depletion of the limited natural resources were also an area of concern from the panel of experts. Although both advantages did not gain much attention during the first round, all experts in the second round agreed that there is a need for the adoption of effective CWM measures in order to gain such benefits. According to experts E3, E5 and E6, reducing environmental pollution by minimising CW is a very important issue, especially as CW reuse and recycling techniques are rarely adopted by the Jordanian construction industry; the most adopted methods of handling CW is through harmful measures for the environment such as burning and illegal dumping. Site manager E6 stated: "*our construction industry is lagging behind other countries in terms of using effective waste minimisation techniques especially recycling, while major portions of discarded waste are being burned resulting in serious air pollution and therefore, need more focus and consideration*".

Moreover, experts E3 and E5, emphasised the need for CWM since construction activities consume a large amount of raw materials and energy, especially that Jordan is a poor country in natural resources. Expert E5 said: "…*Jordan has limited natural resources, for that reason we have to utilise construction materials properly*". However, it is clear from the range of responses in the first round those expectations, particularly from foremen and labourers, about what CWM initiatives could offer to enhance the environment was found to be very little. A possible explanation for this is that employees who have a lower educational attainment seemed to be less informed of the environmental benefits of CWM as, according to site manager E6, there is a lack of knowledge and awareness of the significance of such problems especially among labourers.

5.3.2 Personal variable

Personal variable incorporates factors which refer to the belief in an individual's capabilities to perform or not to perform a particular behaviour. Self-efficacy beliefs function as an important set of proximal determinants of human motivation, affect and action; self-efficacy operates on action through motivational, cognitive and affective intervening processes (Bandura, 1989; Davies et al., 2002). According to the following subsections, a number of key personal factors affect the behaviour of contractors in Jordan towards CWM.

5.3.2.1 Construction-related knowledge factor

The opinions of the experts' panel emphasised the importance of knowledge, skills and experience of construction in order to improve the attitudes and perceptions of contractors towards the adoption of CWM behaviour. Based on the discussions of the first round, five subfactors were identified which all reached consensus during the second round. Table 5.4 presents these subfactors in rank order according to their degree of consensus.

Table 5.4: Delphi-study results - construction-related knowledge subfactors affecting CWM behaviour

Issues affecting CWM behaviour	Round 1 (frequency of occurrence)	Round 2 (consensus)
Awareness of the causes and types of CW	7 experts	100%
Knowledge and awareness of LWTs	6 experts	100%
Skills and expertise in the handling of construction errors	3 experts	100%
Awareness of the financial gains of CWM	4 experts	90%
Awareness of the negative environmental impacts of CW	2 experts	70%

The opinion of experts accentuates the importance of construction-related knowledge with regards to CWM. Awareness of the causes and types of CW gained the highest frequency of response in the first round (7 experts). Experts E1, E2, E3, E8, E10, E11 and E12 revealed that adequate knowledge and experience of labourers and supervisors regarding the proper and effective implementation of work will raise their level of understanding of the different types and causes of CW; this can help them complete the job more efficiently with minimal resources and time wasted. For instance, Project manager E2 with 25 years' experience stated: "*some types of construction materials can be only used as once and therefore; such understanding will help workers to maximise the use of these materials*".

Six experts (E1, E2, E4, E6, E7 & E9) were convinced that understanding the importance of LWTs is a critical requirement in reducing CW more efficiently. According to experts E4 and E7, sufficient knowledge of the different types of LWTs and their effectiveness in CWM can promote the adoption of these technologies more efficiently in the Jordanian construction sector. Indeed, expert E6 stated, "*many contractors have poor knowledge of the significant importance of building technologies and the huge amount of waste that can be minimised by adopting these technologies in construction projects*". Lead manager E1 explained that the construction industry is a naturally low-skilled labour-based industry and, therefore, construction projects are less likely to use advanced technologies. However, senior project manager E2 took another perspective suggesting that the skills and experience of site managers, supervisors and labourers in utilising technologies in construction will make project managers tend to adopt them instead of using familiar conventional methods. During the second round, all experts showed full agreement regarding the awareness of the importance of LWTs in CWM. Expert E5 confirmed that LWTs facilitate quicker construction, produce better quality work, decrease waste and, thus, awareness of such advantages will encourage their adoption.

Capability in dealing with design changes and handling errors during the construction process was another issue identified by those that had the longest experience within the construction industry (E1, E2 & E3). This was considered, according to project manager E3, to be one of the key requirements for on-site management in order to control the level of CW production. Project manager E2 indicated that errors and design changes in construction are inevitable and can adversely affect work performance resulting in waste generation, particularly when they are mishandled by site supervisors and managers who should be competent in dealing with such circumstances. According to expert E2, "…*errors and frequent design changes occurs in construction sites all the time resulting in rework and producing waste. Thus, on-site management should have good experience of resolving such situations in the best way possible*". During the second round, supervisor E7 emphasised the need for addressing errors correctly as they arise due to the continuous consequences that they can lead to in other aspects of the project, eventually causing increased CW production.

On the other hand, experts E4, E5, E7 and E10 focused on understanding the positive impacts of CWM instead of the technical aspects of construction. They believed that there was a lack of awareness and understanding among some managers regarding the financial gains that could be achieved through CWM. According to expert E5, increasing awareness of financial incentives (cost saving) is very influential in motivating clients and managers to take appropriate action to minimise CW. As experts E7 and E110 explained, some managers perceive that CWM is not cost effective and takes more time to undertake. Expert E7 said: "*...and that why I think that there should be some kind of educational courses specially for managers, because many of them have this idea that reducing construction waste will take a lot of time and not worth the effort*". During the second round, project manager E2 confirmed that some project managers do not invest in CWM in order to save time and money as they may not perceive the financial gains in the long term of the construction project.

With regard to environmental sustainability, site managers E5 and E6 focused on understanding the positive impacts of CWM on the environment. They highlighted the fact that awareness, in the longer term, of the implications of CW in terms of the environmental impacts will help clients and contractors make suitable decisions and actions to minimise CW when performing their work. Site manager E5 stated: "*knowing the environmental benefits that could result from construction waste minimisation, will help clients, managers and labourers to act and follow appropriate procedures to minimise waste*". Further, site manager E6 emphasised the importance of increasing the environmental awareness of employees, particularly labourers, in relation to CWM. This is because the nature of the work with such employees does not require high educational attainment and, therefore, they might be less informed of the environmental benefits of CWM. According to site manager E6 during the second round, "…*basic knowledge might exist among many labourers about the obvious advantages of construction waste minimisation for the environment, however, I think the problem is that there not fully aware of the level of the environmental impacts, construction waste can cause*". Although, this issue gained the lowest frequency of responses (2 experts) in the first round, it succeeded in achieving consensus during the second round (80%) except for two experts (E4 & E9) who noted that awareness of the positive influence of CWM on the environment can be important but does not necessarily guarantee CWM. As labourer E9 said: "…*there are limitations to such knowledge alone in minimising construction waste*".

5.3.2.2 Personal norms factor

The experts' panel elaborated on how the moral norms of employees reflect their attitudes towards the adoption of CWM behaviour. Based on the discussions of the first round, two subfactors were identified which all reached consensus during the second round. Table 5.5 presents these subfactors in rank order according to their degree of consensus.

Table 5.5: Delphi-study results - personal norms subfactors affecting CWM behaviour

Issues affecting CWM behaviour	Round 1 (frequency of occurrence)	Round 2 (consensus)
Courtesy between the different levels of employees	9 experts	100%
Religious obligations	4 experts	70%

Amongst the experts there was little question that an employee with strong moral principles and obligations would influence their likelihood to act towards CWM. It is clear from the range of responses in the first round (9 experts) that the predominant focus of the experts' panel was on the employee's morals and ethics in terms of politeness and respect for other employees. This was argued by experts E2, E5, E6, E7, E8, E9, E10, E11 and E12 who believed that courtesy in the workplace, which rests on a shared moral norm of professional integrity, contributes to a positive work atmosphere and, therefore, there is increased productivity. Labourers E9 and E12 emphasised this, as they focused particularly on the importance of courtesy between the different levels of employees, and between managers and their staff. The reason for this, as they noted, was that a poor working atmosphere resulting from the disrespectful treatment of employees can lead to resentment and careless behaviour, and therefore, poor job performance and diminished productivity. Labourer E9 stated: "*…is important, especially if you are a manager, to have a strong relationship with your employees. By building your relationship with your staff you encourage them to be more loyal to the organisation*". However, during the second round, lead manager E1 noted that courtesy in professional relationships can be considered an indirect influence on CWM and is therefore not guaranteed to greatly impact the level of CW but, nonetheless, still requires consideration.

Religious beliefs were also an apparent issue, seeming to receive a degree of focus from four experts (E1, E3, E4 & E11) who argued that CWM can be influenced by moral norms in the form of religious obligations. They indicated that religious beliefs can provide moral guidance and rules which influence one's self-concept regarding the implementation of their job and the consequences of their actions. Project manager E4 noted, "*some employees actions are sometimes derived from their religious beliefs, and they feel obligated in performing their job in the best way possible with minimum negative consequences, which in this case construction waste generation*". Nonetheless, there was a conditional agreement between the experts during the second round (70% consensus) that religious obligation depends on the degree of knowledge an employee holds. For example, according to expert E6, an employee may be inclined to engage in CWM behaviour as a result of their religious obligation but unintentionally harm CWM efforts out of ignorance.

5.3.2.3 Perceived usefulness factor

The opinions of the experts' panel pointed out how positive outcomes from CWM can motivate employees towards adopting CWM behaviour. Based on the discussions of the first round, five subfactors were identified which all reached consensus during the second round. Table 5.6 presents these subfactors according to their degree of consensus.

Table 5.6: Delphi-study results - perceived usefulness subfactors affecting CWM behaviour

Issues affecting CWM behaviour	Round 1 (frequency of occurrence)	Round 2 (consensus)
Cost reduction incentives	11 experts	100%
Enhanced work performance incentives	7 experts	100%
Health and safety incentives	6 experts	100%
Rewards incentives	5 experts	100%
Environmental benefits incentives	2 experts	70%

Whilst the panel of experts had no doubts about the value of CWM in terms of its resulting benefits, the main focus of this discussion was over the matter of which benefits act as the strongest incentives. Project manager E2 stated, "*the perceived likely positive consequences from conducting construction waste minimisation can influence the contractor's willingness and interest towards minimising waste*". Cost reduction incentives were consistently found to be the strongest motivational issue based on the range of responses in the first round (10 experts). According to eleven experts (E1, E2, E3, E4, E5, E6, E7, E8, E9, E10 & E12), reducing project costs through minimising CW can significantly motivate clients and managers towards taking effective measures and procedures that will ensure CWM. Expert E5 stated "*…clients and contractors are generally more interested in saving money when it comes to construction waste minimisation*". Moreover, during the second round, experts that are involved in the tender pricing process (E1 & E4) added that reducing the project cost by adopting effective CWM measures will increase the opportunities for managers in gaining more future project tenders. Lead manager E1 stated: "*…construction waste minimisation will also increase their chances when bidding for future tenders*".

Another motivational issue identified through this interview (E1, E2, E4, E6, E7, E8 & E11) was the enhancement of work performance. Experts E2 and E6 indicated that CWM can enhance the quality of work and increase the productivity and efficiency of the construction process through saving time and costs dealing with waste. This issue was emphasised by project manager E2 since increasing the productivity of the work through CWM will ultimately lead to increasing the profit of the project. Another point was made by supervisors E7 and E8 who indicated that the workflow on construction sites can be improved by avoiding obstacles occurring during the construction process such as CW. Therefore, CWM helps make the work of on-site workers much easier, which in turn will increase their motivation toward avoiding waste generation. Foremen E8 said: "*the prevention of waste can provide more space for storing goods and equipment and make moving materials around the site quicker and easier. It also makes the site cleaner, more organised, and more pleasant to work in*". During the second round this issue succeeded in achieving full consensus as a strong incentive toward CWM. This was especially true for those who are responsible for managing and supervising on-site operations such as site managers and foremen as, according to site manager E5, improving the workflow will make their job a lot easier.

Health and safety were also confirmed as a strong motivational issue especially for on-site workers. Experts E4, E5, E7, E8, E10 and E11 highlighted the fact that injuries are common problems that occur on construction sites in Jordan. Therefore, through minimising CW and better management of construction sites, obstructions and accidents can be largely avoided. Indeed, as commented by site manager E5 and E6, CW usually contains dangerous and hazardous materials which are a serious threat to on-site workers. Project manager E4 noted that a responsible employee who is enlightened about the physical harm which CW may cause, will be incentivised towards CWM for their own wellbeing as well as others. He stated: "…*I think if they care about such problem and are aware of the potential danger, they will be very much motivated to reduce waste*".

Reward incentives were also an apparent issue receiving a degree of focus from five experts (E2, E4, E6, E9 & E10). They argued that rewards which can be gained through involvement in CWM can help raise the motivation of managers, supervisors and labourers in adopting CWM behaviour. Expert E6 said, "*benefits such as bonuses and promotions offered for being proactive in minimising construction waste can be very helpful in encouraging them to perform the job well enough to reach waste minimisation targets*". Moreover, project manager E2 indicated that rewards for 'green' construction projects, achieved by implementing sustainable green construction practices, can incentivise project managers to engage in such practices. During the second round, the arguments of experts E5 and E7 took the perspective that the benefits of CWM can also push employees into taking the initiative and being creative to ensure that the job is done properly with minimum wasted materials. Site manager E5 added, "…*they may start to suggest new ideas, look for better solutions and generally work harder to get these benefits*".

According to two experts (E5 & E6), environmental sustainability can also act as an incentive for contractors to perform CWM behaviour. They revealed that internal desire which arises from the consideration of the environmental problems such as air pollution and the depletion of raw materials, can encourage waste minimisation in construction projects. One example of such an understanding came from expert E5, who stated: "…*we must minimise construction waste, to avoid its negativity, maintain a clean and healthy environment, and try our best to make our cities look more beautiful*". It is clear that this issue did not achieve full consensus (70%) during the second round, although all experts in the first question (see section 5.3.1) cited environmental concerns as an important issue regarding the necessity of CWM. This indicates that although some employees may recognise the importance of the environmental benefits in general, nonetheless, they do not lend it the same consideration as other advantages of CWM which apply to them personally.

5.3.2.4 Additional factors

The opinions of the experts' panel highlighted additional personal factors affecting the behaviour of contractors towards CWM. Based on the discussions of the first round, three factors were identified, two of which reached consensus in the second round while the third factor failed to reach the minimum required percentage of consensus. Table 5.7 presents these factors according to their degree of consensus.

Table 5.7: Delphi study results - additional personal factors affecting CWM behaviour

Issues affecting CWM behaviour	Round 1 (frequency of occurrence)	Round 2 (consensus)
Perceived increased workloads	6 experts	100%
Belief that waste is inevitable	6 experts	90%
Manager's encouragement	3 experts	50%

The panel of experts identified one or two additional important issues that require further consideration in the Jordanian construction sector. The perception of the increased workload and that waste is inevitable are important issue identified through this question since the majority of the opinions in both rounds seemed to constantly refer back to those two issues. According to six experts (E1, E4, E5, E7, E8 & E10), the perception of increased workload has a major influence on labourers' engagement in CWM which can result in large amounts of wasted materials. The general direction of their arguments indicated that some labourers might have little intention of minimising CW as they believe conducting CWM measures require more time and effort and, therefore, will increase the amount of work. Site manager E5 stated that "*sometimes labourers neglect the aspect of construction waste as they don't want to spend extra time or conduct extra activities to minimise waste*".

Moreover, six experts (E2, E3, E5, E6, E9 & E10) indicated that the belief that waste is inevitable in construction projects can have a huge negative impact on CWM. They indicated that there is a widespread perception among some site supervisors and labourers that waste minimisation efforts will never be sufficient to completely eliminate waste in construction activities. This can result in careless acts (not necessarily intentional) from such employees when performing their work which can significantly affect CWM. Expert E3 stated that "*...many of the workers have the wrong idea that waste can still be generated, no matter how accurate the construction process is*". During the second round there was strong agreement from the rest of the experts that such issue can have a huge impact on the amount of waste materials. In fact, according to project manager E2, the introduction of courses intended to raise the awareness of on-site workers regarding CWM has been proposed by a number of firms in the Jordanian construction industry.

Manager encouragement is the third issue which was identified from the comments of three panel experts (E8, E11 & E12). They believed that recognising good performance (e.g., CWM) and providing positive feedback can help foster a sense of responsibility in employees toward maintaining a high quality of work. Labourer E12 stated: "*to make sure contractors get the best performance from workers, including minimising waste, it's always better to show appreciation of their good work. This will make workers more interested in performing their job in a way that will please the managers*". However, during the second round, this issue failed to reach the minimum required percentage of consensus (50%), as there was weak agreement from the rest of the experts that such an issue could be considered as having a direct influence on CWM.

5.3.3 Technological variable

Technological variable incorporates factors which refer to the nature and characteristics of technologies which are associated with the level of acceptance and usage of these technologies from potential adopters (Davis, 1993). In a similar way, the implementation attributes of a technology (e.g., ease of use, compatibility) function as an important set of determinants for its adoption. According to the following subsections, a number of key technological factors encourage/ inhibit the willingness of contractors in Jordan towards the acceptance of LWTs.

5.3.3.1 System ease of use factor

The experts' panel elaborated on how system ease of use can encourage the adoption of LWTs in Jordanian construction projects. Based on the discussions of the first round, two subfactors were identified which all reached a consensus during the second round. Table 5.8 presents these subfactors according to their degree of consensus.

Table 5.8: Delphi study results - system ease of use subfactors affecting LWTs' adoption

Issues affecting LWTs' adoption	Round 1 (frequency of occurrence)	Round 2 (consensus)
System complexity and learning difficulties	10 experts	100%
Technical support from vendor	5 experts	100%

When exploring the perceptions of the expert panel in this regard, all experts, without exception, were in strong agreement with the influence of "ease of use" on the successful adoption of LWTs in construction projects. According to ten experts (E1, E2, E4, E5, E6, E8, E9, E10, E11 & E12), the perceived complexity of some LWTs (equipment and/or system) is a strong inhibitor of contractors' willingness towards the utilisation of such technologies in construction projects. Decision makers, managers E1 and E2, have noted that the perceived complexity of the operational process of certain technological methods of construction can result in an organisation implementing traditional methods as the former may require more time and effort to utilise. Lead manager E1 stated that "*when construction companies make a decision about whether or not they want to use a new technology, they will look at how complicated the methods are … traditional methods may be easier and cheaper to use*".

A further point was made by experts E5, E6, E8 and E10 who noted that sometimes contractors face difficulties in understanding and learning how to use certain LWTs. For example, they revealed that the complexity of certain construction information systems, such as BIM, requires high professionality and expertise to use. This presents a challenge to contractors in understanding and managing such technologies and may discourage their adoption. Expert E6 said: "*…I think it can take time and effort to learn how to use new methods and criteria, and it is common to make many mistakes at any point of implementing such complicated technology throughout design and construction processes*". During the second round all experts confirmed the importance of the "ease of use" issue in the acceptance of LWTs. Project manager E4 supported this point, arguing that one of the main challenges of using certain LWT is successfully integrating their outcome with other components of the project. Failure to do so can result in errors and therefore CW generation.

Moreover, five experts (E1, E2, E3, E6 & E7) revealed that as some LWTs can be complex to implement and/or operate, technical support may be required from the vendor. For instance, guidelines and directions may be required when utilising certain technologies, as expert E7 stated: "*…lack of such technical support may discourage those that are involved in decision making from adopting the technology, as the availability of technical assistance may restrict usage*". Indeed, site manager E6 noted that malfunctions which can occur during operation can also require technical support for sourcing replacements and conducting repairs. This issue was strongly supported during the second round (full consensus), as lead manager E1 added that in the construction industry, its important how vendors and customers (i.e., clients and contractors) interact and follow a pathway after their decision to adopt a technology.

5.3.3.2 System compatibility factor

The opinions of the experts' panel explained how system compatibility can govern the adoption of LWTs in construction projects. Based on the discussions in the first round, two subfactors were identified with both reaching consensus during the second round. Table 5.9 presents these subfactors according to their degree of consensus.

Table 5.9: Delphi study results - system compatibility subfactors affecting LWT's adoption

Issues affecting LWT's adoption	Round 1 (frequency of occurrence)	Round 2 (consensus)
Compatibility with the existing construction practices	9 experts	100%
Compatibility with the project nature	6 experts	100%

It is clear from the range of responses depicted in Table 5.9 that the compatibility of LWTs has a large impact on the project managers' intentions towards the adoption of such technologies. Nine experts (E1, E2, E3, E5, E6, E7, E8, E9 & E12) stated that integrating some types of LWTs with existing construction practices can prove challenging. They indicated that difficulties arise when the adoption of traditional construction methods is practiced by contractors (particularly small and medium-sized contractors), since many of these methods are dated, depended on simple resources and were consequently incompatible with advanced and complex technologies. Lead manager E1 said: "*I believe that many companies still use the old* *common practices because of their familiarity and simplicity, and they aren't compatible with more advanced technologies*". Furthermore, experts E1, E2, E3 and E6, who seemed to be more knowledgeable about various types of LWTs, did express great concern about the current status of the Jordanian construction industry's readiness for the adoption of many types of LWTs. Indeed, project manager E2 commented that the construction industry in Jordan is lagging behind other countries in the region in terms of the adoption of contemporary technologies. This can result in limited options for contractors due to the dependency of some LWTs on others. In the second round the issue reached full consensus.

Furthermore, the type, size and budget of a construction project are not always compatible with certain LWTs. This is the view of six experts (E2, E3, E4, E9, E10 & E11), who said that a project's nature may not fit with a particular technology, making it difficult to implement. As expert E2 explained, projects that are very simple or have limited budgets do not necessarily need complex or advanced LWTs. Expert E4 stated that "…*just because a technology is efficient, doesn't mean it is the best one for the job… there adoption would not be so much practical*". During the second round, all experts emphasised this issue. However, expert E1 suggested that this can work in both directions: large-scale projects may be too complex or expensive to justify the use of certain LWTs.

5.3.4 Social variable

Social variable incorporates factors which refer to the individual's perceived social pressure to perform or not to perform a particular behaviour. It reflects an individual's sense of social pressure to behave in a certain way (Ajzen, 1991). According to the following subsections, a number of key social factors influence the behaviour of contractors in Jordan towards CWM.

5.3.4.1 Descriptive norms factor

The opinions of the experts' panel revealed how the behaviour of work colleagues, managers and the surrounding society can influence an individual in their engagement with CWM. Based on the discussions of the first round, four subfactors were identified with three reaching consensuses during the second round, while the fourth subfactor failed to reach the minimum required percentage of consensus. Table 5.10 presents these subfactors according to their degree of consensus.

Table 5.10: Delphi study results - descriptive norms subfactors affecting CWM behaviour

Issues affecting CWM behaviour	Round 1 (frequency of occurrence)	Round 2 (consensus)
The practices of peer-practitioners	8 experts	100%
Interest of managers in CWM	5 experts	100%
Wasteful culture	4 experts	70%
Influence of difficult employees	2 experts	30%

The panel of experts generally believed that the performance of co-workers can influence an individual (either consciously or unconsciously) in following their trend. The practices of peer-practitioners were identified to be one of the most influential issues based on the frequency of responses in both rounds (Table 5.10). According to eight experts (E2, E4, E5, E6, E7, E8, E10 & E11), a high skills level, professionality and perfectionism of colleagues, can incentivise the employee, particularly labourers, to examine their performance and try to behave like their colleagues. Site managers E5 and E6 indicated that labourers can increase productivity and high standards of work (e.g., CWM) through peer pressure when surrounded by hard-working and high-achieving colleagues. Site manager E6 stated that "…*labourers will tend to perform their job better because they feel pressure to measure up to their colleagues in order to be seen to be as competent, and achieve the same levels of productivity they observe with hard work*".

Conversely, the opposite is also true, as experts E5, E6 and E7 revealed that in an unproductive work environment, work performance will decrease ultimately affecting CWM. Foremen E7 noted that "*poor work and performance can be contagious and create some kind of careless behaviour among labourers in the sense that workers often copy the actions and attitudes of their workplace peers*". A possible reason for this according to experts E4, E6, E7, E8 and E10 was lack of interest and support from managers and supervisors in CWM, which can weaken the motivation of labourers and make them less likely to adopt waste minimisation behaviour. Expert E4 said: "*the labourers will have poor interest in construction waste minimisation when they perceive that the managers are not concerned about it*". During the second round, the remaining experts showed full agreement regarding the influence of the work environment on the individual's behaviour towards CWM.

Moreover, four experts (E1, E3, E4 & E6) argued that CWM behaviour can sometimes be affected by a wasteful culture. They explained that a 'throw-away society', strongly influenced by consumerism and materialism, encourages wasteful habits in people, including those in the construction industry. Expert E1 revealed that the practice of continuously purchasing goods in the belief that ‘the newer, the better’ is commonplace and affects attitudes towards being wasteful. Confirming this, Expert E3 said: “*in my opinion many contractors are ignorant about the issues of waste. As they tend to dispose of consumables without considering whether they really have to, in favour of using new product*”. During the second round this issue did not reach full consensus (70%), however, the rest of the expert panel agreed with the importance of such issue on CW generation.

Finally, experts E9 and E12 stated that some employees hold poor attitudes towards their work and/or organisation typically being consistently negative, repeatedly complaining, undermining the company and challenging authority. This attitude can spread among colleagues, even amongst normally happy, satisfied employees which in turn affects their performance of work and, thus, CWM. Expert E12 stated that “*negative employees can make normally hard workers less positive and happy with their work, and then also spread bad attitudes around the workplace*”. However, during the second round, this issue failed to reach the minimum required percentage of consensus (30%), as there was disagreement from the rest of the experts that such an issue is important and/or can directly impact CWM.

5.3.4.2 Injunctive norms factor

The opinions of the experts’ panel emphasised the importance of policies and regulations in order to pressure contractors towards adopting CWM. Based on the discussions of the first round, three subfactors were identified which all reached consensus during the second round. Table 5.11 presents these factors according to their degree of consensus.

Table 5.11: Delphi study results - injunctive norms subfactors affecting CWM behaviour

Issues affecting CWM behaviour	Round 1 (frequency of occurrence)	Round 2 (consensus)
Financial charges and penalties	9 experts	100%
Governmental supervision	5 experts	100%
Green construction practices	3 experts	80%

According to the experts’ panel, the success of CWM depends heavily on policies and legislation as they perceived the importance of forcing waste minimisation behaviour in construction projects. Seven experts (E3, E4, E6, E7, E9, E10 & E11) revealed that disposal charges for dumping CW can promote financial incentives for project managers toward taking effective measures to minimise CW. Project manager E3 stated: "*disposal fees, especially if its high, will make managers think again before dumping the construction waste*". Supporting this argument, it was said that low or the absence of disposal charges can decrease the likelihood of contractors reusing excavated soil which is considered one of the highest percentages of dumped materials. Site manager E6, who had extensive experience in construction sites, said: "*the large amounts of excavated soils from construction sites can be reused in many ways such as back-fill material. Instead, contractors take the easy approach and dump it*". Another point was made by experts E2, E4 and E8 that fines and penalties for illegal dumping are very important in limiting such practices, especially given that it is a common problem in the construction industry in Jordan. Expert E2 said that "…*because some contractors will not even bother and they want to take the easy way for getting rid of their waste*". It can be noted that financial charges and penalties is an important matter which has attracted the attention of most experts in both rounds. As E5 commented during the second round, such issue should be much more reinforced by the relevant authorities.

Five experts (E4, E5, E6, E8 & E12) revealed that governmental supervision can largely control the disposal of CW. They indicated that inspections and strict supervision on CW handling, transportation and disposal can largely control illegal dumping as well as pressure contractors towards proper methods of treatment such as reuse, recycling and safe disposal (designated landfills). Project manager E4 stated that "*by enforcing strict governmental supervision and monitoring waste in construction projects, the practice of illegal dumping can be more controlled and construction waste disposal can be better managed*". During the second round, the remaining experts showed strong agreement particularly on the aspect of site inspections as according to Site manager E5, "…*establishing strict polices and regulations won't be as much effective unless they are enforced by inspections*".

A further point was made by three project managers (E1, E2 & E3) who strongly supported the idea that green construction, through the application of green practices (e.g., BREEM, LEED, etc.), can make a significant difference to CWM. Experts E2 and E3 indicated that focusing resources and attention on government bodies would put pressure on clients/contractors to engage in these practices. Indeed, the application of environmentally responsible and resource-efficient practices, require considerable attention from the relevant authorities in order to be encouraged, regulated or even enforced, due to their major advantages. Project manager E3 stated: "*the construction industry will struggle to adopt green practices unless there is pressure from the authorities, setting an example*". A further point was made by expert E2 that governmental support through a provision of comprehensive waste management plans and recycling facilities can exert a sense of pressure and increase the obligation of project managers towards CWM. This is because according to project manager E2, *"there is still a lack of effective and informative strategies targeting solid waste in Jordan, and till the moment there still a very limited number of recycling plants which is why the recycling market in Jordan is very poor*". During the second round this issue reached consensus. However, lead manager E1 noted that encouraging green practices depends to some extent on the type and size of the project. This is because such practices may not be perceived as worthy and profitable in apartment buildings, especially as they account for the majority of construction projects in Jordan.

5.3.5 Organisational variable

Organisational variable incorporates factors which refer to the objective issues in the work environment which make an act easy to accomplish (Thompson et al., 2003). According to the following subsections, a number of key organisational factors affects the controllability of employees towards their engagement with CWM in Jordanian construction projects.

5.3.5.1 Project constraints factor

The opinions of the experts' panel elaborated on how can project constraints such as time and money, make it easy/difficult to minimise waste in construction projects. The two subfactors gained full consensus during the second round. Table 5.12 presents these subfactors.

Table 5.12: Delphi study results - project constraints subfactors affecting CWM behaviour.

Issues affecting CWM behaviour	Round 1 (frequency of occurrence)	Round 2 (consensus)
Time constraints	12 experts	100%
Cost constraints	11experts	100%

The panel of experts stated that when more resources are put into construction projects, it will increase the opportunities for employees, particularly site supervisors and labourers, towards achieving CWM. They also indicated that the ability of on-site workers to contribute to waste minimisation in construction activities is dictated largely by the managers' interest and willingness to commit financial resources to such issue. The experts' panel stated that it is difficult for workers to take the issue of CWM seriously in construction sites, especially when they perceived that the managers are more concerned with time and cost savings rather than assigning adequate resources and effort in minimising waste. Site manager E5 stated: "*the pressure from managers toward finishing the job within limited time and budget will make it very difficult for the staff to perform their job good enough which will result in poor work quality*". All twelve experts realised that the attempts of labourers in minimising CW can sometimes be largely constrained by a limited time framework. They revealed that when managers do not invest sufficient time in the construction process, it will result in sub-standard work quality. Additionally, time pressures will decrease the likelihood of labourers doing further important activities to promote more CWM. Supervisor E8, who is extensively involved in on-site operations, stated that "*sometimes managers don't allow enough time during construction activities which forces the workers to rush in their work. This can significantly result in huge amount of wasted materials*".

A further point was also made the experts' panel. They indicated that in construction projects, some managers focus on maximising their profit which makes them neglect implementing effective CWM measures, such as assigning adequate numbers of labourers for waste sorting, collecting and reuse on construction sites and the use of LWTs. Those that are involved in the planning aspect of construction (E2 & E3) said: "...*therefore, enough workers in construction projects and more use of building technologies will make it much easier for them to minimise waste*". It can be noted from Table 5.12 that experts' opinions consistently seemed to refer back to time constraints in relation to the ease of adopting effective CWM behaviour. A possible reason for this is that time pressure prevents site supervisors and labourers from performing high standards of construction work which is one of the main barriers to CWM in Jordan. However, both issues, i.e., time pressure and cost pressure, achieved full consensus during the second round.

5.3.5.2 Facilitating conditions factor

The experts' panel elaborated on how the organisations' provision of requisites resources and opportunities can facilitate waste minimisation in construction projects. Based on the discussions of the first round, five subfactors were identified which all reached consensus during the second round. Table 5.13 presents these subfactors according to their degree of consensus.

Table 5.13: Delphi study results - facilitating conditions subfactors affecting CWM behaviour.

Issues affecting CWM behaviour	Round 1 (frequency of occurrence)	Round 2 (consensus)
On-site planning and management	10 experts	100%
Technical support	8 experts	100%
On-site supervision	4 experts	100%
Training and information support	5 experts	90%
Management change	3 experts	80%

The findings from the interview data, interestingly, confirmed the importance of the issues relating to personal and technological factors since all the issues described here facilitate the adoption of CWM behaviour. There were distinct variations in the experts' perception of the relative importance of organisational support. Nonetheless, during the second round the expert panel emphasised the fact that all the issues in Table 5.13 can strongly influence the feasibility of the work, including, CWM. It became apparent from the majority of the expert panel's opinions in the first round (E1, E2, E3, E4, E5, E6, E8, E9, E10 & E11) that on-site planning plays a significant role in CWM. They believe that effective planning helps in establishing organisational goals, overcoming difficulties and streamlines the construction process towards being well managed and more productive, ultimately leading to CWM. According to these experts good on-site planning helps make effective decisions towards the efficient management of construction materials including salvaging waste, avoiding excess material use, minimising the risk of materials damage and consequently reducing wastage. Foremen E8 stated that it was important to, "*...make proper decisions on how to handle materials in a way that will avoid wastage. This will lead to increases in productivity and ensure that materials are not wasted*". Likewise, site manager E6 stated that efficient planning of construction activities ensures proper allocation of time, money, material and human resources, which in turn, will help avoid errors and mistakes and enhance the work performance.

Lead manager E1 also believed that team building and cooperation between managers, supervisors and labourers is a significant advantage resulting from good planning and management, which in turn helps reduce CW through improving job performance. He elaborated saying that "*good planning promotes teamwork and effective cooperation. Everyone will know what their responsibilities when such planning is communicated to employees of the organization*". Further, those that had extensive experience in the field (E2 & E3) viewed the planning process as an important procedure towards managing risk and uncertainty. Unforeseen events can occur and must be dealt with quickly before negative consequences arise such as CW generation. Project manager E2 said that "*...the what-if" scenarios can be effectively addressed by good planning, as managers attempt to develop contingency plans to deal with possible risk factors*". However, during the second round, experts E2, E5 and E7 added that client interference in the project's planning process can have an adverse effect and actually damage productivity and CWM efforts. Expert E2 clarified that "*…constant interfering of the clients can obstruct the planning process, which should be reduced in order to maintain its efficiency*".

With regard to technical support, eight experts (E2, E5, E6, E7, E8, E9, E10 & E11) suggested that a key issue in CWM is the adequate provision of support for the LWTs that a company adopts as well as support for the implementation of work in general. This support may be in the form of equipment maintenance, repairs or software support and updates. Supervisor E8 explained that "*some technicalities in the implementation of work require further attention and support from the organisation in order to maintain good performance*". A further point was made by labourers E9 and E11, who added that the provision of efficient construction equipment, including LWTs, is very important during the construction process, as old and worn-out equipment produces poor work quality and therefore increases waste materials. Labourer E11 stated that "*it's very difficult to avoid waste generation when using old construction equipment*".

Four experts (E1, E2, E3 & E5,) revealed that company policies such as quality control can largely help in CWM. They indicated that substandard work performance and breaking work procedures, resulting in CW generation, can be reduced by taking effective quality control measures such as inspections and strict supervision. Lead manager E1 stated that "*by setting out standard work procedures and monitoring the work performance, construction can be more controlled*". During the second round the remaining experts showed strong agreement, particularly on the aspect of strengthening site supervision, as according to site manager E5, "*...site supervision must be very important during the whole period of the construction process*". Furthermore, five experts (E3, E5, E6, E10 & E12) emphasised the importance of facilitating support for on-site workers such as training and education on CW types, causes, the negative impacts of CW and CWM methods. As expert E12 explained "*it is vital that a company supports its staff by educating and training workers on the different aspects of waste, in order for the company to achieve its targets for reducing waste*".

With regard to effective management change in construction projects, three experts (E7, E11 & E12) revealed that it a very important matter when it comes to waste minimisation. They indicated that management changes can frequently occur in the workplace, and when that process occurs it must be well organised in order to maintain the workflow of the construction process, avoid any interruptions and reduce difficulties for employees such as with following up with the new plans. If this does not happen, it will result in confusion among supervisors and labourers and there will be task overlapping which can increase the chance of generating CW. Expert E7 stated that "*…the process of changing the management during the construction process must be well organised, in order for them to keep up with the new changes, and avoid interruptions which affect the work performance resulting in negative consequences*". During the second round, two experts (E1 & E2) did not perceive a strong influence from such issue on CWM. However, the remainder of the experts showed strong agreement, such as supervisor E9, who added that the new management must have extensive experience in order to control the construction process in the shortest time possible.

5.4 Summary of the Delphi result

The resultant two-round Delphi study concluded with a total of 31 consensuses achieved with regards to the factors influencing the behaviour of Jordanian contactors towards CWM. Two issues did not reach consensus namely: manager's encouragement and the influence of difficult employees. Both issues respectively reached a consensus of 50% and 30% in the second round. The main reason behind this is that the majority of experts were not certain that such issues would have a significant direct influence on the behaviour of the Jordanian contractors towards CWM. However, this matter is debatable; some experts believed that encouragement from managers helps to build loyalty to their work and organisation, and this can significantly enhance work performance, including CWM. Moreover, the negative effect of difficult employees in the work environment, creating a negative working atmosphere, can diminish productivity, which in turn results in poor work performance and a higher chance of CW generation. Thus, it is worth taking these two issues into consideration for future research, or indeed, they may not be applicable to the Jordanian construction industry at this particular time. Therefore, it was decided that it was not necessary to undertake a third round of Delphi for just these two issues. Figure 5.1 demonstrates the final template derived from the second round of the Delphi study taking into account the identified factors influencing the behaviour of contractors toward CWM in the Jordanian construction industry.

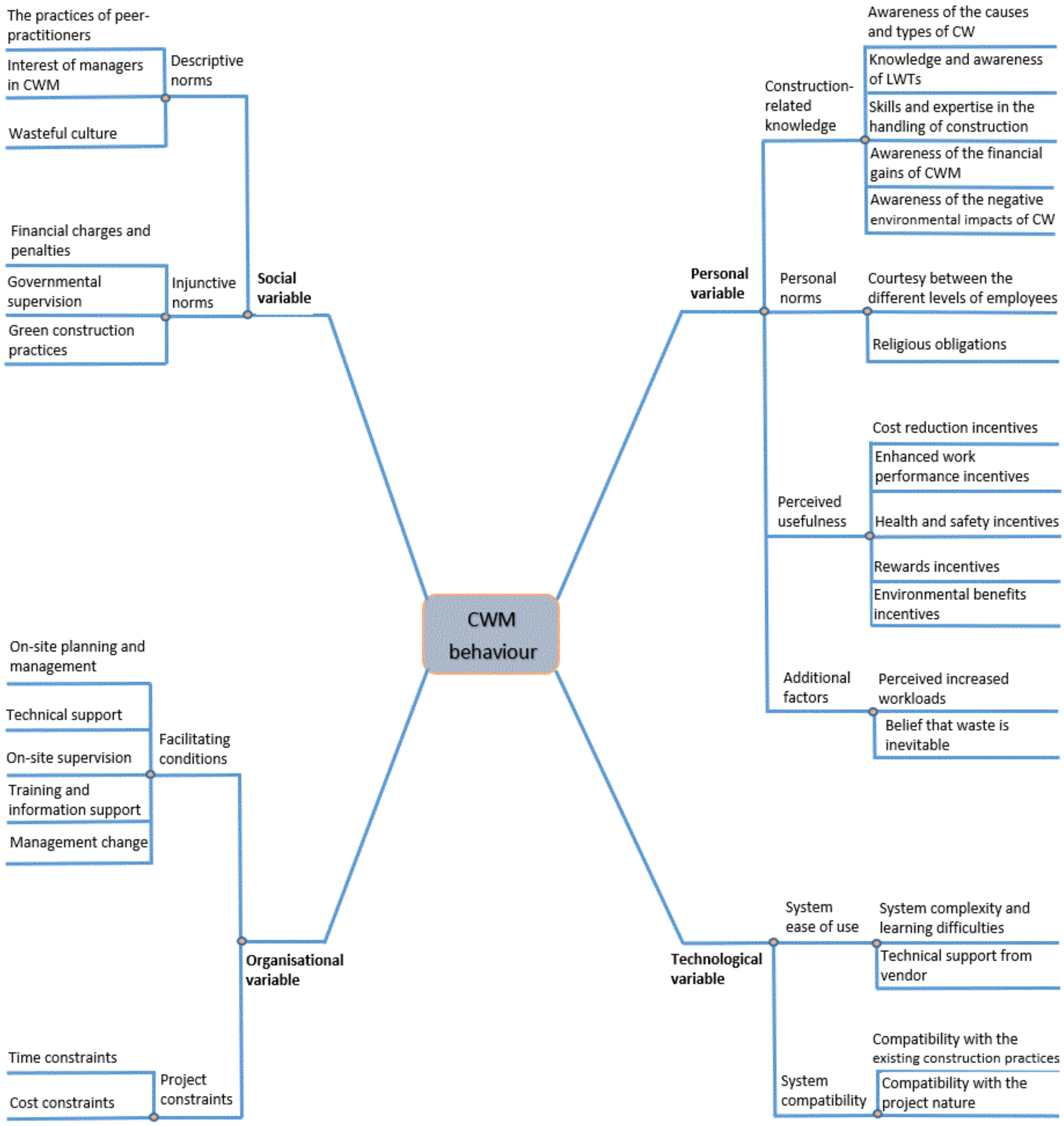

Figure 5.1: The Delphi study final template - factors influencing the behaviour of Jordanian contractors towards CWM.

5.5 Conclusion

This chapter presented the analysis and discussion of the findings of two rounds of the Delphi study. The researcher has identified and verified the factors that influence the behaviour of contractors towards CWM in Jordan. The identified factors will be used to construct a BF to support the adoption of waste minimisation in Jordanian construction projects. Therefore, the discussion and development of the initial BF will be undertaken in the next chapter.

Chapter 6

Development of the Behavioural Framework (BF)

6.1 Chapter overview

Chapters 2 and 3 highlighted the need for CWM especially in the Jordanian construction industry and focused on the adoption of CWM behaviour. Chapter 4 discussed the research methodology employed to develop the BF. Chapter 5 presented the findings of the Delphi study which identified the factors influencing the behaviour of contractors towards CWM in Jordan. Thereafter, based upon the combination of findings from Chapters 2, 3 and 5, this chapter will assimilate findings in the literature review and Delphi study, and present the development of the BF, which aims to support the adoption of waste minimisation behaviour by contractors in Jordanian construction projects.

6.2 The BF definition

Prior to proceeding with the definition of the BF, it is important to delineate the various meanings of the term "framework" as it is used within the scientific world. A framework can be defined as a set of concepts used to solve a problem in a specific domain; and considered as a conceptual structure that enables different business objects to be framed and treated homogeneously (Paim & Flexa, 2011). Similarly, Sekaran (2000) defined the term framework as a "conceptual model of how one theory makes logical sense of the relationships amongst the several factors that have been identified as important to the problem". Within the management sector, Wiig et al. (1997) defined a framework as a set of guiding principles and a methodology that can be thought of as a specific, detailed description of how to carry out the ideas and objectives.

In this study, the developed BF will enhance the explanatory power in the prediction of CWM behaviour in terms of identifying and understanding the factors influencing the behaviour of contractors towards CWM in Jordan. This will support the adoption of waste minimisation in Jordanian construction projects. The BF is developed using findings from a critical appraisal of the literature (Chapters 2 & 3) and on comprehensive analysis of the findings of the Delphi study conducted by the researcher (Chapter 5). The resultant BF can be defined as a decision-making tool which includes a set of integrated factors influencing the behaviour of Jordanian contractors towards CWM, and therefore can be used to support waste minimisation in construction projects.

6.3 The need for the BF

Due to the numerous environmental, economic and social problems that are a direct result from the generation of CW (see section 2.4.2), there is a growing need to improve CWM in order to deliver the global sustainability agenda (Begum et al., 2009). These problems are identified as significant in Jordan due to a number of critical issues, such as the increased raw material prices, consumption of limited natural resources, lack of landfill space, impact on health and the environment, and the heavy financial load on the government, especially given the poor economic situation in Jordan (Al-Rifai & Amoudi, 2016; Alshboul & Abu Ghazaleh, 2014). This was confirmed by the Delphi study (see section 5.3.1), as the findings emphasised the need for effective waste minimisation measures in the Jordanian construction industry in order to achieve more SC and enhance the performance in the environment.

The behaviour factor is integrated with every stage and phase in construction projects as the majority of the causes underlying CW are directly or indirectly affected by the behaviour of those working in the construction industry (see section 2.3.3.1). This is confirmed by Osmani et al. (2008) who noted that negative behaviour towards CWM could lead to the generation of CW. The behaviour of contractors is a crucial element in the implementation of successful CWM measures, as many studies have emphasised their impact on the generation and minimisation of waste in construction projects (see sections 2.3.3). Kulatunga et al. (2006) argued that CW occurs on site for a number of reasons, most of which can be prevented, in particular, by changing the attitude of contractors.

In reviewing the existing literature, numerous studies have attempted to explore and understand CWM behaviour by utilising the most applicable and practical theories and frameworks available to support the prediction of human behaviour. However, these behaviour adoption theories and frameworks have attracted heavy criticism from researchers in various disciplines for being simplistic and inadequate in successfully predicting behaviour (see section 3.3.5). Additionally, the application of these theories and frameworks in the context of CW, confirmed what was reported by the other researchers in terms of their inadequate and simple construct which lacked additional important factors for the effective prediction of CWM behaviour (see section 3.4). This is in addition to the fact that they have all been constructed with reference to developed countries and may be inappropriate and less open to generalisation in relation to developing countries, such as in the Middle-East region, especially since there are few research studies dedicated to investigating CWM behaviour and particularly in Jordan (see section 2.5). According to Humphreys (1996), to avoid issues surrounding surmounting cultural differences, developing countries are advised not to adopt ideas from developed countries without modifying them to suit their local contexts.

Consequently, there exists a significant need for a BF that can address the weaknesses of existing theories and frameworks in order to enhance the explanatory power in the prediction of CWM behaviour. Such a framework will support the adoption of waste minimisation in Jordanian construction projects by identifying and understanding the factors influencing contractors' behaviour towards CWM. The need for the BF is also necessitated because, to date, the construction industry in Jordan is still suffering insufficient sustainability practices characterised by poor production, sub-standard performance and a wasteful culture (Tewfik & Ali, 2014; Aldayyat et al., 2019). Thus, the BF will help in create a more in-depth understanding of how contractors can observe, define and adopt CWM behaviour which will support a more improved SC sector.

There are, however, some uncertainties as to what extent the BF will contribute to the successful implementation of CWM behaviour in a real-life context. According to Sniehotta et al. (2014), psychological theories and frameworks should define their range of intended applications which should be empirically substantiated, rather than implicitly making untenable claims to explain all behaviour. Therefore, the next section discusses how can the BF be implemented in practical cases in order to support the adoption of waste minimisation behaviour by contractors in Jordanian construction projects. In addition, a definition of which persons/ organisations can benefit from such a framework and when can they apply it, is provided.

6.4 Application criteria for the BF

Theoretically, the process for developing the BF can be a useful reference for other studies which attempt to understand CW and its related issues in other socio-economic contexts, as researchers can conduct their investigations to structure future research and provide further improvement. Empirically, the BF is to be implemented through assessing the integrated factors in a real-life social context (whether on an individual project, organisation, country or geographical regional basis) in consultation with targeted stakeholders to formulate a set of various scenarios so that the best CWM strategies could be identified before being implemented in practice (see Figure 6.1). Consequently, the BF will provide a solid basis to assist those who are involved in decision-making in construction (e.g., clients, contractors and consultants), towards adopting effective measures and the required mechanisms for improving CWM behaviour and obtaining effective CWM outcomes. Osmani et al. (2006) noted that the increasing awareness of CWM and its resulting benefits has led to a growing demand from construction stakeholders to improve waste minimisation performance in construction projects. Further, the BF is of value in facilitating the establishment of policies and regulations from the relevant governmental authorities for the promotion of effective CWM, and thus sustainable development for the Jordanian construction sector. According to Gangolells et al. (2014), reliable information can help governments and professional associations to set future CW management regulations, training programmes and dissemination tools. Figure 6.1 illustrates the operationalisation process of the BF and is divided into three stages:

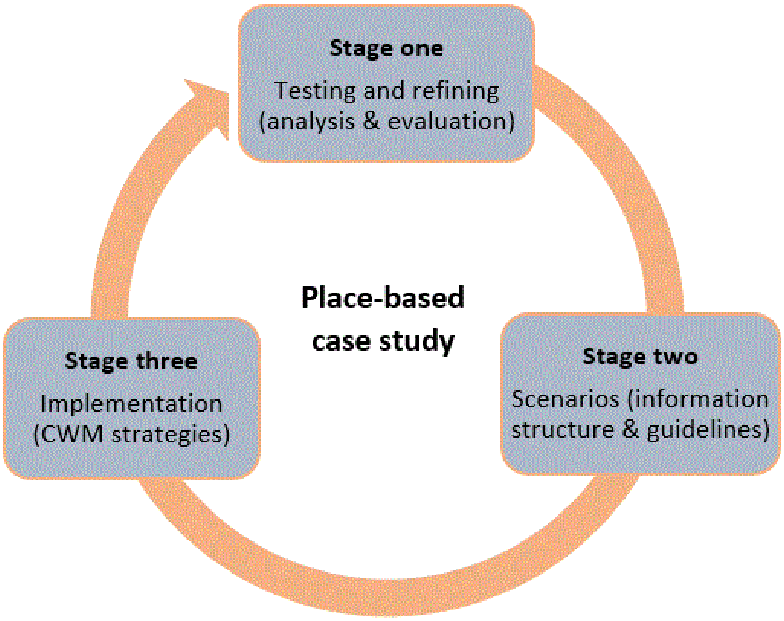

Figure 6.1: The application process of the BF in a real-life social context

- **Stage one**: This involves the analysis and evaluation of the BF to address CW issues in a particular case study (e.g., project, organisation, etc). There are no universal standards for selecting what test procedures or criteria to use for analysing and evaluating the BF, as the evaluation process can be conducted through either qualitative or quantitative data collection and analysis methods, in relation to the identification of the factors influencing CWM behaviour in case study context. The choice of a method is, however, usually determined by the number of cases available, which does not allow statistical techniques to be used. For instance, Renzi and Klobas (2008) and Zoellner et al. (2012) suggested that qualitative theory testing (e.g., interviews and data coding) is mostly used when there is a limited number of cases (targeted sample) in the under study. On the other hand, a number of authors (e.g., Hyde, 2000; Grix, 2018; J. Li et al., 2018a) recommended the use of a quantitative method (e.g., survey questionnaires and factor analysis) for testing social theories and frameworks, when there is a large number of cases in the case under study.

- **Stage two**: This involves formulating an information structure based on the findings from the first stage that will provide scenarios and, thus, guidelines for the development of appropriate CWM approaches and strategies. Such scenarios can be assessed, if necessary, for further refinement and/or validation.

- **Stage three**: This involves the effective implementation of the developed approaches and strategies in order for CWM issues to be properly addressed. Such approaches can be refined and further developed based on the feedback from implementation.

In terms of application within a construction project, the BF can be applied at any stage and phase (e.g., tender, design, construction stage); it is to be determined by the decision makers as to when to schedule its application. However, the effectiveness of the BF can vary between construction projects depending on the nature of the project and the time period of the framework application. For example, a client may identify a certain CWM strategy based on the BF testing outcomes, however, they can fail to achieve good results that may also lead to a higher project cost simply because the budget aspect of CWM was not considered. Furthermore, a client may not achieve successful CWM outcomes if there is insufficient time to investigate and identify effective CWM approaches. Equally, the BF could be highly successful if implemented at a very late stage of a construction project if effective reward mechanisms are introduced which bear no impact on additional resources. Therefore, further work is required to investigate the time aspect regarding the effective application of the BF in order to achieve the most effective CWM results.

In conclusion, the primary benefit of implementing the BF lies in the enhancement of the explanatory power in the prediction of CWM behaviour of the Jordanian contractors. Additionally, the process of the BF development can be a useful reference for other studies which attempt to understand CW and its related issues worldwide. The significance of the BF is that it can be applied by different groups of construction stakeholders and in different periods and stages in construction projects (or within organisations, regional or country contexts). Moreover, the application process of the BF can be conducted using different methods of evaluation and testing. Accordingly, this results in an effective, flexible and more reliable application of the BF towards achieving successful waste minimisation outcomes in construction projects. The next section discusses the development process of the BF based on the findings of both the literature review (Chapters 2 & 3) and the Delphi study (Chapter 5).

6.5 The BF development and structure

The BF consists of four constituent variables that work together to explain and predict CWM behaviour. These are: personal, technological, social and organisational variables, as illustrated in Figure 6.2. Personal variable involves factors which refer to the perceptions and beliefs which influence the adoption of CWM behaviour; technological variable involves factors which refer to the technology's characteristics that could impact behaviour towards its adoption. Social variable involves factors which refer to the cultural issues that reflect a sense of social pressure, either voluntarily or mandatorily, towards the adoption of CWM behaviour. Finally, organisational variable involves factors which refer to the organisational internal issues that influence the degree of ease or difficulty of performing CWM behaviour.

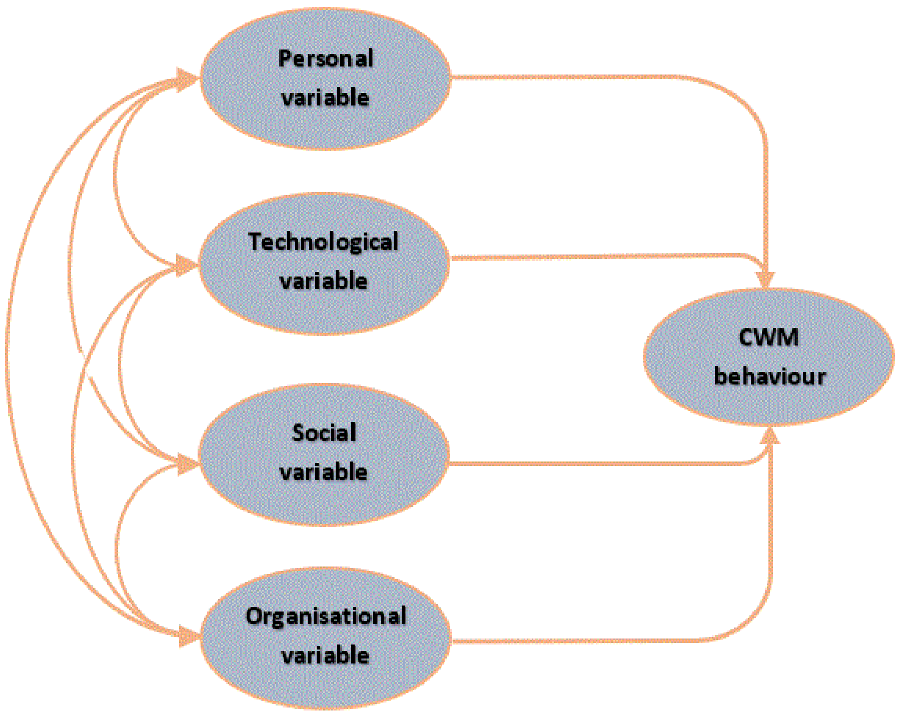

Figure 6.2: The BF structure

According to the literature review (see section 3.4), numerous studies have revealed the significance of personal factors such as knowledge, personal norms and perceived usefulness, and their impact on waste minimisation in construction projects. The individual's self-efficacy can determine their capabilities to perform or not to perform the behaviour (Bandura, 1986). In other words, people will take the lead role in driving sustainability forward and bringing about the necessary changes in an organisation with regard to CWM. Social factors were also of great interest in previous research studies (see section 3.4) due to their huge effect on CWM behaviour. According to J. Li et al. (2018a), in terms of the overall effect on CWM behaviour, social pressure plays a significant role in influencing the individual's performance and actions. With regard to technological factors, it was noted when undertaking the literature review (see section 3.4) that such factors was given little attention despite their huge impact on the willingness to adopt LWTs that support CWM. This was confirmed by the Delphi study (see section 5.3.3), as the findings showed strong agreement that issues associated with technologies adoption can significantly affect the likelihood of their acceptance. A great deal of emphasis was placed on the effect of organisational factors in providing opportunities and the necessary requirements that will facilitate the adoption of CWM behaviour. The effective adoption of CWM behaviour depends heavily on the support of a well-balanced infrastructure consisting of an interaction between the important issues which affect the work environment (Thompson et al., 2003). Notably, the novelty of the BF is that it incorporates all the aforementioned variables which are considered essential for effective prediction of CWM behaviour, as according to the literature review (see sections 3.3.5 & 3.4), each of the existing adoption theories and frameworks have been criticised for being too simplistic and inadequate in successfully predicting the factors impeding the adoption of CWM behaviour.

The development of the BF is based on the discussion and tabulation of the results of the literature review (Chapters 2 & 3) as well as the results of the Delphi study (Chapter 5). The literature review Chapter 3 identified a list of factors (see section 3.4) influencing the behaviour of contractors towards CWM adoption. This is in addition to the issues identified through the literature review in Chapter 2 which limit the successful adoption of CWM (section 2.4.3). As explained in section 4.5.5.1, secondary data from the literature review will be combined with primary data in order to ensure that it is comprehensive, up-to-date and appropriate for the precise needs of this study, which in this particular case is to ensure that it is relevant to Jordan. Subsequently, a Delphi study (Chapter 5) involving members of the Jordanian contractors was conducted to gather qualitative primary data to be combined with the secondary data from the literature review to develop the BF of factors influencing the behaviour of Jordanian contractors towards CWM behaviour (see Figure 6.3).

The researcher argues that the BF adoption is based on a dynamic interaction between the four variables (personal, technological, social & organisational) influencing CWM behaviour (see Figure 6.2). This is because there is a clear cause-effect relationship between the integrated factors within the aforementioned variables and, thus, failure to consider any one of them will lead to failure for achieving successful CWM behaviour. For example, if a worker has the necessary construction-related knowledge, he/ she may not be able to successfully implement CWM without senior management support, or without adequate time and money resources, and vice versa. According to the cross-referencing of the findings from the literature review with the Delphi study (discussed in the following subsections), 10 main factors, which includes 31 subfactors, are identified and have been combined in order to develop the initial BF to support the adoption of the waste minimisation behaviour by contractors in Jordanian construction projects (see Figure 6.3). However, it should be noted that the BF variables, including its integrated ten factors, will be subject to inclusion or exclusion at the framework validation stage of this study; this will be described in detail in the next chapter: Validation of the BF. The following subsections discuss the tabulation process of the findings of both the literature review and the Delphi study and their respective contributions to the development of the BF.

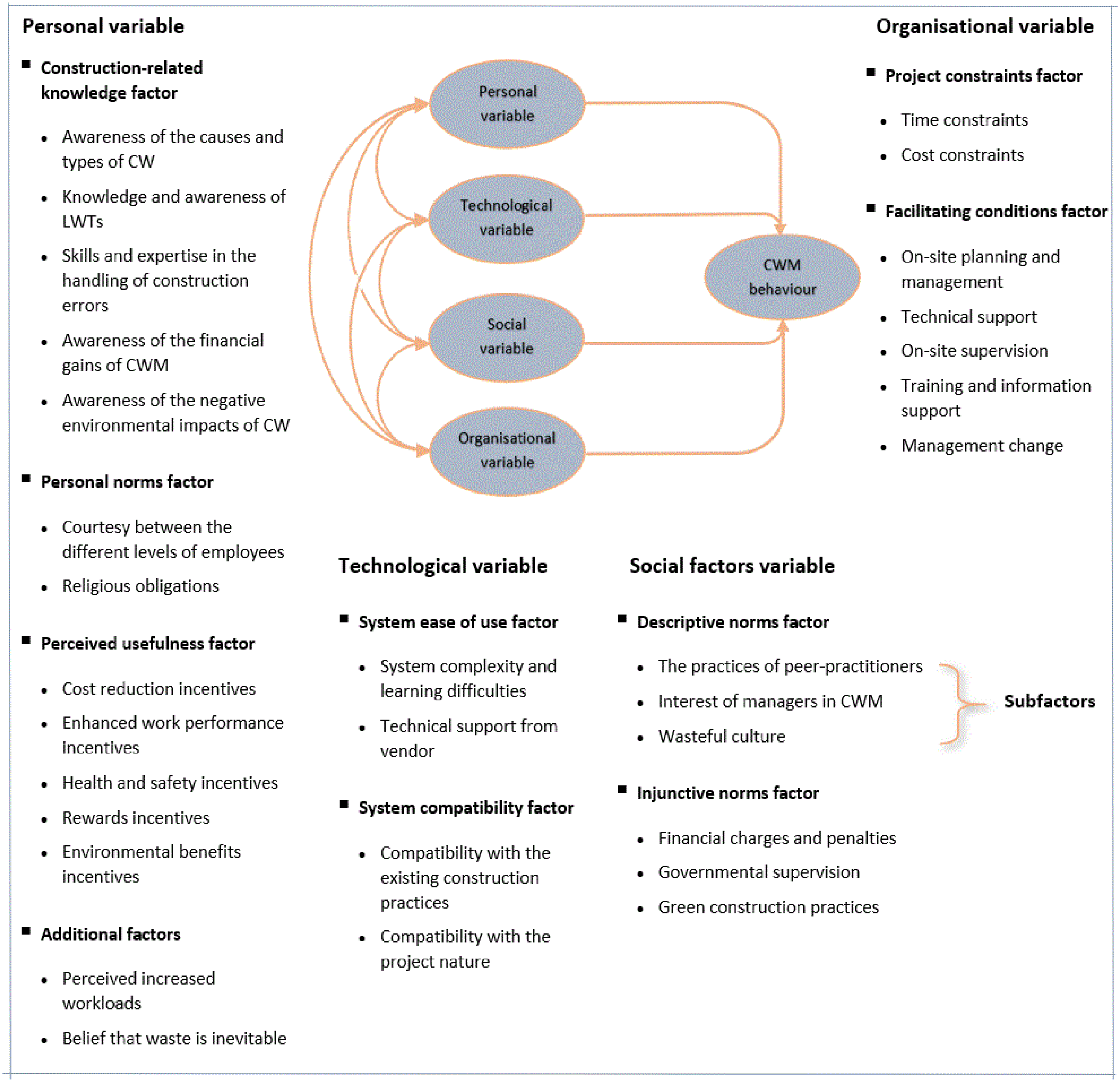

Figure 6.3: The initial BF of factors influencing the behaviour of Jordanian contractors towards CWM

6.5.1 Personal variable

As highlighted in the previous section, findings from both the literature review (sections 2.4.3.5 & 3.4) and the Delphi study (section 5.3.2) identified that personal factors are associated with the behaviour of Jordanian contractors towards their engagement with CWM. These factors are discussed in detail below:

- **Construction-related knowledge factor**

  According to the literature review (sections 2.4.3.5 & 3.4), the awareness and understanding of the CW subject have a profound impact on the behaviour of employees towards CWM. This includes knowledge and experience of the causes and types of CW and its minimisation approaches as well as awareness of the benefits of CWM in terms of cost savings and environmental and social sustainability. These issues have been identified to a great extent by past research (e.g., Teo & Loosemore, 2001; Al-Hajj & Hamani, 2011; Udawatta et al., 2015; Sepasgozaar et al., 2017; J. Li et al., 2018a; Luangcharoenrat et al., 2019). Their studies revealed that such issues help to raise contractors' perceptions of the subject of CW which in turn will increase their consciousness of the implications of their activities in the project and, therefore, effective CWM can be achieved. However, cross-referencing the construction-related knowledge factor that emerged from the Delphi study (see section 5.3.2.1) with the issues that had already been identified from the literature review (see sections 2.4.3.5 & 3.4), highlights one additional significant issue that had not been found previously in the literature (see Table 6.1).

Table 6.1: Cross-referencing of construction-related knowledge factor based on the tabulation of findings from the literature review and the Delphi study

Construction-related knowledge subfactors	Literature	Delphi study
1. Awareness of the causes and types of CW	✓	✓
2. Knowledge and awareness of low waste technologies	✓	✓
3. Skills and expertise in the handling of construction errors	×	✓
4. Awareness of the financial gains of CWM	✓	✓
5. Awareness of the negative environmental impacts of CW	✓	✓

From Table 6.1, it can be seen that the Delphi study confirmed all the issues that had been previously identified through the literature review under the construction-related-knowledge factor. However, discussions during the Delphi study were more detailed compared to the literature review and focussed specifically on Jordan. For example, the discussions in the literature review concentrated mostly on the effectiveness of LWTs as well as the skills in applying such technologies. The experts' panel in the Delphi study, however, were more focused on understanding the different types of LWTs to promote their adoption more efficiently in order to achieve improved CWM results. This is due to the fact that the majority of Jordanian contractors are adopting the familiar conventional methods of construction with minimal technology adoption.

In terms of awareness and knowledge of the resulting benefits of CWM, findings from the Delphi study confirmed the significant impact of such issues on the willingness of contractors towards minimising CW. Indeed, Udawatta et al. (2015) indicated that awareness of financial incentives (cost saving) helps to motivate project stakeholders in taking effective action towards CWM. However, the experts noted that there is a general lack of awareness of the significant environmental impact of CW, particularly among labourers. This is because most of the construction labourers in Jordan have low educational attainment and, therefore, are less informed about such an issue.

One new issue emerged through the Delphi study: knowledge of the handling of construction errors (see section 5.3.2.1). The findings of the Delphi study indicated that this issue is a key requirement for on-site management in order to control the level of waste production. According to the experts' panel, rework resulting from design changes and construction errors are common issues facing contractors in Jordanian construction projects. Therefore, their focus was on managers and their capability and competency in handling such issues in construction sites.

- **Personal norms factor**

The literature review (sections 2.4.3.5 & 3.4) showed that personal norms is one of the most important issues affecting CWM. Personal perception and judgment, desire for decision objectives and consequences of decision making can be perceived as a form of personal obligation towards CWM, since the benefits of CWM are shared within the work environment and community in addition to the person involved. Previous studies revealed that such issue is relatively important predictor with regard to commitment to CWM behaviours. However, it is heterogeneous across individuals since the consequences of violating or upholding personal norms are tied to one's self-concept (Davies et al., 2002; Bortoleto et al., 2012; Yuan & Wang, 2017). The cross-referencing of the issues that emerged from the Delphi study (see section 5.3.2.2) with those identified from the literature review under the personal norms factor (see sections 2.4.3.5 & 3.4), highlights differences as displayed in Table 6.2).

Table 6.2: Cross-referencing of personal norms factor based on the tabulation of findings from the literature review and the Delphi study

Personal norms subfactors	Literature	Delphi study
1. Courtesy between the different levels of employees	×	✓
2. Religious obligations	×	✓
3. Perceived shared benefits	✓	✓

From Table 6.2, the findings from the Delphi study confirmed what had been previously identified through the literature review regarding perceived shared benefits. However, one interesting issue was identified in relation to such issue, as in this Delphi study, it has been found that religious obligation of some employees can provide moral guidance and rules regarding the implementation of their work. This is because some employees' actions are derived from their religious beliefs when performing construction work, and they feel obliged in performing their work in the best way possible with minimum negative consequences such as generating CW. According to the experts' panel, Jordan is highly influenced by religious and cultural traditions when it comes to their actions and, therefore, religious obligations is an important issue when it comes to the job performance. Courtesy between managers and employees is another interesting issue emerged from the Delphi study which seems to have a major impact on the behaviour of Jordanian contractors towards CWM (see section 5.3.2.2). This is because such issue helps to build a strong relationship between both parties and create a positive working atmosphere. This will encourage employees to be more loyal to the organisation and, therefore, increase productivity.

- **Perceived usefulness factor**

  The literature review (sections 2.4.3.5 & 3.4) revealed that the benefits of conducting CWM at the project as well as the community level has a profound impact on CWM behaviour. Previous studies revealed that benefits such as cost reduction, rewards, environmental benefits and enhancing the work performance can largely incentivise contractors towards the adoption of CWM behaviour (Osmani et al., 2006; Yuan et al., 2018; Liu et al., 2019). Table 6.3 shows the results of cross-referencing the perceived usefulness factor that emerged from the Delphi study (see section 5.3.2.3) with the issues that had already been identified from the literature review (see sections 2.4.3.5 & 3.4).

Table 6.3: Cross-referencing of perceived usefulness factor based on the tabulation of findings from the literature review and the Delphi study

Perceived usefulness subfactors	Literature	Delphi study
1. Cost reduction incentives	✓	✓
2. Enhanced work performance incentives	✓	✓
3. Health and safety incentives	×	✓
4. Rewards incentives	✓	✓
5. Environmental benefits incentives	✓	✓

From Table 6.3, it can be seen that the Delphi study confirmed the effect of all the issues that were reported in the literature review under the perceived usefulness factor. There were no doubts among the panel of experts about the value of CWM in terms of its resulting benefits. However, the main focus of their discussions was over the financial benefits since it acts as the strongest incentive towards adopting CWM behaviour. For example, the experts focused on project cost reduction as a key advantage that highly incentivises Jordanian contractors towards CWM. As argued by Liu et al. (2019), managers are highly interested in cost, time and quality objectives. Moreover, findings of the Delphi study (see section 5.3.2.3) emphasised that CWM can lead to the enhancement of work performance through time and cost saving and by enhancing the quality of work. Therefore, such issues can benefit both managers and workers by maximising the profit and enhancing the workflow in the construction project.

With regard to rewards, experts indicated that benefits which can be gained through involvement in CWM can help raise motivation towards adopting CWM behaviour. For instance, bonuses and promotions can encourage managers, supervisors and labourers in minimising CW. This supported the research by Osmani et al. (2006) who stated that financial rewards was one of the key incentives to drive waste minimisation for both architects and contractors. One new issue that emerged from the Delphi study findings regards the health and safety of the on-site workers. The experts highlighted the importance of CWM in order to avoid accidents and injuries which are common issues in Jordan. Notably, the health and safety standards for construction projects in Jordan are mostly focused on large construction projects, whereas small to medium size projects do not often comply with such standards.

- **Additional factors**

The literature revealed that factors such as "believe that waste is inevitable" can have an impact on the behaviour of contractors towards the success and effectiveness of CWM (Teo & Loosemore, 2001; Ajayi et al., 2015, 2016; Wu et al., 2017). According to Abarca-Guerrero et al. (2017), the perception that waste minimisation efforts will never be sufficient to completely eliminate waste in construction activities can significantly affect willingness to minimise CW. Ajayi et al. (2015, 2016) revealed that there is a general belief among contractors that waste is accepted as inevitable, which in turn is considered a huge barrier limiting the adoption of CWM. The interview findings in the Delphi study confirmed what was reported in the literature review. Table 6.4 shows the results of cross-referencing the issues that emerged from the Delphi study (see section 5.3.2.4) with issues appearing in the aforementioned studies in the literature (see sections 2.4.3.5 & 3.4).

Table 6.4: Cross-referencing of the additional factors based on the tabulation of findings from the literature review and the Delphi study

Additional factors	Literature	Delphi study
1. Perceived increased workloads	×	✓
2. Belief that waste is inevitable	✓	✓

In Table 6.4, the process of cross-referencing the additional factors reveals that the findings of the Delphi study confirmed what had been previously identified through the literature review with regard to the second factor. The experts' panel emphasised that the beliefs among Jordanian contractors about waste being inevitable in construction projects can have a huge negative impact on CWM. In fact, the panel of experts indicated that the introduction of courses intended to raise the awareness of contractors, especially labourers, regarding this issue had been proposed by a number of firms in the Jordanian construction industry. One interesting issue that was identified which did not feature in the literature review was the perceived increased workload (see section 5.3.2.4). According to the findings of the Delphi study, the perception that CWM will increase the workload has a major influence on employees' attitudes towards minimising waste in Jordanian construction projects. The experts' panel elaborated that such perceptions can result in workers neglecting the aspect of minimising waste as they believe that it requires more time and effort in terms of waste sorting, collection or even source reduction measures and, therefore, will increase the workload. Notably, the experts' comments were mainly concentrated on labourers, as most of their job required physical work, therefore, they would be responsible for the most effort if there was any increased workload.

6.5.2 Technological variable

Findings from both the literature review (sections 2.4.3.5 & 3.4) and the Delphi study (section 5.3.3) showed that technological factors are significantly associated with the level of acceptance of LWTs in Jordanian construction projects. These factors are discussed in detail below:

- **System ease of use factor**

  According to the literature review (sections 2.4.3.5 & 3.4), there is a strong correlation between the ease of use of LWTs and the likelihood of their adoption. According to a number of construction-related studies (e.g., Son et al., 2012; Sepasgozaar et al., 2017) the degree to which a technology is perceived as difficult to understand and use will affect the willingness of the project managers in adopting that technology. Son et al. (2012) noted that complexity in utilising some LWTs is a challenging issue as it requires skilled experts and can be difficult to understand and, will therefore affect the degree of their acceptance. The cross-referencing of the system ease of use factor that emerged from the Delphi study (see section 5.3.3.1) with the issues that had already been identified in the literature review (sections 2.4.3.5 & 3.4), is discussed in Table 6.5.

Table 6.5: Cross-referencing of system ease of use factor based on the tabulation of findings from the literature review and the Delphi study

System ease of use subfactors	Literature	Delphi study
1. System complexity and learning difficulties	✓	✓
2. Technical support from vendor	✓	✓

From Table 6.5, it can be seen that the Delphi study confirmed all the issues that had been previously identified through the literature review under the system ease of use factor. The experts' panel showed strong agreement with the influence of "ease of use" on the successful adoption of LWTs in construction projects. Concern was voiced by both managers and employees that the complexity of a technology is a strong inhibitor to managers' willingness to adopt such technology instead of using traditional methods of construction. For instance, working with complex equipment and a complicated operation process can strongly decrease the likelihood of technology adoption in construction projects. Furthermore, some experts argued that difficulties may exist in integrating the outcome of some complex technologies with other components of the project and, therefore, there was a strong chance of errors and mistakes occurring which would result in waste.

It was also clear that technical support from vendors was considered a major issue that would facilitate the adoption of LWTs in construction projects. The findings of the Delphi study emphasised the fact that the availability of technical support from vendors can strongly restrict technology usage, as guidelines and directions may be required when utilising certain LWTs (see section 5.3.3.1). Sepasgozar et al. (2017) noted that lack of vendor support can significantly discourage technology adoption. This issue is unique to the Jordanian construction sector due to the fact that there is a lack of professional bodies that provide technical assistance and support in the utilisation of LWTs and especially those that are perceived as complex.

- **System compatibility factor**

According to the literature review (sections 2.4.3.5 & 3.4), there a strong correlation between the degree to which a technology is perceived as being compatible with existing needs and the likelihood of its adoption. Past research studies (e.g., Lee & Yu, 2016; Sepasgozaar et al., 2017; Shirowzhan et al., 2020) revealed that the compatibility of LWTs with the work environment, current methods of construction and overall objectives will have a significant influence on the organisation’s intention to adopt that technology. Sepasgozaar et al. (2017) have argued that the compatibility of construction technology, in terms of integrating the outcomes with other building components, and incorporating services and reinforcement is very important in order to achieve better, faster and perhaps lower-cost buildings. Table 6.6 illustrates the cross-referencing of the system compatibility factor that emerged from the Delphi study (see section 5.3.3.2) with the issues that had already been identified from the literature review (sections 2.4.3.5 & 3.4).

Table 6.6: Cross-referencing of system compatibility factor based on the tabulation of findings from the literature review and the Delphi study

System compatibility subfactors	Literature	Delphi study
1. Compatibility with the existing construction practices	✓	✓
2. Compatibility with the project nature	✓	✓

From Table 6.6, it can be seen that the Delphi study confirmed both issues that had been previously identified through the literature review under the system compatibility factor. The findings from the Delphi study supported the literature findings, as integrating some LWTs with existing construction practices can sometimes prove challenging. Experts explained that the adoption of LWTs can face difficulties as some of these technologies may not be compatible with the traditional methods of construction practiced by contractors. For instance, some of the traditional construction methods are simple and depend on basic resources and are, consequently, incompatible with advanced technologies. This issue was expressed with great concern as the current status of the Jordanian construction industry is still suffering from insufficient adoption of contemporary technologies. This is because many contractors (particularly small or medium-sized contractors) are still using the old traditional methods of construction that often do not contribute to sustainability. The compatibility of some LWTs with the project nature was also found to be a major issue affecting the adoption of these technologies (see section 5.3.3.2). The experts' panel said that the type, size and budget of a construction project may not fit with a particular technology, as some construction projects are very simple or have limited budgets and do not necessarily require advanced technologies. However, some experts added that such a scenario can work in both directions as some construction projects may be too large or complex, therefore the utilisation of certain LWTs that are unsuitable for the project can be too expensive.

6.5.3 Social variable

Findings from both the literature review (sections 2.4.3.5 & 3.4) and the Delphi study (section 5.3.4) confirmed that social pressures can significantly influence the behaviour of contractors in Jordan towards adopting CWM. Social factors are divided into two main factors: descriptive and injunctive norms. Each factor includes subfactors discussed in detail below:

- **Descriptive norms factor**

  The literature review (sections 2.4.3.5 & 3.4) revealed that descriptive norms which are accompanied by the expectation that individuals will behave according to a particular pattern, play a significant role in the behaviour of contractors towards CWM. Past research (e.g., Lorente et al., 2014; Liu et al., 2018; Yuan et al., 2018; J. Li et al. (2018a) revealed that individual CWM behaviour can be largely influenced by the behaviour of colleagues and/or managers. J. Li et al. (2018a) argued that the social pressure on workers to contribute to CWM activities is dictated largely by managers' willingness to commit organisational resources to it. The process of cross-referencing the descriptive norms factor that emerged from the Delphi study (see section 5.3.4.1) with the issues that had already been identified in the literature review (see sections 2.4.3.5 & 3.4) is discussed in Table 6.7.

Table 6.7: Cross-referencing of descriptive norms factor based on the tabulation of findings from the literature review and the Delphi study

Descriptive norms subfactors	Literature	Delphi study
1. The practices of peer-practitioners	✓	✓
2. Interest of contractors in CWM	✓	✓
3. Wasteful culture	×	✓

From Table 6.7 it is clear that the experts in the Delphi study confirmed what had been previously identified within the literature review under the descriptive norms factor. They confirmed the significant effect of the practices of co-workers on the individual's engagement with CWM, in the sense that the individual is largely influenced by the actions and attitudes of their workplace peers. However, the Delphi results were more detailed compared to the literature review. This is because the result indicated that such issue can work in both ways; while the poor and unproductive work performance of co-workers can affect individual engagement in CWM, the professionality and perfectionism of colleagues can also incentivise the worker to perform high standards of work performance and therefore promote CWM. Further, the experts indicated that the performance of CWM can also be influenced by the level of interest from managers towards CW. This is usually because the employees, particularly foremen and labourers, are less likely to adopt waste minimisation behaviour when they perceive that the managers are not that concerned about CW.

Wasteful culture is an interesting issue which did not feature in the literature review and emerged as a new issue which can significantly influence the behaviour of Jordanian contractors towards CWM (see section 5.3.4.1). The experts' panel paid more attention to the contractors' behaviour in CWM in terms of its being affected by the society's morals in addition to the surrounding work environment. They explained that Jordan's society is strongly influenced by consumerism and materialism which encourages wasteful habits in people, including those in the construction industry.

- **Injunctive norms factor**

According to the literature review (sections 2.4.3.5 & 3.4), the regulatory environment plays a crucial role in promoting CWM practices. Previous studies (e.g., Udawatta et al., 2015; Wu et al., 2017; Yuan et al., 2018; Liu et al., 2018; 2019) suggested that in order to achieve CWM targets, subjective norms should be strengthened through mandatory systems, as the success of CWM depends heavily on the compulsory laws and regulations in terms of pressuring contractors towards minimising waste in construction projects. Table 6.6 shows the process of cross-referencing the injunctive norms factor that emerged from the Delphi study (see section 5.3.4.2) with the issues that had already been identified in the literature review (see sections 2.4.3.5 & 3.4).

Table 6.8: Cross-referencing of injunctive norms factor based on the tabulation of findings from the literature review and the Delphi study

Injunctive norms subfactors	Literature	Delphi study
1. Financial charges and penalties	✓	✓
2. Governmental supervision	✓	✓
3. Green construction practices	✓	✓

From Table 6.8, it is clear that the Delphi study confirmed all the issues that had been previously identified in the literature review under the injunctive norms factor. During the interviews in the Delphi study, the issue of financial charges and penalties was recognised by the experts as having a major impact on the success of waste minimisation in Jordanian construction projects. The experts' panel elaborated on this issue and concluded that waste disposal charges and penalties for illegal dumping can increase the likelihood of the recycling and safe disposal of CW. Financial charges and penalties can also increase the likelihood of contractors reusing excavated soil which is considered, according to the experts panel, as one of the highest proportions of dumped materials in the Jordanian construction sector.

Clearly, strict governmental supervision is an important aspect to ensure that laws are enforced and, therefore, there is better implementation of CWM (Wu et al., 2017). The findings of the Delphi study (section 5.3.4.2) showed strong agreement with such an issue especially as illegal dumping of CW is a very common practice in Jordan's construction industry. They emphasised that through inspections and the strict monitoring of CW handling, transportation and disposal, the practice of illegal dumping will be more controlled and CW disposal can be better managed. With regard to green construction practices, the panel of experts revealed that the provision of effective waste management plans can exert a sense of obligation on managers towards adopting CWM. However, the experts were highly focused on the aspect of regulation implementation of green construction practices (e.g., BREEM) in Jordan. This is due to their major advantages and contribution to CWM. Notably, the green construction concept had already been introduced in the Jordanian construction sector (Matarneh, 2017), nonetheless, the adoption of such a system is still very minimal. A possible reason for this is that apartment buildings account for the majority of construction projects in Jordan (Jordan Strategy Forum, 2019) and therefore, according to the experts, most of the project stakeholders are mainly interested in profit maximisation; this interest overcomes any interest adopting green practice (i.e., green building).

6.5.4 Organisational variable

Findings from both the literature review (see sections 2.4.3.5 & 3.4) and the Delphi study (section 5.3.5) showed that organisational factors can significantly influence the degree of ease or difficulty in performing CWM behaviour in Jordanian construction projects. These factors are discussed in detail below:

- **Project constraints factor**

  According to the literature review (see sections 2.4.3.5 & 3.4), the quality of work is constrained by the project's budget, deadlines and scope. A number of authors (e.g., Fapohunda & Stephenson, 2011; Madhavi et al., 2013; Lorente et al., 2014; Abarca-Guerrero et al., 2017) have noted that the more resources and opportunities that the employees, especially supervisors and labourers, believe they possess in construction projects, the fewer obstacles they anticipate and consequently the greater level of perceived control over CWM behaviour. The cross-referencing of the project constraints factor that emerged from the Delphi study (see section 5.3.5.1) with the issues that had already been identified in the literature review (see sections 2.4.3.5 & 3.4), is discussed in Table 6.9.

Table 6.9: Cross-referencing of project constraints factor based on the tabulation of findings from the literature review and the Delphi study

Project constraints subfactors	Literature	Delphi study
1. Time constraints	✓	✓
2. Cost constraints	✓	✓

From Table 6.9 it can be seen that the Delphi study confirmed both issues that had been previously identified through the literature review under the project constraints' factor. The findings from the Delphi study identified that many project managers in Jordan focus on maximising their profit and neglecting the issue of CWM. The experts indicated that neglecting the adoption of effective CWM measures, such as assigning adequate and sufficient resources and the use of LWTs, is common among Jordanian contractors in order to increase their profits. However, their arguments consistently seemed to refer back to time constraints in relation to the ease of adopting effective CWM behaviour (see section 5.3.5.1). A possible reason for this is that time pressures prevent workers from performing high standards of construction work. Indeed, as noted by Wu et al. (2017), when the duration of the project is limited, the contractor may implement fewer CWM measures.

- **Facilitating conditions factor**

The literature review (see sections 2.4.3.5 & 3.4) demonstrates that the provision of requisite opportunities and resources by the organisation is very important in order to facilitate the adoption of CWM behaviour. A number of authors (e.g., Wang et al., 2008; Al-Hajj & Hamani, 2011; Lee et al., 2012; Yuan et al., 2018) revealed that intention, in conjunction with appropriate opportunities and resources, enables the attainment of a behavioural goal in CWM. The cross-referencing of the facilitating conditions factor that emerged from the Delphi (see section 5.3.5.2) study with the issues that had already been identified from the literature review (see sections 2.4.3.5 & 3.4), highlights differences as displayed in Table 6.10.

Table 6.10: Cross-referencing of facilitating conditions factor based on the tabulation of findings from the literature review and the Delphi study

Facilitating conditions subfactors	Literature	Delphi study
1. On-site planning and management	✓	✓
2. Technical support	✓	✓
3. On-site supervision	✓	✓
4. Training and information support	✓	✓
5. Management change	×	✓

From Table 6.10, the findings from the Delphi study confirmed all the issues that had been previously identified through the literature review under the facilitating conditions factor. There was no doubt from the experts' panel that organisational support is an important issue which can strongly influence the feasibility of the work. In terms of on-site planning, the findings of the literature review are supported by the findings from the Delphi study, confirming that good on-site planning and management is a key issue that strongly influences and streamlines the construction process towards being well managed and more productive and which leads, ultimately, to CWM. However, discussions during the Delphi study were focused on the issue of using poor and worn-out building equipment, especially as such equipment is still being utilised by many small-size contractors in the Jordanian construction sector. Al-Rifai and Amoudi (2016) noted that the quantity of materials saved through using efficient construction equipment can be significant in a construction project.

The findings of the Delphi interviews revealed that adequate provision of technical support by the organisation can strongly affect the degree of ease/ difficulty in conducting CWM measures. However, the discussions of some experts were concentrated mostly on the technicalities regarding the implementation of LWTs, as the Jordanian construction industry is still suffering from insufficient adoption of contemporary technologies and, thus, requires more consideration and support from project managers. Clearly, company policies such as on-site supervision is an important aspect in ensuring the implementation of standard work performance and, hence, minimising CW. The findings of the Delphi study showed strong agreement that monitoring the work performance through strengthening site supervision, is very important for project managers during the entire period of the construction process in order for the CW generation to be more controlled.

Furthermore, providing education and training on the different aspects of waste was also found to be a contributing issue towards improving the awareness and knowledge of Jordanian contractors in order for the company to achieve its targets (see section 5.3.5.2). Construction literature (e.g., Teo & Loosemore, 2001; Wang et al., 2008; Udawatta et al., 2015) showed that the effectiveness of CWM can be improved by educating supervisors and staff about waste minimisation strategies highlighting its resultant advantages. One interesting new issue that was identified through the discussion of the Delphi study was effective change management (see section 5.3.5.2). The panel of experts indicated that management changes, which can be frequent, can heavily impact waste minimisation. This is due to the fact that well-organised management changes help in maintaining the workflow of the construction process, avoid any interruptions and reduce difficulties for workers in following up with new plans. If these changes do not occur, it will result in confusion among workers and tasks overlapping which can increase the chance of generating CW.

6.6 Conclusion

This chapter presented the development of an initial BF (see Figure 6.3) of the factors influencing the behaviour of contractors towards CWM in Jordan. This was based on the tabulation of the key findings from the literature review (Chapters 2 & 3) and the Delphi study (Chapter 5). All the factors in the literature review have been substantiated by the Delphi study except for seven interesting subfactors which emerged from the Delphi study and are foreseen to have a major impact on the behaviour of Jordanian contractors towards CWM. These are: (I) skills and expertise in the handling of construction errors, (II) courtesy between the different levels of employees, (III) religious obligations, (IV) health and safety incentives, (V) perceived increased workloads, (VI) wasteful culture and (VII) management change. According to the Delphi study, such issues seem to be culturally specific and are strongly associated with the traditions and culture of the Jordanian construction sector. Nonetheless, it is important that the BF is validated to ensure that it is acceptable for its intended use and meets specified performance requirements. Therefore, the following chapter will validate the BF from the perspective of contractors in Jordan who have extensive experience in the construction industry.

Chapter 7

Validation of the Behavioural Framework (BF)

7.1 Chapter overview

Chapter 6 formulated a BF that seeks to identify and understand the factors influencing the behaviour of Jordanian contractors towards CWM. The development of the BF was based on the triangulation of findings from the literature review (Chapters 2 & 3) and the Delphi study (Chapter 5). The aim of this chapter is to validate the BF, through an industry review, for widespread application in the Jordanian construction context, and to further investigate the importance of the factors in the framework by means of an industry workshop among Jordanian contractors. This chapter begins by presenting the selection process and the profile of the respondents participating in the workshop, followed by a description of the workshop process discussing the key methodological issues surrounding the collection and analysis of the data. From this explanation, it proceeds to analyse and discuss the findings from the workshop validation of the BF. Finally, the eventual outcome and findings and the final BF will be presented.

7.2 Workshop process and schedule

The validation workshop was successfully conducted in February 2020, at the main office of the Jordanian Construction Contractor Association (JCCA) in Amman. The JCCA agreed to host the workshop, and provided the venue and facilities for the workshop which lasted four hours. As discussed in section 4.5.5.4, the workshop agenda was divided into two themes/sessions of discussion (see Appendix 5). The first session began with an introduction by the researcher explaining his background and rationale for the research, followed by a briefing on the objectives of the workshop as well as the ethical and anonymity procedures of the research. This was followed by a general discussion of the participants' previous experience of the adoption of CWM practices in construction projects and this involved two main areas: the challenges faced during the implementation of CWM measures, and the need for a framework to assess the implementation of CWM in Jordanian construction projects. During the second session, the BF, including the factors affecting CWM behaviour, was presented to the participants for validation. This included verification of the BF factors in addition to the evaluation of the terminology, structure and applicability of the framework itself. Finally, the session summarised the conclusions of the workshop by adding any further comments and/ or recommendations towards CWM. a pilot study was conducted to enhance the appropriateness and suitability of the workshop questions for achieving the objectives, as discussed in section 4.5.5.4. The participants' selection is presented in the following subsection.

7.2.1 Selection of the workshop participants

Following the same inclusion criteria discussed in section 4.5.5.3.2, invitations were sent out to 50 potential participants from the lists of employees. These invitations contained an information sheet explaining the purpose and process of the workshop as well as a consent form and a short questionnaire, which included a list of questions to ensure the potential participants met the inclusion criteria (Appendix 4). A total of 21 respondents agreed to participate, resulting in a 42% response rate. Based on the answers received from the short questionnaire, only 13 participants were considered as the true sample completely satisfying the inclusion criteria to participate in this workshop. While it is acknowledged that a larger sample may have allowed additional insights to be gathered, it is asserted that only seven participants were seen by the researcher to be a sufficient and feasible number to validate the BF (explained in section 4.5.5.4). The details of the seven participants are presented in Table 7.1. Their identities have been anonymised (i.e., P1, P2, etc.).

Table 7.1: Profiles of the workshop participants

Name	Education level	Participants discipline group	Experience (years)
P1	MSc in Civil engineering	Lead manager	27
P2	MSc in Architectural engineering	Lead manager	22
P3	BSc in Civil engineering	Project manager	15
P4	BSc in Material engineering	Project manager	10
P5	BSc in Architectural	Project manager	18
P6	BSc in Civil engineering	Site manager	9
P7	BSc in Quantity surveying	Foremen/supervisor	7

7.3 Discussion of the findings

The same technique used in the Delphi study of thematic/ coding analysis is adopted to analyse the data to form descriptive information and also to identify a pattern of responses amongst the participants throughout the workshop activities (i.e., group discussion, presentation and plenary feedback). The patterns were cross-checked with the proposed BF and any differences or similarities were then used to refine the validity of the final BF and conclusion. Interestingly, the findings from the workshop did not appear to contradict the findings of the Delphi study, however, some minor refinements were made to the BF and its incorporated factors as a consequence of the results of the participants' discussions in section 7.4. The following subsections presents the analysis of the findings from the workshop.

7.3.1 Verification of the need for BF

After completing the workshop's introduction and ethical procedure briefing during the first session, the researcher then opened the topic of discussion to the current situation regarding the adoption of CWM practices in the Jordanian construction industry. Accordingly, three questions were presented to seek information on the perspectives of the workshop participants. The first two questions were as follows:

- "*In your experience and opinion, is it important to understand the issues influencing waste minimisation behaviour of contractors in construction projects? If so, what are the issues that you think affect the behaviour of Jordanian contractors towards construction waste minimisation?*"

The aim of these two initial questions is to gain a clear insight into the need for the effective adoption of CWM measures, and to explore the issues affecting its adoption in the Jordanian construction industry. It was anticipated that the workshop participants may identify other issues and concepts that had not been identified from previous findings (the literature review and the Delphi study) which may, in turn, highlight new areas that need to be focused on that will then need to be included in the BF.

Immediately, all the participants agreed on the importance of understanding the issues affecting the behaviour of Jordanian contractors towards CWM. This is because, according to the participants, the current level of CWM adoption in the Jordanian construction sector is not satisfactory, since the amount of CW is ever increasing resulting in huge financial losses and environmental problems. They indicated that it is vital for stakeholders in the construction industry to appreciate the issues that present themselves as obstacles to the adoption of CWM. According to all workshop participants, over the last two decades, the construction industry of Jordan has generated greater volumes of waste than ever before. This is due to the rapid development of urbanisation in many cities in Jordan. The participants indicated that CW generation is significantly increasing as the Jordanian construction sector is not making sufficient effort towards CWM. They argued that this behaviour is clearly obvious from the large amount of waste being disposed of in landfills each year such as in the GHABAWI dumpsite, which is considered the largest landfill site in Jordan. Managers (P1, P2 & P5) with more than 10 years of experience in the procedures and formalities related to waste disposal in construction projects, pointed out the fact that the capacity of the designated landfills could not accommodate the enormous amounts of generated waste and, thus, enforced the authorities to open new areas for dumping waste. Lead manager P2 said: "…*it's just because there was no space for anymore waste. the construction industry is really struggling to adopt effective measures to minimise waste, and this is a real problem. More effort must be made towards this matter, recycling and reusing should strengthen and dumping waste into landfills should be the least solution, but unfortunately, for many contractors it's the preferred solution*". Furthermore, participants P6 and P7 emphasised the need for the CW issue to be more controlled since large volumes of waste are illegally disposed in many areas over the entire country, especially in rural areas.

Furthermore, losses in profit is a very common issue which occurs in Jordanian construction projects. Many clients and contractors suffer from financial losses which can sometimes be significant, with Project managers P3 and P5 arguing that such thing, sometimes, is largely associated with a lack of awareness and not paying enough attention to CWM. Participant P5 said that "*...considering the fact that construction waste results in higher cost of construction process and slow growth of the construction industry performance*". This was confirmed by lead manager P1 who argued that increasing prices at the tender stage of many construction projects is a result of the increased final cost of the project due to the cost of wasted materials. This affects the competitiveness of the organisation and opportunities for obtaining future projects. Site manager P6 agreed with this, however, he indicated that this is mostly the case for large-size contractors; as for the small and medium-size contractors the cost of CW is deducted from their profit in projects with little or no change in their future tender prices. This is because this type of contractor is usually very competitive in the market and their tender prices are mostly calculated based on a small percentage of profit and, therefore, they are more affected by the cost of CW. In response to the second question, all workshop participants expressed the belief that a number of issues can significantly affect the behaviour of contractors, from management to labourer level, towards the adoption of CWM in Jordanian projects. These were as follows:

- According to all workshop participants, having a clear and comprehensive background about the different causes of CW is very important during the construction process. Understanding the correct work procedures and curtailing any wrong habits regarding the implementation of work, can help complete the job more efficiently with minimal materials wasted. This argument confirms the findings of the Delphi study and the literature review (see section 6.5.1), as well as highlighting one of the major reasons why it may be more difficult to implement effective waste minimisation measures in construction projects.

- Those in the lower level of the managerial hierarchy (P6 & P7), revealed that a good employee-manager relationship encourages a strong sense of loyalty in employees while performing their work. This heightened sense of loyalty, bolstered by mutual respect, can improve company productivity and maintain employee retention. Supervisor P7 said that "*... when respect is violated between managers and their employees, the quality of the work will suffer*". This finding is in line with findings from the Delphi study (see section 6.5.1). However, site manager P6 added an important point saying that a strong employee-manager relationship encourages a sense of loyalty in employees to go beyond their work remit ensuring that the work is completed effectively. For example, an employee can perform the work and agree to make an extra effort as part of their dedication to their managers when he/ she works in a respectful, encouraging work environment.

- According to all participants, maximising the profit of the construction project is a major concern for many project stakeholders towards CWM. This will increase their interest and willingness to maintain the minimum amount of CW. However, participants P4 and P7 argued that some contractors and clients do not invest in CWM as they try to reduce costs, such as the use of LWTs, and invest more time and money in construction planning and supervision. According to participant P4, this issue could be overcome by enhancing the awareness of the project stakeholders about the financial gains that can result from the effective implementation of such measures including enhanced work performance and quality, increased productivity and less CW generation. This is particularly important for small and medium-size contractors as they try to maximise their profits as much as possible by reducing the initial cost while not perceiving the long-term profit from CWM. This finding is in the line with findings from the literature review as well as the Delphi study (see section 6.5.1).

- According to participants P1, P2, P5, P6 and P7, landfill disposal charges and a higher penalty for illegal waste dumping, both act as strong influencers in respect of CW collecting and reuse as well as proper and safe CW disposal. There were no doubts among these participants that both issues are significant in terms of forcing project managers to adopt such measures. This indeed confirms the findings of both the literature review and Delphi study in section (see section 6.5.3).

- Another interesting point was made by those responsible for the project planning (P3, P4 & P5), in that there is a strong link between the opportunities which a construction organisation provides and the degree of effort in minimising CW. In this respect, project manager P5 with the longest experience in project planning pointed out: "…*at the end, it was noted that construction workers over issues such as effective planning, proper equipment, and adequate material storage, were key constraints affecting to the workers willingness to conduct construction waste minimisation measures*". The many issues mentioned in the above quote confirm the findings from the literature review as well as the Delphi study (see section 6.5.4).

- Lead managers P1and P2 indicated that the adoption of modern LWTs is largely useful for the Jordanian construction industry in respect of CWM. However, they argued that the adoption of such technologies is mostly dependent on the level of convenience and practicality of integrating these technologies with the current practices, especially given that many contractors are still utilising traditional methods of construction. This finding is in line with findings from the literature review as well as the Delphi study (see section. 6.5.2).

In terms of the responses to the third question:

- *"Have you used any frameworks in past projects as a means to understand the issues influencing the adoption of construction waste minimisation behaviour?"*

It was interesting to note that the workshop participants revealed that they were not aware of any behaviour adoption frameworks which could be used to understand the issues influencing the adoption of CWM behaviour in the Jordanian construction industry. They indicated that in some projects they have utilised simple and common methods in order to gain information about issues affecting the job performance in construction projects, such as survey questionnaires and a complaints form. However, the participants noted that such methods are considered basic and inadequate in order to effectively explain CWM behaviour. Lead manager (P1) with the longest experience commented: "*we had no idea about any behavioural adoption frameworks that could deal with the implementation of construction waste minimisation measures, and if we had known about them, we would have definitely used them*".

Another participant, P6, added that: "*we always depend on the old traditional method when there is a need to figure out a certain problem affecting the work performance, these methods can sometimes do the job, but it's still much better if we have a comprehensive system to employ, for such situations*". Comments such as this provided the researcher with extra justification for undertaking this study and also emphasised the importance of ensuring that the results are properly valid.

7.3.2 Verification of the BF content, structure and applicability

Following discussion on the need for BF, it was presented to the workshop participants who were then asked to validate the factors within each of the four main variables of the framework (i.e., personal, technological, social and organisational), affecting CWM behaviour. They were instructed to assess the BF structure and its integrated factors in terms of terminology, appropriateness and how applicable they were to the Jordanian context. This validation process aims to validate the BF through the different perspectives of the workshop participants, from their knowledge and experiences working the in Jordanian construction industry.

7.3.2.1 Verification of the BF content

To validate the factors influencing the behaviour of Jordanian contractors towards CWM, the workshop participants were asked the following questions:

- "*In your experience and opinion, are the factors presented in the BF applicable in the Jordanian context? Are there any other factors missing?*"

The workshop participants were in agreement with all of the BF factors influencing the behaviour of Jordanian contractors towards CWM. Interestingly, all workshop participants indicated that not all of the BF factors were considered to have the same degree of significance as some were seen as more fundamental than others by different participants. They argued that the level of influence of the factors can be different depending on several issues, such as the nature of the project, regional location and the particular socioeconomic circumstances a project takes place in. This is as expected as the BF factors could potentially vary from project to project when applied. Notably, this confirmed what was reported in section 6.4 about the application criteria and situation of the BF. Having discussed the workshop participants' views and opinions on the factors within the BF, the results from the literature review, the Delphi study and the workshop are tabulated and presented in Table 7.2. A detailed analysis of the discussions is presented in the following subsections. It should be noted that as the BF was introduced, workshop participants provided more insights and highlighted important aspects of implementation.

Table 7.2: Cross-referencing of the BF factors based on the tabulation of findings from the literature review, Delphi study and the workshop

Factors	Subfactors	Literature	Delphi study	Workshop
Construction-related Knowledge	Awareness of the causes and types of CW	✓	✓	✓
	Knowledge and awareness of LWTs	✓	✓	✓
	Skills and expertise in the handling of construction errors	×	✓	✓
	Awareness of the financial gains of CWM	✓	✓	✓
	Awareness of the negative environmental impacts of CW	✓	✓	✓
Personal norms	Courtesy between the different levels of employees	×	✓	✓
	Religious obligations	×	✓	✓
Perceived usefulness	Cost reduction incentives	✓	✓	✓
	Enhanced work performance incentives	✓	✓	✓
	Health and safety incentives	×	✓	✓
	Rewards incentives	✓	✓	✓
	Environmental benefits incentives	✓	✓	✓
Additional factors	Perceived increased workloads	×	✓	✓
	Belief that waste is inevitable	✓	✓	✓
System ease of use	System complexity and learning difficulties	✓	✓	✓
	Technical support from vendor	✓	✓	✓
System compatibility	Compatibility with the existing construction practices	✓	✓	✓
	Compatibility with the project nature	✓	✓	✓
Descriptive norms	The practices of peer-practitioners	✓	✓	✓
	Interest of contractors in CWM	✓	✓	✓
	Wasteful culture	×	✓	✓
Conjunctive norms	Financial charges and penalties	✓	✓	✓
	Governmental supervision	✓	✓	✓
	Green construction practices	✓	✓	✓
Projects' constraints	Time constraints	✓	✓	✓
	Cost constraints	✓	✓	✓
Facilitating conditions	On-site planning and management	✓	✓	✓
	Technical support	✓	✓	✓
	On-site supervision	✓	✓	✓
	Training and information support	✓	✓	✓
	Management change	×	✓	✓

7.3.2.1.1 Verification of the factors within the personal variable

All the workshop participants agreed with all of the personal factors in the BF as essential factors in successfully integrating CWM processes into Jordanian construction projects. The participants held similar views which confirmed the findings from both the literature review and the Delphi study (see section 6.5.1). According to participants P1, P2, P3, P5 and P6, labourer knowledge of CW, especially regarding its causes and the different types, is very important. Site manager (P6) with extensive on-site experience said: "…*even with the best intentions of reducing unnecessary waste, without the labourers knowing how to do so, it is very hard to deliver on construction waste minimisation targets*". All project managers (P3, P4 & P5) were particularly enthusiastic when it came to discussing knowledge of how to handle design changes, especially those imposed by the client, as this is commonplace in the Jordanian construction industry. They pointed out how, without proper handling of on-site management, design changes can lead to the generation of excess CW.

Another point made by participants P3, P4, P5 and P7 was that the cost reduction aspects of CWM can act as a major incentive for project managers. However, they added that whilst financial incentives encourage some managers, others may not see CWM as an opportunity for financial gain because they perceive it as an increased cost due to lack of awareness and knowledge about such an issue. Further, participants P6 and P7 emphasised the importance of reward incentives and their huge influence on enhancing CWM behaviour. Foremen (P7) with an extensive experience supervising labourers indicated with regard to CWM incentives, that there is little controversy over their effectiveness. This was particularly pertinent to labourers, who are major contributors to CW generation. Despite this, incentive schemes are not implemented in Jordan and, therefore, participants P6 and P7 strongly believed that more consideration should be given to this issue.

All participants confirmed the positive effects of good employer-employee relations in order to improve productivity, and therefore CWM, through an increased sense of loyalty and commitment. One interesting point was made by project managers P3 and P5, regarding the perception of many labourers that generating CW is inevitable. They explained that many contractors use traditional methods of construction, some of which will result in waste generation by default (unavoidable waste). This, over time, can lead labourers to believe that this waste is inevitable. Therefore, the adoption of LWTs that can minimise or even eliminate waste at its source can help change these attitudes. Participant P5 said that "… *many contractors rely on traditional methods, but the criteria of applying some of these construction methods may result in unavoidable waste, whilst they are unaware alternative methods can prevent this*".

Lead manager (P1) with more than 15 years' experience in LWTs, further explained that as a result, education about the types of technologies that can assist CWM and their effectiveness should be emphasised. This reflected the comments made by participant P4 in section 7.3.1, when discussing the importance of enhancing knowledge of LWTs

7.3.2.1.2 Verification of the factors within the technological variable

It is clear from the participants' discussion that there was consensus on the relevance of the technological factors to CWM. Particular emphasis was placed on two aspects of the application of LWTs that aid CWM: operational difficulty in the use of a system, and the compatibility of a system with the project's nature (i.e., size, type and budget). It is evident that both have a strong influence on the success of the projects' performance, which in turn encourages the adoption of LWTs to achieve CWM. However, if inappropriate LWTs are applied, they may negatively affect performance and actually inhibit the adoption of such technologies.

Those that are on the front line and responsible for supervising the implementation of LWTs in construction sites (P6 &| P7), discussed how system ease-of-use affects the adoption and success of LWTs' implementation. They were mostly concerned with the difficulty in operating complex technological systems and/or tools and applying them efficiently. Site manager P6 indicated that "*…a big issue in the Jordanian construction industry is that many projects sometimes adopt sophisticated, modern technologies, but a lot of contractors lack the experience to use them properly*". Project manager P4 added that "*not many companies in Jordan can provide the technical support for complex technologies such as BIM, lean, etc. and this can also make it difficult to use these systems effectively*".

On the other hand, participants P1, P2, P3 and P5 emphasised the importance of system compatibility particularly with regard to a projects' type, but also the size and budget, which are strongly related issues. Project manager P5 explained that "*many projects in Jordan are small to medium-sized, and stakeholders don't see a lot of construction technologies that could reduce waste as appropriate, discouraging their adoption*". It became clear in the participants discussion that many stakeholders may not perceive the application of certain or, in some cases, all LWTs as suitable, particularly in smaller scale projects. Therefore, Lead managers P1 and P2 agreed that applying LWTs can benefit CWM, but it is, most importantly, a matter of selecting the appropriate technology for a specific project.

7.3.2.1.3 Verification of the factors within the social variable

With regard to social factors, it was notable that the participants, particularly those that are in the upper level of the managerial hierarchy (leader managers & project managers), focused more on the role of conjunctive norms than descriptive norms in terms of social effects. Lead manager P1 discussed the importance of CW laws and regulations saying: "…*in countries where awareness of waste and the issues it causes are not common, measures to minimise construction waste can still be enforced through fines and penalties*". All participants confirmed that waste disposal fees, illegal dumping penalties and establishing effective policies, whether the policies are created by governments or within construction organisations, can be greatly effective in forcing the construction industry to minimise waste. However, some interest was also expressed in how contractors may be unconsciously influenced by wasteful habits present in their society as these social influences can affect all aspects of life, including work.

There was debate over the provision of waste management plans by Jordan's government. While there was no doubt, among all participants, that regulating effective waste management plans are extremely influential with respect to CWM outcomes. However, participants P2 and P5 showed concern over the availability of requisite opportunities and resources with such an issue. They provided one example where the recycling infrastructure for solid waste in Jordan is very poor, as there are insufficient numbers of recycling plants as well as a lack of advanced effective technologies for recycling. Further, the recycling market in Jordan is very limited and immature and as a consequence would discourage contractors from adopting recycling practices. Participant P6 pointed out that "…*the problem is that even if there is initiative from the government to do so, it will not be feasible or practical. There should be solid bases for any plan in order to be successful, and how can they regulate such plan if there is not even a proper recycling facility or a robust governmental monitoring in waste disposal*".

7.3.2.1.3 Verification of the factors within the organisational variable

There was no doubt amongst the workshop participants that the availability of resources and opportunities provided by the organisation is significant in facilitating waste minimisation in construction projects. Project manager P4 said that "*the success of construction waste minimisation all depends on the company providing the employees with the means and ability to implement waste reduction*". According to project managers responsible for the planning of construction projects (P3, P4 & P5), not putting sufficient resources into a project (e.g., time and money) can seriously affect work performance in general, including CWM. Without adequate resources, many workers, especially labourers, are more liable to rush and produce low quality work. Some managers will try to save costs by saving time rather than minimising waste, and therefore will not invest in CWM. Project manager P4 explained: "*managers can save money by reducing the timeline for a project, perceiving this as the best way to reduce financial costs, perhaps not realising the financial benefits of providing time to properly minimise waste*".

Another point was made by the on-site management (P6 & P7) that the provision of adequate opportunities for employees, such as the availability of efficient planning, can greatly enhance work performance which will support CWM. By improving the general job performance, construction managers can also reduce the chance of logistical issues with supply-chain management as well as the work structure breakdown and the sequence of work, as these issues may result in large amounts of CW. Furthermore, efforts to minimise these incidents which generate CW can be supported by equipping the on-site workers with efficient and well-maintained equipment. Supervisor P7 explained how it is particularly important to address these issues, as they are particularly prevalent in Jordan. He said that "…*in the Jordanian construction industry, many contractors don't realise that by focusing on minimising waste, they can also reduce costs in this way. The measures put in place to minimise waste, such as proper planning and execution of work, can also benefit the project in general*".

One point which was not confirmed by the lead managers (P1 & P2), was how management change can affect CWM. Whilst there was some agreement over the effect management change may have on work performance, these two participants did not see such issue as having a major or direct influence on CWM. One example provided by lead manager P1 was how management change, in many cases, does not result in a sudden change to a project or the workflow of an organisation. Even if changes are implemented, lead manager P1 added that these changes tend not to be significant and often effect the management structure rather than on-site workers. Furthermore, there was debate over how quality control can impact CWM in relation to on-site supervision. All participants agreed that monitoring the quality of work is extremely influential with regard to CWM outcomes. However, those with the responsibility for conducting such measures (P6 & P7) emphasised that efficient application of quality control measures was more important than the content and structure of the quality systems being utilised. ParticipantP6, pointed out that "*even a robust monitoring and reporting system will be ineffective in minimising waste if it is not sufficiently applied to a project in an effective and strict way*".

7.3.2.2 Verification of the BF structure and applicability

To validate the applicability and structure of the BF, the workshop participants were asked the following questions:

- "*Do you think that the BF's structure and terminology is easy to understand? Is it valid as a tool for identifying and understanding the factors influencing waste minimisation behaviour in Jordanian construction projects?*"

When the BF was demonstrated to the workshop participants there was general agreement with the logical flow, contents of the framework and its relevance to application in construction projects. All participants agreed that the BF's structure was well planned, clearly set out, useful and easy to understand. Project manager P5 stated that "*in my view, the framework is very useful and understandable as it covers all the issues affecting the implementation of CWM in the Jordanian construction industry*". However, participants P1, P2, P3 and P6 argued that some of the terms within the BF such as "system complexity" and "management change" might seem vague or difficult to understand for some construction professionals. Thus, they suggested that the BF should be accompanied by some additional information, such as a brief explanation of the factors within the BF, that could help to avoid any confusion caused by the ambiguity of the terms, particularly as they will be used by different organisations.

Upon discussion and review of the BF, the participants were satisfied with the its capacity as a solid basis for decision makers in the construction industry to explain and predict CWM behaviour. Participants P1, P3 and P5 with extensive experience in the construction industry, believed that the BF is robust and applicable to a wide range of construction projects in terms of scale, technological and sociological contexts. They also suggested that the BF would be very efficient not only for contractors but for consultants as well, since the four variables of the BF can also influence the perception of architects and designers towards a better and more efficient design. Lead manager P2 added that such a framework would also be very useful for the relevant governmental authorities in Jordan such as: The Ministry of Environment and The Ministry of Municipals Affairs, for establishing effective waste management plans. Moreover, some participants (P2, P4, P6 & P7) also made the observation that the BF is capable of a better explanation of CWM behaviour in certain contexts than existing methods, due to the structure in which the variables are categorised. They indicated that due to the BF's clear separation of key variables, it could be an intuitive tool for project managers to use in decision making on CWM.

According to participants P2, P5 and P6, many of the existing methods (e.g., survey questionnaire) cluster the causes of CW generation into categories (e.g., handling materials, on-site operations, etc.), which in fact, can be better discriminated from others. This is because such methods do not provide a comprehensive explanation of the relationship dependency and interaction between the causative factors of CW generation, and the lack of explanatory power as a result of this. Confirming this, project managers with extensive planning experience (P4 & P5) commented that the BF encompasses and integrates recognised key variables, successfully mapping the relationships between them and, in doing so, adds value to the overall predictive power of the BF. For example, the inclusion of technological factors as a main variable in the BF was recognised by the participants as a relevant and more contemporary way of understanding CWM behaviour in the 21st century, where technological advancement is one of the main shaping issues in the construction industry. The following comments illustrate the key points of the workshop participant's discussions on the applicability of the BF:

- Workshop participants P2, P3, P5 and P6 were in consensus that part of the strength of the BF lies in recognising personal factors as a primary variable in impacting CWM behaviour. According to participants P2 and P3, personal factors can influence one's self-concept which is reflected in their ability to take the appropriate and necessary actions to achieve CWM whilst performing construction activities. Therefore, they recognised such factors as a critical element in influencing the contractors' job performance. Project manager P3 discussed how personal factors reflect the mental state of readiness, in terms of experience, moral norms and self-efficacy, exerting a direct and dynamic influence on the individual's behaviour whilst engaged in their work. For instance, a construction labourer may not be well engaged in CWM activities if they perceive that it will increase their workload or if they lack the experience, knowledge or concern to engage in CWM activities. Furthermore, project managers P3 and P5 were in strong agreement with the effect of personal factors in the BF, on strongly influencing the other three variables of the BF. They elaborated that if the personal factors are not sufficiently addressed within the framework, the other variables are insufficient to explain and predict CWM behaviour. For example, even when utilising efficient modern LWTs or provided with sufficient time, resources and effective planning, CWM behaviour may not be successfully achieved if the employee lacks concern or experience.

- All participants of the workshop were in agreement that the adoption of effective and modern LWTs can assist in CWM. This finding was also mentioned in the Delphi study (section 5.3.3) as a major contributing issue. Participants (P6 & P7) with more than eight years' experience in construction sites operations, commented that minimising CW through the adoption of LWTs, especially in the finishing phase of the project, can make a major difference in achieving CWM targets. Site manager P6 said that "… *using modern tools can make the work easier and faster, and in most cases, it can largely prevent the generation of material waste*". They further elaborated that in order to predict and explain the issues affecting the adoption of LWTs in construction projects, the application of the BF would best be carried out with two parties simultaneously: firstly, in explaining the behaviour of construction stakeholders as decision makers in the adoption of CWM technologies; secondly, in explaining the behaviour of construction staff (e.g. site engineers, foremen, labourers) in providing feedback for on the utilisation of these technologies.

- Social factors were also accepted by all workshop participants as a significant variable influencing CWM. The participants were mostly concerned with policies and regulations which they regarded as most important due to their significant impact on CWM behaviour. As reflected in the Delphi study (see section 5.3.4.2), participant P5 elaborated that rules and policies can be considered, in many cases, to be the most effective way of controlling CW as they can discourage wasteful behaviour through imposing penalties. One interesting point was made by participants P1 and P6, who emphasised the link between technological progress and social pressure. They commented that imposing mandatory restrictions on the adoption of LWTs (i.e., minimum requirements) can greatly assist CWM measures. Participant P6 said: "*the adoption of standardised methods of construction and the introduction of minimum requirements for the technologies utilised in construction projects can both help avoid generating waste, additionally helping familiarise the workforce with these technologies*". Despite this, Project manager P3 discussed how societal pressure may influence CWM through social attitudes and norms (e.g., cultural conscientiousness towards waste in general). He elaborated that wasteful behaviour can be a significant societal issue unless it is kept in check by incentives such as moral and religious norms. Lastly, all participants agreed that social aspects, either enforced by rules and regulations, or strengthened by societal norms, should be considered when analysing any kind of human behaviour as people are predominately influenced by their social conditions.

- Participants P2, P4, P5 and P7 emphasised that the logistical role construction organisations perform is also an important influence on the success of implementing CWM measures. Participant P2 went on to specify how organisational factors are strongly connected to technological factors; if sufficient investment and technical support is allocated to LWTs in a project, the efficacy of these technologies will be improved. As a result, employees are more likely to interpret any proposed CWM measures as feasible, increasing the success of these measures in minimising waste and encouraging managers to utilise these technologies in other projects. Furthermore, in contrast to project managers P3 and P5's comment on the importance of personal factors, conversely, supervisor P7 discussed how organisational factors such as increased resources (e.g., time, opportunities for training and technical support) can increase the labourers' perceived control over CWM, and improve attitudes towards CWM measures. This confirms the view of Ajzen (1985), who emphasised the dependency of performing certain behaviour on the availability of requisite opportunities and resources.

7.4 Summary of the workshop

The workshop participants agreed on the importance of identifying and understanding the factors influencing the behaviour of contractors towards CWM. This is to enhance the current level of CWM adoption in the Jordanian construction sector which was confirmed as unsatisfactory. The BF was considered valid because the participants perceived it as useful in providing an effective understanding of the factors influencing CWM behaviour in the Jordanian construction industry. In expressing their belief that no appropriate behavioural adoption framework is currently available, they have welcomed the proposed BF indicating this to be a good starting point from which a road map might be produced for the effective implementation of CWM behaviour in order to achieve the best outcomes.

The discussions made by the workshop participants revealed that the four main variables of the BF are perceived to have a significant impact on the explanatory power towards the adoption of CWM behaviour. This is in addition to the dynamic interaction between these variables, successfully mapping the relationships between them adding value to its overall explanatory power. Further, the participants indicated that the practicality of the BF lies in it being easy to understand and applicable to a wide range of construction projects, in terms of scale, technological and sociological context. This is in addition to the framework capacity as a solid basis for decision makers in the construction industry including consultants and contractors, to explain and predict CWM behaviour. They also suggested that the explanatory power of the BF would be of great benefit to relevant governmental authorities for establishing effective waste management plans.

Accordingly, there were no changes made to the initial behavioural framework in section 6.5, as it's structure, variables and integrated factors have all been validated and confirmed (see Figure 7.1). However, the participants made interesting suggestions for the effective application of the BF. They suggested that some of the BF terminology might seem vague or difficult to understand for some construction professionals and thus, should be accompanied by some additional information such as a brief explanation of the factors to avoid any confusion and ambiguity. Additionally, the participants indicated that the BF factors could potentially vary from project to project when applied, depending on the nature of the project, regional location and the particular socioeconomic circumstances. Consequently, the outcomes of the BF in a project should not be used in another project. Figure 7.1 illustrates the final BF incorporating the factors influencing the behaviour of contractors towards CWM as validated by the workshop participants. It should be noted that the validated variables and factors affecting CWM behaviour may not be entirely applicable in other countries as they would need to be assessed and validated in their socioeconomic context. They are also time-dependent on Jordan’s current construction climate at the time of investigation.

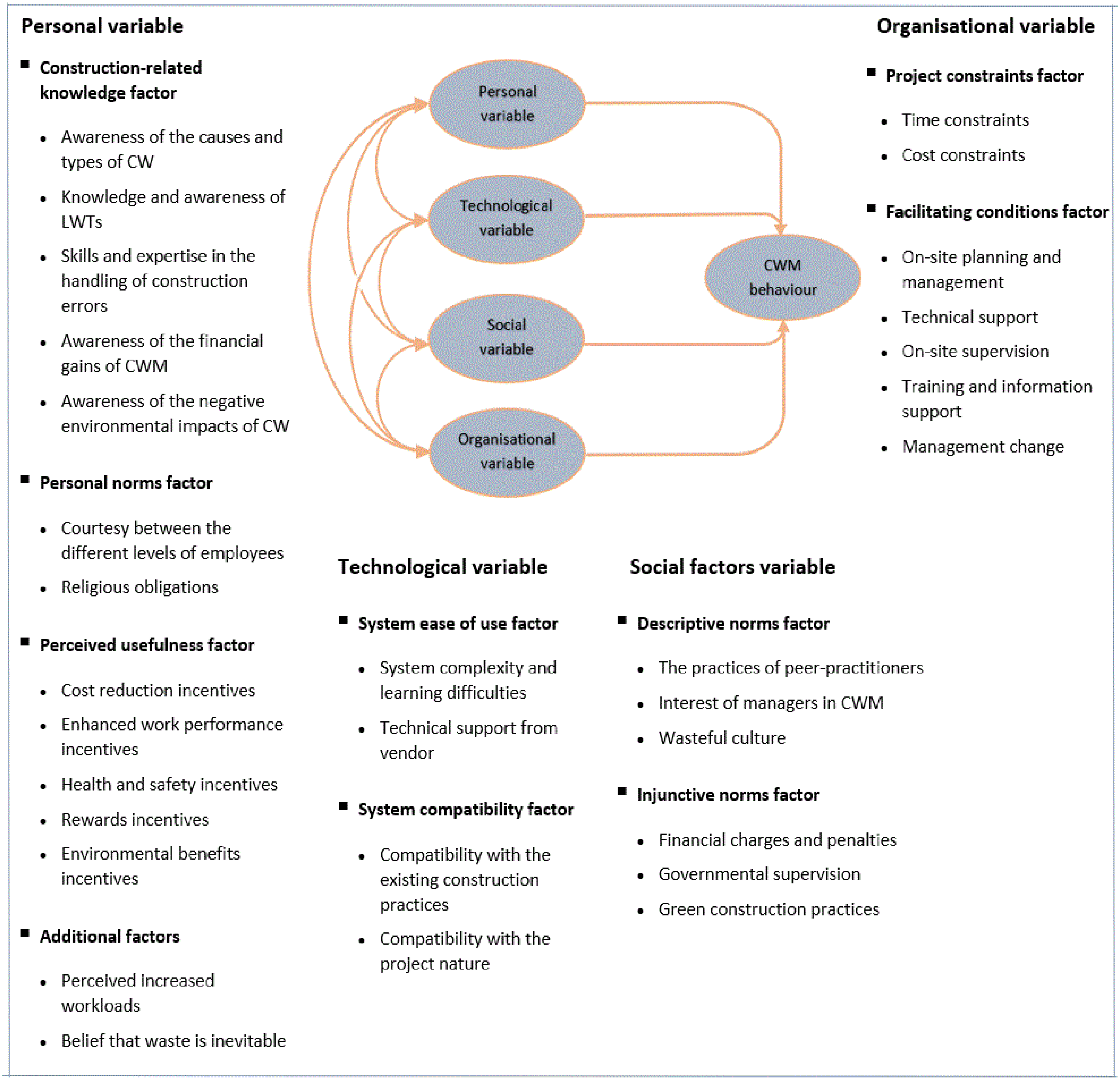

Figure 7.1: The final BF of factors influencing the behaviour of Jordanian contractors towards CWM

7.5 Conclusion

This chapter has presented the final stage of the research which was to validate the developed BF. A workshop method was used in which seven participants with extensive expertise in the construction industry, assessed the applicability of the BF and the factors influencing the behaviour of contractors towards CWM in the Jordanian context. The workshop participants were asked to bring their experience and knowledge of the implementation of CWM behaviour to bear in verifying the BF. In conducting this, they were able to offer intelligence that subsequently enabled the researcher to validate the BF so as to be of value to the Jordanian construction industry. This contribution is also seen to be of particular value in providing researchers and future studies with agenda in respect of securing the foundation for attitudinal change among the construction stakeholders including clients, designers and contractors. A summary of the entire research, including the main findings, its limitations, novelty and recommendations for future research, will be provided in the following chapter.

Chapter 8

Conclusion, Limitations and Recommendations

8.1 Chapter overview

As stipulated in Chapter 1, this study aimed to develop a behavioural framework (BF) to support the adoption of waste minimisation behaviour by contractors in Jordanian construction projects. Chapters 2 and 3 reviewed the relevant literature on the topic of CW and the need to address behavioural approaches to foster improved CWM. Accordingly, Chapter 4 discussed and justified the research methodology employed for this study. Chapter 5 detailed and discussed the findings from the Delphi study interviews and, subsequently, Chapter 6 formulated the initial BF of the factors influencing the behaviour of Jordanian contractors towards CWM. Thereafter, Chapter 7 refined and validated the final BF. This final chapter summarises the research findings as they were presented in this thesis, and highlights how the research aims and objectives of this study were investigated and addressed. It begins by presenting a synthesis of the research objectives with a discussion of the key findings and a summary of the value (contribution to knowledge) of this PhD study. Following this, the research methodology critique, the study's limitations and the research novelty are discussed and, finally, recommendations for future research are presented.

8.2 Synthesis of the research objectives

To achieve the aim of this study, namely to develop a behavioural framework (BF) to support the adoption of waste minimisation behaviour by contractors in Jordanian construction projects, five objectives were established, as presented in section 1.4. The first objective was to gain an extensive knowledge and understanding of the need for waste minimisation and its related adoption issues in the construction industry; the second objective was to explore existing behavioural theories and frameworks and their effective application in a CWM context. Both these objectives were achieved through a comprehensive review of the literature (i.e., journal articles, books, conference papers, websites, reports and statistics) and were presented in Chapters 2 and 3 respectively. The third objective was to investigate and identify the factors influencing the behaviour of Jordanian contractors toward waste minimisation during the construction stage; this was achieved through the analysis of the data gathered via the Delphi study interviews, as described in Chapter 5. Based on the tabulation of the findings of the literature review and the Delphi study, in Chapter 6, the fourth objective was addressed, namely, to develop a BF to support the adoption of waste minimisation in the construction stage of projects using Jordan as a case study. The fifth and final objective was to validate the developed BF for effective waste minimisation for contractors in Jordanian construction projects; a workshop with seven construction professionals, as presented in Chapter 7, ensured that this objective was accomplished. Figure 8.1 provides a pictorial illustration of the research process which was successfully carried out through the execution of the literature review, Delphi study and validation workshop. However, the following subsections discuss in more detail how the research objectives were achieved and briefly outline the key findings.

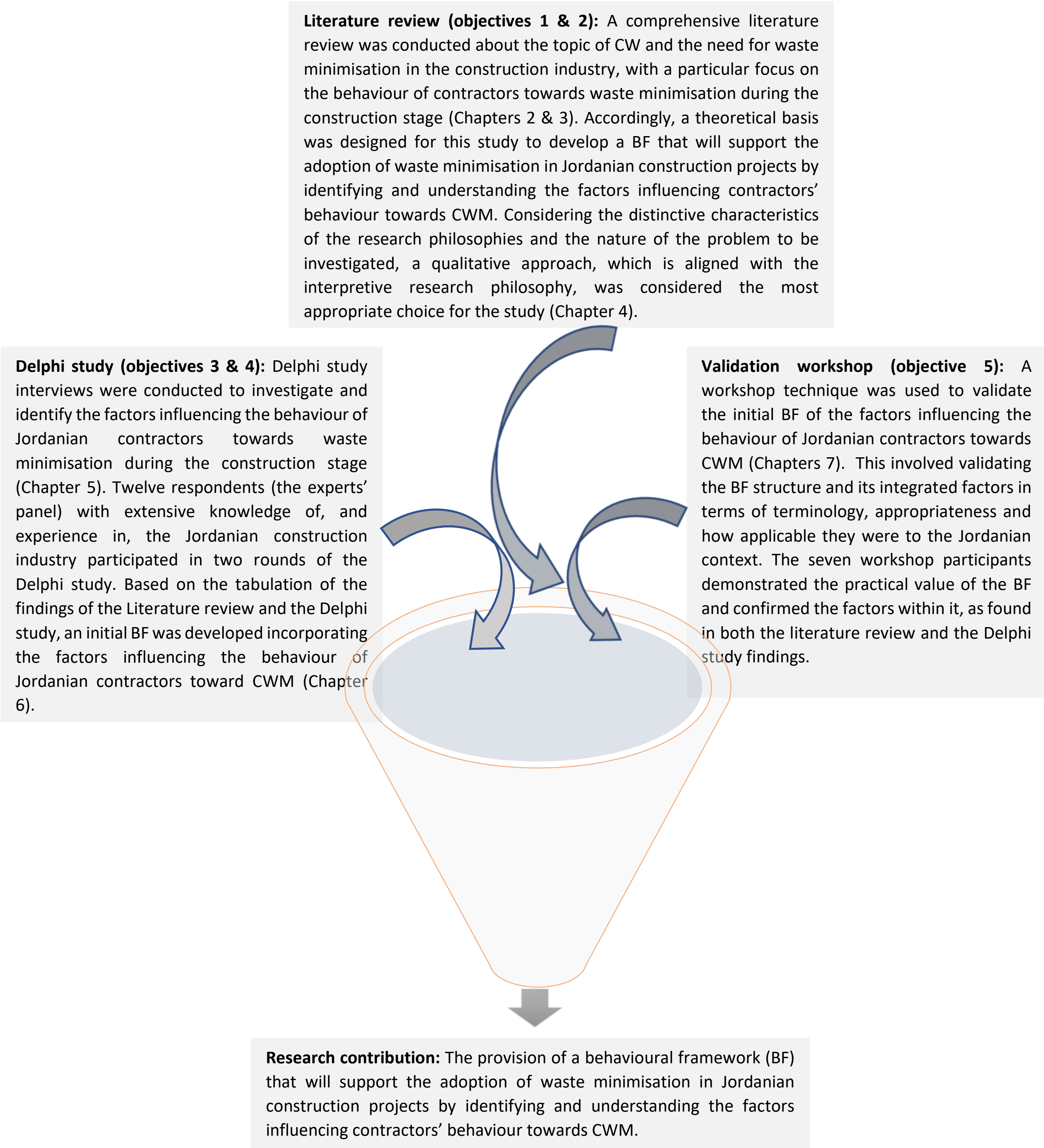

Figure 8.1: Pictorial representation of the research process (findings and contribution)

8.2.1 Objective 1: To gain an extensive knowledge and understanding of the need for waste minimisation and its related adoption issues in the construction industry

This thesis began with an extensive review of the existing literature (Chapter 2) on the fundamentals of CW as a subject together with its definition, origins, causes and its minimisation methods and need. Following this, the chapter went on to discuss the need and current uptake of CWM in the Jordanian construction industry. The purpose of this was to gain a theoretical understanding of the principles of, and the need for, CWM as well as to benefit from the challenges and experience of the developed countries toward effective waste minimisation in the Jordanian construction industry. In doing so, the problem of waste was found to be largely attributed to the behaviour of those working in the construction industry towards waste minimisation. The following is a summary of the key findings:

- Solid materials waste is a colossal problem in construction sites and is considered to be one of the major contributors to the total waste production, generating around 36% of the total solid waste worldwide equating to 2.5-3.5 billion tonnes each year. It was identified as most critical due to its impact on the three pillars of sustainability at the project, as well as, the national level. At the project level, CW impacts stakeholders' profits and reputation as well as the project's performance and productivity. At the national level, CW causes national and even global environmental problems as well as a financial load on governments dealing with CW and its related problems (see section 2.4.2).

- The construction stage was identified as the most critical stage in terms of CWM. This is because of two main reasons. First, waste generation is usually upmost in the construction stage since it includes a wide range of activities that may contribute to waste generation. While it was acknowledged that design-out practices are important issues in terms of their benefit towards waste minimisation, the amount of waste generation can still be significant, if it is poorly executed during the construction process. Conversely, effective implementation of on-site practices can minimise any waste that originates directly from the construction stage and indirectly from the design stage and, therefore, mistakes and errors made during design can be corrected and avoided. Second, waste generation can be avoided and reduced at the origin during the construction stage, whereas demolition waste is often considered as non-avoidable waste since there is a strong chance of producing significant amounts of it once the whole structure is demolished (see section 2.3.3).

- Human factors play a major part in waste generation and minimisation in construction projects. This is because most common causes of CW are directly or indirectly affected by the behaviour of the personnel involved in the construction industry and, therefore, by changing their perceptions and attitudes, particularly that of contractors, it will lead to the avoidance of these causes (see section 2.3.3.1).

- Different approaches have been established to address the issue of CW during the construction stage, including on-site waste minimisation practices, technological approaches, behavioural approaches and legislation. Despite the importance of these approaches and their relative benefits, waste minimisation in the construction industry has not always been successfully controlled due to a number of obstacles which constrain the successful adoption of such approaches. It was notable that behavioural issues such as lack of interest, poor attitude and perception, and lack of awareness and knowledge were the most common obstacles limiting the successful adoption of nearly most of the aforementioned CWM approaches (see section 2.4.3).

- CW has increasingly become a pressing issue in Jordan due to the scarcity of resources and a subsequent, unsteady energy supply, which are two serious challenges facing Jordan today. This is in addition to the poor economic situation in Jordan with CW considered a major financial burden on government spending having to deal with CW and its associated issues (see section 2.5.1).

- There are few studies currently available in Jordan concerning the subject of CW. However, from the researcher's s experience in the construction industry of Jordan and based on the existing studies found in the literature, it was noted that the construction industry is still suffering from insufficient sustainability practices. The following issues all contribute to the overall inefficiencies of CWM in Jordan (see section 2.5.2): the existing gaps in CW legislation; the participation of Jordan's construction industry in waste minimisation; the lack of provision of a comprehensive waste management plan; the capabilities of municipalities in controlling CW; and public awareness.

- It was noted that the human factor role is significant in terms of its impact on waste generation and minimisation in the Jordanian construction industry. More importantly, a critical appraisal of existing literature revealed that few studies are currently available regarding CWM behaviour in Jordan (see sections 2.5.2).

8.2.2 Objective 2: To explore existing behavioural theories and frameworks and their effective application in a CWM context

The literature review in Chapter 2 highlighted the apparent need to address behavioural approaches that support waste minimisation in the construction industry. Accordingly, Chapter 3 investigated the adoption of CWM behaviour through exploring existing behavioural theories and frameworks for their application in a construction context. This was to build a theoretical base for the research by identifying the factors influencing the behaviour of contractors towards CWM. Further, it provided a body of literature which helped the researcher's attempt to explore and understand the potential factors influencing the behaviour of contractors towards the adoption of CWM in the Jordanian context. In doing so, the following key findings are summarised:

- To date, there has been a lack of structured research that has fully addressed the role of the 'human factor' in CWM, as understanding CWM behaviour has proven to be most challenging and complex. This is because adopting positive CWM behaviour is dependent on many factors that contribute to its success or failure (see section 3.2).

- An extensive review of existing well-known behavioural adoption theories and frameworks revealed that nearly all of them have attracted heavy criticism from researchers for being too simplistic and inadequate in successfully predicting behaviour (see section 3.3.5). It has also been observed that the application of these behaviour theories and frameworks in the context of construction confirmed what was reported by those researchers in terms of their inadequate and simple construct which lacks additional important factors for the effective prediction of CWM behaviour (see section 3.4).

- Various factors in the relevant literature have been found to influence CWM behaviour (see section 3.4). However, such factors have been identified in developed countries and lack empirical evidence as to their applicability in the Middle-East region, particularly in Jordan; CWM behaviour is perceived and valued differently by different cultures.

- Based on the points above, it was concluded that there is a real need for a BF that will address the limitations of the existing behavioural adoption theories and frameworks in order to enhance the explanatory power in the prediction of CWM behaviour in the Jordanian context. The need for the BF was also necessitated because, to date, there is a lack of studies dedicated to identifying and understanding the factors influencing the behaviour of Jordanian contractors towards CWM.

8.2.3 Objective 3: To investigate and identify the factors influencing the behaviour of Jordanian contractors towards waste minimisation during the construction stage

To achieve this objective, data collection was conducted via the Delphi study through a series of semi-structured interviews with twelve participants (the experts' panel) with extensive knowledge and experience in the Jordanian construction industry. After the deployment of the interview questions in the Delphi study (Chapter 5), developed from the literature review in Chapters 3, the data that emerged from the opinions of the twelve experts confirmed that the positive behaviour of contractors in Jordanian construction projects can offer significant potential in terms of realising successful CWM outcomes. The experts' panel discussions revealed a number of issues that affect the perceptions and attitudes of Jordanian contractors towards the adoption of CWM behaviour (see section 5.4). The following is a summary of the key investigative findings:

- All experts, from management to labourer level, emphasised the importance of waste minimisation for the Jordanian construction industry in order to achieve SC (see section 5.3.1).

- The experts' panel emphasised the importance of the issues that can significantly influence the self-efficacy and capability of employees towards CWM behaviour in terms of motivational, cognitive and affective intervening issues (see section 5.3.2).

- There was little doubt amongst the experts that the characteristics of LWTs can act as an important determinant towards their adoption in Jordanian construction projects (see section 5.3.3).

- The experts' panel highlighted the importance of social pressure through which the engagement of Jordanian contractors in CWM can be largely influenced (see section 5.3.4).

- The experts' panel focused on how the provision of the requisite resources and opportunities by construction organisations can largely facilitate waste minimisation in Jordanian construction projects (see section 5.3.5).

8.2.4 Objective 4: To develop a BF to support the adoption of waste minimisation in the construction stage of projects using Jordan as a case study

The information gathered from the literature review (Chapters 2 & 3) and from the Delphi study interviews (Chapter 5) was subsequently used as a basis for the development of a BF (Chapter 6), which supports the identification and understanding of the factors influencing the behaviour of Jordanian contractors toward CWM. The tabulation of the findings of the literature review and the Delphi study was to ensure a comprehensive, up-to-date and appropriate development of the BF for the precise needs of this study; in this particular case, it was to ensure that it is relevant to Jordan. The following is a summary of the key findings:

- The BF consisted of four constituent variables that work together to explain and predict CWM behaviour. These are: personal, technological, social and organisational variables; each of these variables include several factors influencing the behaviour of Jordanian contractors towards CWM (see Figure 6.3)

- The successful application of the BF is based on a dynamic interaction between the aforementioned variables influencing CWM behaviour. This is because it was clear that there is a cause-effect relationship between the factors within the framework and, thus, failure to consider any one of them will lead to failure in achieving successful CWM behaviour (see section 6.5).

- All the issues identified in the literature review in section 3.4 were confirmed in the Delphi study. However, seven important issues emerged from the Delphi study which seem to have a major impact on the behaviour of Jordanian contractors towards CWM. According to the Delphi study, such issues seemed to be culturally specific and are strongly associated with the traditions and culture of the Jordanian construction sector as discussed below.

    - There was little question amongst the experts that the skills and expertise in the handling of construction errors can significantly aid CWM (see section 6.5.1). They indicated that rework resulting from design changes and construction errors are common issues facing contractors in Jordanian construction projects and, therefore, the capability and competency of managers in handling such issues during the construction process can largely reduce the chances of CW generation.

- The experts' panel emphasised the importance of courtesy between managers and employees in terms of creating a positive working atmosphere to encourage employees to be more loyal to the organisation and, as a consequence, productivity will also increase. The religious obligation of employees regarding the implementation of their work was also identified as an important issue in terms of enhanced work performance as well as increased productivity. This is because Jordan is highly influenced by religious and cultural traditions which can provide moral guidance for such employees regarding the implementation of their work (see section 6.5.1).

- On-site safety was highlighted by the experts' panel as a strong incentive, especially for on-site workers, towards CWM. They indicated that the sharp and heavy materials in construction debris create hazards and can result in injuries and accidents, which are common problems on Jordanian construction sites (see section 6.5.1).

- The experts' panel revealed that the perception that CWM will increase the workload had a major influence on a worker's attitude, particularly foremen and labourers, towards minimising waste in Jordanian construction projects. They elaborated that such a perception can result in workers neglecting the need to minimise waste as workers believed that it requires more time and effort in terms of waste sorting, collection or even source reduction measures (see section 6.5.1).

- Concern was voiced by the experts' panel that the behaviour of Jordanian contractors towards CWM can be largely influenced by the wasteful culture. They explained that Jordan's' society is strongly influenced by consumerism and materialism which encourages wasteful habits in people, including those in the construction industry (see section 6.5.3).

- The experts' panel focused on the impact of management change on the performance waste minimisation in construction projects. One interesting new factor that was identified through the discussion of the Delphi study was effective change management. They indicated that management changes, which can be frequent, sometimes cause interruptions which can affect the workflow of the construction process resulting in confusion among workers and task overlapping which, in turn, can increase the chance of generating waste (see section 6.5.4).

8.2.5 Objective 5: To validate the developed BF for effective waste minimisation for contractors in Jordanian construction projects

Seven construction professionals participated in a workshop (Chapters 7) in order to validate the initial BF, as presented in Chapter 6, in respect of the structure and the incorporated factors influencing the behaviour of Jordanian contractors toward CWM. The workshop participants demonstrated the practical value of the BF and confirmed the factors within it, as found in both the literature review and the Delphi study findings. The following is a summary of the key validation findings:

- The workshop participants demonstrated the practical value of the framework. They revealed that they were not aware of any behaviour adoption frameworks which support the adoption of waste minimisation behaviour in the Jordanian construction industry, as the common methods utilised to gain information about such issue are characterised as simple, basic and inadequate. Therefore, the participants were happy with the BF, indicating that it would provide a good starting point and, hopefully, become a road map for assessing CWM behaviour. Thus, the need for undertaking this study was confirmed (see section 7.3.1).

- The workshop participants expressed agreement with the BF in terms of its structure, logical flow, content and its relevance for application in construction projects (see section 7.3.2). The participants confirmed the importance of the BF factors towards CWM and their significant relevance for the Jordanian construction sector. However, they recommended that some additional information (such as a brief definition of some factors in the framework) should be accompanied with the BF to facilitate understanding. On these bases, the initial framework in Chapter 6 (see Figure 6.3) was validated in Chapter 7 (see Figure 7.1).

- The workshop participants indicated that the level of influence of the factors of the BF can be different depending on several issues such as the nature of the project, regional location and the particular socioeconomic circumstances of the project. This confirmed what was reported in Chapter 6 (see section 6.4) as to the ‘need’ and ‘how’ of the BF application. Further, the participants expressed strong agreement particularly on the importance of technological variable towards the adoption of LWTs in Jordanian construction projects (see section 7.3.2.1.2). This is because many of the contractors in Jordan (particularly small or medium-sized contractors) are still adopting familiar conventional methods of construction with minimal technology adoption.

8.3 Research methodology critique

The methodology applied in this study enabled the successful collection of data regarding the phenomenon of focus, that is, the development of a behavioural framework (BF) to support the adoption of waste minimisation behaviour by contractors in Jordanian construction projects. Since the nature of this study required the researcher to understand, explore and elicit opinions, views and perceptions of the Jordanian contractors toward the adoption of CWM (as stipulated in Chapter 3), it was clear that the research falls mainly within the interpretivist philosophy paradigm (see section 4.4.3). This is because such a paradigm which is governed by the qualitative inquiry of "what" and "how" questions, allowed the researcher to investigate in-depth and insightful information and explanations of the data to be collected: factors influencing the behaviour of contractors towards CWM. Accordingly, a qualitative approach, which is aligned with the interpretive research philosophy, was selected and a Delphi interview technique and validation workshop were used to meet the study's aim and objectives.

The Delphi technique, incorporating a series of semi-structured interviews, was chosen as the primary research investigative method because of its ability to offer a well-informed look at the current and potential status of the adoption of CWM behaviour among Jordanian contractors (section 4.5.5.3). Such a technique was undoubtedly invaluable allowing the Delphi experts' panel (interviewees) holding differing perspectives and differing cognitive abilities, to refine their views based on the results of each round of questions. The researcher determined that no specific type of construction project would be targeted (e.g., commercial, residential, etc.) as the nature of the built environment is labour intensive and, thus, waste is generated in all types of projects. There was, however, a limitation realised throughout the Delphi technique which is that the sample experts for the Delphi study were restricted to the views of the twelve experts that the researcher had managed to gain access to. The reliability of the findings could be increased by including more experts. However, the experts were well balanced and included representatives from across the contractor's employees, including lead construction managers, project managers, site managers, foremen and labourers, which strongly supports the validity of the findings of the Delphi study.

The workshop technique was used as an effective qualitative method for validating the BF (see section 4.5.5.4) as it enabled detailed roundtable discussions. A group of seven participants were capable of providing insights in respect of the factors currently influencing the behaviour of Jordanian contractors towards CWM, as well as offering intelligence that subsequently enabled the researcher to refine the BF in such a way that it was tailored to be of value to the Jordanian context.

8.4 Research limitations

In the course of conducting this research, the following challenges were encountered. They have been categorised under four main group, namely literature review, Delphi study, sampling, and data analysis.

- literature review: There were problems in finding adequate information relevant to the study area in the Jordanian context, as only a limited amount of work (e.g., research studies, reports, statistics, etc.) was available on the CW subject in the Jordanian construction sector. That said, in adding to the small body of knowledge already available, this study has made a strong contribution to the literature.

- Delphi study: Additional and more extensive interviews could have been conducted to gather a larger body of qualitative data for the Delphi study. However, as an independent researcher, there were financial and time constraints regarding how much data could feasibly be collected and analysed. Further, although, in this study, the developed BF has proven to be valid and applicable for its intended use there are, however, some uncertainties as to what extent the BF will contribute to the successful implementation of CWM behaviour in a real-life context. This is because the true effectiveness of the BF can vary between construction projects depending on the nature of the project, the time period of the framework application and the methods of evaluation and testing and, thus, further investigation in future studies is required.

- Sampling: No female perspectives were included in both the Delphi study interviews and the validation workshop, and nor was the influence of gender on SC practices explored in the literature. Despite being a traditionally male-dominated landscape, the modern era is seeing more females entering the domain of construction either as physical operatives or as management professionals. However, generally, there are still very few females working in the construction industry in Jordan, and the researcher did not ensure that females were a requirement of the expert sample. Whether this lack of gender focus would have influenced the findings of this study remains unclear, but the fact that it was not considered represents a limitation to this study.

- Data analysis: Since this study was conducted in an Arabic country, translating the Delphi questions proved challenging, as some of the translated Arabic terminology was overly technical and/ or academic and ought to be rephrased in simpler words while ensuring the same meaning. However, the researcher managed to overcome this challenge by consulting Jordanian construction professionals, who have a strong ability to understand and speak the English language, during the pilot study. Further, due to the researcher's involvement in the Delphi interviews, it was inevitable, to a certain extent, that there will be some bias in the results of the investigation; the researcher's presence may have affected the behaviour of the participants. However, this bias will be of a small scale as the interaction of the researcher in the course of the interview process was limited with the avoidance of body language signals. This is in addition to avoiding interference with the responses from the interviewees unless it required more explanation (unclear answers) and/or deviated from the subject of the interview.

8.5 Research novelty

Despite the above limitations, the research described in this thesis is both original and valuable in that it bridged the gap in the CW literature through the development of a BF which will support the adoption of waste minimisation in Jordanian construction projects. The BF promotes a more holistic understanding of the factors influencing the behaviour of Jordanian contractors towards CWM, especially as there is a lack of extensive and empirical research dedicated to investigating CWM behaviour in Jordan, where the circumstances and culture are different from other countries. The BF was developed using existing best practice behavioural adoption theories and frameworks to enhance the explanatory power in the prediction of CWM behaviour in the Jordanian context. The BF is original in that it incorporates all the variables (see Figure 7.1) considered essential for the effective prediction of CWM behaviour as, according to the literature review (see sections 3.3.5 & 3.4), each of the adoption theories and frameworks is criticised for being too simplistic and inadequate in successfully predicting the factors impeding the adoption of CWM behaviour. This is in addition to the dynamic interaction between these variables and the successful mapping of the relationships between them, both of which add value to its overall explanatory power.

The value of the BF also relies on being strongly reflective of the attitudes, values and beliefs of Jordanian contractors, as the integrated BF factors are strongly associated with the traditions and culture of the Jordanian construction sector. However, the BF is not only applicable to the Jordanian context, but may also be used in other countries in the Middle-East region where the circumstances and culture are similar to those in Jordan. Further, the process for developing the BF can be a useful reference for other studies which attempt to understand CW and its related issues in other socio-economic contexts, as researchers can conduct their investigations to structure future research and provide further improvement. Moreover, the significance of the BF is that it can be applied to various real life social contexts (whether in an individual project, organisation, country or geographical regional basis), by different groups of decision makers (e.g., government, clients, contractors, construction managers and consultants), and in different periods and stages of the construction project (e.g., tender, design, construction stage). Moreover, the application process of the BF can be conducted using different methods of evaluation and testing (e.g., interviews, survey questionnaires, etc.) and, consequently, the application of the BF can be more flexible, effective and reliable with regard to achieving successful waste minimisation outcomes in construction projects. In conclusion, based on the discussions in this section, the BF is considered both novel and valuable in regard to promoting an effective CWM in Jordanian construction projects especially as, to date, the Jordanian construction industry is still suffering from insufficient sustainability practices characterised by poor production, sub-standard performance and a wasteful culture.

8.6 Research recommendations

This section presents suggestions for future work to further investigate and extend the findings from this research:

- Further research is recommended to validate the BF in other countries in the Middle-East region, where contractors share a similar cultural background to the Jordanian construction industry. Additionally, it might be useful to consider a comparative study with other Middle-Eastern countries at a different developmental stage to Jordan to establish whether those that are further down the SC path (including CWM) have managed to overcome the innate obstacles presented by cultural conditioning.
- The success of the BF application in construction projects can vary depending on the nature of the project, the time period of the framework application and the methods of evaluation and testing, thus require further investigation in order to explore through benchmarking, the most practical criteria for its successful application. Targeted construction stakeholders may require to formulate a set of various scenarios so that the best CWM strategies could be identified before being implemented in practice.
- A longitudinal study with Jordanian contractors would be useful that gradually involves more personnel and to moves to a quantitative approach as the study progresses in order to secure more data and increase the generalisability of the research results.

- With this study's lens of focus placed on the general project context, as the nature of the built environment is labour intensive resulting in waste being generated in all types of construction projects, it would be also of an interest to explore in a more granular manner how CW issues may differ within different project contexts (e.g., new build, heritage, public and private sector). Therefore, future work could consider investigating the CW issues that arise in specific project types in order to offer even greater insight for both researchers and practitioners.

8.7 Final words

This chapter presented a summary of the five objectives underpinning this study, alongside evidence of how each was achieved, with a presentation of the research key findings. Following this, the methodology employed to undertake this research was critiqued, followed by the study's limitations, the research novelty, the study's recommendations and a chapter conclusion. Notwithstanding the limitations highlighted in section 8.4, this study has successfully enabled the development of a BF that will supports the identification and understanding of the factors influencing the behaviour of Jordanian contractors towards CWM. Although the data interpretation has now been concluded, further refining of the findings and their significance may be carried out in future. To date, several academic journal publications, workshops and academic conference publications have been undertaken as a consequence of this research. Further presentations at seminars involving practitioners, and more journal publications, have already been planned.

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Appendices

Appendix 1 (A)

Participant Invitation Letter
(Delphi Interviews)

Dear Participant,

I am a Ph.D. student at the School of Built & Environment at Salford University. I would like to invite you to take part in a research study which I am currently undertaking, titled: An Interpretivist Approach for the Development of a Behavioural Framework (BF) to Support the Adoption of Waste Minimisation Behaviour of Contractors: The Case Study of Jordan. The purpose of this interview is to explore the perceptions and views of contractor on the adoption of waste minimisation behaviour in Jordanian construction projects. This interview will offer a better-informed look at the current and potential status of the factors that encourages (incentives) and/or prevent (barriers) Jordanian contractor in adopting an effective measure toward construction waste minimisation. This is in addition to examining the effectiveness of the Jordanian construction- related authorities in their role toward minimising construction waste. The collected data along with the observation will support the development of the proposed framework that could guide those in the construction industry for developing favourable attitudes and perceptions towards minimising construction waste.

You have been nominated as a 'panel member' in the Delphi interview process and your participation will involve responding to at least two different interview questions in two different Delphi rounds (at two separate dates). Each round of interview questionnaire will take no more than one hour of your time. There are no identified risks from participating in this research and it is completely voluntary and you can windthrow your participation at any stage without consequence. All data collected will be confidential and will be completely erased after the results of the study are published. Your identity will remain anonymous and for the purpose of the data analysis, an anonymous code will be given to each participant instead of their names. your name. If you agreed upon participating in this interview, kindly fill out the attached short questionnaire and send back to the below email. I hope you will be able to participate this interview so you can share your experience and knowledge, which will help in achieving this study aim and objectives.

If anything, you read is not clear or if you would like more information. please don't hesitate to ask questions to the researcher, the contact details are provided bellow. Take time to decide whether or not to take part.

Sincerely,

Mahmoud Alhawamdeh
PhD Researcher
School of Built Environment

University of Salford
Salford/Manchester
M5 4WT
Number: 0044 7591036551, 00962 777482085
E-mail: m.h.m.alhawamdeh@edu.salford.ac.uk

Appendix 1 (B)

Participant Invitation Letter
(Delphi Interviews)

- What is your educational level?

- What is your Job role?

    - Job title?

    - Years of experience?

    - Responsibilities?

- How many construction projects involved during your entire experience?

- Are these projects public or private? if both, approximately how many each?

- In general, did you work in a construction project that have a budget exceeding 400,000 JOD? If yes, approximately how many?

Appendix 1 (C)

Participant Consent Form
(Delphi Interviews)

Title of research: An Interpretivist Approach for the Development of a Behavioural Framework to Support the Adoption of Waste Minimisation Behaviour of Contractors: The Case Study of Jordan.

Name of Researcher: Mahmoud Alhawamdeh
Researcher E-mail: m.h.m.alhawamdeh@edu.salford.ac.uk

Please tick the appropriate boxes:

	Yes	No
• I confirm that I have read and understood the information sheet for the above study and what my contribution will be.		
• I have been given the opportunity to ask questions (face to face, via telephone and e-mail)		
• I agree to the interview being tape recorded		
• I understand that my participation is voluntary and that I can withdraw from the research at any time without giving any reason		
• I would you like to see a copy of the results		
• I agree to take part in this interview		

Name of participant:

Signature:

Date:

If you have any concerns about this research that have not been addressed by the researcher, please contact the researcher's supervisor via the contact details below:

Name of Supervisor: Professor Angela Lee
Supervisor E-mail: a.lee8@salford.ac.uk

Appendix 2

Delphi Round 1 Interview Questions

Q1) Construction waste minimisation has become a major focus nowadays in many countries around the world, why do you think it is needed in the Jordanian construction sector?

Q2) In your experience and opinion, to what extent do these benefits you mentioned in question 1, motivate the individual towards minimising construction waste and are there any other motivational benefits? please explain

Q3) In your experience and opinion, in what way can construction skills and expertise affect the individual's performance in construction waste minimisation? please explain

Q4) In your experience and opinion, in what way can personal ethics reflect the individual's performance in construction waste minimisation? please explain

Q5) In your experience and opinion, in what way can the behaviour of colleagues, managers or the surrounding society influence the individual's performance in construction waste minimisation? Please explain

Q6) In your experience and opinion, in what way can legislations pressure managers toward adopting construction waste management? Please explain

Q7) In your experience and opinion, to what extent does the availability of adequate time and money resources facilitate waste minimisation in construction projects? please explain

Q8) In your experience and opinion, to what extent does the complexity of a construction technology (tool or system) discourage its adoption? Please explain

Q9) In your experience and opinion, are there any other issues that may discourage the adoption of construction technologies (tool or system) in projects? Please explain

Q10) In your experience and opinion, what are the matters that an organisation should consider, in order to facilitate waste minimisation in construction projects? please explain

Q11) In your experience and opinion, are there any other issues that may affect the performance of waste minimisation in construction projects? please explain

Appendix 3

Delphi Round 2 Interview Questions

Q1) The following points were identified in the first round of interviews as the key benefits of construction waste minimisation, and they have been ranked according to their frequency of occurrence. Do you agree with each one of them? Please expand your answer if needed

1. Reducing construction cost
2. Increasing the productivity of the construction process
3. Improving safety at construction site
4. Reducing the environmental pollution
5. Reducing the depletion of the limited natural resources

Q2) knowledge, skills and expertise in construction affect the individual's performance in construction waste minimisation. In this regard, the following key issues were identified in the first round of interviews, and they have been ranked according to their frequency of occurrence. Do you agree with each one of them? Please expand your answer if needed

1. Awareness of the causes and types of construction waste
2. Knowledge and awareness of construction technologies (tool or system)
3. Awareness of the financial gains of construction waste minimisation
4. Skills and expertise in the handling of construction errors
5. Awareness of the negative environmental impacts of construction waste

Q3) Personal ethics reflect the individual's performance in construction waste minimisation. In this regard, the following key issues were identified in the first round of interviews, and they have been ranked according to their frequency of occurrence. Do you agree with each one of them? Please expand your answer if needed

1. Courtesy between the different levels of employees
2. Religious obligations

Q4) The benefits of construction waste minimisation motivate the individual towards minimising construction waste. In this regard, the following key issues were identified in the first round of interviews, and they have been ranked according to their frequency of occurrence. Do you agree with each one of them? Please expand your answer if needed

1. Cost reduction incentives
2. Enhanced work performance incentives
3. Health and safety incentives
4. Rewards incentives
5. Environmental benefits incentives

Q5) The following points were identified in the first round of interviews as key issues that may affect the individual’s performance in construction waste minimisation, and they have been ranked according to their frequency of occurrence. Do you agree with each one of them? Please expand your answer if needed

1. Perceived increased workloads
2. Belief that waste is inevitable
3. Manager’s encouragement

Q6) The complexity of a construction technology (tool or system) discourages its adoption. In this regard, the following key issues were identified in the first round of interviews, and they have been ranked according to their frequency of occurrence. Do you agree with each one of them? Please expand your answer if needed

1. System complexity and learning difficulties
2. Technical support from vendor

Q7) The incompatibility of a construction technology (tool or system) with the project, discourage its adoption. In this regard, the following key issues were identified in the first round of interviews, and they have been ranked according to their frequency of occurrence. Do you agree with each one of them? Please expand your answer if needed

1. Compatibility with the existing construction practices
2. Compatibility with the project nature

Q8) The behaviour of colleagues, managers or the surrounding society influence the individual's performance in construction waste minimisation. In this regard, the following key issues were identified in the first round of interviews, and they have been ranked according to their frequency of occurrence. Do you agree with each one of them? Please expand your answer if needed

1. The practices of peer-practitioners
2. Interest of managers in construction waste minimisation
3. Wasteful culture
4. Influence of difficult employees

Q9) Legislations pressure managers toward adopting construction waste management. In this regard, the following key issues were identified in the first round of interviews, and they have been ranked according to their frequency of occurrence. Do you agree with each one of them? Please expand your answer if needed

1. Financial charges and penalties
2. Governmental supervision
3. Green construction practices

Q10) The availability of adequate time and money resources facilitate waste minimisation in construction projects. In this regard, the following key issues were identified in the first round of interviews, and they have been ranked according to their frequency of occurrence. Do you agree with each one of them? Please expand your answer if needed

1. Time constraints
2. Cost constraints

Q11) The availability of adequate time and money resources facilitate waste minimisation in construction projects. In this regard, the following key issues were identified in the first round of interviews, and they have been ranked according to their frequency of occurrence. Do you agree with each one of them? Please expand your answer if needed

1. On-site planning and management
2. Technical support (e.g. equipment maintenance, repairs or software support, updates & the provision of efficient construction equipment)
3. Training and information support
4. On-site supervision
5. Management change

Appendix 4 (A)

Participant Invitation Letter
(Workshop)

Dear Participant,

I am a Ph.D. student at the School of Built & Environment at Salford University. I would like to invite you to take part in a research study which I am currently undertaking, titled: An Interpretivist Approach for the Development of a Behavioural Framework (BF) to Support the Adoption of Waste Minimisation Behaviour of Contractors: The Case Study of Jordan. The purpose of this workshop is to evaluate the proposed framework of the research study (i.e. BF) which aid to identify and understand the factors that encourages (incentives) and/or prevent (barriers) Jordanian contractor in adopting an effective measure toward construction waste minimisation. You have been nominated to participate in this validation workshop process study which will take no more than four hours of your time. There are no identified risks from participating in this research and it is completely voluntary and you can windthrow your participation at any stage without consequence. All data collected will be confidential and will be completely erased after the results of the study are published. Your identity will remain anonymous and for the purpose of the data analysis, an anonymous code will be given to each participant instead of their names. your name. If you agreed upon participating in this workshop, kindly fill out the attached short questionnaire and send back to the below email. I hope you will be able to participate this interview so you can share your experience and knowledge, which will help in achieving this study aim and objectives.

If anything, you read is not clear or if you would like more information. please don't hesitate to ask questions to the researcher, the contact details are provided bellow. Take time to decide whether or not to take part.

Sincerely,

Mahmoud Alhawamdeh
PhD Researcher
School of Built Environment
University of Salford
Salford/Manchester
M5 4WT
Number: 0044 7591036551, 00962 777482085
E-mail: m.h.m.alhawamdeh@edu.salford.ac.uk

Appendix 4 (B)

Participant Invitation Letter
(Workshop)

- What is your educational level?

- What is your Job role?
    - Job title?
    - Years of experience?
    - Responsibilities?

- How many construction projects involved during your entire experience?

- Are these projects public or private? if both, approximately how many each?

- In general, did you work in a construction project that have a budget exceeding 400,000 JOD? If yes, approximately how many?

Appendix 4 (C)

Participant Consent Form
(Workshop)

Title of research: An Interpretivist Approach for the Development of a Behavioural Framework to Support the Adoption of Waste Minimisation Behaviour of Contractors: The Case Study of Jordan.

Name of Researcher: Mahmoud Alhawamdeh
Researcher E-mail: m.h.m.alhawamdeh@edu.salford.ac.uk

Please tick the appropriate boxes:

	Yes	No
• I confirm that I have read and understood the information sheet for the above study and what my contribution will be.		
• I have been given the opportunity to ask questions (face to face, via telephone and e-mail)		
• I agree to the workshop being tape recorded		
• I understand that my participation is voluntary and that I can withdraw from the research at any time without giving any reason		
• I would you like to see a copy of the results		
• I agree to take part in this workshop		

Name of participant:

Signature:

Date:

If you have any concerns about this research that have not been addressed by the researcher, please contact the researcher's supervisor via the contact details below:

Name of Supervisor: Professor Angela Lee
Supervisor E-mail: a.lee8@salford.ac.uk

Appendix 5

Workshop Agenda and Questions

Discussion topic and questions	Time
❖ **Part A** ▪ **Introduction** - Back ground and rationale for the research - Objectives of the workshop - Ethical and anonymity procedures of the research ▪ **General discussion** ▪ In your experience and opinion, is it important to understand the issues influencing waste minimisation behaviour of contractors in construction projects? If so, what are the issues that you think affect the behaviour of Jordanian contractors towards construction waste minimisation? ▪ Have you used any frameworks in past projects as a means to understand the issues influencing the adoption of construction waste minimisation behaviour?	**90 minutes**
❖ Break, free sandwiches and drinks	**30 minutes**
❖ **Part B** ▪ **Verification of the BF content** - In your experience and opinion, are the factors presented in the BF applicable in the Jordanian context? Are there any other factors missing? ▪ **Evaluation of the BF terminology**, **structure and applicability** - Do you think that the BF's structure and terminology is easy to understand? Is it valid as a tool for identifying and understanding the factors influencing waste minimisation behaviour in Jordanian construction projects?	**120 minutes**

▪ **Summing up** Thank you for participating	

Appendix 6

Ethical Approval for the Study

University of Salford MANCHESTER

Research, Innovation and Academic Engagement Ethical Approval Panel

Doctoral & Research Support
Research and Knowledge Exchange,
Room 827, Maxwell Building
University of Salford
Manchester
M5 4WT

T +44(0)161 295 5278

www.salford.ac.uk/

27 September 2019

Mahmoud Hasan Mahmoud Alhawamdeh

Dear Mahmoud

RE: ETHICS APPLICATION STR1819-60 – Development of a Behavioural Framework for Minimising Solid Waste in Construction Projects

Based on the information you provided, I am pleased to inform you that your application STR1819-60 has been approved.

If there are any changes to the project and/ or its methodology, please inform the Panel as soon as possible by contacting S&T-ResearchEthics@salford.ac.uk

Yours sincerely,

Dr Devi Prasad Tumula
Deputy Chair of the Science & Technology Research Ethics Panel