SUSTAINABLE BUILT ENVIRONMENTS AND CONSTRUCTION ACTIVITY THROUGH DYNAMIC RESEARCH AGENDAS

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Thank you to my partner Sheela for her continuous understanding and support, and to my father and Alison for their diligent proof-reading.

DEDICATION

"A light has gone out,
But its glory will never die
In the memories of those it shone upon,
Shed its warmth upon,
Blessed"

(James Sexton, 1989)

The personal journey of learning and, hopefully, contribution this thesis represents I dedicate to my brother David, who lost his life in tragic circumstances in the Himalayas while doing fieldwork for his own doctorate.

DECLARATION

Parts of this thesis, in particular Sections' 4.3., 4.4. & 4.5., are based on the research findings from the Integrated Delivery Systems for Sustainable Construction (IDS) research project[1]. The author of this thesis was the principal research assistant for this project, and made significant intellectual input into the research design. I then organized and carried through the execution of the project. The project was a separate initiative from the PhD work, but overlapped strongly and involved my supervisor who as Principal Investigator held very much the same relationship within the project as for the PhD.

I declare that the remainder of the research contained in this thesis was solely carried out by me. This thesis has not been previously submitted to this or any other institution for the award of a degree or any other qualification.

[1] Barrett, P.S., Sexton, M.G. & Green, L., (1998), **Integrated Delivery Systems for Sustainable Construction: Unpublished Report for the Construction Sponsorship Directorate, Department of Environment Transport and the Regions,** DETR: London.

ABSTRACT

There is a growing consensus that appropriate strategies and actions are needed to develop sustainable built environments and construction activity. This thesis contextualises this consensus within the broader sustainable development literature. First, the review of the literature culminates in the development of the Holographic Dynamic PSR (pressure, state, response) model as a holistic, system-orientated framework to better understand the focus of, and interaction between, stakeholders' worldviews and actions to progress sustainable development. Second, five systemically linked hypotheses are articulated to test the argument that the current body of research knowledge is not sufficiently focused and integrated to support progressive, significant and balanced sustainable development.

The hypotheses are tested using built environment and construction activity specific literature, through a 'nested' research methodology comprising an interpretative philosophy, a soft systems research approach and literature review and synthesis research techniques.

The thesis substantially supports the overall argument mapped out by the hypotheses, and proposes both a generic dynamic research agenda framework to progress sustainable development in general; and a UK prioritised research agenda for sustainable built environments and construction activity.

1. Introduction

1.1. Background to the research

There is an increasing appreciation that Earth's ecological systems cannot indefinitely sustain present trajectories of human activity. The nature and scale of human activity is exceeding the carrying capacity of the earth's resource base, and the resultant waste and pollution streams are exceeding the assimilative capacity (see Section 2.2.2.). The contribution of the built environment and construction activity to this unsustainable activity is substantial (see Section 2.3.2.), with it being argued, for example, that:

> *"... responsibility for much of the environmental damage occurring today – destruction of forests and rivers, air and water pollution, climate destabilization – belongs squarely at the doorsteps of modern buildings."*[1]

The implications of such unsustainable development across this, and other areas, of human activity, are potentially profound; indeed, it has been asserted that:

> *"The home planet is in crisis ... our modern cultures threaten the integrity, stability, and beauty of earth and thereby of the culture superimposed on Earth. Beyond the vision of one world is the shadow of none."*[2]

The prevailing 'vision' which is arguably preventing a sustainable future is the failure to appreciate and embrace the reality that human well-being is a derivative function, secondary to the well-being of the Earth[3], and that ecological processes provide the biophysical context for human existence[4]. This human dependency on ecological health is summarised in the observation that:

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[1] Lenssen, N. & Roodman, D.M., (1995), "Making Better Buildings", in L.R. Brown (Ed.), **State of the World 1995**, Earthscan: London. Pages 95-112. Page 95.
[2] Rolston, H., (1996), "Earth Ethics: A Challenge to Liberal Education", in J.B. Callicot, F.J.R. da Rocha, (Eds.), **Earth Summit Ethics: Towards a Reconstructive Postmodern Philosophy of Environmental Education**, State University of New York Press: Albany, New York. Page 162.
[3] Swimme, B. & Berry, T., (1992), **The Universe Story**, Harper Collins: New York.
[4] Shrivastava, P., (1995), "Ecocentric Management for a Risk Society", **Academy of Management Review**, 20: 118-137.

> *"We draw our sustenance from the environment in which we live. It is, therefore, an irrefutable fact that the quality of our life depends on that environment. Any degradation of its quality is sure to affect us adversely."*[5]

Human activity and the natural world are thus viewed as being on a collision course, which will result in global decay and chaos in the absence of urgent and radical reform[6], and that, according to the World Bank:

> *"... the achievement of sustained and equitable development remains the greatest challenge facing the human race."*[7]

The 'urgent and radical reform' to meet this challenge was influentially envisioned and contextually defined by the World Commission on Environment and Development as "...development which meet the needs of the present without compromising the ability of future generations to meet their own needs[8]" (see Section 2.4.1.).

This concept is particularly pertinent for the built environment and construction industry, as the construction industry has always had the ability to produce a built environment which its contemporary society has required, and has played an important part in the development of the human race[9]. This ability has never been so important as now when there is a growing consensus that appropriate strategies and actions are needed to ensure sustainable built environments and construction activity[10]. The systemic relationship between sustainable development and the built environment is portrayed in the statement that:

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[5] Haque, M.M., (1991), "Sustainable Development and Environment: A Challenge to Technology Choice Decision-making", **Project Appraisal**, 6: 3: 149-157. Page 150.
[6] Kaplan, R.D., (1994), "The Coming Anarchy", **Atlantic Monthly**, 273: 2: 43-76.
[7] World Bank, (1992), **World Development Report 1992: Development and the Environment**, Oxford University Press: New York. Page 1.
[8] World Commission on Environment and Development, (1987), **Our Common Future**, Oxford University Press: New York. Page 8.
[9] Dolan, D.F., (1979), **The British Construction Industry: An Introduction**, MacMillan Press: London.
[10] For example, Conseil du Bâtiment, (1999), **CIB Agenda 21 on Sustainable Construction: CIB Report 237**, Conseil du Bâtiment: Rotterdam, Netherlands.; Department of Environment, Transport and the Regions, (1998), **Opportunities for Change**, DETR: London.; Department of Environment, Transport and the Regions, (1998), **Opportunities for Change: Sustainable Construction**, DETR: London.; The Building Services Research and Information Association, (1998), **Sustainable Construction: The UK Viewpoint**, BSRIA: Bracknell, Berkshire.; Construction Research and Innovation Strategy Panel Sustainable Construction Group, (1998), **Research and Innovation for**

> "... *the built environment constitutes one of the main supports (infrastructures, buildings) of economic development, and, on the other side, its construction has significant impacts on resources (land, materials, energy, water, human/social capital) and on the living and working environment. Hence the construction industry has significant direct and indirect links with the various aspects of sustainable development.*"[11]

Within this broad context of the need for sustainable built environments and construction activity, the following section considers the specific research problem which this study addresses.

1.2. Research problem

Progress toward sustainable built environment and construction activity must build on robust knowledge about the interaction between, and consequences of, the built environment and construction activity and the natural environment. This need is recognised, and "... environmental issues are now becoming a critical edge in construction research.[12]" The research direction to date has been varied, as:

> "*The understanding or interpretation of sustainability in building and construction has ... undergone change over the years. In the beginning the emphasis was on how to deal with the issue of limited resources ... and ... technical issues in construction such as materials, building components, construction technologies ... Today, the understanding of the significant of the nontechnical issues is growing and it is realized that these so-called soft issues are at the least as crucial for a sustainable development in construction. Economic and social sustainability must be accorded explicit treatment in any definition.*"[13]

Sustainable Construction: Report for the Construction Research and Innovation Strategy Panel, CRISP: London; Counseil du Bâtiment, (1998), **Proceedings of the CIB World Building Congress: Construction and the Environment,** CIB: Gälve, Sweden: 7^{th} – 12^{th} June.; CERF, (1996), **Proceedings of the Engineering and Construction for Sustainable Development in the Twenty-first Century: An International Research Symposium and Technology Showcase,** Washington, D.C.

[11] Bourdeau, L., (1999), "Sustainable Development and the Future of Construction: A Comparison of Visions from Various Countries", **Building Research and Information,** 27: 6: 355-367. Page 355.

[12] Yashiro, T., (1996), "Global Perspectives in Construction for Global Environment", **Proceedings of the CIB W55 Building Economics 7^{th} International Symposium: Economic Management of Innovation, Productivity and Quality in Construction,** Zagrb, Croatia: 4^{th} – 7^{th} September. Page 798.

The research problem from which this thesis is setting out is that although such research has generated a considerable body of knowledge on sustainable development issues in the built environment and construction activity, this research is unfocused, fragmented, and has developed from particular, potentially conflicting or restricted, research perspectives characterised by 'psychic prisons'[14], 'iron cages'[15], and other forms of constricted sense making[16].

An awareness of the current fragmented nature of the body of research knowledge in this area is articulated in the CIB Agenda 21 for Sustainable Construction, where, as shown in Figure 1.1., it emphasises the need for a widening of the research agenda, with the traditional performance criteria for construction being widened from cost, quality and time, to consider the resource, emission and biodiversity issues within the systemic context of broader social, economic and environmental concerns[17].

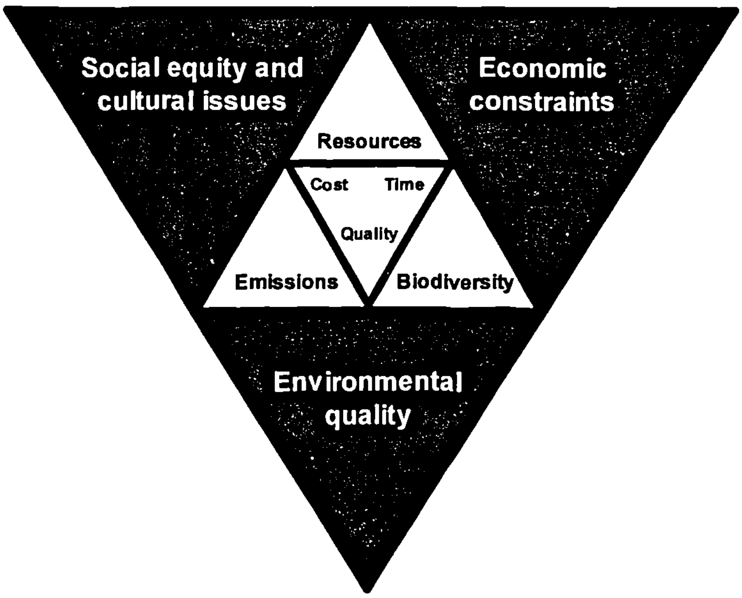

Figure 1.1. Holistic, integrative approach to sustainable development

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[13] Sjöström, C. & Bakens, W., (1999), "CIB Agenda 21 for Sustainable Construction: Why, How and What", **Building Research and Information,** 27: 6: 348-354. Page 351.
[14] Morgan, G.,(1986), **Images of Organization,** Sage: Newbury Park.
[15] DiMaggio, P. & Powell, W.W., (1983), "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields", **American Sociological Review,** 19: 252-284.
[16] Weick, K.E., (1969), **The Sociology of Organising,** Addison-Wesley: Reading.

This type of holistic, systemic approach is viewed as being the way forward to create and support the type of:

> *"Joined-up action to achieve sustainable development, [through the] understanding and integration of a range of issues of exceptional breadth and diversity. Some are highly technical involving, for example, the detailed study of the properties and potential uses of waste materials. Some are economic, such as devising financial incentives to the re-use of previously developed sites. Some are social, understanding the motivations of consumers and finding the levers that will bring about changes in lifestyle."*[18]

The focus of the research problem, and its solution, thus resonates with the articulation that:

> *"... the future trend of sustainable construction will be for all groups involved with or impacting [the construction] industry to examine their activities relative to sustainability and to interlink the wide range of actors into a coherent whole. The issues of sustainability are extremely complicated and involve complex systems and relationships. Understanding and then acting on the understanding of these relationships is the key to success, not only in construction, but across all sectors of human activity."*[19]

1.3. Justification for the research

The need is clear for an appropriately focused and systemically integrated research agenda to create and support sustainable built environments and construction activity. Research agendas characterised by a lack of clear focus and by fragmentation cannot adequately address the investigation and understanding of the myriad of complex and systemically interactive issues embodied within the concept of sustainable development. As a consequence, research attempts to cope with the scale and complexity of issues raised by sustainable built environments and construction activity cannot simply aim to add some new pieces to an already existing, unfocused and fragmented knowledge base. The investigation of the

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[17] Conseil du Bâtiment, (1999), **CIB Agenda 21 on Sustainable Construction: CIB Report 237**, Counseil du Bâtiment: Rotterdam, Netherlands. Page 42.

[18] Courtney, R. (1999), "COB Agenda 21 and the Building Research Community", **Building Research and Information**, 27: 6: 374-378. Page 375.

[19] Kibert, C.J., Eilenberg, I. & Huovila, P., (1997), "Implementation of Best Practice for Sustainable Construction", **CIB Coordinators' Trend Reports: An Anthology for Future Perspectives: CIB Report 211**, CIB. Page 5.

relationships and interactions between built environments and construction activity to their natural environments, and of the relationships between the built environment and construction activity, and the different (social, economic, cultural etc.) dimensions to sustainable development, sets up the challenge of overcoming the limitations imposed by the fragmentation of the built environment and construction activity knowledge base.

It is therefore argued that the concept of sustainable development creates the need for research agendas characterised by focused, interdisciplinary and transdisciplinary modes of enquiry[20]. Similarly, putting sustainable built environment and construction activity into practice requires knowledge about the interactions among society, economy, politics and environment. Research on sustainable development, therefore, demands cross-disciplinary cooperation on different levels among the built environment disciplines, as well as between the built environment body of knowledge and other bodies of knowledge located in the broad sphere of the natural and social sciences. The need is emphasised, for example, in the observation that:

> *"There is a growing appreciation that behavioural scientists, ecological researchers, organisational specialists and others can contribute to a more complete solution of construction problems."*[21]

As a result, the drawing of disciplinary boundaries must be reviewed and, where needed, revised. It is becoming clear that sustainable development presents many challenges. Given this background, the justification for this research is to contribute to the effort to better understand and realign our collective research efforts to face up to these challenges.

[20] For example, see Buchholz, R., (1993), **Principles of Environmental Management: The Greening of Business**, Prentice-Hall: Englewood Cliffs, NJ.; Gladwin, T.N., (1993),"The Meaning of Greening: A Plea of Organizational Theory", in K. Fischer & J. Schot (Eds.), **Environmental Strategies for Industry**, Island Press: Washington, D.C. Pages 37-62.; Orr, D.W., (1994), **Earth in Mind: On Education, Environment, and the Human Prospect**, Island Press: Washington, D.C.; Stead, W.E. & Stead, J.G., (1992), **Management for a Small Planet: Strategic Decision Making and the Environment**, Sage: Newbury Park, CA.

[21] Seaden, G., (1997), "The Future of National Construction Research Organizations: Scenarios for the Changing Roles, Functions, Research Agendas and Funding", **Building Research and Information**, 25: 5: 250-256. Page 255.

1.4. Research methodology

Sustainable development is, by its intrinsic nature, a diverse and complex study area. There was a clear need for a holistic, integrated research methodology which was sympathetic to the issues being investigated: in effect to "... suit the method to the problem, and not the problem to the method.[22]" With this imperative in mind, a 'nested' research methodology, shown in Figure 1.2., was developed (see Section 3.2.), with an interpretative research philosophy which guided and energised the inner research approach and research technique. The research approach consisted of a soft systems method of theory generation and testing. The research technique comprised the use of literature review and synthesis techniques as data collection and manipulation tools.

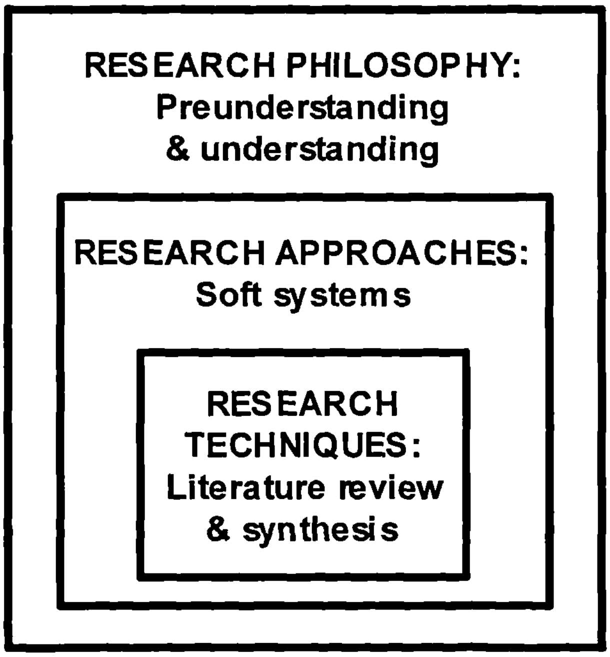

Figure 1.2.: Research methodology 'nesting'

The interpretative research philosophy is considered appropriate, with its ability to accommodate the research focus on understanding stakeholders' worldviews and how they influence built environment and construction activity goals and strategies with respect to sustainable development (see Section 3.3.). The soft systems approach is justified because of its ability to deal with 'fuzzy' problem situations such as sustainable development, with its characteristic systemic complexity and poorly defined and/or conflicting stakeholder objectives (see Section 3.4.). The use of literature sources as 'primary data' for the research is considered appropriate because of the strong match between the systemic nature of the research and the systemic, contextual nature of secondary data sources (see Section 3.5.).

1.5. Synopsis of the thesis

Chapter 1: Introduction

Chapter 1 introduces the core research problem and sets out the route by which the reader will travel towards the thesis' conclusion.

Chapter 2: Research issues

In this chapter, the substance of the sustainable development challenge is explored; identifying, in particular, the importance of appreciating and accommodating diverse stakeholder worldviews, and the need to develop and operate a system-orientated framework to guide decision-making and action. The discussion culminates in the presentation of the *Holographic Dynamic PSR model* as a fruitful way of integrating and developing these two central issues; and five hypotheses are articulated to test the assumptions and operation of this model.

Chapter 3: Research methodology

This chapter discusses the methodology used for this research. First, the need for a 'nested' approach, which integrates the research philosophy, approach and techniques employed, is identified. Second, the interpretative 'preunderstanding-understanding' philosophy underpinning the research is reviewed. Third, the soft systems research approach developed for the research is examined. Finally, the literature review and synthesis research techniques used are deliberated. The chapter concludes with a discussion of how the validity of the research methodology is ensured, and the rationale for the thesis structure is given.

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[22] Linstone, H.A., (1978), "The Delphi Technique", in J. Fowles, (Ed.), **Handbook of Futures Research**, Greenwood Press: London. Page 275.

Chapter 4: Research findings

This chapter presents key research findings (using the research methodology set out in Chapter 3), to test the five hypotheses developed and articulated in Chapter 2.

Chapter 5: Conclusions

The final chapter summarises the research study, and draws together key strands to set out implications for both general sustainable development, and more specifically for sustainable built environments and construction activity theory. Further research directions will be indicated.

1.6. Summary and link

This chapter has laid out the foundations for this research. It introduced the research problem and hypotheses. Then reasons for the was articulated, the methodology was briefly described, and the thesis outlined. The next chapter will contextualise the outlined research issues within the relevant general sustainable development literature (see Section 3.4.) through a review and synthesis.

2. Research issues

2.1. Introduction

Chapter 2 develops the research issues outlined in Chapter 1 through a review and a synthesis of key strands of the relevant literature. The chapter is organised into the following sections:

1. A model of the interaction between social systems and ecological systems is presented. Its operation is described, introducing the notion of sustainable and unsustainable systems' interaction. (Section 2.2.)
2. The current interaction between social systems and ecological systems is described. Evidence is furnished to argue that these interactions are unsustainable. The widely endorsed prescription of 'sustainable development' is introduced as the means to bring the social and ecological systems back into an interaction which is temporally and spatially durable. It is argued that successful sustainable development requires relevant stakeholders (both individually and collectively) to have both appropriate *goal orientation* to achieve it and the necessary *ability* to make a positive contribution. (Section 2.3.)
3. The concept of sustainable development is discussed more fully. It is shown that there is a wide range of different definitions of sustainable development, each of which reflects a particular goal orientation. (Section 2.4.)
4. The diversity of focus and degree of goal orientation to achieve sustainable development is investigated by revealing the apparent conflicts between the various definitions of sustainable development. The role of diverse worldviews in generating these conflicting conceptualisations is developed. A classification framework is presented as a means to locate the worldview being engendered by a given conceptualisation of sustainable development. (Section 2.5.)
5. The *Dynamic PSR* (pressure, state, response) *model* is presented as a holistic, system-orientated framework to better understand the focus of, and interaction between, stakeholders' actions to progress sustainable development. (Section 2.6.)
6. The worldviews framework and the *Dynamic PSR model* are integrated to create a *Holographic Dynamic PSR model.* This model forms the analytical framework

for the data collection and analysis presented in Chapter 3 and Chapter 4 respectively (Section 2.7.).

2.2. Model of societal-ecological system interaction

2.2.1. Model design considerations

Before describing the model of interaction between the social system and the ecological system, the design considerations underpinning it will be discussed to illuminate the model's intended purpose and to identify its limitations.

The Earth is a complex suprasystem, comprising of interacting, interdependent subsystems linked together by exchanges of energy, matter and information[1]. The suprasystem is characterised by strong (usually nonlinear) interactions between the parts, complex feedback loops that make it difficult to distinguish cause from effect, and significant temporal and spatial lags, discontinuities, thresholds and limits[2]. The following difficulties, for example, have been cited in measuring environmental effects[3]:

- Discharges of material and energy residuals into air, water and land are of many different types.
- A diverse range exists for both the rate of change in environmental quality and for the geographical area of influence of residual discharges on environmental quality.
- There is a wide range in the time scale of effects on receptors from changes in environmental quality.
- A large element of randomness exists in the levels of environmental quality over time because of differences in the time pattern of discharges and of the absorption capacity of the environment.

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[1] For example, see Gallopin, G.C., Gutman, P. & Maletta, H., (1989), "Global Impoverishment Sustainable Development and the Environment: A Conceptual Approach", **International Social Science Journal**, 121: 375-397.; Lovelock, J., (1988), **The Ages of Gaia**, W.W. Norton: New York.; Vernadsky, V., (1945), "The Biosphere and the Noosphere", **American Scientist**, 33: 1: 1-12.

[2] For example, see Costanza, R., Wainger, L., Folke, C. & Maler, K., (1993), "Modelling Complex Ecological Economic Systems", **BioScience**, 43: 8: 545-556.; Stern, P., Young, O. & Druckman, D., (1992), **Global Environmental Change: Understanding the Human Dimensions**, World Wildlife Fund: Washington. Page 167.

- Residuals discharged from human activities are not the only factors affecting the quality of the environment.

In response to such attributes, a dynamic view of ecosystems has been proposed, for example, that depicts system behaviour as following a spiralling developmental path shaped by variability, spatial heterogeneity and nonlinear causation[4]. Such ecosystem characteristics are illustrative of the following key system principles guiding the Earth's suprasystem behaviour[5]:

- The Earth does not necessarily behave simply as the sum of its individual parts (subsystems) and the behaviour of the parts does not necessarily allow the behaviour of the whole (suprasystem) to be predicted. For example, global climate behaviour cannot be understood by a simple summation of regional climate behaviour. Likewise, global climate behaviour cannot be simply decomposed to provide an understanding of regional climate behaviour.
- The complex whole may have 'emergent' properties that are essential for understanding and describing the whole but may have little or no meaning in terms of constituent parts. For example, symbiotic phenomena associated with certain species' interaction is crucial to understanding the ecology of the constituent species, but is largely irrelevant for understanding the physiology of the individual species involved.
- The concept of emergent properties implies a view of reality as existing in the layers of a suprasystem-system-subsystem hierarchy. For example, human beings perceive reality in distinct, but interactive ways, at national (suprasystem), organisational (system) and individual (subsystem) levels.
- Feedback mechanisms exist within the hierarchically organised whole that allow adjustment and adaptation in the face of stress. For example, the population of

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[3] Hufschmidt, M.M., James, D.E., Meister, A.D., Bower, B.T. & Dixon, J.A., (1983), **Environment, Natural Systems and Development: An Economic Valuation Guide**, John Hopkins University Press: Baltimore.
[4] Holling, C.S., (1992), "Cross-scale, Morphology, Geometry, and Dynamics of Ecosystems", **Ecological Monographs**, 64: 24: 447-502.
[5] Adapted from Goldberg, M., (1989), **On Systemic Balance – Flexibility and Stability in Social, Economic and Environmental Systems**, Praeger: New York.; Checkland, P. & Scholes, J., (1990), **Soft Systems Methodology in Action**, Wiley: Chichester.

predator species in a given ecosystem will adjust to keep in balance with the population of their prey.

An appropriate system model of the Earth is thus required to better identify and understand key elements in this suprasystem: their attributes, the interactions among the elements, and the degree of organisation inherent in the system. A system model is understood to be a deliberate simplified representation[6] of a set of certain relationally arranged and interdependent components organised as a definable entity in a given environment[7]. The use of appropriate system models has been widely used to 'disentangle' the complexities of various ecological systems[8].

The design of the system model described in Section 2.2.2. is informed by the important consideration of the inherent subjectivity of model construction. The general view is that the level or unit of analysis within systems theory is the system itself, focusing on relationships and interactions. However, because the notion of a system is broad and flexible, the definition of what is to be internal and external to a system, and what elements and interactions are to be considered, largely depend on the system model designer's purpose and perspective[9].

The subjectivity dimensions of system model design can be fruitfully guided by the three criteria of realism (simulating system behaviour in a qualitatively realistic

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[6] Arbnor, I. & Bjerke, B., (1997), **Methodology for Creating Business Knowledge**, Sage: Lund, Sweden. Page 83.; Schoderbek, P.P., Schoderbek, C.G. & Kefalas, A.G., (1985), **Management Systems: Conceptual Considerations**, Business Publications: Plano, Texas. Page 292.

[7] Von Bertalanffy, L., (1975), **Perspectives on General Systems Theory**, Braziller: New York.; Banathy, B.H., (1992), **A Systems View of Education: Concepts and Principles for Effective Practice**, Educational Technology Publications: Englewood Cliffs, NJ. Page 191.

[8] For example, see J. Roughgarden, R.M. May & S.A. Levins, (Eds.), (1997), **Perspectives in Ecological Theory**, Princeton University Press: Princeton, N.J.; Allen, T.F.H., Bandurski, B.L. & King, A.W., (1993), **The Ecosystem Approach: Theory and Ecosystem Integrity: Report to the Great Lakes Science Advisory Board**, IJC: Ottawa and Washington.; Corn, L.M., (1993), **Ecosystems, Biomes, and Watersheds: Definitions and Use – Report for Congress**, The Committee for the National Institute for the Environment: Washington; Kraus, M., (1987), "Energy Forecasting: The Epistemological Context", **Futures**, 19: 3: 254-276.; Forrester, J.W., (1973), **World Dynamics**, Wright-Allen Press: Cambridge, MA.; Meadows, D.H., (1972), **The Limits to Growth: A Report to the Club of Rome's Project on the Predicament of Mankind**, Universe Books: New York.

[9] Churchman, W., (1968), **The Systems Approach**, Dell: New York.; Ruben, B.D., (1972), "General System Theory: An Approach to Human Communication", in R.W. Budd & B.D. Ruben (Eds.), **Approaches to Human Communication**: 120-144, Hayden: Rochelle Park, NJ.; Lindfors, L.G., Christiansen, K., Hoffman, L., Virtanen, Y., Juntilla, V., Hanssen, O.J., Rønning, A., Ekvall, T. & Finnveden, G., (1995), **Nordic Guidelines on Life-cycle Assessment**, Nordic Council of Ministers: Copenhagen. Page 20.

way), precision (simulating behaviour in a quantitatively precise way), and generality (representing a broad range of systems' behaviours with the same model)[10]. There are fundamental trade-offs in modelling among these three criteria – no single model can maximise all three of these goals, and the choice of which objectives to pursue depends on the fundamental purposes of the model[11].

High generality models, in striving for breadth, must give up some realism and/or precision. They can simplify relationships and/or reduce resolution. For example, the ecological economy model contains only three state variables (labour, capital and natural resources), and the relationships among these variables are highly idealised[12]. But the purpose of the model was not high realism or precision but rather to address some basic questions about the limits of economic systems in the context of their dependence on an ecological life-support base.

High-precision models aim for high precision (quantitative correspondence between data and model) at the expense of realism and generality. For example, an economic input-output model was developed to examine the relationships between biotic and abiotic stocks in a marine ecosystem[13]. The model enabled the direct and indirect connection of any species to any other and to the external environment in this system to be made at high precision (but low generality and realism).

High-realism models aim to develop realistic assessments of the behaviour of specific complex systems, and thus generality and precision must be relaxed. High-realism models are concerned with accurately representing the underlying processes in a specific system, rather than with precisely matching quantitative behaviour or being generally applicable. For example, a coastal landscape dynamics model was

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[10] Holling, C.S., (1964), "The Analysis of Complex Population Processes", **Canadian Entomology**, 96: 335-347.

[11] Levins, R., (1966), "The Strategy of Model Building in Population Biology", **American Science**, 54: 421-431; Holling, C.S., (1964), "The Analysis of Complex Population Processes", **Canadian Entomology**, 96: 335-347.

[12] Brown, G.M. & Swierzbinski, J., (1992), "An Ecological Economy: Notes on Harvest and Growth", **Beijer Discussion Paper Series 12**, Biejer International Institute of Ecological Economics: Stockholm, Sweden.

[13] Hannon, B. & Joiris, C., (1987), "A Seasonal Analysis of the Southern North Sea Ecosystem", **Ecology**, 70: 1916-1934.

developed which divided a coast landscape into one-square-kilometre cells, each of which contains a process-based dynamic ecological simulation model[14].

With these criteria in mind, a high-generality model of interaction between the social system and the economic system was constructed to better understand the aggregated behaviour of the suprasystem at a correspondingly high level of resolution. This focus provides a broad context to inform and locate the subsequent broad-based discussion on the concept and operation of sustainable development. The adoption of a high-generality model therefore precludes exact predictions of system behaviour, but does provide a conceptual arena where an overall understanding of system dynamics can be developed[15].

This section has made explicit the high-generality focus of the system model of interaction between the social system and the ecological system. The model will now be described.

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[14] Costanza, R., Sklar, F.H. & White, M.L., (1990), "Modelling Coastal Landscape Dynamics", **BioScience**, 40: 91-107.

[15] For example, see Hall, C.A.S., (1991), "An Idiosyncratic Assessment of the Role of Mathematical Models in Environmental Sciences", **Environment International**, 17: 507-517.; Hall, C.A.S.,

2.2.2. Description of model

Figure 2.1. presents a systems model of social system and ecological system interaction. The rational and operation of the model is described below.

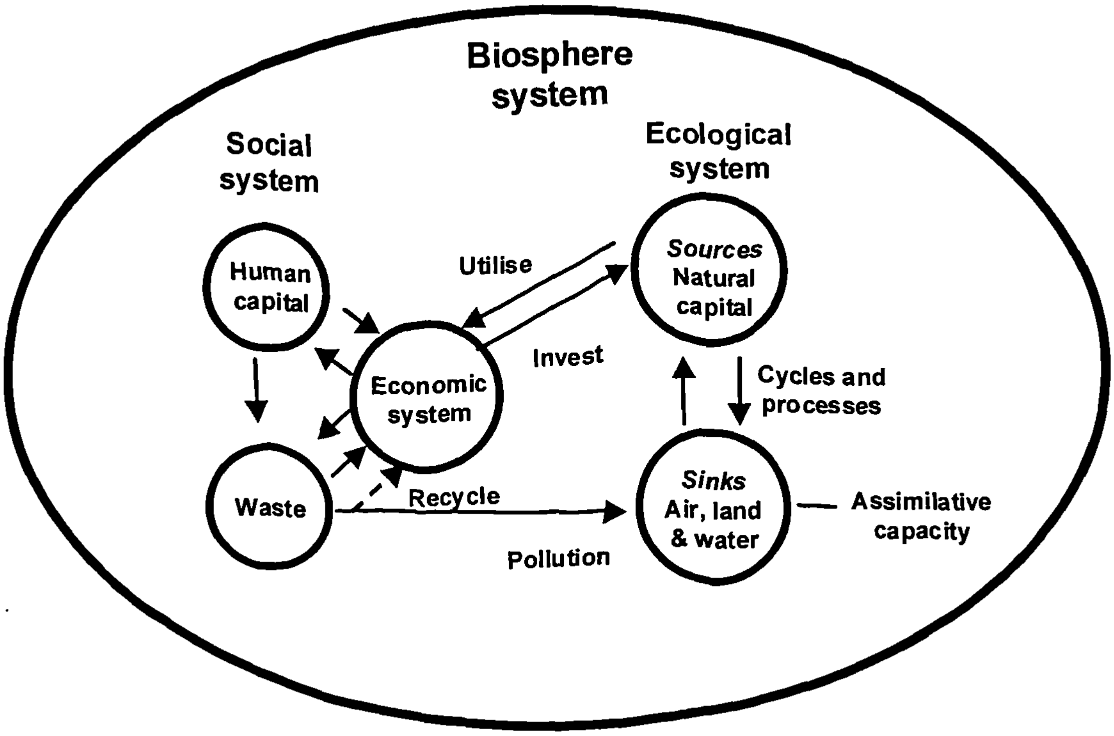

Figure 2.1. Model of interaction between ecological and social systems

The finite *biosphere* suprasystem represents the Earth and encompasses all the elements of both the social and ecological systems. The *ecological* system contains sources and sinks[16]. *Sources* are energy and natural resources which make up *natural capital,* which are *utilised* (or *invested* in for future utilisation) by the *economic* system (a subsystem of the *social* system). The economic system serves, and is nurtured by, the ongoing development of *human capital* production and consumption. A distinction is made between exhaustible (or non-renewable) and renewable natural capital[17]. Exhaustible natural capital (such as minerals and fossil

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(1988), "An Assessment of Several of the Historically Most Influential Theoretical Models Used in Ecology and of the Data Provided in their Support", **Ecological Modelling,** 43: 5-31.

[16] For example, see Dasgupta, P.S., (1982), **The Control of Resources,** Basil Blackwell: Oxford.

[17] For example, see Stallworth, H., (1996), "The Economics of Sustainability", **Office of Sustainable Ecosystems and Communities Issue Brief,** U.S. Environmental Protection Agency; Tietenberg, T., (1996), **Environmental and Natural Resource Economics,** Harper Collins: New York; Peterson, F.M. & Fischer, A.C., (1977), "The Exploitation of Extractive Resources: A Survey", **Economics Journal,** 87: 681-721.; Roberts, P., (1995), **Environmentally Sustainable Business: A Local and Regional Perspective,** Paul Chapman: London. Pages 14-15.

fuels) consists of an initial stock which, from a human time perspective, is only very slowly renewed[18]. Renewable natural capital (such as fish, forests, groundwater) in principle is reproduced within the human time perspective[19] although, increasingly, it is becoming exhausted[20]. The *sinks* are physical components of the ecological system (air, land and water) for the assimilation of materials and energy, which are transferred from the economic system back to the ecological system as *pollution* (from both production and consumption *waste* which has not been *recycled*). The source and sink functions are related in the sense that a higher extraction of resources, such as oil or coal, will mean more pollution and waste and increased pressure on the assimilative capacity of the ecosystem[21]. The sources and sinks of the ecological system are linked by the natural services provided by the natural capital system[22] (such as the maintenance of essential climatic and ecological cycles and processes), the quality of which is essential for supporting economic production and welfare[23]. The system model is dynamic, with the composition and interaction changing through time, either because of natural system disturbance or because of internal ecological mechanisms[24].

The ecological system has a limited resource-creating capacity for the substances that the social system extracts and a limited assimilation capacity for the pollution and waste that society returns to nature. When the societal influence exceeds these capacities of nature, damage occurs. Sustainability, in the system terms set out in this model, is thus achieved when resource extraction from the ecological system

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[18] See Slaughter, R.A., (1996), "Long-term Thinking and the Politics of Reconceptualisation", **Futures**, 28: 1: 75-86.
[19] For example, see Tromp, O., (1997), **Sustainable Use of Renewable Resources for Material Purposes: A Conceptual Approach**, United Nations Environment Programme Working Group in Sustainable Product Development: Amsterdam, Netherlands.; National Academy of Sciences, (1976), **Renewable Resources for Industrial Materials**, NAS: Washington, DC, USA.
[20] For example, see Brown, L.R *et al.*, (1991, 1992, 1993, 1994, 1995, 1996, 1997. 1998), **State of the World**, Earthscan Publications: London.
[21] Goodland, R., (1991), "The Case that the World Has Reached Limits. More Precisely that Current Throughput Growth in the Global Economy Cannot be Sustained", in R. Goodland, H. Daly, S. El Setrafi & B. von Droste, (Eds.), **Environmentally Sustainable Economic Development: Building on Bruntland**: 15-27, UNESCO: Paris.
[22] Barbier, E.B., (1989), **Economics, Natural Resource Scarcity and Development: Conventional and Alternative Views**, Earthscan: London.
[23] Daily, G.C., (1997), "Valuing and Safeguarding Earth's Life Support Systems", in G. Daily, (Ed.), **Natures Services: Societal Dependence on Natural Ecosystems**: pages 365-374. Island Press: Washington, DC.
[24] Ehrenfeld, D., (1993), "Ecosystem Health", **Orion**, Winter: 12-15.; Pimm, S.L., (1991), **The Balance of Nature?**, University of Chicago Press: Chicago.; Odum, E., (1971), **Fundamentals of Ecology**: 3rd edition, Saunders: Philadelphia. Page 251.

occurs within the carrying capacity of the resource base and when waste transfer to the physical components of the ecological system does not exceed the assimilative capacity of the particular ecosystems[25]. This need for balance resonates strongly with the arguments proposed by relevant literature. From a thermodynamics perspective, for example, it has been argued that:

> *"... since matter and energy cannot be destroyed, an equal amount of matter and energy in the form of waste must be returned to the environment, leading to pollution. Hence lower rates of throughput lead to less depletion and pollution, higher rates to more. The limits regarding what rates of depletion and pollution are tolerable must be supplied by ecology."*[26]

The idea of the ecology subsystem being a constraint to the size and operation of the social system is developed elsewhere. It has been argued that exponential economic growth is incompatible with survival in a biosphere that is finite in its capacity to yield materials and energy resources and in its capacity to absorb economic waste[27], and that "... the economic process is solidly anchored to a material base which is subject to definite constraints.[28]" Similarly, it has been stressed that ecological systems have a limited capacity for absorbing the environmental degradation caused by human activities. After that capacity is exceeded, ecosystems will deteriorate and human health and welfare will suffer.[29]

This model thus firmly identifies the key issues as being the organisation of production and consumption of the social system, the quantity and quality of

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[25] Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C.S., Jansson, B.O., Levin, S., Mäler, K.G., Perrings, C. & Pimentel, D., (1995), "Economic Growth, Carrying Capacity and the Environment", **Science**, 268: 520-521.; Common, M., (1995), **Sustainability and Policy: Limits to Economics**, Cambridge University Press: Cambridge.; Brown, L.R., (1994), **State of the World 1994: A Worldwatch Institute Report on Progress Toward a Sustainable Society**, Norton: New York; Daly, H.E. & Cobb, J.B., (1994), **For the Common Good** (2nd edition), Beacon Press: Boston.; Rees, W.E., (1991), **Understanding Sustainable Development**, School of Community and Regional Planning: University of British Columbia, Vancouver.

[26] Daly, H.E. & Townsend, K.N., (1993), **Valuing the Earth: Economics, Ecology, Ethics**, The MIT Press: Cambridge. Page 32.

[27] Townsend, K.N., (1993), "Steady State Economics and the Command Economy", in H.E. Daly, H.E. & K.N. Townsend, (Eds.), **Valuing the Earth: Economics, Ecology, Ethics**, The MIT Press: Cambridge. Page 293.

[28] Georgescu-Roegen, N., (1993), "The Entropy Law and the Economic Problem", in H.E. Daly & K.N. Townsend, (Eds.), **Valuing the Earth: Economics, Ecology, Ethics**, The MIT Press: Cambridge. Page 81.

ecological system functions, and the dynamic interaction between the social system and the ecological system – in summary, the model captures the thesis that humans are dependent upon ecological systems, for "... without the services provided by natural ecosystems, civilisation would collapse and human life would not be possible ..."[30], and "... that human society and nature make up a single ecosystem, and that human activities must be appraised and managed in the light of their effects on all other components of the ecosystem.[31]"

At present, it is argued the organisation of, and interaction between, the social and ecological systems is not sustainable and, unless rearranged, will lead to a permanent breakdown, in human time span terms, of suprasystem resilience (the ability of the system to stay in dynamic balance[32]) and integrity (the ability of the system to support services of value to humans[33]). The next section will present evidence to support this claim by first, examining the present state of socio-ecological system interaction at a global level, and, second, identifying the built environment and construction industry contribution to this interaction.

2.3. Present state of socio-ecological system interaction

2.3.1. Global situation

Mounting evidence shows that the ecosystems of Earth cannot sustain current levels of economic activity, let alone increased levels[34]. By the year 2025, the world

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[29] Environmental Protection Agency Science Advisory Board, (1990), **Reducing Risk: Setting Priorities and Strategies for Environmental Protection**, Environmental Protection Agency: Washington, DC. Page 17.
[30] Ehrlich, P.R., (1986), **The Machinery of Nature**, Simon & Schuster: New York. Page 239. Also see Odum, E.P., (1993), **Ecology and Our Endangered Life Support Systems**: 2nd edition, Sinauer: Sunderland, Massachusetts.
[31] Darling, F.F. & Dasmann, R.F., (1969), "The Ecosystem View of Human Society", **Impact of Science on Society**, 19: 109-121.
[32] Common, M. & Perrings, C., (1992), "Towards an Ecological Economics of Sustainability", **Ecological Economics**, 6: 7-34.; Pimms, S,L., (1991), **The Balance of Nature?**, University of Chicago Press: Chicago, Illinois.
[33] Reiger, H.A., (1994), **The Notion of Natural and Cultural Integrity: Ecological Integrity and the Management of Ecosystems**, St. Lucie Press,; Karr, J.R. & Dudley, D.R., (1981), "Ecological Perspective on Water Quality Goals", **Environmental Management**, 5: 55-68.
[34] For example, see Goodland, R., (1991), "The Case that the World has Reached Limits: More Precisely that Current Throughput Growth in the Global Economy Cannot be Sustained", in R. Goodland, H.E. Daly & El Serafy, (Eds.), **Environmentally Sustainable Development: Building on Brundtland**, The World Bank: Washington, DC.; Meadows, D.H., Meadows, D.L. & Randers, J., (1992), **Beyond the Limits**, McClelland: Toronto, Canada. Pages 97-103.; Posal, S., (1994), "Carrying Capacity: Earth's Bottom Line", in L.R. Brown *et al.*, (Eds.), **State of the World: 1994**, Worldwatch Institute, Norton: New York.; Rees, W.E. & Wackernagel, (1994), "Ecological

population is projected to total about 8.3 billion people, or about forty-five percent more than the estimated current population of 5.7 billion. By 2050, the global population could be about ten billion[35]. The population increase, coupled with a five-fold increase in global economic activity since 1950[36], is elevating the consumption of levels of natural capital and the production of pollution and waste[37] in excess of the replenishing rate of the ecological systems sources and the assimilation capacity of its sinks[38]. At present rates of consumption, for example, world reserves of oil, natural gas, coal and all minerals are predicted to be substantially depleted within the next century[39]; while global energy production and consumption has risen forty-five percent from 1973 to 1993[40], and is predicted to increase by some sixty percent between 1994 and 2010[41]. Similarly, the demand for fresh water has expanded rapidly, rising six hundred percent from 1940 to 1990[42]. Present trajectories of water consumption and water contamination pose serious obstacles to sustainable development in many countries[43].

Footprints and Appropriate Carrying Capacity: Measuring the Natural Capital Requirements of the Human Economy", in A. Jansson, M. Hammer, C. Folke & R. Costanza, (Eds.), **Investing in Natural Capital: The Ecological Economics Approach to Sustainability**, Island Press: Washington, DC. Page 383.; Corson, W.H., (1994), "Changing Course: An Outline of Strategies for a Sustainable Future", **Futures**, 26: 206-223.

[35] United Nations Population Fund, (1998), **The State of World Population 1998**, UNFPA: New York.

[36] OECD, (1997), **Sustainable Consumption and Production: Clarifying the Concepts**, OECD: Paris. Page A2.

[37] For example, see Ohmae, K., (1990), **The Borderless World: Power and Strategy in the Interlinked Economy**, Harper: New York.

[38] Silver, C.S. & DeFries, R.S., (1990), **One Earth/One Future: Our Changing Global Environment**, National Academy Press: Washington, D.C. Page iii.

[39] Clark, M., (1989), **Ariadne's Thread**, St. Martin's Press: New York.; Daly, H.E., (1977), **Steady State Economics**, Freeman: San Francisco.; McNeill, J., (1989), "Strategies for Sustainable Development", **Scientific American**, September: 155-165.; World Commission on Environment and Development, (1987), **Our Common Future**, Oxford University Press: New York.

[40] Energy Information Administration, U.S. Department of Energy, (1995), **International Energy Outlook, 1995, Report No. DOE/EIA-0484(95)**, U.S. Government Printing Office: Washington, D.C.

[41] International Energy Agency, (1996), **World Energy Outlook 1996**, IEA: London.

[42] Shiklomanov, I., (1993), "World Fresh Water Resources", in P.H. Gleick, (Ed.), **Water in Crisis: A Guide to the World's Fresh Water Resources**, Oxford University Press: New York. Table 2.8., page 20.

[43] For example, see Postel, S.L., Daily, G.C. & Ehrlich, P.R., (1996), "Human Appropriation of Renewable Fresh Water", **Science**, 271: 785-788.; United Nations Economic and Social Council, Committee on Natural Resources, (1994), **Water Resources: Progress in the Implementation of the Mar del Plata Action Plan and of Agenda on Water-related Issues**, United Nations: New York. Pages 4-9.; United Nations Economic and Social Council, Commission on Sustainable Development, (1994), **Freshwater Resources: Report of the Secretary-General**, United Nations: New York. Pages 3-5.

The adverse effects of such consumption trends are significant. Various biodiversity projects suggest that from 1975 to 2015 between one and eleven percent of the world's species per decade will be committed to extinction[44]. The depletion of biodiversity on this scale will have serious consequences for water resource protection, soil formation and protection, nutrient storage and cycling, pollution breakdown and absorption, climate stability, maintenance of ecosystems and system recovery from unpredictable events[45]. The current atmospheric carbon dioxide concentration is about twenty-eight percent greater than that at the beginning of the industrial revolution and is growing at an average of 0.4 percent per year[46]. These emissions, along with other greenhouse gases: carbon monoxide, nitrogen oxide, non-methane hydrocarbons and methane, are changing the composition of the atmosphere at an unprecedented rate. While the complexity of the global climate system makes it difficult to accurately predict the impacts of these changes, the evidence from modelling studies indicates that global mean temperature will increase by 1.5°C to 4.5°C by the year 2025[47]. The magnitude and rate of this potential climate change pose serious risks for human and ecosystem adaptation, with potentially large environmental and socioeconomic consequences, in particular sea level rises, increased climatic variability and storm intensity and changes in vegetation[48]. Solid waste generation is increasing worldwide at a rate of two percent per year[49], and appropriate forms of disposal are under increasing pressure with, for example, untreated waste leading to contamination of soils and water bodies with heavy metals such as mercury, lead and arsenic[50].

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[44] United Nations Environment Programme, (1995), **Global Biodiversity Assessment**, Cambridge University Press: Cambridge, UK.; World Conservation Monitoring Centre, (1998), **Global Biodiversity: Status of the Earth's Living Resources**, Chapman and Hall: London.
[45] World Conservation Monitoring Centre, (1992), **Global Biodiversity: Status of the Earth's Living Resources**, IUCN, UNEP, WWF and WRI: Chapman Hall: London.
[46] Intergovernmental Panel on Climate Change, Radiative Forcing of Climate Change: The 1994 Report of the Scientific Assessment Working Group of IPCC (World Meteorological Organization/United Nations Environment Programme, Geneva, 1994), p. 5, 11, 14.
[47] Intergovernmental Panel on Climate Change, (1992), **Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment**, Cambridge University Press: Cambridge, UK. Page 5.
[48] Lazarus, M. & von Hippel, D., (1995), **A Guide to Environmental Analysis for Energy Planners**, Stockholm Environment Institute: Boston, MA. Page 14.
[49] United Nations Environment Programme, (1994), **Environmental Data Report 1993**, UNEP: Nairobi, Kenya. Page 329.
[50] Bureau of Territorial Planning and Regional Economics, China National Planning Commission, Planning Bureau, China National Environmental Protection Agency, and Chinese Academy of Geological Information, (1994), "Major Environmental Problems in China", **Chinese Environment and Development**, 4: 4: 18-52. Page 28.

2.3.2. Built environment and construction industry contribution

The contribution of the built environment and construction to these trends is substantial. Between 1971 and 1992, primary energy use in buildings worldwide grew on average two percent annually. In 1992, the built environment accounted for about a third of total world energy consumption, including twenty-six percent fossil fuels, forty-five percent of hydropower and fifty percent of nuclear power[51]. Lighting accounts for fifteen percent of electricity consumption in developed countries and about eight percent in developing countries and accounts for almost six percent of the OEDC's carbon dioxide emissions[52]. It is estimated that between thirteen percent and thirty percent of all solid waste deposited in landfills worldwide comprises construction and demolition waste[53]. The construction industry, including building material production, is probably the greatest consumer of natural resources, using from between seventeen percent and fifty percent of the extracted resources, as water, wood, minerals and fossil fuels[54]. According to the Worldwatch Institute, building construction consumes forty percent of the raw stone, gravel and sand used globally annually, and twenty-five percent of the virgin wood. Buildings also account for sixteen percent of the water used annually worldwide[55].

2.3.3. Summary

These global trends, to which the built environment and the construction industry is a substantial contributor, have fuelled the inevitable conclusion that "... the major cause of the continued deterioration is the unsustainable pattern of consumption and production, particularly in industrialized countries ..."[56] to a degree where "...it is abundantly clear that human activities now match or even surpass natural processes

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[51] Vale, B. & Vale, R., (1991), **Green Architecture: Design for an Energy-conscious Future**, Bulfinch Press: Boston.; U.S. Department of Energy, Energy Information Administration, (1994), **Annual Energy Review 1993**, U.S. Department of Energy, Energy Information Administration: Washington, DC.

[52] Sexton, M.G., "The Greening of Industry: The Case of Office Lighting", **Unpublished M.Sc. Dissertation**, Manchester School of Management: University of Manchester Institute of Science and Technology: Manchester, UK.

[53] Bossink, B.A.G. & Brouwers, H.J.H., (1996), "Construction Waste: Quantification and Source Evaluation", **Journal of Construction and Engineering Management**, 122: 1.

[54] Editors, (1996), "The Construction Industry: Building for Sustainability?, **Industry and Environment**, 19: 2: 3.

[55] Roodman, D.M. & Lenssen, N., (1995), **A Building Revolution: How Ecology and Health Concerns are Transforming Construction: Worldwatch Paper 124**, Worldwatch Institute: Washington, DC.

[56] Agenda 21 Chapter 4

as agents of change in the planetary environment.[57]" A diverse range of commentators increasingly argues that unless there is an appropriate, fundamental reconceptualisation of the interaction between social and ecological systems, a sustainable society in the twenty-first century is unlikely[58]. The Brundtland Report framed the challenge by saying:

> *"the time has come to break out of past patterns. Attempts to maintain social and ecological stability through old approaches to development and environmental protection will increase instability."*[59]

It is argued that two principal elements are needed to bring about and maintain such a reconceptualisation: an envisioning, motivating portfolio of goal orientations which can direct and shape the transition; and a conceptual framework to locate and integrate stakeholders' diverse policies and actions to generate the ability for appropriate, complementary progress. The portfolio of goal orientations has been loosely captured in the term 'sustainable development.' What this term means is discussed more fully in the next section.

2.4. Sustainable development

2.4.1. What is it?

The concept of sustainable development was contextually defined by The World Commission on Environment and Development as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs"[60], and, in its broadest sense, this influential definition has been widely accepted by many firms, institutions and governments across the globe[61]. At

[57] Silver, C.S. & DeFries, R.S., (1990), **One Earth/One Future: Our Changing Global Environment**, National Academy Press: Washington, D.C.
[58] Arrow, K., Bolin, R., Costanza, P., Dasgupta, C., Folke, C.S., Holling, B.O., Janssen, S., Levein,K., Mäler, C., Perrings, C. & Pimentel, D., (1995), "Economic Growth, Carrying Capacity, and the Environment", **Science**, 268: 520-521.; Shrivastava, P., (1994), "Castrated Environment: Greening Organizational Studies", **Organization Studies**, 15: 5: 7-5-726.; Wilbush, J., (1990), "Impact Management, Worse Scenario: Possible Technological Strategic Options"" **Technology Analysis & Strategic Management**, 2: 1: 27-38.; Schumacher, E.F., (1973), **Small is Beautiful: Economics as if People Really Mattered**, Abacus: London.
[59] World Commission on Environment and Development, (1987), **Our Common Future**, Oxford University Press: New York. Page 21.
[60] World Commission on Environment and Development, (1987), **Our Common Future**, Oxford University Press: New York. Page 8.
[61] Levin, S.A., (1996), "Forum on Economic Growth and Environmental Quality", **Ecological Applications**, 6: 12-31.; Haas, P.M., Levy, M.A. & Parson, E.A., (1992), "Appraising the Earth Summit: How Should We Judge UNCED's Success?", **Environment**, 34: 8: 6-33.

an international level, for example, the Group of Seven industrialised countries declared, "protecting the environment calls for a determined and concerted international response and for early adoption, worldwide, of policies based on sustainable development[62]"; at an institutional level, the powerful World Business Council for Sustainable Development (a coalition of one hundred and twenty international companies) has set out " ...to develop closer co-operation between business, government and all other organizations concerned with the environment and sustainable development ... [and] ...to encourage high standards of environmental management in business itself[63]"; and at a firm level Costain, the large construction and civil engineering concern, is endeavouring to "... control or minimise environmental disruption [and] make a positive contribution to the environment and improve the quality of our lives.[64]"

The precise interpretation and operationalisation of sustainable development has remained elusive, however, for the concept of sustainable development is at once vague and complex, stimulating "... a wide range of potential definitions which can be used to support divergent objectives[65]" directed at envisioning what to sustain and what to develop[66]. Since the time of the Commission report, numerous definitions of sustainable development have been proposed[67]. For example, sustainable development has been viewed in terms of political ideology[68], vision expression[69],

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[62] Group of Seven, (1989), **Summit of the Arch: Economic Declaration**, Paris: 16th July. Page 3.
[63] World Business Council for Sustainable Development, (1998), **Trade and Environment: A Business Perspective**, WBCSD: Geneva, Switzerland. Page 7.
[64] Costain Environmental Policy. [Online] Available http://www.costain.com/environm/envifrnt.htm, August 4th, 1999.
[65] Blowers, A., 1993), "Preface", in A. Blowers, (Ed.), **Planning for a Sustainable Environment: A Report by the Town and Country Planning Association**, Earthscan: London. Page xi.'
[66] For example, see Grant, J., Manuel, P. & Joudrey, D., (1996), "A Framework for Planning Sustainable Residential Landscapes", **Journal of the American Planning Association**, 63: 3: 331.
[67] For example, see Carpenter, S.R., (1993), "When are Technologies Sustainable?", in L.A. Hickman & C.F. Porter (Eds.), **Technology and Society**: 202-214., Society for Philosophy and Technology: Carbondale, Ill.; El Serafy, S., (1992), "Sustainability, Income Measurement, and Growth', in R. Goodland, H.E. Daly & S. El Serafy (Eds.), **Population, Technology, and Lifestyle: The Transition to Sustainability**: 63-79. Island Press: Washington, DC.; Gladwin, T.N., (1993), "The Meaning of Greening: A Pleas for Organizational Theory", in K. Fisher & J. Schot (Eds.), **Environmental Strategies for Industry**: 37-61. Island Press: Washington, DC.; Pezzey, J., (1989), **Economics Analysis of Sustainable Growth and Sustainable Development**, Working paper, Environmental Department, World Bank: Washington, DC.
[68] Conca, K., Alberty, M. & Dabelko, G., (Eds.), **Green Planet Blues: Environmental Politics from Stockholm to Rio**, Westview Press: Boulder.; El Serafy, S., (1992), "Sustainability, Income Measurement, and Growth', in R. Goodland, H.E. Daly & S. El Serafy (Eds.), **Population, Technology, and Lifestyle: The Transition to Sustainability**: 63-79. Island Press: Washington,

value change[70], moral development[71], social reorganisation[72], ethical imperative[73], economic reconfiguration[74] or transformation process[75] toward a desired future or better world. The range of definitions demonstrates that the construct is fundamentally infused with multiple objectives and constituents, complex interdependencies and considerable "moral thickness[76]. Consequently, the goals (and thus supporting policies and measures of progress) stressed in one instance may not be the same as those emphasized in another. In fact, they may actually be in conflict[77]. This argument underpins, for example, the observation that "sustainability is a multifaceted concept. Many different ecosystem components may be valued by society or parts of society. Sustainable use from one perspective

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DC.; Redclift, M.R., (1987), **Sustainable Development: Exploring the Contradictions**, Methuen: London.

[69] President's Council on Sustainable Development, (1996), **Sustainable America: A New Consensus for Prosperity, Opportunity, and a Healthy Environment for the Future**, PCSD: Washington, DC.; Lee, K.N., (1993), "Greed, Scale Mismatch and Learning", **Ecological Applications**, 3: 4: 560-564.

[70] Campbell, S., (1996), "Green Cities, Growing Cities, Just Cities?", **Journal of the American Planning Association**, 63: 3: 302; Haywood, T., (1995), **Ecological Thought: An Introduction**, Polity Press.; Clark, W.C., (1989), "Managing Planet Earth", **Scientific America**, 261: 3: 47-54.

[71] Rolston, H., (1994), **Conserving Natural Value**, Columbia University Press: New York.; Solow, R.M., (1991), **Sustainability: An Economist's Perspective**, Marine Policy Center: Woods Hole, Massachusetts, USA.; Dasgupta, P. & Heal, G.F., (1979), **Economic Theory and Exhaustible Resources**, Cambridge University Press.

[72] Irwin, A., (1995), **Citizen Science: A Study of People, Expertise and Sustainable Development**, Routledge: London.; Gore, A., (1992), **Earth in Balance: Ecology and the Human Spirit**, Houghton Mifflin: New York.

[73] For example, see Carpenter, S.R., (1991), "Inventing Sustainable Technologies", in J. Pitt & E. Lugo, (Eds.), **The Technology of Discovery and the Discovery of Technology: Proceedings of the Sixth International Conference of the Society for Philosophy and Technology**, Society for Philosophy and Technology: Blacksburg.; Shiva, V., (1992), **Staying Alive: Women, Ecology, and Development**, Zed: London.

[74] Barbier, E.B., (1987), "The Concept of Sustainable Development", **Environmental Conservation**, 14: 2: 101-110.; Goodland, R. & Ledec, G., (1987), "Neoclassical Economics and Principles of Sustainable Development", **Ecological Modelling**, 38: 19-46,; James, D.E., (1989), "Achieving Sustainable Development: Applications of Economic Techniques", Milieu, 4: 129-133.; Klaassen, G.A.J. & Opschoor, J.B., (1991), "Economics of Sustainability or the Sustainability of Economics: Different Paradigms", **Ecological Economics**, 115: 93-115.; Pezzy, J., (1989), "Economic Analysis of Sustainable Growth and Sustainable Development", **World Bank Environment: Working Paper 15**, Washington, D.C.

[75] Ontario Institute for Studies in Education, (1994), **Awakening Sleepy Knowledge: Transformative Learning in Action: Final Report of the Transformative Learning Through Environmental Action Report**, OISE: Toronto.; Viederman, S., (1994), "The Economics of Sustainability: Challenges", **Paper presented at the Workshop: The Economics of Sustainability**, Fundacao Joaquim Nabuco, Recife, Brazil.

[76] Williams, B., (1985), **Ethics and the Limits of Philosophy**, Harvard University Press: Cambridge, MA.

[77] For example, see Sexton, M.G., (1998), "Is There a Sustainable Definition of Sustainable Development?", **Unpublished Working Paper for the Integrated Delivery Systems for Sustainable Construction Project**, University of Salford, England.; Gatto, M., (1995), "Sustainability: Is it a Well Defined Concept?", **Ecological Applications**, 5: 4: 1181-1184.

is unsustainable from another."[78] However, it is vital to develop some degree of clarity of the different perspectives of sustainable development, as the issue of definition is linked to ranking and prioritising goals as well as to the policies needed to meet goals and allocate costs and benefits. More specifically, the goals embedded within the various definitions of sustainable development serve several important functions (described below) which vary according to the perspective of sustainable development advocated:

- *Focus.* A given view of sustainable development will generate a distinctive set of goals which serve as guidelines for action, directing and channelling efforts and activities of relevant stakeholder participants. In this regard, a clear view of sustainable development provides focus for activity by prescribing what 'should be' done. This crucial role is set out, for example, in the need for "... establishing a vision of sustainable development and clear goals that provide a practical definition of that vision in terms that are meaningful for the decision-making unit in question.[79]" It has been stressed that there is a need for an appropriate hierarchy of goals: aims at the general level (e.g. preserving and improving environmental quality); qualitative goals at the intermediate level (e.g. preserving the ozone layer); and specific quantitative targets at a more specific level (e.g. reduction of car pollution levels in a given city)[80]. Further, the lack of clear focus of this kind, for example, underpins the observation that more attention is needed on how sustainable development can be translated into concrete goals and criteria at the level of sectors, regions and projects[81].
- *Constraints.* To the extent that a given set of sustainable development goals prescribes what 'should be' done, they also serve to prescribe what 'should not be done'. A given view of sustainable development that commits itself to certain goals reduces the amount of discretion it has to pursue other outcomes. The concept of 'accessibility space', for example, argues that the range of sustainable

[78] Oriens, G.H., (1990), "Ecological Concepts of Sustainability", **Environment**, 32: 9: 10-39.
[79] Hardi, P. & Zdan, T., (1997), **Assessing Sustainable Development: Principles in Practice**, International Institute for Sustainable Development: Winnipeg, Manitoba. Page 1.
[80] Organisation for Economic Co-operation and Development, (1997), **OECD Environment Performance Reviews: A Practical Introduction – OCDE/GD(97)35**, OECD: Paris. Pages 8-9.
[81] Van Pelt, M.J.F., Kuyvenhaven, A. & Nijkamp, P., (1990), "Project Appraisal and Sustainability: Methodological Challenges", **Project Appraisal**, 5: 3: 139-158.

development trajectories available is restricted by a raft of physical, human and time constraints which vary depending on the goals being pursued[82].

- *Source of motivation and legitimacy.* Goals also provide a source of motivation and legitimacy for relevant stakeholders by justifying its activities. The work of the President's Council on Sustainable Development in the United States, for example, "... gave [people] credibility to continue innovative projects for which they did not yet have widespread support.[83]" Similarly, it has been noted that a variety of organisations and institutions, with very different interests and objectives, utilise the notion of sustainable development to justify or rationalise particular strategies and actions as being in the global interest[84].
- *Measures of performance* To the extent that sustainable development goals are clearly stated and understood, they offer a seedbed of appropriate measures or indicators for evaluating performance. This need, for example, is expressed in the argument that, "if we genuinely embrace sustainable development, we must have some idea if the *path* we are on is heading towards it or away from it. There is no way we can know that unless we know what it is we are trying to achieve – i.e. what sustainable development means – and unless we have indicators that tell us whether we are on or off a sustainable development path.[85]"

In summary, a clear understanding of different sustainable development perspectives will make more transparent the differing objectives, criteria and constraints guiding action, along with the underpinning sources of motivation and legitimacy driving and protecting the various sustainable development trajectories being pursued.

There is thus a clear tension between the normative need for establishing a clear understanding of sustainable development from which consistent and coherent goals and actions can be stimulated, and the reality of multiple, often discordant views of sustainable development obstructing what these goals and actions should be. This

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[82] Bossel, H., (1999), **Indicators for Sustainable Development: Theory, Method, Applications**, International Institute for Sustainable Development: Winnipeg, Canada. Pages 3-6.
[83] The President's Council on Sustainable Development, (1999), **Towards a Sustainable America: Advancing Prosperity, Opportunity, and a Healthy Environment for the 21st Century**, PCSD: Washington. Page 4.
[84] Harvey, D., (1996), **Justice, Nature and the Geography of Difference**, Blackwell: Cambridge, MA. Page 339.
[85] Pearce, D., (1998), "Measuring Sustainable Development", in the **Proceedings of the Sustainable Development Indicators OECD Expert Workshop**, 8th – 9th October: Paris. Page 22.

tension is seen as very real, with some commentators forecasting that the concept of sustainable development will remain fuzzy, elusive, contestable and ideologically controversial for some time to come[86] - indeed, it has been stressed that "... any claim to have discovered the definite solution to the sustainability problem is, almost certainly, false. It is not even clear that the problem can be definitely formulated.[87]". Some commentators have concluded that the degree of definitional diversity has discredited the concept of sustainable to the point that the term is just a cliché[88]. Such a view is misplaced. Definitional diversity is to be expected during the embryonic stage of any potentially fundamental and globally pervasive ideology that transcends the specificities of "... human circumstance, economic conditions, and political institutions ...[89]"; the concept of sustainable development can be likened to, for example, democracy, liberty, justice or equality. The genesis and subsequent development and consolidation of such new paradigms tend to emerge from entirely new fundamental principles and, at first, without a full set of concrete rules or standards[90]. Indeed, sustainable development, in the end, may be obstinately located in what has been described as the realm of "unabsolute truths"[91]. For now, we are forced to deal with the topic at a rather high level of abstraction. Rather than lament or withdraw from this embryonic stage, there is a need to positively engage

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[86] Pannell, D.J. & Schilizzi, S., (1997), "Sustainable Agriculture: A Question of Ecology, Economics, Ethics or Expedience?, **Proceedings of the 41st Annual Conference of the Australian Agriculture and Resource Economics Society**, Gold Coast, Queensland, 21st 23rd January.; Grundy, K., (1994), "Sustainable Development: An Emerging Paradigm", **Proceedings of the 17th New Zealand Geographical Society** Conference, Christchurch, New Zealand.; Beckerman, W., (1994), "Sustainable Development: Is it a Useful Concept?" **Environmental Values**, 3: 3: 191-209.; Dowie, M., (1995), **Losing Ground: American Environmentalism at the Close of the Twentieth Century**, The MIT Press: Cambridge, MA.; Levin, S.A., (1993), "Science and Sustainability", **Ecological Applications**, 3: 4: 1-2.

[87] Common, M., (1995), **Sustainability and Policy: Limits to Economics**, Cambridge University Press: Cambridge. Page 348.

[88] Holmberg, J., (1992), **Making Development Sustainable: Redefining Institutions, Policy, and Economics**, Washington, DC. Page 20.; Graham-Tomasi, T., (1991), "Sustainability: Concepts and Implications for Agricultural Research Policy", in P.G. Pardy, J. Roseboom & J.R. Anderson (Eds.), **Agricultural Research Policy, International Quantitative Perspectives**, Cambridge University Press: Cambridge. Page 84.

[89] Tinker, T., (1991), "Falling Down the Hole in the Middle of the Road: Political Quietism in Corporate Social Reporting", **Accounting, Auditing and Accountability Journal**, 4: 2: 28-54. Page 41.

[90] Kuhn, T.S., (1962), **The Structure of Scientific Revolutions**, University of Chicago Press: Chicago.

[91] Berreby, D., (1995), "Unabsolute Truths: Clifford Geertz", **New York Times Magazine**, April 9th: 44-47.

the unfolding process of paradigmatic debate, for the advance of all sciences requires conflict between competing schools of thought[92].

To try and better understand this tension, and thus tease out some guidance on how progress can be made to its resolution, there is a need to understand why different stakeholders have such divergent, often incompatible aspirations of sustainable development that can severely hinder progress at policy and operational levels. Two key strands will be followed. First, some of the principal components of the ideas that are generally shared by the majority of sustainable development perspectives will be identified (see Section 2.4.2.). Second, the complex role of peoples' worldviews in shaping the focus and composition of these sustainable development components will be discussed (See Section 2.5.).

2.4.2. Principal elements of sustainable development

A number of recurring elements which flavour, to varying degrees, the majority of the definitions of sustainable development can be articulated. For the purposes of contextualising these elements, sustainable development is viewed as:

> *Endurable, appropriate progress*, built on *socio-ecological system* principles, that are temporally and spatially *equitable* in its focus and *participatory* in its formulation and implementation.

It is appreciated, as discussed in Section 2.4.1., that the debate over the meaning of sustainable development is still evolving, and that the abstract conception set out above is one of many that might be offered at this time. Each of the components is discussed below.

<u>Endurable, appropriate progress.</u> Most definitions of sustainable development appreciate that development must be within the carrying and assimilation capacities of the Earth (see 'socio-ecological system' below), and that it must be distributed fairly across spatial and temporal dimensions, (see equity below). The term

[92] Kuhn, T.S., (1970), **The Structure of Scientific Revolutions** (2nd edition), University of Chicago Press: Chicago.; Hall, S., (1988), **The Hard Road to Renewal**, Verso: London.

'development' is generally viewed as progress in the quality of life[93] through social and cultural progress[94], rather than the more traditional goal of increasing economic activity[95]. Progress does not rule out growth but it certainly dictates the type of growth which is desirable[96]. Indeed, development trajectories "... which raise ... per capita level of real income over time but does so without making any transformations in its social and economic structure is unlikely to be said to be "developing".[97] This view of development is consistent with the post-materialistic thesis which argues that societies are changing their cultural values towards "quality of life" issues, away from material consumption and away from economic distribution conflicts[98]. It has been argued, for example, that the 'quality of life' emphasis necessitates the following dimensions to human development[99]:

- an economic component dealing with the creation of wealth and improved conditions of material life, equally distributed;
- a social ingredient measured as well-being in health, education, housing and employment;
- a political dimension including values such as human rights, political freedom, enfranchisement, and some form of democracy;
- a cultural dimension recognising that cultures confer identity and self-worth to people; and
- a full-life paradigm, which refers to meaning systems, symbols, and beliefs concerning the ultimate meaning of life and history.

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93 For example, see World Conservation Union, United Nations Environment Programme and World Wide Fund for Nature, (1991), **Caring for the Earth: A Strategy for Sustainable Living**, WCU, UNEP and WWFN: Gland, Switzerland. Page 5.

94 Pearce, D.W., Markandya, A. & Barbier, E.B., (1989), **Blueprint for a Green Economy**, Earthscan. Page 175.

95 For example, see Allen, R., (1980), **How to Save the World**, Kogan Page: London; Mishan, E.J., (1973), "The Growth of Affluence and the Decline of Welfare", in H.E. Daly, (Ed.), **Economies, Ecology, Ethics: Essays Toward a Steady-state Economy**, Freeman: pages 267-281.

96 Pearce, D.W., Markandya, A. & Barbier, E.B., (1989), **Blueprint for a Green Economy**, Earthscan. Page 22; Coomer, J., (1979), "The Nature of the Quest for a Sustainable Society", in J. Coomer (Ed.), **Quest for a Sustainable Society**, Pergamon Press: Oxford.

97 Pearce, D.W., Markandya, A. & Barbier, E.B., (1989), **Blueprint for a Green Economy**, Earthscan. Page 29.

98 For example, see Inglehart, R., (1977), **The Silent Revolution: Changing Values and Political Styles Among Western Publics**, Princeton University Press: Princeton, NJ.

99 Goulet, D., (1993), "Biological Diversity and Ethical Development", in L.S. Hamilton, (Ed.), **Ethics, Religion and Biodiversity: Relations Between Conservation and Cultural Values**: pages 17-39, White Horse Press: Cambridge, England. Pages 32-33.

A representative definition expressing this dimension of sustainable development is:

> *"'Sustainable', by definition, means not only indefinitely prolonged, but nourishing for the self-actualizing of persons and communities. The word 'development' need not be restricted to economic development activity, much less to the kind of economic activity that now dominates the world, but can mean the evolution, unfolding, growth, and fulfillment of any and all aspects of life. Thus 'sustainable development', in the broadest sense, may be defined as the kind of human activity that nourishes and perpetuates the historical fulfillment of the whole community of life on Earth."* [100]

Socio-ecological system principles. The majority of sustainable development perspectives appreciate that the production and consumption demands of the social system must not exceed the carrying capacity of the resource base and that resultant waste and pollution flows do not exceed the assimilative capacity of the ecology system[101] (see Section 2.2.2.). A representative definition setting out these system issues is:

> *"In simple terms [sustainable development] argues for (a) development subject to a set of constraints which set resource harvest rates at levels no higher than managed or natural regeneration rates; and (b) use of the environment as a 'waste sink' on the basis that waste disposal rates should not exceed rates of (natural or managed) assimilation by the counterpart ecosystem."* [102]

Equitable. Fair distribution of benefits from development across intergenerational, intragenerational and spatial dimensions is a central consideration in most conceptions of sustainable development. Commentators contend that the resource use of each present generation is depriving the right or possibility of future generations using the same resource[103]. Intergenerational equity draws upon this

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[100] Engel, J.R., (1990), "Introduction: The Ethics of Sustainable Development", in J. Engel & J.G. Engel, (Eds.), **The Ethics of Environment and Development**: 1-23, University of Arizona Press: Tucson. Page 1.

[101] For example, see Costanza, R., Daly, H.E. & Bartholomew, J.A., (1991), "Goals, Agenda and Policy Recommendations for Ecological Economics", in R. Costanza (Ed.), **Ecological Economics: The Science and Management of Sustainability**: Pages 1-20. Columbia University Press: New York. Page 8.; IUCN, WWF & UNEP, (1980), **The World Conservation Strategy**, IUCN, WWF & UNEP: Gland Switzerland.

[102] Pearce, D., (1988), "Optimal Prices for Sustainable Development", in D. Collard, D. Pearce & D. Ulph, (Eds.), **Economics, Growth and Sustainable Environments**, St. Martin's Press: New York. Page 58.

[103] For example, see Pearce, D.W. & Atkinson, G., (1992), "Are National Economies Sustainable? – Measuring Sustainable Development", **CSERGE GEC Working Paper 92-11**, University College

tension to argue that the opportunity for quality of life must not diminish for future generations, requiring that future generations should have access to the same resource base as existing generations[104]. A representative definition setting out these intergenerational equity issues is:

> *"[Sustainable development] is concerned with (a) the rights of future generations to the services of natural and produced assets and (b) whether the formal and informal institutions which affect the transfer of assets to future generations are adequate to assure the quality of life in the long run."* [105]

Intragenerational equity is generally conceived as the elimination of poverty[106], with almost one quarter of the global population living in absolute poverty[107]. The rationale behind this principle is that poverty has an adverse impact upon the environment and, thereby, jeopardises welfare and resources along with intergenerational equity since natural capital will be diminished for future generations. Implicit within the notion of equity is spatial equity: sustainable development cannot be achieved in one nation or region at the expense of another nation or region[108]. The share of global income going to the richest twenty percent of the world's people, for example, rose from seventy percent in 1960 to eighty-three percent in 1989[109]. A representative definition laying out these intragenerational equity issues is:

London.; Dasguta, P.S. & Heal, G.M., (1979), **Economic Theory and Exhaustible Resources**, Cambridge University Press: Cambridge.

[104] For example, see Solow, R.M., (1992), "Sustainability: Our Debt to the Future", **USA Today**, September: page 40.; Weiss, E.B., (1989), **In Fairness to Future Generations: International Law, Common Patrimony, and Intergenerational Equity**, United Nations University: Tokyo.; Page, T., (1982), "Intragenerational Justice as Opportunity", in D, Maclean & P. Brown, (Eds.), **Energy and the Future**, Rowman & Littlefield: Totowa.; Howe, C., (1979), **Natural Resource Economics**, Wiley: New York.

[105] Norgaard, R., (1992), "Sustainability of the Economics of Assuring Assets for Future Generations", **World Bank, Working Paper Series No. 832**, World Bank: New York.

[106] For example, see Barbier, E., (1987), "The Concept of Sustainable Economic Development", **Environmental Conservation**, 14: 2.; Burayidi, M., (1997), "Environmental Sustainability of Third World Economic Development: Constraints and Possibilities", **Environmental Sustainability**, 9: 2: 31-42.; Dasgupta, P., (1993), **An Inquiry into Well-being and Destitution**, Oxford University Press: Oxford.

[107] United Nations Development Programme, (1993), **Human Development Report**, Oxford University Press: New York.

[108] For example, see Bhaskar, V. & Glyn, A., (Eds.), (1995), **The North and South: Ecological Constraints and the Global Economy**, United Nations University Press: Tokyo; Pearce, D.W., Markandya, A. & Barbier, E.B., (1989), **Blueprint for a Green Economy**, Earthscan. Pages 178-179.

"The concept of sustainable economic development .... is therefore directly concerned with increasing the material standard of living of the poor at the "grassroots" level, which can be quantitatively measured in terms of increased food, real income, educational services, health care, sanitation and water supply, emergency stocks of food and cash, etc., and only directly concerned with economic growth at the aggregate, commonly national, level. In general terms, the primary objective is reducing the absolute poverty of the world's poor through lasting and secure livelihoods that minimize resource depletion, environmental degradation, cultural disruption and social instability." [110]

Participatory. This facet of sustainable development is closely linked to intragenerational equity. The essence of the argument is that if there is to be positive discrimination in favour of poorer groups and minorities, then such groups have to be closely involved in defining their own needs and engaging relevant decision-making authorities and processes. This consistent strand of sustainable development resonates strongly with the minority issue literature which encourages participatory approaches to social problems[111]. A representative definition setting out these participatory issues is:

"Sustainability is a participatory process that creates and pursues a vision of community that respects and makes prudent use of all its resources – natural, human, human-centred, social, cultural, scientific, etc. Sustainability seeks to ensure, to the degree possible, that present generations attain a high degree of economic security and can realize democracy and popular participation in control of their communities." [112]

The common, principal elements of sustainable development have been outlined. In any given conceptualisation of sustainable development, however, the emphasis and combination of these elements will differ, which will, in turn, produce different goals and policies. To understand why different stakeholders have different conceptualisations of sustainable development, it is critical to understand how they

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[109] United Nations Development Programme, (1992), **Human Development Report 1992**, Oxford University Press: New York.

[110] Barbier, E., (1987), "The Concept of Sustainable Economic Development", **Environmental Conservation**, 14: 2.

[111] Rahman, A., (1993), **People's Self-development: Perspectives on Participation Action Research – A Journey Through Experience**, Zed Books: London.; Maguire, P., (1987), **Doing Participatory Research: A Feminist Approach**, Centre for International Education: Amherst.

[112] Viederman, S., (1994), "The Economics of Sustainability: Challenges", Paper presented at the **Workshop of the Economics of Sustainability**, Recife, Brazil.

perceive the environment, their relationship with it, and their interactions with each other. These perceptions are very much shaped and filtered through stakeholders' 'worldviews.' The concept and role of worldviews will now be discussed.

2.5. Sustainable development and worldviews

2.5.1. The nature and role of worldviews

Worldviews are understood to be "... the constellations of beliefs, values and concepts that give shape and meaning to the world a [stakeholder] experiences and acts within"[113], providing "... a system of co-ordinates or a frame of reference in which everything presented to us by our diverse experiences can be placed. It is a symbolic system of representation that allows us to integrate everything we know about the world and ourselves into a global picture, one that illuminates reality as it is presented to us"[114]. Worldviews play a major role in complex decision-making, particularly in complex, ambiguous and subjective issues[115]. Stakeholders' worldviews are thus critical in helping them determine which elements of the sociological and ecological systems are important to heed when formulating objectives, policies and actions[116]. Research has supported the view, for example, that stakeholders' values, beliefs and attitudes shape their environmental norms[117]. The powerful influence of different worldviews, for example, in producing divergent frames of reference between economists and ecologists on the issue of global warming is captured in the following observation[118]:

> *"Few people have addressed issues of global change within a benefit-cost framework, and few seem inclined to do so, even after the framework is brought to their attention. Not only do [economists] not control the debate, but the language and framework have been defined*

[113] Norton, B.G., (1991), **Toward Unity Among Environmentalists**, Oxford University Press: New York. Page 75.

[114] Aerts, D., Apostel, L., De Moor, B., Hellemans, S., Maex, E., van Belle, H., & van der Veken, J., (1994), **Worldviews: From Fragmentation to Integration**, VUB Press: Brussels. Page 39.

[115] For example, see Jolly, J., Reynolds, T. & Slocum, J., (1988), "Application of the Means-end Theoretical for Understanding the Cognitive Bases of Performance Appraisal", **Organizational Behavior and Human Decision Processes**, 41: 153-179.

[116] For example, see Gary, R. & Belbington, K.J., (1993), "The Global Environment and Economic Choice", D.K. Adams (Ed.), **Environmental Issues: The Response of Industry and Public Authorities**: 21-35, Ryburn: Halifax, England. Pages 21-22.

[117] Stern, P.C. & Dietz, T., (1994), "The Value Basis of Environmental Concern", **Journal of Social Issues**, 50: 3: 65-84.

[118] Lave, L., (1990), "Comments: Tax Policy to Combat Global Warming", in R. Dornbusch & J. Poterba, (Eds.), **Global Warming: Economic Policy Responses**, MIT Press: Cambridge. Pages 98-104. Quote pages 98-99.

> *by people who see a balancing approach as unnatural, even wrongheaded, in thinking about these issues. If economists are going to engage a more general audience, [they] need to give more attention to the "world views" of the public and those who dominate the debate."*

Further, it is stressed that "... different perceptions of the environment are neither more or less "rational" – they merely reflect the way we look at the world ... divergent views are not necessarily correct or false and are unlikely to be consistent as long as people have different interests ..."[119]; and that these differing perceptions are "...dynamic ... societies and their environments change, technologies and cultures change, values and aspirations change, and a sustainable society must allow and sustain such change ...."[120]

Interaction and understanding (though not necessarily mutual acceptance) of worldviews is thus required to develop a discourse of shared terms and language that are needed in order for analysis, debate, negotiation and problem-solving to occur[121]. The need for dialogue of this nature is firmly located within the relevant literature, with it being argued that the basic causes of conflict between stakeholders are the differences in their knowledge and values[122], and that these shape the way information is gathered, perceived and acted upon by these various groups[123]. This idea is developed in the observation that:

> *"Within the construction industry there is a range of parties who are stakeholders, that is within the context of the built environment. We need to promote initiatives that bring these stakeholders together and promote co-operation. Many of the processes involved in construction projects, ... encourage confrontation. The confrontation, prejudice and lack of understanding between members*

[119] Redclift, M., (1989), **Sustainable Development**, Routledge: London. Page 201-202.
[120] Bossell, H., (1999), **Indicators for Sustainable Development: Theory, Method, Applications: A Report to the Balaton Group**, International Institute for Sustainable Development: Winnipeg, Canada. Page 4.
[121] Dryzek, J.S., (1997), **The Politics of the Earth: Environmental Discourses**, Oxford University Press: Oxford.
[122] Dorcey, A.H.J., (1986), **Bargaining in the Governance of Pacific Coastal Resources: Research and Reform**, Westwater Research Centre, University of British Columbia: Vancouver.
[123] Simmons, I.G., (1993), **Interpreting Nature: Cultural Constructions of the Environment**, Routledge: New York.

of the design team should not be underestimated as a barrier to sustainable construction"[124]

Thus, it is argued for example, that in order to incorporate all the appropriate components of sustainable development, the identification of criteria and indicators of sustainable development must not only be approached by scientific means, but must also include perceptions and values set by society as a whole[125], and by individual stakeholder groups[126]. (This understanding, in part, has focused attention on the need to create and manage a participatory dimension to sustainable development, to ensure that all relevant stakeholders are closely involved in defining their own needs and engaging relevant decision-making authorities and processes.[127])

To investigate the concept and role of worldviews, numerous commentators have categorised similar worldviews into groups, and located these groups along continua or in frameworks, in order to better understand the relative position of one worldview against another. This need has been identified and developed in such continua as "weak" sustainability and "strong" sustainability[128]; "technocentrism" and "ecocentrism"[129]; ecologists or Greens (capital G) and environmentalists or greens (lower case g)[130]; anthropocentrism and biocentrism[131]; and frontier, conservationist

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[124] Construction Research and Innovation Strategy Panel, (1998), **CRISP Response to *Opportunities for Change:* Sustainable Construction**, CRISP: London. Page7.

[125] For example, see Young, J.W.S., (1997), "A Framework for the Ultimate Environmental Index – Putting Atmospheric Change into Context with Sustainability", **Environmental Monitoring and Assessment**, 46: 135-149.; Cairns, J., McCormick, P. & Neiderlehner, N., (1993), "A Proposed Framework for Developing Indicators of Ecosystem Health", **Hydrobiologica**, 263: 1-44.

[126] Thompson, M., Ellis, R. & Wildavsky, A., (1990), **Culture Theory**, Westview Press: Boulder, USA.; Schwartz, M. & Thompson, M., (1990), **Divided We Stand: Redefining Politics, Technology and Social Choice**, Harvester Wheatsheaf: New York.; Vreis, H.J.M. de (1989), **Sustainable Resource Use: An Inquiry into Modelling and Planning**, University Press: Groningen, The Netherlands.

[127] Sexton, M.G. & Barrett, P.S., (2000), "The Need to Understand 'Worldview' Diversity in Developing Sustainable Built Environments', **Proceedings of the Millennium Conference: Cities and Sustainability – Sustaining Our Cultural Heritage**, Dambulla, Sri Lanka: 21st – 26th February.

[128] Pezzy, J., (1992), "Sustainable Development Concepts: An Economic Analysis, **World Bank Environment Paper No.2**, World Bank: Washington, DC.; Pearce, D., Markandya, A. & Barbier, E.B., (1989), **Blueprint for a Green Economy**, Earthscan Publications: London.

[129] Turner, K.R., Pearce, D.W. & Bateman, I., (1994), **Environmental Economics: An Elementary Introduction**, Harvester Wheatsheaf: London.

[130] Dobson, A., (1990), **Green Political Thought**, Harper Collins: London. Pages 3-5.

[131] Pauchant, T. & Fortier, J., (1990), "Antropocentric Ethics in Organizations, Strategic Management and the Environment", in P. Shrivastava & R. Lamb (Eds.), **Advances in Strategic Management**, Volume 6: 99-114, Jai Press: Greenwich.; Eckersley, R., (1992), **Environmentalism and Political Theory**, University of New York Press: Albany. Page 51.; Taylor, P., (1986), **Respect for Nature: A Theory of Environmental Ethics**, Princeton University Press: Princeton, N.J.

and preservationist worldviews[132]. Each of these continua focuses on particular strands of the sustainable development debate – for example, the concepts of "weak" and "strong" sustainability are resource-management based; while anthropocentrism and biocentrism are concerned with contrasting ethical positions. The implication of this is that while each strand illuminates an important aspect of a stakeholder's worldview, no single strand provides a complete picture.

To ameliorate this situation, these continua can be usefully bundled together to form two 'worldview' umbrella clusters: the currently dominant 'neoclassical' worldview, and the 'ecological' worldview espoused to varying degrees in the sustainable development movement. (The argument that the 'neoclassical' worldview is currently dominant is supported in the discussion below.) This process enables a more integrated discussion to take place, with otherwise fragmented ideas being interwoven to develop a more holistic, systemic understanding of stakeholder worldviews. Further, the discussion will follow three interdependent lines of enquiry:

- The different positions engaged by the neoclassical and ecological worldviews on the *relationship between human beings and the environment will be examined.* This will provide the ethical context which motivates and legitimises;
- The opposing standpoints articulated by the neoclassical and ecological worldviews on the *relationship between the firm and the environment.* The organisational behavioural norms provide insights into;
- The differing views taken by the neoclassical and ecological worldviews on the *interaction between social capital and ecological capital.* The nature and scale of this interaction is a key determinant of whether system interaction is sustainable or not.

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132 Lave, L., (1990), "Comments: Tax Policy to Combat Global Warming", in R. Dornbusch & J. Poterba, (Eds.), **Global Warming: Economic Policy Responses**, MIT Press: Cambridge. Pages 98-104.

2.5.2. Relationship between human beings and the environment

Neoclassical worldviews adopt the anthropocentric ethic, namely that there is a fundamental dualism between human beings and the natural environment[133], and can be defined as:

> *"... the belief that there is a clear and morally relevant dividing line between humankind and the rest of nature, that humankind is the only principal source of value or meaning in the world."*[134]

This ethic grants moral standing exclusively to human beings and considers nonhuman natural entities and nature as a whole to be only a means for human ends.

In contrast, ecological worldviews reject the anthropocentric premise that human beings occupy a privileged place in the biosphere. Rather, they adopt an ecocentric ethic that morally enfranchises, to varying degrees, living and nonliving things. The spirit of the ecocentric ethic is expressed in such arguments as the 'rights approach' which argues that some animals have moral rights through being sentient, that is self-conscious, experience desire and frustration, and that they anticipate future states of consciousness[135]; through to the bolder 'deep ecology' articulation that the biosphere as a totality (species, land, water and air, as well as ecosystems) is of equal "inherent worth", independent of human anthropocentric instrumental valuation of it[136]. Commentators argue that the anthropocentric-based neoclassical worldview must be recognised and eradicated before fundamental changes can take place toward an ecocentric nurtured ecological worldview[137].

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[133] Pauchant, T. & Fortier, J., (1990), "Anthropocentic Ethics in Organizations, Strategic Management and the Environment", in P. Shrivasta & R. Lamb (Eds.), **Advances in Strategic Management**, Volume 6: 99-114, Jai Press: Greenwich.

[134] Eckersley, R., (1992), **Environmentalism and Political Theory**, University of New York Press: Albany. Page 51.

[135] For example, see Regan, T., (1983), **The Case for Animal Rights**, University of California Press: Berkeley.

[136] For example, see Pearce, D,W. & Atkinson, G., (1995), "Measuring Sustainable Development", in D.W. Bromley (Ed.), **The Handbook of Environmental Economics**, Blackwell: Oxford.; Taylor, P., (1986), **Respect for Nature: A Theory of Environmental Ethics**, Princeton University Press: Princeton, N.J.

[137] Oelschlaeger, M., (1991), **The Idea of Wilderness: From Prehistory to the Age of Ecology**, Yale University Press: New York.

The anthropocentric ethic is, however, the dominant ethic at present[138]. Indeed, the Rio Declaration at the Earth Summit asserted the claim that "human beings are at the centre of our concerns"[139]. This appreciation of the neoclassical worldview dominance provides significant insights into what guides and motivates the relationship between the firm (taken to be the vehicle for stakeholder influence) and the ecological system is discussed in the following section.

2.5.3. Relationship between the firm and the ecological system

The neoclassical worldview legitimises, through its anthropocentric ethic, the means whereby rational, self-interested agents can optimise and exploit the social system and ecological system for their own end. It has been commented on, for example, that this worldview shapes the observation that "traditional organizations serve only their own ends. They are, and indeed are supposed to be selfish[140]"; and that firms are more likely to pursue an economically advantageous course of action when confronted with a choice between environmental preservation or economic development[141]. In particular, the dominant drive would seem to be towards profits and profit maximisation. This is justified by neoclassical economists: "... few trends could so thoroughly undermine the very foundations of our free society as the acceptance by corporate officials of social responsibility other than to make as much money for their stockholders as possible[142]" This view is supported by research which suggests that firms are financially disadvantaged from investing into the environment[143]. Further, neoclassical economic welfare arguments largely ignore intergenerational equity issues, tending toward utilitarian assessments that celebrate aggregate growth.

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138 For example, see Midgley, M., (1994), "The End of Anthropocentrisn?", in R. Attfield & A. Belsey, (Eds.), **Philosophy and the Natural Environment - Royal Institute of Philosophy Supplement: 36**: Pages 103-112, Press Syndicate: Cambridge.
139 United Nations Conference on Environment and Development, (1992), **Rio Declaration**, United Nations: New York.
140 Trist, E.L., (1981), "The Sociotechnical Perspective: The Evolution of Sociotechnical Systems as a Conceptual Framework and an Action Research Program", in A.H. Van de Ven & W.F. Joyce (Eds.), **Perspective on Organization Design and Behavior**: 19-75, Wiley: New York. Page 43.
141 Axlerod, L.J., (1994), "Balancing Personal Needs with Environmental Preservation: Identifying Values that Guide Decisions in Ecological Dilemmas", **Journal of Social Issues**, 50: 3: 85-104.; Merchant, C., (1992), **Radical Ecology: The Search for a Liveable World**, Routledge: New York.
142 Friedman, M., (1963), **Capitalism and Freedom**, Phoenix Books, University of Chicago Press: Chicago. Page 133.

The anthropocentric ethic generates "simple thought"[144], which produces organisational policies and actions which have difficulty understanding and perceiving that they are nested within a broader biosphere[145]. Such firms do not give adequate consideration to how their activities will have an impact on, alter, or interfere with the complex behaviour of the biosphere's constituent social and ecological systems[146]. Indeed, commentators have (perhaps cynically) concluded that even:

> *" ...marginalist reformers ... [do not] ...consider the dominant ideology of present forms of capitalism and they lack the imagination and creativity to develop the real strategies which will bring about the fundamental change which is needed. ... They merely scratch the surface of the problem and quickly paper over the cracks with industry-centred and profit-centred solutions."*[147]

Commentators, for example, have demonstrated that some firms manipulate their accounting procedures and/or outsource their pollution activities to project a 'greener image' to their stakeholders[148].

It is increasingly apparent that neo-classical economics does not reflect social, economic and environmental realities in a world of limited resources[149]. A seminar entitled 'Speaking with the enemy: Is reconciliation possible?", for example, brought together senior representatives from industry, academic and environmental groups[150]. The ensuing debate indicated that environmental groups and industry were in deadlock over how to achieve sustainable development. Industry regarded

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143 Walley N. & Whitehead B. (1996), "It's Not Easy Being Green", **Harvard Business Review**, May-June.
144 Morin, E., (1992), "The Concept of System and the Paradigm of Complexity", in M. Maruyama (Ed.), **Context and Complexity: Cultivating Contextual Understanding**: 125-136, Springer-Verlag: New York.
145 Bateson, G., (1972), **Steps to an Ecology of Mind**, Ballantine: New York.; Odum, E.P., (1959), **Fundamentals of Ecology**: 2nd edition, Saunders: Philadelphia.
146 Dunlap, R.E. & Catton, W.R., (1993), "The Development, Current Status, and Probable Future of Environmental Sociology: Toward an Ecological Sociology", **Annuals of the International Institute of Sociology**: 3.
147 Welford, R., (1995), **Environmental Strategy and Sustainable Development: The Corporate Challenge for the Twenty-first Century**, Routledge: London. Pages 2-3.
148 For example, see Tyteca, D, (1996), "On the Measure of the Environmental Performance of Firms" **Journal of Environmental Management**; Ytterhus, BE, (1996), **SME's and Environmental Management,** Norwegian School of Management: Sandvika.
149 Friend, A.M., (1992), "Economics, Ecology and Sustainable Development: Are they Compatible?", **Environmental Values**, 1: 157-170.
150 Juniper, T., (1997), "Hard Work to Bridge a Gap", **The Financial Times**, September 3rd: Page 24.

sustainable development as a technical challenge, overlooking, in the opinion of the environmentalists, the social and economic changes which must also take place.

At its most basic, neo-classical economics treats nature as an infinite supply of physical resources (i.e., raw materials, energy, soil and air) to be used for human benefit, and as an infinite sink for the by-products of the consumption of these benefits, in the form of various types of pollution and ecological degradation. This throughput aspect of the flow of resources from ecological system sources into the economic system and the flow of wastes back into the ecological system does not enter into economic thinking, as it is believed to be infinite in extent[151]. Thus, there is no explicit biophysical 'environment' to be managed, since it is irrelevant to the economy. According to one commentator, "... worries about natural resource exhaustion are hard to rationalize from the point of view of [neoclassical] economics"[152], as the worldview assumes that environmental impacts (as well as social impacts) can be accurately reflected by being described by an economic valuation framework which defines them as "externalities"[153]. Externalities highlight what can be termed "market failure"; that is, that the market does not capture the full environmental implications of social system – ecological system interactions[154].

The neoclassical worldview thus generates a market that consumes and substitutes ecological capital for social capital, and this adverse interaction has become a major contributor to current environmental problems (see Section 2.3.)[155].

In contrast, ecological worldviews argue that firms and industries as a whole need to take a much broader view of the business environment to embrace (a) the ecology of the planet Earth; (b) the world economic, social and political order; and (c) the

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[151] Daly, H.E., (1989), "Steady-state versus Growth Economics: Issues for the Next Century", **Proceedings of the Hoover Institute Conference on Population, Resources and Environment**, Stanford University: 1st – 3rd February.
[152] Thurow, L., (1980), **The Zero-sum Society**, Basic Books: New York. Page 112.
[153] Anderson, T.L. & Leal, D.R., (1991), **Free Market Environmentalism**, Pacific Research Institute for Public Policy, Westview Press: San Francisco, CA.; Nordhaus, W., (1992), "An Optimal Transition Path for Controlling Greenhouse Gases", **Science**, 258: 20.
[154] For example, see Rees, J., (1990), **Natural Resources: Allocation, Economics and Policy**: 2nd edition, Routledge: London. Page 261.
[155] Welford, R.J. & Gouldson, A.P., (1993), **Environmental Management and Business Strategy**, Pitman: London.

immediate market, technological and socio-political context of organisations[156]. The starting point is " ...the recognition that the world's problems, like all other major problems of our time, cannot be understood in isolation. They are systematic – interconnected and interdependent – and need a new kind of systematic, or ecological, thinking to be understood and solved.[157]". Indeed, firm behaviour is motivated by the argument that "... the notion of an absolute limit to natural resource availability is untenable when the definition of resources changes drastically and unpredictable over time ... A limit may exist, but it can be neither defined nor specified in economic terms"[158].

This discussion has drawn upon the neoclassical ethic to explain its role in legitimising and motivating firms to exploit the ecological system in an unbalanced fashion. The key issue is the degree to which firms substitute social capital for ecological capital in its exploitative endeavours. This issue is discussed in the following section.

2.5.4. Relationship between social capital and ecological capital

The clear implication from the previous discussion on the interaction between the firm and the environment is that the fundamental assumption in neoclassical worldview states substitutions can be made between social and ecological capital. The diversity of sustainable development worldviews on this issue can be fruitfully located along a "weak" sustainability – "strong" sustainability continuum[159]. Both are based on the concept that humanity should live on the "interest" of its ecological capital, preserving the capital for future generations[160]. The ecological capital

[156] Davis, J., (1991), **Greening Business**, Basil Blackwell: Oxford, England.; Smith, D., (1992), **Business and the Environment**, Chapman: London.; Stead, W. & Stead, J., (1992), **Management for a Small Planet**, Sage: Newbury Park, CA.
[157] Callenbach, E., (1993), **EcoManagement – The Elmwood Guide to Ecological Auditing and Sustainable Business**, Berret-Koehler: San Francisco.
[158] Barnett, H.J. & Morse, C., (1963), **Scarcity and Growth**, John Hopkins University Press: Baltimore. Pages 7 & 11.
[159] Pezzy, J., (1992), "Sustainable Development Concepts: An Economic Analysis, **World Bank Environment Paper No.2**, World Bank: Washington, DC.; Pearce, D., Markandya, A. & Barbier, E.B., (1989), **Blueprint for a Green Economy**, Earthscan Publications: London.
[160] For example, see Daly, H.E. & Cobb, J.B., (1990), **For the Common Good: Redirecting the Economy Towards Community, the Environment and a Sustainable Future**, Greenprint: London.; Pearce, D., Markandya, A. & Barbier, E.B., (1989), **Greenprint for a Green Economy**, Earthscan: London.

comprises source and sink resources (see Section 2.2.2.). The basic debate between the opposing positions is captured in the following observation:

> *"No one can doubt that the stocks of non-renewable resources are finite. No one can doubt that ecosystems (individually and collectively within the biosphere) have limits in their capacity to absorb pollutants. There is general agreement that some environmental assets are irreplaceable ... The debate centres on which environmental assets are irreplaceable and the extent to which current (and projected) future levels of resource use degrade the capital stock of environmental assets for future generations, the extent to which one resource can be substituted for another (for instance, a synthetic substance replacing a natural one) and the extent to which pollutants from human activities are damaging the biosphere."* [161]

Neoclassical worldviews tend toward "weak" sustainability, contending that resources (both in the ecological system and in the social system) are substitutes for others (solar energy for oil, for example) and allow substitutions as long as the combined social and ecological capital is not diminished. Neo-classical worldviews assume a high level of resource substitution, particularly through technological development and the price mechanism which increases resource cost as it becomes relatively scarcer[162]. Technocentrism, for example, emphasises the pursuit of sustainable development through human ingenuity (i.e. technological innovation) and intensive use of the environment[163].

In contrast, ecological worldviews embrace "strong" sustainability. Under strong sustainability, both ecological and social capital should be independently maintained in physical/biological terms[164]. The motivation for this view is either the recognition that ecological resources are essential inputs into the social system that cannot be substituted for by social capital, or the ecocentric ethic acknowledgement of environmental integrity and rights in nature. In either case, it is understood that

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[161] Mitlin, D. & Satterthwaite, D., (1991), "Sustainable Development and Cities", Prepared for **How Common is Our Future?**, Global NGO Forum.
[162] Dasgupta, P.S. & Heal, G.M., (1979), **Economic Theory and Exhaustible Resources**, Cambridge University Press: Cambridge.; Solow, R.M., (1974), "Intergenerational Equity and Exhaustible Resources", **Review of Economic Studies**, 41: 29-45.
[163] O'Riordan, T., (1995), "Frameworks for Choice: Core Beliefs and the Environment", **Environment**, 37: 8: 5.
[164] For example, see Brekke, K.A., (1997), **Economic Growth and the Environment: On the Measurement of Income and Welfare**, 24: 231-240.

environmental components are unique and that environmental processes may be irreversible (over relevant time horizons)[165].

The level of source and sink ecological resource depletion and degradation discussed in Section 2.3. indicates that the neoclassical worldview is dominant, and is not sustainable. Indeed, it has been (emotionally) argued that:

> *"Humanity is living largely on its "capital" – non-renewable resources .... The capital that we inherited included fossil fuels, high grade mineral ores, rich agricultural soils, groundwater stored up during the ice ages, and above all, the millions of species that inhabit the earth along with us. Our total inheritance took billions of years to assemble; it is being squandered in decades ... Humanity is rapidly and wastefully depleting fossil fuels before satisfactory substitute energy supplies have been developed and, in the process, seriously damaging its environment ... We are a nouveau riche species struggling to become nouveau broke."*[166]

2.5.5. Summary and worldview framework

This discussion of neoclassical and ecological worldviews has shown two contrasting ways of perceiving and understanding social system and ecological system interaction. Sections 2.3. – 2.5. have developed the argument that the concept and operationalisation of sustainable development is located within different stakeholders worldviews, within which ethical positions guide, shape and legitimise firm behaviour, and the scale and form of social system and ecological system interaction. All stakeholders operate to a greater or lesser extent in keeping with the neoclassical worldview, although the ecological worldview is emerging as a viable and necessary alternative. Further, it is clear that the current diversity of worldviews is unlikely to change, except in focused areas, and that this should ideally be appreciated and accommodated, rather than viewed as a source of debilitating confusion. This imperative is captured by the observation that:

> *"Given the multiplicity of perspectives, one option is to disagree endlessly. We can promote our own [worldviews] and ridicule others. Another option is to acknowledge the inherent ambiguity in the choice of models ... If that is done, if worldviews and models are*

[165] For example, see Pearce, D.W. & Atkinson, G., (1995), "Measuring Sustainable Development", in D.W. Bromley (Ed.), **The Handbook of Environmental Economics**, Blackwell: Oxford.
[166] Ornstein, R. & Ehrlich. P., (1990), **New World, New Mind**, Touchstone: New York. Pages 45-46.

exposed to view, if their plurality is not only recognized but appreciated, [it] can play an emancipatory role."[167]

The latter option of both making transparent and accommodating stakeholder worldviews, "... is useful to identify the interlinkages between concepts - despite [stakeholders having] different starting points and philosophies there are many common elements which can serve as a basis for policy thinking.[168]"

The neoclassical and ecological worldview matrix, shown in Figure 2.2. is proposed as a simple, but effective typology which allows the worldviews embodied in definitions of sustainable development to be categorised[169].

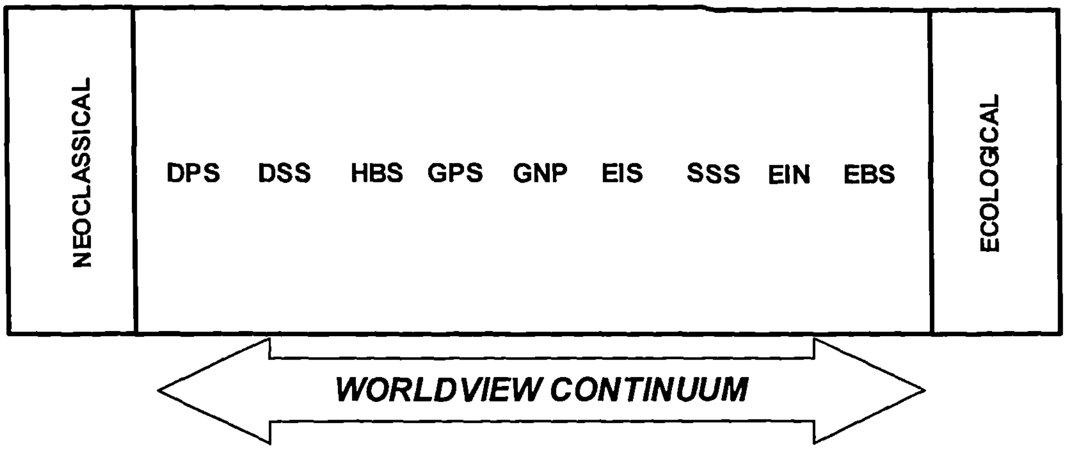

Figure 2.2.: Worldview framework

The framework categorises different definitions of sustainable development along a sociological continuum from 'neoclassical worldview sustainability' (DPS – dominant product/service sustainability) through to 'ecological worldview sustainability' (EBS – ecosystem benefit sustainability). The different categories are discussed below:

[167] Meadows, D., 1998), **Indicators and Information Systems for Sustainable Development**, The Sustainability Institute: Hartford Four Corners: Page 9.
[168] OECD, (1997), **Sustainable Consumption and Production: Clarifying the Concepts**, OECD: Paris. Page 5.
[169] Barrett, P.S., Sexton, M.G. & Green, L., (1998), **Integrated Delivery Systems for Sustainable Construction: Unpublished report for the Construction Sponsorship Directorate**, Department of Environment, Transport and the Regions: London.

1. *Dominant product sustainability* (DPS) results in a narrow range of ecosystem products defined as economically valuable by existing markets. The rationale is economic efficiency rather than aesthetic value. Economic gain or provision of a vital product justifies sustaining the dominant product.
2. *Dependent social systems sustainability* (DSS) is orientated toward specific human social systems, such as communities, occupations or families, that depend on an ecosystem and its products. The rationale represents a value judgement that asserts an anthropocentric priority of designated social systems, and implies a deliberate decision about which social systems should be sustained.
3. *Human benefit sustainability* (HBS) maintains the flow of diverse human benefits that result from intensive resource management. In contrast to dominant product sustainability, this type emphasises a greater range of resource products and contributions to the larger society rather than to targeted resource-dependent social systems. Resources are valued on both economic and noneconomic criteria. This broader focus approaches a subsistence rights perspective, which can be defined as "... unpolluted air, unpolluted water, adequate food, adequate clothing, adequate shelter, and minimal preventive public health care."[170] The rationale represents the idea that ecological systems should be managed to yield the maximum good for the greatest number of people.
4. *Global product sustainability* (GPS) emphasises the flow of unique or increasingly valuable natural resource commodities produced by local ecosystems for the international market. The dominant rationale is that nations and their ecosystems are encouraged to produce specialised goods for the global market place. This rationale attempts to balance the diverse needs of international consumers with the ability of local ecosystems to produce unique or increasingly valuable natural resource products for the global village. Definitions of value are primarily economic, since it is the international market, reflecting comparative advantage that assigns value.
5. *Global niche preservation* (GNP) sustains some specific local ecosystems judged as integral to the larger goal of sustaining the entire Earth. This global perspective has led to wilderness preservation, marine sanctuary protection, and efforts to identify and safeguard endangered species. Some continued human

[170] Shue, H., (1980), **Subsistence, Affluence, and U.S. Foreign Policy**, Princeton University Press: Princeton, New Jersey. Page 23.

benefit is often implicit. The dominant rationale is that both ecosystems and human populations occupy interdependent global niches, and that humans have no right to destroy ecosystems.

6. *Ecosystem identity sustainability* (EIS) is orientated toward a general land use or ecosystem type, such as forest, desert, estuary or wetland. The dominant rationale is a long-term commitment to sustaining resources within a broad land use. This rationale is captured in the observation: "... unnecessary, permanent conversions of superior quality agricultural lands to nonagricultual uses may benefit the present generation, but these conversions will probably adversely affect all future generations. How selfish and short-sighted can we be?"[171] Implicit is the principle that it is better to sustain existing ecosystem identity than to convert to a radically different pattern or use.
7. *Self-sufficient sustainability* (SSS) supports long-term natural resource ecosystem integrity, as characterised by relatively balanced, self-sustaining ecosystems. Such ecosystems, needing little human intervention, may nonetheless yield products for human use. However, because of the less intensive management, sustained output levels are likely to be significantly lower than under human benefit sustainability. The rationale is an ecocentric ethic which asserts that humans have no right to intervene in ecological system evolution. A secondary rationale focuses on the lack of scientific knowledge about how ecosystems function; allowing ecosystems to operate without human intervention assists in clarifying how complex ecosystems sustain themselves.
8. *Ecosystem insurance sustainability* (EIN) is concerned with ecosystem diversity. Specific ecosystems, plant species, or animal species are divided into two categories: the first continues to supply traditional products or use, while the second is protected in a more natural condition as a genetic storehouse. The dominant rationale is of ecosystem disaster, occurring either cataclysmically or through the gradual reduction of ecosystem diversity because of human intervention.
9. *Ecosystem benefit sustainability* (EBS) focuses most strongly on ecological systems rather than social systems. Natural ecosystems as free from human intervention as possible are targeted, even if their condition falls below the

[171] Bentley, F., (1984), "Why Protect Agricultural Land?", **Journal of Soil and Water Conservation**, 39: Page 295.

threshold of self-sufficient sustainability. The principal assumption is that nature exists for its own benefit rather than for humans and that nature has its own intrinsic value.

This tool can assist in enabling:

- different stakeholders to better understand each others particular needs and aspirations, thereby creating;
- the necessary common foundation and language to facilitate the development of 'win-win' solutions which engage and motivate all relevant stakeholders.

2.6. Holistic, systemic framework

2.6.1. Introduction

The discussion to date has explored the significant influence of stakeholder worldviews on the *goals* of sustainable development. Goals set out a broad vision which different stakeholders aspire to, but this in itself is insufficient to make any substantial or coherent progress. Goals provide an essential starting point, but need to be translated into, and operationalised by, appropriate indicators so that progress towards these goals can be measured and guided. It is argued that before this can be done, there is a critical need for an appropriate holistic, systems-orientated framework to locate and integrate stakeholders' diverse policies and actions to generate the *ability* for appropriate, complementary progress.

The next section will first discuss the need for a conceptually rigorous, but practice-orientated framework which facilitates the identification and integration of key sustainable development indicators. Second, a review of conceptual models will be made. From this survey the pressure-state-response framework will be discussed in greater depth. Finally, the *Dynamic PSR model* will be proposed as a way of addressing the key weaknesses of the traditional pressure-state-response model

2.6.2. The need for an appropriate framework

The interrelations between the social system and the ecological system are extremely complex and systemic in nature (see Section 2.2.2.) to the degree where:

> *"... no longer are various environmental problems viewed as discrete phenomena; rather, they are recognised as interrelated manifestations of unprecedented human impact on ecosystems – from local to global. The various environmental threats are inextricably linked, both in their causes and effects, they cannot be addressed or solved in isolation from the others."*[172]

Thus approaches to sustainable development measurement and progression which do not appreciate this systemic nature are being (quite rightly) criticised. Commentators, for example, observe that indicator sets are often derived ad-hoc, without a theoretical systems framework to reflect the operation and viability of the total system[173], "... since the planetary system shows many interactions between different subcomponents and processes, a picture of the whole cannot be gained just by summing up the various parts covered in sectoral assessments.[174]" Indeed, it is argued that problems associated with trying to progress sustainable development, "... are more serious when there is little or no conceptual framework at all, and that this is the case with much of the literature on 'sustainability indicators'. Simply put, they have overlooked the question of what these are meant to be indicators *of*."[175]

There is a need, therefore, to use a framework which provides direction, consistency and coherence in the development of, and linkage between, sustainable development goals and indicators. It has been argued, for example, that:

> *"An effective framework accomplishes two important goals: first, it helps determine priorities in the choice of indicators; and second, it triggers the identification of indicators which may be more important in the future."*[176]

[172] Rath, A. & Herbert-Copley, B., (1993), **Green Technologies for Development: Transfer, Trade and Cooperation**, International Development Research Agency: Ottawa. Page 7.
[173] For example, see United Nations, (1996), **Work Programme on Indicators of Sustainable Development of the Commission on Sustainable Development**, UN-DPCSD; World Bank, (1995), **Monitoring Environmental Progress**, World Bank: Washington, DC.
[174] United Nation System-wide Earthwatch Cordination, (1999), **Discussion Document: Earthwatch Strategic Framework for Environmental Observing, Assessment and Reporting**, UNEP: Geneva. Page 3.
[175] Pearce, D., (1998), "Measuring Sustainable Development", **Sustainable Development Indicators: OECD Expert Workshop**, OECD: Paris, 8th – 9th October. Page 32. Emphasis in original.
[176] Hardi, P. & Zdan, T., (1997), **Assessing Sustainable Development: Principles in Practice**, International Institute for Sustainable Development: Winnepeg: Canada. Page 10.

The key point being made here is that an effective framework needs to balance the tension of identifying indicators that are relevant for the *present*, whilst sensing and interpreting changing conditions to develop appropriate indicators for the *future*.

These goals are clearly evident in the DETR's statement that "the development of improved understanding of the role of construction in sustainable development is ... a priority, as is development of a comprehensive framework to assess the sustainability of construction." The contribution that such a framework will make is expressed in the claim that:

- "in the longer term, [will help] to develop a more sustainable construction industry, embracing all aspects of manufacture, design, construction, use and disposal of the built environment.
- in the shorter term, [will help] to clarify the actions required to improve the sustainability of construction.[177]"

Further, and more specifically, frameworks of this nature can assist in the[178]:

1. Inclusion of stakeholders and their activities in the ecosystem.
2. Consideration of ecosystem structure and function at multiple levels and scales.
3. Definition of ecological boundaries to guide environmental planning, assessment and management.
4. Geographically comprehensive, systems-level analyses of interactions among physical, chemical, biological, economic and social components.
5. Adaptive management strategies based on feedback information, to improve management and policy under conditions of uncertainty / ambiguity.
6. Participatory management involving all stakeholders.
7. Integration of ecocentric and anthropocentric values in formulating goals and strategies for protecting ecosystem integrity.
8. Recognition of ecosystem limits to carrying capacity.

[177] Department of the Environment Transport and the Regions, (1998), "Developing a Framework for Sustainable Construction", **CIRM Business Plans**, Page 1.
[178] Schulze, I. & Colby, M., (1996), **A Conceptual Framework to Support Development and Use of Environmental Information in Decision-making**, United Nations Environmental Protection Agency – Environmental Statistics and Information Division.

Effective conceptual frameworks are characterised as being[179]:

1. Understandable – stakeholders from all domains should find the framework easy to understand and explain.
2. All-inclusive – the framework must strive to be all-inclusive: all elements of the system being investigated should fit. This ensures consideration of all possible alternatives during the selection of sustainable development indicators.
3. Expandable – the framework must be very general at its 'strategic' level, yet be expandable or flexible enough to accommodate greater detail at an 'operational' level.
4. Compatible – the framework should be compatible with other frameworks and concepts used in indicator development and sustainable development in general.
5. Internally consistent – constituent elements of the framework should be consistent with each other.

2.6.3. Classification and review of conceptual models

A diverse raft of conceptual models has been developed, and they can be usefully categorised into four groups[180]: human/environment interaction conceptual frameworks; economy/environment interaction conceptual frameworks; human/economy interaction conceptual frameworks; and environment/human/economy interaction conceptual frameworks.

Human / environment interaction models concern themselves with the substance and interaction between the human subsystem and the source and sinks of the ecological system (see Figure 2.1. Model of interaction between ecological and social systems). A representative example of a human / environment interaction model is the ecological footprint concept. This is underpinned by the carrying capacity principle, and is an accounting framework that calculates the productive land area required to sustain resource consumption and waste assimilation requirements for a defined

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[179] Development Watch, (1994), **Sustainable Development Indicators**, UNDP: New York.
[180] Murcott, S., (1997), "Sustainable Systems: Definitions, Principles, Criteria, and Indicators", **Proceedings of the American Association for the Advancement of Science Annual Meeting and Science Innovation Exposition**, Seattle: 13th – 18th February.

human population or economy[181]. The assumption is that as wealth and consumption power increase, the area of productive land and throughput of material required to support every individual increases. The conceptual framework is essentially a static concept, seeking to stabilise net global consumption within total aggregated production levels, calculated on the basis of current input-output ratios.

Frameworks of this nature are intuitively easy to understand, and capture the essence of the carrying capacity concept. However, such frameworks tend to be too *static* in nature – they do not enlighten stakeholders on *what* change is needed, and *how* to bring about desired change. In addition, such frameworks address only the effects of *economic* decisions with regard to resource use on the environment.

Economy / environment interaction models concern themselves with the interaction between the economic subsystem and the ecological system (see Figure 2.1. Model of interaction between ecological and social systems). A representative example of an economy / environment interaction model is the steady state framework, which assumes a non-growth economy in biophysical equilibrium with natural systems[182]. A dynamic element is allowed for in terms of human culture but the objective is to maintain ecological equilibrium. It is argued that the steady state economy is achievable only through the "moral growth" of human society, in which consensus on "objective values" would take precedence over technical determinism and which would enable society to consciously choose a path. The indicators identified in steady state economics are:

- Service efficiency, measured in terms of allocative efficiency (does the stock consist of artefacts that people most want to use and are they allocated to the most important uses?) and distributive efficiency (is the distribution of the stock among alternative people such that the trivial wants of some people do not take precedence over the basic needs of others?)

[181] Wackernagel, M. & Rees, W., (1996), **Our Ecological Footprint: Reducing Human Impact on the Earth**, New Society Publishers: Gabriola Island.; Rees, W. & Wackernagel, M., (1994), "Ecological Footprints and Appropriated Carry Capacity: Measuring the Natural Capital Requirements of the Human Economy", in A.M. Jannsson, M. Hammer, C. Folke & R. Costanza, (Eds.), **Investing in Natural Capital: The Ecological Economics Approach to Sustainability**, Washington Island Press: Washington D.C.

- Maintenance efficiency, measured in terms of durability (lifetime of an individual artefact) and replaceability (how easily can the artefact be replaced?)

The framework is proposed as an alternative to the conventional neoclassical growth-orientated economic model, and as such presents a moral and intellectual framework. The framework's value arguably is in its possible influence on challenging and shaping stakeholders worldviews. This "self-examination" role is very important. The framework cannot be translated into any meaningful operational indicators, and does not have the systemic properties required to guide and monitor appropriate policies and actions.

Human / economy interaction frameworks concern themselves with the interaction between the human subsystem and the economic subsystem (see Figure 2.1. Model of interaction between ecological and social systems). A representative example of a economy / environment interaction model is the Human Development Index (HDI), which was developed to rank a country's performance on the criteria of human development, instead of economic performance reported by the Gross Domestic Product (GDP). The HDI is a function of three components deemed necessary for human development, regardless of spatial and temporal factors: education attainment (measured by adult literacy and mean years of schooling), longevity (measured by life expectancy) and standard of living (measured by purchasing power which is derived as GDP per capita and income above the poverty line)[183]. The HDI has the advantage of focusing on trends in human development instead of economic performance. However, the index is arbitrary in terms of the criteria selected, and does not explicitly address the environmental issues.

Environment/human/economy interaction models provide frameworks to understand and guide the interaction between the social system and ecological system (see Figure 2.1. Model of interaction between ecological and social systems). It is argued that although the other types of model develop particular aspects of the

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[182] Daly, H., (1977), **Steady State Economics: The Economics of Biophysical Equilibrium and Moral Growth**, W.H. Freeman.

[183] United Nations Development Programme, (1990/1994/1996), **Human Development Report Series**, Oxford University Press: New York.; Murray, C.J.L., (1991), **Development Data Constraints**

interaction between the ecological system and social system, only the environment / human / economy type models provide the holistic, systemic frameworks needed to both achieve a broad, indepth understanding, and to direct and monitor cohesive progress. The Pressure-State-Response framework is the principal example of this type of interaction model, and will be discussed in the next section.

2.6.4. Pressure-state-response framework

The influential pressure / state / response (PSR) model was developed by the United Nations Commission on Sustainable Development[184], and is robust and well proven[185]. Further, the framework is considered sufficiently generic and simple to be readily adopted for a diverse range of policy-making[186]. Indeed:

> *"This framework, having been embraced by some of the major institutional players in the sustainable development arena, is one of, if not the dominant conceptual model for sustainable development at the present time"* [187]

The Pressure-state-response (PSR) framework (Figure 2.3.) is based on a concept of causality: human activities exert pressures on the environment (the "pressure" box)

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and the Human Development Index, United Nations Research Institute for Social Development: Geneva.

[184] OECD, (1991), **Environmental Indicators: A Preliminary Set**, Organization for Economic Co-operation and Development: Paris.; OECD, (1993), **OECD Core Set of Indicators for Environmental Performance Reviews – Environmental Monograph No. 83**, Organization for Economic Co-operation and Development: Paris.

[185] For example, see Subsidiary Body of Scientific, Technical & Technological Advice, (1997), **Convention on Biological Diversity: Recommendations for a Core Set of Indicators of Biological Diversity**, United Nations Environmental Protection: New York.; Adriaanse, A., (1993), **Environmental Policy Performance Indicators: A Study of Indicators for Environmental Policy in the Netherlands**, The Hague: Sdu Uitgeverji Koninginnegracht.; Municipality of Metropolitan Toronto, (1995), **The State of the Environment Report: Metropolitan Toronto**, Metropolotan Toronto Planning Department: Toronto.; Stanners, D. & Bourdeau, P., (Ed.), (1995), "Europe's Environment", **The Dobrís Assessment**, European Environmental Agency.; United States Interagency Working Group on Sustainable Development Indicators, (1998), **Sustainable Development in the United States: An Experimental Set of Indicators**, USIWGSDI: Washington, DC.; Swart, R.J. & Bakkes, J., (1995), **Scanning the Global Environment: A Framework and Methodology for Integrated Environmental Reporting and Assessment**, RIVM: Bilthoven, Netherlands.; Jesinghaus, J., (1995). "Green Accounting and Environmental Indicators: The Pressure Indices Project", **SCOPE Workshop on Indicators of Sustainable Development**, EUROSTATE / Commission of the European Communities: Wuppertal.; Guinomet, I., (1997), "Approaches to Indicators of Sustainable Development in the European Commission", in B. Moldan & Billharz, S., (Eds.), **Sustainability Indicators**, Wiley: New York.

[186] For example, see Lindblom, C.E. & Cohen, D.K., (1979), **Usable Knowledge**, Yale University Press: New Haven.

[187] Environmental Resources Management, (1995), **Background Paper to the OECD Workshop: Sustainable Consumption and Production – Clarifying the Concepts**, Rosendal, Norway: July 2nd – 4th.

and change its quality and quantity of natural resources (the "state" box). Society responds to these changes through environmental, general economic and sectoral policies (the "societal response" box). The latter form a feedback loop to pressures through human activities.

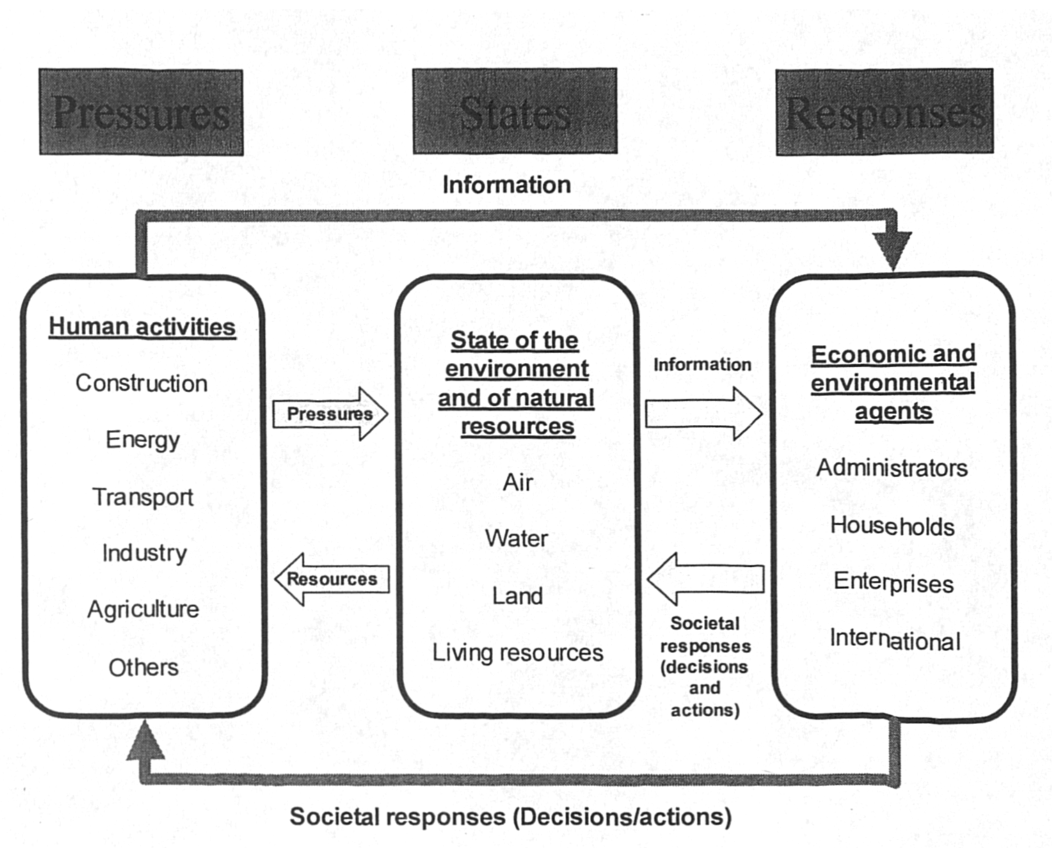

Figure 2.3.: Pressure – state – response framework[188]

This is considered consistent with the systemic nature of social system and ecological system interaction (see Section 2.2.2.). It enables a synoptic approach that addresses the interdependencies between the pressure-state-response causal chains. Given the complexity of the system under consideration, and the relative ignorance about the basic processes and interactions that determine its dynamics, the systems approach can help to foster an understanding of the causal relationships that are responsible for changes in the structure and dynamics of the system.

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[188] Adapted from O'Connor, J.C., (1994), "Towards Environmentally Sustainable Development – Measuring Progress", **Proceedings of the International Union for the Conservation of Nature and Natural Resources, 19th Session of the General Assembly**, Environment Department, World Bank: Washington, DC.

The framework is populated and driven by indicators. Indicators are pointers that can be used to reveal conditions and trends that help in development planning and decision-making[189], and are argued to be the core element in operationalising sustainable development[190]. The key word here is 'help', an issue stressed in Chapter 40 of Agenda 21 which focuses on environmental information to improve decision-making:

> *"Commonly used indicators such as the gross national product and measurements of individual resource or pollution flows do not provide adequate indications of sustainability. Methods for assessing interactions between different sectoral environmental, demographic, social and developmental parameters are not sufficiently developed or applied. Indicators of development need to be developed to provide solid bases for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems."*[191]

An environmental indicator has been defined as: "a parameter (i.e. a measured or observed property), or some value derived from parameters (e.g. via an index or model), which provides *managerially significant* information about patterns and trends (changes) in the state of the environment, in human activities that affect or are affected by the environment, or about relationships among such variables."[192] Further, indicators should provide a clue to a matter of larger significance, or make perceptible a trend or phenomenon that is not immediately detectable[193]. Table 2.1. presents the type of characteristics needed to achieve these objectives[194].

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[189] Tchirley, J., (1996), **Environment Protection Analysis: Indicators**, Sustainable Development, Environment and Natural Resources Service, FAO Research, Extension and Training Division: Rome, Italy.

[190] For example, see Rennings, K. & Wiggering, H., (1997), "Steps Towards Indicators of Sustainable Development: Linking Economic and Ecological Concepts", **Ecological Economics**, 20: 25-36.

[191] United Nations Conference on Environment and Development, (1992), **Agenda 21**, UNCED: Rio de Janeiro, 3-14th June. NCED, 1992: Chapter 40, section 4).

[192] Schulze, I. & Colby, M., (1995), **A Conceptual Framework to Support Development and Use of Environmental Information in Decision-making**, United Nations Environmental Protection Agency: New York.

[193] Hammond, A., (1995), **A Systematic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development**, World Resources Institute: Washington, DC.

[194] Adapted from Hontelez, J., (1995), **Position Paper for the 3rd Session of the United Nations Commission on Sustainable Development, 11th – 28th** April; Intergovernmental Committee on Environmentally Sustainable Development, (1995), **A Survey of Work on Sustainability Indicators**, Australian Department of Primary Industries and Energies; IndEco Strategic Consulting Inc., (1995),

Table 2.1.: Desired indicator characteristics

Validity
Social and environmental relevance: Clear linkage to attributes, values or endpoints of concern
Appropriateness of scale: Reflects conditions/changes at spatial and temporal scales appropriate to the environmental issue of concern
Sensitivity: Has acceptable levels of uncertainty (i.e. signal sufficiently large compared to noise in data) to allow detection of meaningful differences
Broad applicability to stressors: responds to multiple stressor types (i.e. non-specific; important for screening level indicators)
Specificity: Responds specifically to particular stressors (opposite of broad applicability, important for diagnostic indicators for relating cause and effect)
Representativeness: Representative of behaviour of system or other important parameters of interest
Anticipatory; provides early warning of undesired changes
Historical record: Historical record available to define variability, trends and possible acceptable and unacceptable conditions
Feasibility / Cost effectiveness
Measurability: Measurable by standard method with documented performance and low measurement error
Timeliness: data collection, analysis and reporting feasible within decision-making timeframes
Cost effectiveness: Maximises information per unit effort
Non-redundance: provides new information
Data availability: Appropriate data exists and are accessible for secondary use
Minimum environmental impact: of the sampling process itself
Interpretability
Understandability: Is or can be transformed into a form that is understandable by target audience
Interpretability: Decision criteria can be agreed on which distinguish acceptable from unacceptable conditions.
Data compatibility: data collection methods (e.g. analytical methods, sampling design) comparable with other needed data sets.
Documentation / metadata: Adequate documentation to determine if data quality is adequate for intended purpose.

Within the PSR framework, three broad types of indicators can be distinguished[195]:

- Indicators of environmental pressures correspond to the "pressure" box of the PSR framework. They describe pressures from human activities exerted on the environment.
- Indicators of environmental conditions correspond to the "state" box of the PSR framework and relate to the quality and quantity of ecological system sources and sinks. As such they reflect the ultimate objective of sustainable development. Indicators of ecological system conditions should be designed to give an overview of the situation (the state) of the system and its development over time, and not the pressures on it. In practice, the distinction between ecological system conditions and pressures may be ambiguous and the measurement of

Sustainability Indicators: The Transportation Sector – IndEco Report 94029, IndEco Strategic Consulting Inc.: Toronto, Ontario.

environmental conditions can turn out to be difficult or very costly. Therefore, the measurement of ecological system pressures is often used as a substitute for the measurement of environmental conditions.

- Indicators of societal responses correspond to the "response" box in the PSR framework. Societal response indicators are measurements which show to what degree society is responding to ecological system changes and concerns. Societal responses refer to individual and collective actions to mitigate, adapt to or prevent human-induced negative impacts on the environment and to halt or reverse environmental damage already inflicted. Societal responses also include actions for the preservation and conservation of the ecological system.

A simple example of the PSR framework in operation is given in Table 2.2.[196]

Table 2.2.: Example of PSR framework in operation

Issue	Pressure	State	Response
Traffic congestion in cities	• Employment patterns • Urbanisation • Mobility • Car ownership patterns • Stock-level responsiveness • Housing patterns • Land availability • General economy • Community infrastructure patterns	• Pollution (noise, health, materials degradation) • 'Doughnut' effect • Stress • Increased transportation costs (time etc.) • Parking problems	• Mixed transportation planning • Green taxes • Work patterns • Local authority control (car parking restrictions etc.) • Increased infrastructure costs • Planning informed by environmental impact assessment • Political intent • Stiffening / relaxation of green belt protection

It has already been stressed that the PSR model has been used extensively by a range of countries and institutions. It is further noted, however, that the PSR indicator types substantially informed, and flowed out of, the Rio Agenda 21 conference. Table 2.3. maps out, for example, the type and number of indicators contained within

[195] Organisation for Economic Co-operation and Development, (1997), **OECD Environmental Performance Reviews: A Practical Introduction**, OCDE: Paris. Pages 11 and 13.

[196] Barrett, P., Sexton, M.G. & Green, L., (1998) **Integrated Delivery Systems for Sustainable Construction: Unpublished report for the Construction Sponsorship Directorate, Department of Environment Transport and the Regions,**, DETR: London.

the Agenda 21 document. (Pressure: 11 in the social category, for example, shows that there are 11 pressure indicators in this category, and so on.)

Table 2.3.: The United Nations list of sustainable development indicators[197]

Category	Main chapter heading			Chap. No.
Social	Combating poverty			3
	Demographic dynamics and sustainability			5
	Promoting education, public awareness and training			36
	Protecting and promoting human health			6
	Promoting sustainable human settlement development			7
	Pressure: 11	State: 21	Response: 7	
Economic	Changing consumption patterns			4
	Financial resources and mechanisms			33
	Pressure: 9	State: 11	Response: 3	
Environmental	Promoting sustainable agriculture and rural development			14
	Combating deforestation			11
	Conservation of biological diversity			15
	Protection of the atmosphere			9
	Environmentally sound management of biotechnology			16
	Pressure: 22	State: 18	Response: 15	
Institutional	Science for sustainable development			35
	Information for decision making			40
	Strengthening the role of major groups			23-32
	Pressure: 0	State: 3	Response: 12	
Totals	Pressure: 42	State: 53	Response: 37	

While the PSR framework has the advantage of highlighting these pressures, states and responses in a systemic fashion, it tends to suggest linear relationships in the human activity-environment interaction. Indeed, this issue has been picked up forcefully with the observation that "... the most serious objection to this [PSR] approach is that it neglects the systemic and dynamic nature of the processes, and their embedding in a larger total system, containing many feedback loops.[198]", with, for example, resultant ambiguity in whether an indicator is tracking causes or effects[199]. Such criticisms are substantially mitigated if the PSR approach explicitly embodies scale and linkage issues, in order to accommodate complex social system

[197] Adapted from Bell, S. & Morse, S., (1999), **Sustainable Indicators: Measuring the Immeasurable**, Earthscan: London. Page 25.
[198] Bossel, H., (1999), **A Report to the Balaton Group - Indicators for Sustainable Development: Theory, Method, Applications**, International Institute for Sustainable Development: Winnipeg: Canada. Page 14.

and ecological system interactions. The Dynamic PSR model discussed below is presented as a useful development of the PSR framework which addresses these scale and linkage issues.

2.6.5. Dynamic PSR model

Systemic nesting of scales

The first important task is to contextualise the framework within an appropriate portfolio of scales. A key question for sustainable development, for example, is over what space is sustainable development to be achieved, and over what time period?[200] Spatial boundaries can be determined: global, national, regional, and so on, but it must appreciated that these boundaries are socially or politically contrived, and are, in actual fact, systemically interlinked[201]. It has been argued, for example, that the specific regional, environmental and economic structure determines the sensitivity of a region to external environmental and economic forces[202]. Similarly, the time scale over which sustainable development occurs differs depending on whichever system is under consideration[203]. It has been noted, for example, that[204]:

> *"... sustainability is a relationship between dynamic human economic systems and **larger**, dynamic, but normally **slower** changing ecological systems, such that human life can continue indefinitely, human individuals can flourish, and human cultures can develop – but also a relationship in which the effects of human activities remain within bounds so as not to destroy the health and integrity of self-organizing systems that provide the environmental context for these activities ... "*

The key issue being made here is that appropriate deliberation should be made on what point of a given scale is sustainable development being considered, and what the implications of interactions between multiple scales are. The primary

[199] Alfsen, K.H. & Saebo, H.V., (1993), "Environmental Quality Indicators: Background, Principles and Examples from Norway", **Environmental and Resource Economics**, 3: 415-435.
[200] For example, see Fresco, L.O. & Kroonenberg, S.B., (1992), "Time and Spatial Scales in Ecological Sustainability", **Land Use Policy**, 9: 155-168.
[201] Nui, W-Y, Lu, J.J. & Khan, A.A., (1993), "Spatial Systems Approach to Sustainable Development: A Conceptual Framework", **Environmental Management**, 17: 2: 179-186.
[202] Siebert, H., (1995), **Economics of the Environment: Theory and Policy**, Springer-Verlag: Berlin.
[203] For example, see Ehui, S.K. & Spencer, D.S.C., (1993), "Measuring the Sustainability and Economic Viability of Tropical Farming Systems: A Model from Sub-Saharan Africa", **Agricultural Economics**, 9: 279-296.

consequence of this nested context is that any management decisions will affect several scales (higher and lower levels)[205]. Therefore, it has been argued that ecosystem patterns and processes need to be studied at varied spatial and temporal scales or within "ecological time frames.[206]" From an industrial viewpoint, for example, this argument is captured by the observation that:

> *"It is no longer good enough to simply solve an offending environmental problem on a 'one off' basis. We must search for solutions that come together in a global sense, so that we do not waste our energy chasing inappropriate short term goals. Not only is this good for the environment, it is good business and builds credibility with our customers."*[207]

This argument is both captured and amplified, for example, in the 'horizons of influence, attention and responsibility in space and time' model shown in Figure 2.4.[208]

The *horizon of influence* extends over all systems in space and time that are significantly affected by the stakeholders' actions. The horizon of influence is a factual consequence of the relationships in the social and ecological systems and the power of the stakeholder. Given these facts, the stakeholder cannot define his or her horizon of influence at will.

The *horizon of attention* comprises the social and ecological systems whose interaction and development is of some interest to the stakeholder, and whose trajectory is given some attention by the stakeholder. The horizon of attention is defined by the curiosity of the stakeholder. It does not imply any commitment on his or her part for any of the systems within the horizon of attention.

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[204] Norton, B.G., (1992), "A New Paradigm for Environmental Management", in R. Costanza, B.D. Haskell & B.G. Norton, (Eds.), **Ecosystem Health: New Goals for Environmental Management**: Pages 23-41, Island Press. Page 25. Emphasis added.
[205] For example, see Boureron, P.S. & Jensen, M.E., (1994), "An Overview of Ecological Principles for Ecosystem Management", in M.E. Jensen & P.S. Bourgeron, (Eds.), **Ecosystem Management: Principles and Applications**, Pacific Northwest Research Station; Portland, Oregan Pages 45-57.
[206] For example, see Reichman, O.J. & Pulliam, H.R., (1996), "The Scientific Basis for Ecosystem Management", **Ecology Applications**, 6: 3: 694-696.
[207] Robertson, M., (1993), "The Response of Industry to Environmental Concern", in D.K. Adams (Ed.), **Environmental Issues: The Response of Industry and Public Authorities**: Pages 93-102, Rayburn: Halifax, England. Page 101.
[208] Adapted from Meadows, D.H., (1972), **The Limits to Growth: A Report to the Club of Rome's Project on the Predicament of Mankind, Universe Books: New York.**

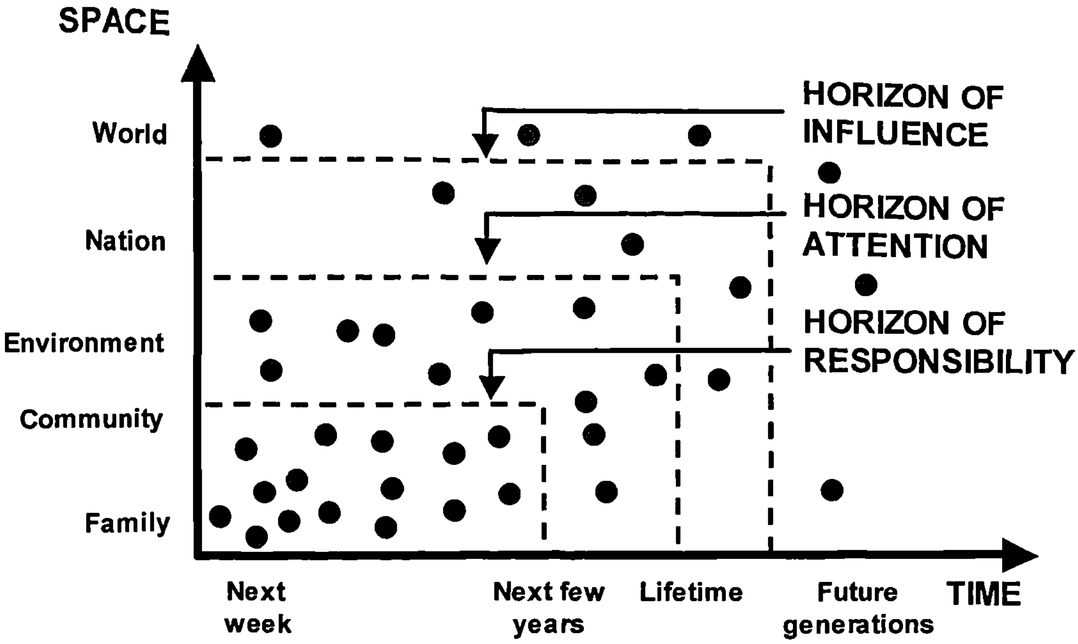

Figure 2.4.: The horizons of influence, attention and responsibility in space and time
(The dots indicate the distance in space and time of different stakeholder objectives and motivations)

The *horizon of responsibility* is limited to those systems for whose interests the stakeholder would actually give up advantages (time, resources) or endure inconvenience. The horizon of responsibility is defined by the ethical considerations of the stakeholder.

Drawing upon these spatial and temporal scale debates, Figure 2.5. presents a framework[209] which can infuse the Dynamic PSR model with the required systemic focus and linkage across a range of pertinent scales. Moving from Level A to Level D involves increasing spatial areas and time frames, as well as increasing complexity and effort, and need for collaboration and integration with third parties outside the industry. This framework identifies the different scales (and the linkages within and between them) that need to be actively investigated and managed to progress sustainable development.

[209] Barrett, P.S., Bootland, J., Cooper, I., Gilham, A. & Jenkins, O., (1998), **Report for the Construction Research and Innovation Strategy Panel –Sustainable Construction Theme Group: Research and Innovation for Sustainable Construction,** CRISP: London. Page 5.

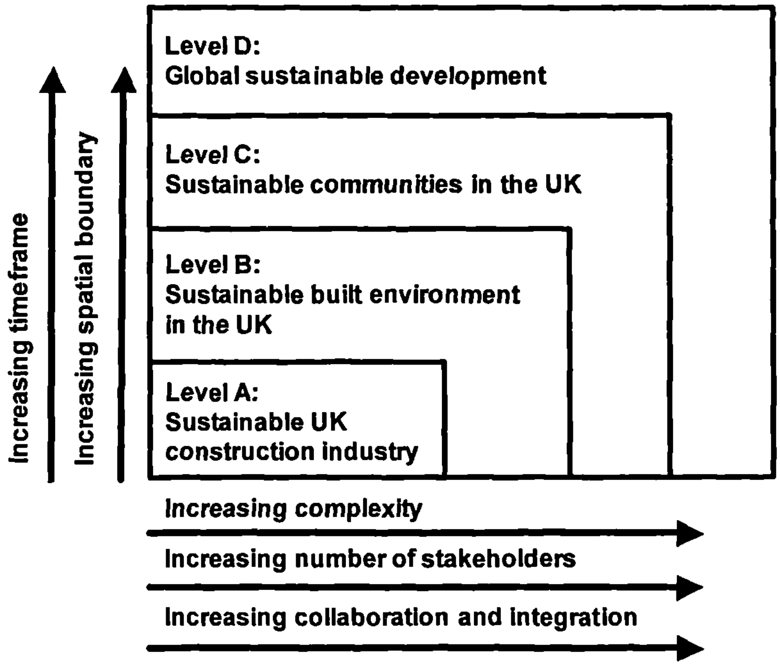

Figure 2.5.: Systemic nesting of scales

Basic framework

The Dynamic PSR model explicitly links pressures-states-responses in a cycle[210]. This is shown in Figure 2.6. Intuitively it makes sense that pressures create states, that in turn demand responses, which in turn have an effect on the original pressures. This rearrangement is important as it creates a simpler, more transparent, continuous learning and improvement cycle than the original PSR model set out in Figure 2.3.

[210]Sexton, M.G., (1998), "Sustainability Indicators: Context, Process and Content", **Working Paper for the Integrated Delivery Systems for Sustainable Construction Project**, University of Salford: Salford.; Barrett, P.S., Bootland, J., Cooper, I., Gilham, A. & Jenkins, O., (1998), **Report for the**

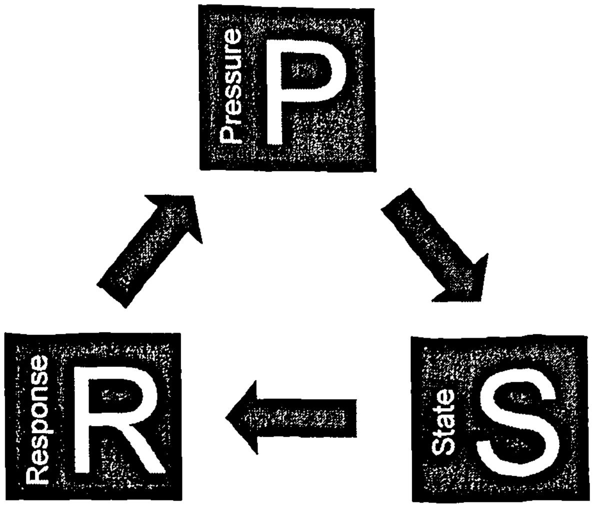

Figure 2.6. Basic rearrangement of PSR framework

Further, the definitions of the PSR boxes are modified to capture the learning and improvement dimensions to the model:

- *Pressure* - drivers for change, from a range of possible sources, such as: regulation, markets, social, technical. Pressures are viewed as ranging from strong to weak.
- *State* - the level of understanding and willingness of relevant actors within the industry to act, viewed as ranging from "unaware" to "aware, but not active" to "aware and active".
- *Response* - actions taken in practice, viewed as ranging from zero (passive) with positive and negative actions either side

Units of analysis

It is crucial if the model is to make sense, that it is used in such a way that, at any one time, the same stakeholder's perspective is used for P, S and R and that the issue or objective in question is also kept constant. For example, an analysis could be done of the construction industry as a whole (stakeholder) in relation to environmental issues generally. This is consistent with the OECD approach to structuring

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Construction Research and Innovation Strategy Panel –Sustainable Construction Theme Group: Research and Innovation for Sustainable Construction, CRISP: London.

indicators by institutional stakeholder[211], an indicative example of which is shown in Table 2.4.

Table 2.4.: Structure of indicators by stakeholder

	Stakeholder	PRESSURE	STATE	RESPONSE
1	Government			
2	Firms			
3	Households			
4	Etc.			

Equally a study on waste minimisation (issue) from a contractors' perspective (stakeholder) could be supported by the framework. Again, this is consistent with the OECD approach to structuring indicators by issue[212], an indicative example of which is shown in Table 2.5.

Table 2.5.: Structure of indicators by issue

	Issue	PRESSURE	STATE	RESPONSE
1	Climate change			
2	Acidification			
3	Waste			
4	Etc.			

The focus on stakeholder and/or issue can be difficult, due to the intrinsic variety of stakeholder perspectives on (see Section 2.5.), and ecological complexity of (see Section 2.3.), sustainable development; but any slippage on this makes it inconsistent with the proposed cause-effect cycle of the model.

The need for consistency on stakeholder/issue may be considered restrictive, but it is strongly proposed that the *same framework* can be and should be used flexibly at different levels of abstraction. For example, a study could be done of the

[211] Group on the State of the Environment, (1993), "OECD Cores Set of Indicators for Environmental Performance Reviews", **Environment Monograph No. 83: OCDE/DG(93)179**, OECD: Paris. Page 9.

[212] Group on the State of the Environment, (1993), "OECD Cores Set of Indicators for Environmental Performance Reviews", **Environment Monograph No. 83: OCDE/DG(93)179**, OECD: Paris. Page 11.

construction industry as a whole (stakeholder) in relation to environmental issues generally. Equally a study on waste minimisation (issue) from a contractor's perspective (stakeholder) could be supported by the framework. The key point being made here is that by keeping a consistent framework, particular stakeholders can make sense of their situation (for example, in relation to their supply chain partners) *and* the possibility of combined analyses is opened up. For example, the impact of a particular regulation could be followed through a number of exercises to understand different responses by different parts of the industry. This approach has the advantage of flexibility and consistency. It can be empowering for particular groups of stakeholders and enable strategic syntheses to be developed, extending to international comparisons. The possibility of infinite applications can be addressed at a strategic level by choosing key issues and stakeholders to focus upon.

Gap analysis

The operationalisation of the *Dynamic PSR model* is fruitfully achieved through viewing the model as a gap analysis framework. Interrogation of the model reveals two categories of gaps. Those related to P, S and R and those related to the relationship between P, S and R. These gaps are shown in Figure 2.7. and defined in broad terms in Table 2.6[213].

[213] Barrett, P.S., Bootland, J., Cooper, I., Gilham, A. & Jenkins, O., (1998), **Report for the Construction Research and Innovation Strategy Panel –Sustainable Construction Theme Group: Research and Innovation for Sustainable Construction**, CRISP: London. Page 13.

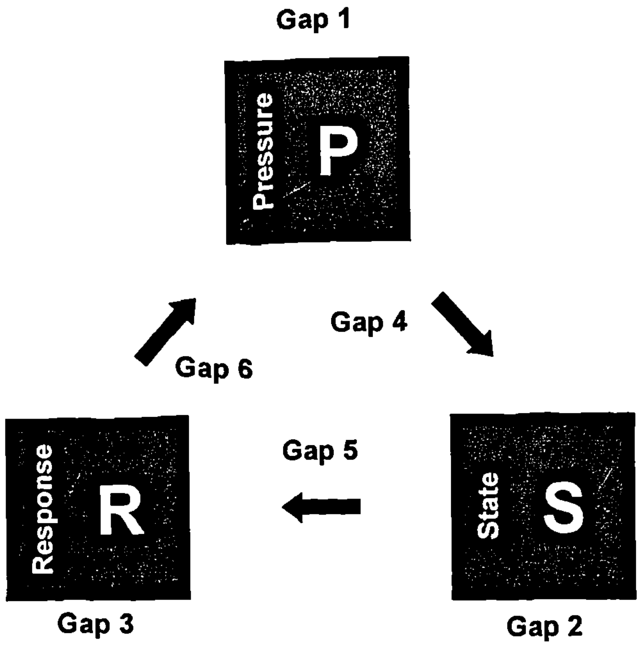

Figure 2.7. Framework for change

Table 2.6. Gaps in knowledge and understanding and their implications

Gap	Lack of Knowledge about...	Generic questions raised
1	*Pressures,* in terms of drivers for change	What are the relevant drivers for the given issue and how strong are they from the point of view of the players?
2	*States,* in terms of players level of understanding, willingness to act	What is the profile of the players' level of understanding and willingness to act on the given issue?
3	*Responses,* in terms of actions taken by players	What is the profile of the players' responses to the given issue ranging from passive to positive or negative?
4	The relationship between *Pressures* and *States*	Is there a mis-match between the strength of drivers and the level of understanding and readiness of the players to respond on the given issue?
5	The relationship between *States* and *Responses*	Is there a mis-match between the level of understanding and readiness to act of the players' and their actual actions, both positive and negative?
6	The relationship between *Responses* and *Pressures*	Is there a mis-match between players' actions and the original intentions of the drivers for change?

The learning and improvement cycle dimension of the Dynamic PSR model provides a *mechanism* for *systemic understanding* to guide decision-making and action, and the gap analysis dimension provides a *process* to drive and support the necessary *effective change*.

2.7. Holographic Dynamic PSR model

Introduction

The discussion up to now has consisted of two themes: the role of worldviews, culminating in a neoclassical – ecological worldview continuum on which sustainable development definitions can be located; and the need for a systemic, improvement orientated sustainable development framework, culminating in the Dynamic PSR model.

The worldview discussion sets out the "what?" dimension of sustainable development, while the Dynamic PSR model progresses the "how?" aspects. The "what" and "how" components need to be combined to generate focused, appropriate decision-making and action. The Holographic Dynamic PSR model (shown in Figure 2.8.) is presented as such an integrative approach. The rational and operation of the model is described below.

Description of model

The "what" element of the model is provided by the worldview dimension which *envisions* the Dynamic PSR core with distinctive, but constantly shifting goals and 'ways of looking at the world.' The model provides an explicit link with the ever-changing social, economic and environmental contexts to provide sustainable development with a 'reality' with its intrinsic multi-dimensional, multi-causal, mutually implicated and constantly changing knowledge bases[214]. Further, the learning generated from the Dynamic PSR core leads, in part, to an ongoing *evolution* of stakeholder worldviews.

The *Dynamic PSR model* is essentially the same, but the learning and improvement dimensions have been strengthened, with the 'pressure' element developing *continuous improvement in understanding*; the state element *continuous involvement in determination*; and, the 'response' element *continuous improvement in*

[214] Adam, B., (1990), **Time and Social Theory**, Polity Press: Cambridge. Page 158.

effectiveness. These strands are brought together in a synergistic hub which develops *continuous improvement in theoretical understanding and practical deployment*.

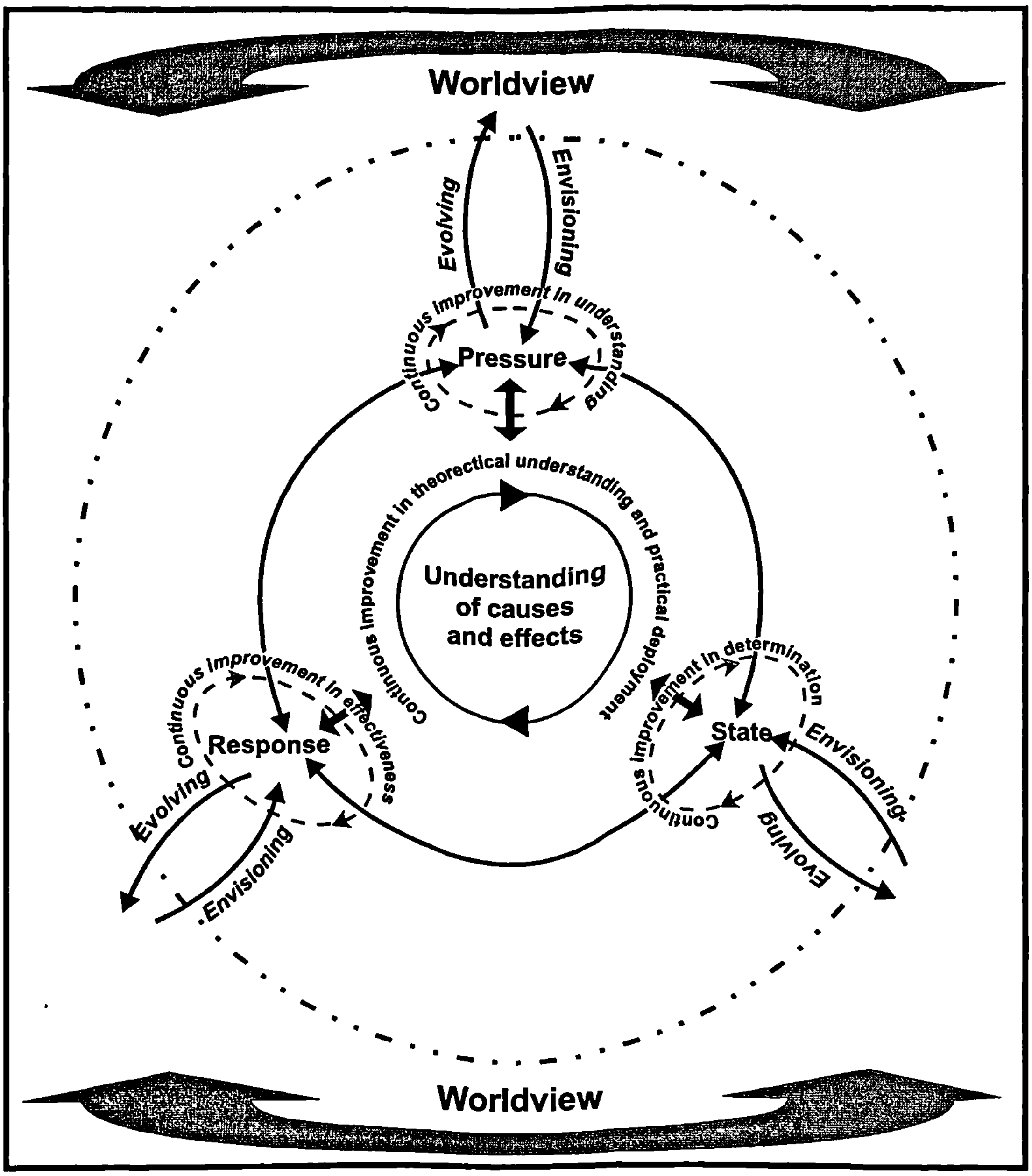

Figure 2.8.: Holographic Dynamic PSR model

The dynamic focus and self-sustaining learning dimensions of the model infuse it with a *hologram* character – "... derived from the Greek words 'holo', meaning 'whole', and 'gram' meaning 'to write'. Thus, the hologram is an instrument that, as it were, 'writes the whole'."[215] First, its systemic nature allows the sustainable development 'photographic plate' to be considered from a range of possible stakeholder and issue perspectives as if looking through a window. The order in the photographic plate, however, is not localised. If only a small part of the plate is illuminated, the viewer will still see the whole structure, but with less sharply defined detail and with less possible points of view, as though looking through a smaller window[216]. Further, the model is dynamic, rather than static, as it, " ... [is] .. able to learn from [its] own experience, and to modify [its] structure and design to reflect what [it has] learned.[217]"

The proposed framework designs in a focused, 'learning-to-learn' dynamic which can critically evaluate, develop and integrate our understanding of our own motivations, policies and actions, on an ongoing basis. The model serves as a locus of innovation, learning and transformation required for appropriate progress towards sustainable development to be made.

2.8. Research hypotheses

The hypotheses set out below illuminate the problem definition set out in Section 1.2., (namely, that the body of knowledge on sustainable development issues in the built environment and construction industry is too unfocused and fragmented) and are informed by the literature review and synthesis presented in this chapter.

H1: Built environment and construction industry stakeholders' conceptualisation of sustainable development will be different, and will result in distinctive, potentially conflicting, focuses (see Section 2.4 and 2.5.).

H2: Stakeholders involved in the built environment and construction industry who do not share similar worldviews on sustainable development will identify and

[215] Bohm, D., (1980), **Wholeness and the Implicate Order**, Routledge & Kegan Paul: London. Page 145.
[216] Bohm, D., (1980), **Wholeness and the Implicate Order**, Routledge & Kegan Paul: London.; Bohm, D., (1978), "The Implicate of Enfolded Order: A New Order for Physics", in J.B. Cobb & D.R. Griffin, (Eds.), **Mind in Nature: Essays on the Interface of Science and Philosophy**, University Press of America: Washington.
[217] Morgan, G. & Ramirez, R., (1983), "Action Learning: A Holographic Metaphor for Guiding Social Change", **Human Relations**, 37: 1: 1-28.

prioritise different key sustainable development objectives (see Section 2.4. and 2.5.).

H3: Stakeholders who are involved in the built environment and construction industry will have varying degrees of responsibility for progressing particular sustainable development objectives (see Section 2.4. and 2.5.).

H4: Efforts to progress sustainable development objectives which do not adequately link pressures, states and responses in a systemic fashion will be unbalanced and fragmented (see Section 2.6.).

The final hypothesis emerged in response to the findings from Hypothesis 4 (see Section 4.5.5.), but is included here for completeness.

H5: Efforts to progress objectives that are contextualised in an ecological view (see Section 2.5.) of sustainable development will be characterised by systemically linked pressures, states and responses (see Section 2.6.), and will lead to progressive, significant and balanced sustainable development.

The general argument here is that for an appropriately focused and integrated body of knowledge to be developed, the outcomes of hypotheses 1 to 4 must be positive. This argument is shown in flow diagram form in Figure 2.9.

Hypothesis 5 develops this argument further by speculating that if the research focus is more ecologically orientated (rather than neoclassically orientated), it will stimulate more progressive, significant and balanced sustainable development.

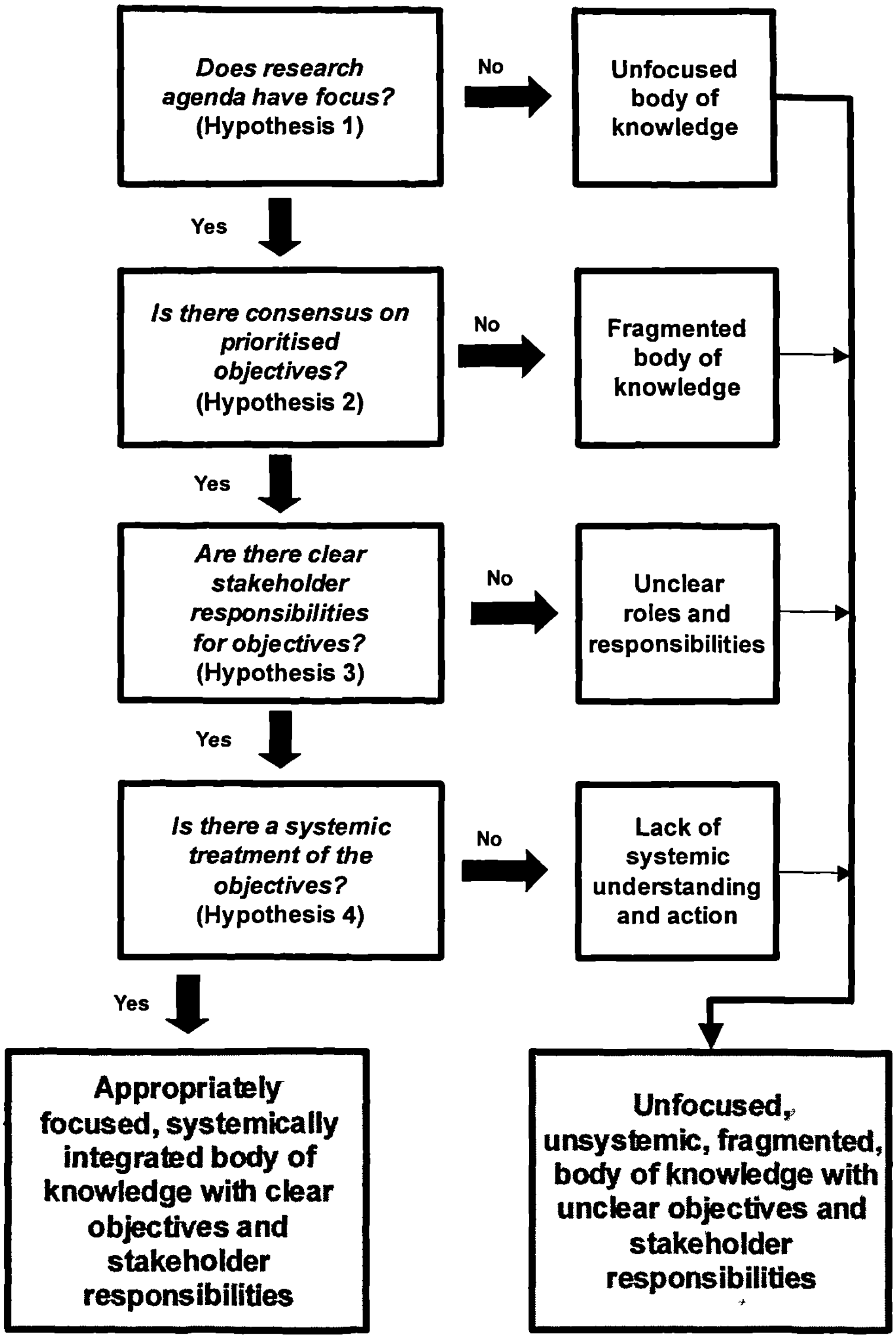

Figure 2.9.: Systemic flow of research hypotheses

2.9. Summary and link

In this chapter, the substance of the sustainable development challenge has been explored; identifying, in particular, the importance of appreciating and accommodating diverse stakeholder worldviews, and the need to develop and operate a system-orientated framework to guide decision-making and action. The discussion culminated in the presentation of the Holographic Dynamic PSR model as a potentially fruitful way of integrating and developing these two central issues; and five hypotheses were articulated to test the assumptions and operation of this model.

In the next chapter, the research methodology employed to test these hypotheses will be discussed.

3. Methodology

3.1. Introduction

The previous chapter set out the research domain and identified the research hypotheses – in effect, mapping out the "what" focus of this piece of research. This chapter concentrates on the design and operation of the research methodology used to test these hypotheses and to generate new theoretical insights – in effect, laying out the "how" element of this research. The chapter is organised around five issues: the 'nested' approach to research methodology, the research philosophy, the research approach, the research techniques, and the validation/generalisation aspects of the methodology..

Research methodology is viewed as the "... systematic, formal, rigorous and precise process employed to gain solutions to problems and/or to discover and interpret new facts and relationships"[1]; with its design being understood to be "... the architectural blueprint of a research project, linking data collection and analysis activities to the research questions and ensuring that the complete research agenda will be addressed."[2]

An integrated 'nested' research methodology approach was adopted for the design and execution of this research. The next section discusses the need for, and nature of, this methodology.

3.2. Research methodology: 'Nested' approach

There are a variety of research methodologies available to the researcher. However, although there are several options to choose from, it is important that the researcher employs a methodology that will be both applicable and relevant to the study area[3]. Indeed, the appropriateness of a research methodology, "... derives from the nature

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[1] Waltz, C. & Bausell, R.B., (1981), **Research: Design, Statistics and Computer Analysis,** MacMillan: New York. Page 1.
[2] Bickman, L., Rog, D.J. & Hedrick, T.E., (1998), "Applied Research Design: A Practical Approach", in L. Bickman & D.J. Rog Eds.), **Handbook of Applied Social Research Methods**: 5-37, Sage: Thousand Oaks, California. Page 11.
[3] McNeill, P., (1990), **Research Methods,** Routledge: London.

of the ... phenomena to be explored"[4]. Sustainable development is, by its intrinsic nature, a diverse and complex issue. The research methodology was thus designed to be sympathetic to the issues being investigated: in effect to "... suit the method to the problem, and not the problem to the method."[5]

To generate an appropriate alignment between the research methodology and the study area, a clear understanding of the constituent elements of research methodology, and their interaction, is required. First, it is useful to distinguish between research approach and research technique. Research approaches are concerned with the formulation and logical relation of concepts; while research techniques focus on the means by which data is gathered and manipulated[6]. The research approach and research technique should not operate in a philosophical vacuum, as this would render the methodology and the technique devoid of any epistemological context; indeed, "... a methodology is more than merely a collection of these things. It is usually based on some philosophical view, otherwise it is merely a method, like a recipe.[7]" The risks associated with viewing research methodology purely in terms of its individual constituent elements are captured in the following argument:

> *"... epistemological [philosophical] foundations are not, strictly speaking, a methodology; yet they direct and inform it ... An unexamined and ill-defined epistemology, therefore, may lead to methodological confusion, just as methodological obtuseness renders the most sophisticated technique useless."*[8]

There is therefore a clear need for an holistic, integrated research methodology and, in response to this need, the 'nested' research model shown in Figure 3.1. was developed. The outer rectangle represents the unifying research philosophy which guides and energises the inner research approach and research technique. The

[4] Morgan, G. & Smircich, L., (1980), "The Case for Qualitative Research", **Academy of Management Review**, 5: 491-500. Page 491.
[5] Linstone, H.A., (1978), "The Delphi Technique", in J. Fowles (Ed.), **Handbook of Futures Research**, Greenwood Press: London: Page 275.
[6] Sartori, G., (1970), "Concept Misinformation in Comparative Politics", **American Political Science**, 64: 1033-1053. page 1033.
[7] Avison, K & Fitzgerald, L., (1994), **Methodological Concepts and Approaches**, Free Press: New York. Page 64.
[8] Sederberg, P.C., (1972), "Subjectivity and Typification: A Note on Method in the Social Sciences", **Philosophical Society of Science**, 2: 167-176. Page 167.

research approach consists of the dominant theory generation and testing method. The *research technique* comprises the data collection and manipulation tool.

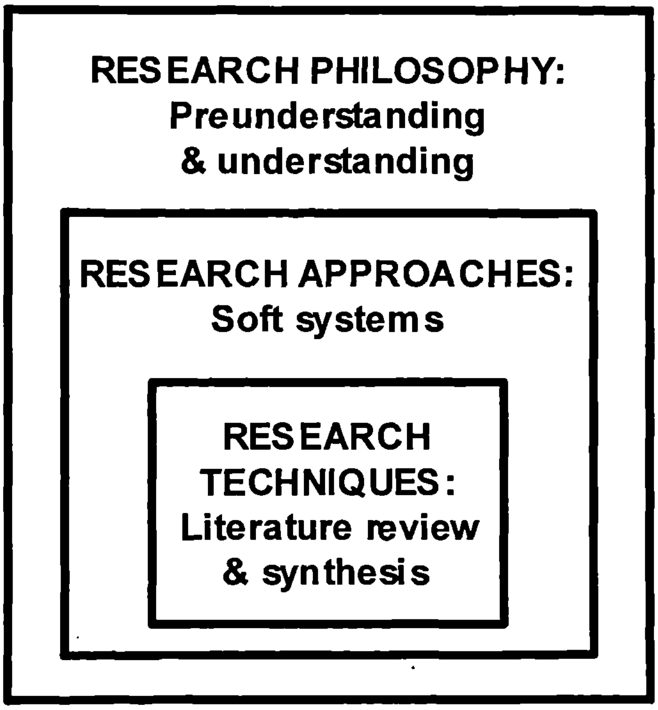

Figure 3.1.: Research methodology 'nesting'

The nesting of the model's elements generates a framework which provided the researcher with a research approach and research technique which benefited from epistemological level direction and cohesion. Each of the model's elements will now be discussed.

3.3. Research philosophy: 'Preunderstanding – understanding'

All research methodology is based on some underlying assumptions about the nature and grounds of knowledge[9]. In order to conduct research, it is therefore important to know what these (often unconscious) assumptions are. For our purposes, the most pertinent philosophical assumptions are those which relate to the underlying epistemology which guides research. Epistemological foundations refer to the assumptions about knowledge and how it can be obtained[10].

[9] Berger, P.L. & Luckman, T., (1966), **The Social Construction of Reality**, New York. Page 1.
[10] Hirschheim, R., (1992) "Information Systems Epistemology: An Historical Perspective," in R. Galliers (Ed.), **Information Systems Research: Issues, Methods and Practical Guidelines**, Blackwell Scientific Publications: Oxford. Pp. 28-60.

There are three broad research philosophies: positivism, interpretism and critical theory[11]:

- *Positivist* research philosophies assume that reality is objectively given and can be described by measurable properties which are independent of the observer (researcher). Positivist studies generally attempt to test theory, in an attempt to increase the predictive understanding of phenomena.
- *Interpretative* research philosophies assume that access to reality is only through social constructions such as language, consciousness and shared meanings. Interpretive studies generally attempt to understand phenomena through the meanings that people assign to them.
- *Critical* research philosophies assume that social reality is historically constituted and that it is produced and reproduced by people. Critical research focuses on the oppositions, conflicts and contradictions in contemporary society, and seeks to be emancipatory in nature.

The study area of this thesis is underpinned by the argument that there is a strong need to appreciate and accommodate diverse stakeholder worldviews, and the need to develop and operate a system-orientated framework to guide sustainable development decision-making and action (see Section 2.7.). Stakeholders' worldviews substantially influence their perspectives as to what the goals of sustainable development should be, and the strategies needed to achieve these objectives. Indeed, as set out in Section 2.4.1., researchers have depicted sustainable development in terms of political ideology, vision expression, value change, moral development, social reorganisation and ethical imperative. These differing views of sustainable development are manifestations of the social construction of knowledge, which stresses that:

> *"there are no pure facts, but only facts as couched in one conceptual system or another. There are no pure observations, but rather observations couched in a theory-laden vocabulary. Theories bring with them their own empirical criteria, which bias the findings in*

[11] Orlikowski, W.J. & Baroudi, J.J. (1991), "Studying Information Technology in Organizations: Research Approaches and Assumptions", **Information Systems Research**, 2: 1-28.

support of them .... Observation depends upon the perspective of the investigator, so that there are no perspective-independent facts."[12]

The argument here then, is that the literature sources which this thesis draws upon, (see Sections 3.4. and 3.5.) contain no 'perspective-independent facts'; indeed, "ultimately, individual [researcher] reality depends on choice: 'we decide to regard those things as important which play an important role in the kind of life we prefer.'"[13], so that, for example, "the spectrum of organisational life is filtered through the researcher's preset categories; elements related to the categories are selected, coded as data, and simultaneously given meaning by the categories.[14]" The subjective nature of the study, then, supports the adoption of an interpretative research philosophy, and precludes the positivist research philosophy that sees reality as 'objectively' constructed.

The focus on progressive, systemic decision-making and action locates the study area very much in the domain of built environment and construction activity objectives and strategies, rather than in the broader arena of societal strata and their political interaction. The latter is very much the focus of critical theory, with its roots in western Marxism, and its emphasis on the "... struggles against imperialism, the private appropriation of scarce resources and the many constraints on personal initiative ...[15]" The research focus on the built environment and construction activity objectives and strategies (rather than a broader Marxist contextualisation of the issues) renders, therefore, a critical research philosophy inappropriate.

In summary, the research focus on understanding stakeholders' worldviews, and how they influence built environment and construction activity goals and strategies with respect to sustainable development, strongly indicates that an interpretative research philosophy is most appropriate for this research area.

[12] Little, D., (1993), "Evidence and Objectivity in the Social Sciences", **Social Research**, 60: 2: 363 – 396. Page 364.
[13] Feyerabend, P., (1981), **Realism, Rationalism and Scientific Method**, Cambridge University Press: Cambridge. :Page xiii.
[14] Evered, R. & Louis, M.R., 1981), "Alternative Perspectives in the Organizational Sciences: Inquiry from the Inside, and Inquiry from the Outside", **Academy of Management Review**, 6: 385-395. Page 391.

More specifically, this research adopted the hermeneutic-based philosophy of the interpretation of (pre)understanding[16]. Hermeneutics is primarily concerned with the interpretation of texts or transcribed meanings[17]. As discussed above, the data sources for this thesis represent and project a variety of different worldviews. In this context, the idea of a hermeneutic circle refers to the dialectic between the understanding of the body of literature as a whole, and the interpretation of its constituent parts (namely, particular articles, conference papers, books, and so). It follows from this that the researcher will have an expectation of what the meaning from a piece of literature will be from the context of what has gone on before. The movement of understanding "... is constantly from the whole to the part and back to the whole." [18]

The preunderstanding - understanding hermeneutic spiral[19], shown in Figure 3.2., depicts research as an iterative process. 'Preunderstanding of researcher 1' represents the researcher's initial *a priori* knowledge, insights and experience which the researcher draws upon to *interpret* a piece of literature ('piece of literature 1'). This interpretation of the literature source *develops* the researchers understanding/expectation of the whole body of literature ('researcher understanding/expectation of the whole body of literature 1'). Finally, this understanding/expectation *shapes* the next phase of preunderstanding ('preunderstanding 2') used to *interpret* a second piece of literature (piece of literature 2'), and so on.

This cycle bridges the differences that exist between the finite province of meaning held by the researcher and the infinite provinces of meaning held within texts

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[15] Held, D., (1980), **Introduction to Critical Theory: Horkheimer to Habermas**, Polity Press: Oxford. Page 13.

[16] For example, see Gadamer, H., (1989), **Truth and Method**, Crossrod: New York.; Bernstein, R.J., (1983), **Beyond Objectivism and Relativism: Science, Hermeneutics, and Praxis**, University of Pennsylvania Press: Philadelphia.; Bleicher, J., (1980), **Contemporary Hermeneutics: Hermeneutics as Method, Philosophy and Critique**, Routledge: London.

[17] Rudestam, K.E. & Newton, R.R., (1992), **Surviving Your Dissertation: A Comprehensive Guide to Content and** Process, Sage: California. Page 33.; Radnitzky, G., (1970), **Contemporary Schools of Metascience**, Scandinavian University Books: Goteborg. Page 20.

[18] Gadamer, H-G., (1976), "The Historicity of Understanding," in P. Connerton, (Ed.), **Critical Sociology: Selected Readings**), Penguin Books Ltd, Harmondsworth. Pages 117-133. Page 117.

[19] Odman, P., (1985), "Hermeneutics", in T. Husen & N.T. Postlewaite, (Eds.), **The International Encyclopaedia of Education**: 2162-2169, Pergamon: Oxford.; Bauman, Z., (1978), **Hermeneutics and Social Sciences**, Hutchinson: London.

generated by multiple stakeholders[20] (in this case, the authors of the secondary sources reviewed and synthesised by the researcher). This 'bridging' enables 'self-conscious reflection'[21] on the part of the researcher, which informs the subsequent stage of understanding of the research domain which, in turn, is the basis for the preunderstanding for the next progressive stage of enquiry, and so on.

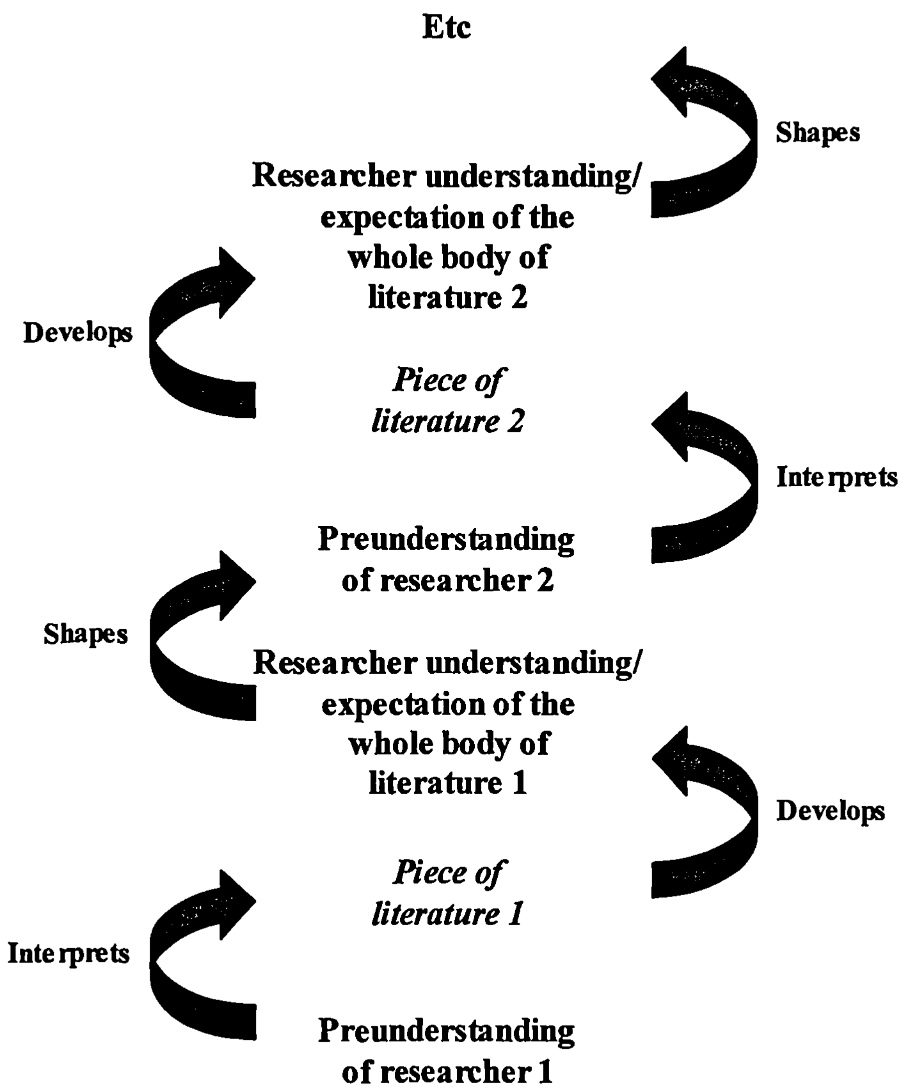

Figure 3.2.: Hermeneutic learning spiral

In summary, the focus of this research, sustainable development, is very much shaped by stakeholder worldviews and systemic ambiguity and uncertainty (see

[20] Phillips, N. & Brown, J.L., (1993), "Analyzing Communication In and Around Organizations: A Critical Hermeneutic Approach", **Academy of Management Journal**, 38: 6: 1547-1576. Page 1573.

Chapter 2). The hermeneutic philosophy is thus considered appropriate as it stimulates a progressive "fusion of [diverse stakeholder] horizons"[22] from the researcher's perspective, through a cycle of creative engagement and reflection with the data.

Guided by this underpinning interpretative research philosophy, a soft systems-based research approach was used. This approach will be discussed in the next section.

3.4. Research approach: Soft systems methodology

The soft systems methodology developed as a systemic approach to problem-solving[23]. The traditional systems approach to problem-solving is based on the technique of reductionism, which solves a problem by fragmentation, one stage at a time[24]. This technique is appropriate for highly structured problems that have clear objectives and which can be well defined. Sustainable development, however, is characterised by its systemic complexity and either poorly defined and/or conflicting stakeholder objectives. In these situations, a holistic, soft systems approach is recommended, rather than a reductionist approach[25]. The soft system approach is better able to deal with such "fuzzy" problem situations, where objectives are unclear or where multiple objectives may exist[26].

Soft systems methodologies have been previously used to investigate sustainable development issues to good effect. A 'soft complex systems' model was developed, for example, to investigate the "... evolutionary complex [air quality] systems, involving interlinked processes of physical, knowledge, technological, institutional,

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[21] Deetz, S., (1985), "Critical-cultural Research: New Sensibilities and Old Realities", **Journal of Management**, 11: 2: 121-126.
[22] Arnold, S.J. & Fischer, E., (1994), "Hermeneutics and Consumer Research", **Journal of Consumer Research**, 21: June: 55-70. Page 55.
[23] Checkland, P.B., (1981), **Systems Thinking, Systems Practice**, Wiley: Chichester.; Checkland, P. & Scholes, J., (1990), **Soft Systems Methodology in Action**, Wiley: Chichester.
[24] For example, see Checkland, P.B., (1981), **Systems Thinking, Systems Practice**, Wiley: Chichester. Pages 57-67,; Flood, R.L. & Carson, E.R., (1988), **Dealing with Complexity: An introduction to the Theory and Application of Systems Science**, Plenum: New York. Pages 2-6.
[25] Checkland, P.B., (1992), "From Framework Through Experience to Learning: The Essential Nature of Action Research", **Proceedings of the Second World Congress on Action Learning**, 14th – 17th 17. July. Pages 1-7.; Checkland, P.B., (1981), **Systems Thinking, Systems Practice**, Wiley: Chichester.; Checkland, P. & Scholes, J., (1990), **Soft Systems Methodology in Action**, Wiley: Chichester.
[26] Rosenhead, J., (1989), **Rational Analysis of a Problematic World**, Wiley: Chichester. Checkland, P.B., (1981), **Systems Thinking, Systems Practice**, Wiley: Chichester. Page 316.

perceptual and behavioural change.[27]" Similarly, 'informal soft systems' were applied to improve the decision-making for Lakeland water quality management[28].

The soft systems methodology was originally designed to allow the human element of complex management systems to be incorporated into system design work. It is now an evolving methodology that has been steadily developed into a systemic process of enquiry structured around a comparison between a real-world problem situation and conceptual models of relevant systems of purposeful activity[29]. However, since soft systems methodology covers 'purposeful human activity', it is possible to envisage other social science fields and traditions in which it is legitimate and appropriate. In many of these the focus is not upon 'action', but upon learning-contributions to knowledge. Often that learning will be represented as theory with the research taking the form of theory generation, or theory testing[30]. This theory building/testing focus of soft systems methodology was adapted for this research to form the generation of theoretical insights.

The design of the soft systems methodology is set out in Figure 3.3.

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[27] Hadfield, L. & Seaton, R.A.F., (1999), "A Co-evolutionary Model of Change in Environmental Management", **Futures**, 31: 6: 577-591. Page 577.
[28] Gough, J. & Ward, J., (1996), "Environmental Decision-making and Lake Management", **Journal of Environmental Management**, 48: 1: 1-16.
[29] Checkland, P.B., (1992), "From Framework Through Experience to Learning: The Essential Nature of Action Research", **Proceedings of the Second World Congress on Action Learning**, 14th – 17th 17. July. Pages 1-7.

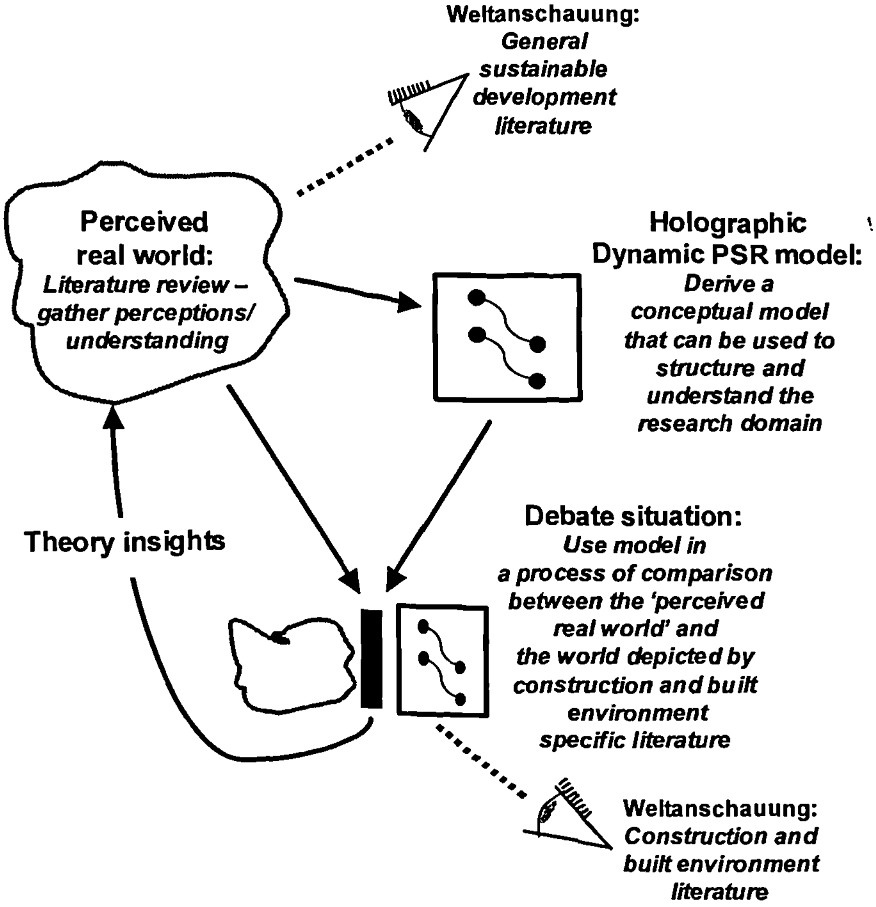

Figure 3.3.: Research approach – Soft systems methodology

Using the model, the researcher interrogated a range of general (rather than construction or built environment specific) secondary sources to develop an understanding of sustainable development in the *perceived real world.* These literature sources were shaped by the general sustainable development researchers' *Weltanschauung* (translatable into the term worldview). This phase of the research produced the *Holographic Dynamic PSR model,* a purposeful 'holons'[31] or conceptual model. The Holographic Dynamic PSR model underpinned the *debate situation,* by being designed in such a way that it provided a source of questions which could be asked of the problem situation as viewed by the *Weltanschauung* of the construction and built environment specific literature. The key issue here is that two distinctive sets of data: general sources relevant to sustainable development, and

[30] Rose, G., (1982), **Deciphering Social Research**, MacMillan: London.
[31] Checkland, P., (1988), "The Case for 'Holon'", **Systems Practice**, 1: 3: 235-238.

construction and built environment specific secondary sources related to sustainable development were compared. Answering these questions within the framework of the Holographic Dynamic PSR model enabled an understanding of the situation to be gained and led to the emergence of a structured and coherent debate about sustainable development[32]. This debate produced new *theory insights* which were then used to inject new meaning into the perceived real world generated by the general sustainable development literature.

The soft systems methodology used secondary data sources and this, along with the literature review research technique, is discussed in the next section.

3.5. Research technique: Literature review and synthesis

A literature review and synthesis seeks to describe, summarize, evaluate, clarify, and/or integrate the content of [secondary data sources][33]" and "...may be considered a type of research in its own right – one using a characteristic set of research techniques and methods"[34], the product of which, "... involves inferences as central in the validity of knowledge as the inferences involved in primary data interpretations."[35]

The increasing recognition of the key role of reviews in synthesising and disseminating the results of research has prompted researchers to consider the validity of reviews – and the need for systematic steps to minimise bias and random errors in reviews of research[36]. The key issues to ensure the validity of literature reviews are an understanding of the nature of secondary data sources, the process by which secondary data is collected, and the way the resultant data is analysed. These three issues will be discussed in turn.

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[32] Checkland, P. & Tsouvalis, C., (1997), "Reflecting on SSM: The Link Between Root Definitions and Conceptual Models", **Systems Research and Behavioral Science**, 14: 3: 153-166. page 153.

[33] Cooper, H.M., (1988), "Organizing Knowledge Syntheses: A Taxonomy of Literature Reviews", **Knowledge in Society**, 1: 104-126. Page 107.

[34] Feldman, K.A., (1971), "Using the Work of Others: Some Observations on Reviewing and Integrating", **Sociology of Education**, 4: 86-102. Page 86.

[35] Cooper, H.M., (1989), **Integrating Research: A Guide for Literature Reviews**, Sage: Newbury Park. Page 12.

[36] Rosenthal, R., (1978), "Combining Results of Independent Studies", **Psychological Bulletin**, 85: 185-193.; Glass, G.V., (1976), "Primary, Secondary, and Meta-analysis of Research", **Education Research**, 5: 3-8.; Light, R.J. & Smith, P.V., (1971), "Accumulating Evidence: Procedures for

Secondary data

Research requires sources of data. Data are often described as falling into one of two broad categories. Primary data is collected by the researcher directly from research subjects to investigate a specific research question. Primary data can come from many different sources, including surveys or questionnaires (e.g. mailings, telephone interviews, face-to-face interviews), observations (e.g. focus groups, participant observation), or through instrumentation (e.g. physiological measures). In contrast, secondary data is data that was collected for another purpose and reanalysed by other researchers to answer new research questions or the same question but with more data. Secondary data sources include published books, reports, journals and conference proceedings.

The distinction between primary and secondary data sources is not always clear, and should be considered as forming a continuum, as illustrated in Figure 3.4. The rationale and operation of the model is described below.

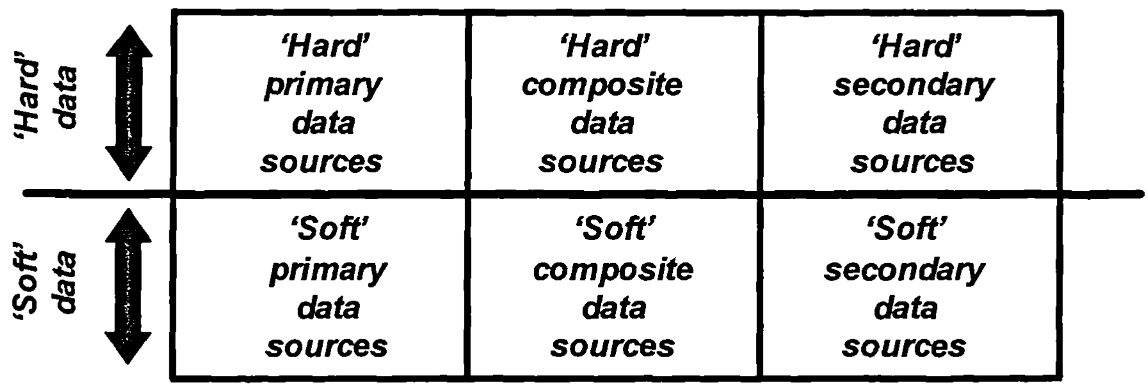

Figure 3.4.: Primary-secondary data continuum

The model is divided into two types of data: the top half is 'hard' data and and the lower half is 'soft' data. 'Hard' data is viewed in broad terms as being data which is generated for, or closely matches the needs of, specific research questions. In contrast, 'soft' data is taken as data which is generated for, nor closely matches the needs of, specific research questions. More specifically, **'hard' primary data** is viewed as data coming from respondents in direct response to the researcher's

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Resolving Contradictions Among Different Research Studies", **Harvard Education Review**: 41: 429-

specific research question. For example, interview and questionnaire data. **'Soft' primary data** is taken as primary data not generated in direct response to the researcher's specific research question. For example, company reports and memoranda. On the top, right hand side of the continuum, **'hard' secondary data** is considered as literature sources which focus significantly on the research question being investigated, but which was not generated in direct response to the researcher's specific research question. For example, a researcher investigating the integration of quality, health and safety and environmental management systems would treat data sources specifically on this subject as a 'hard' secondary data source. In contrast, **'soft' secondary data** sources are those literature sources which focus to a more limited degree on the research question being investigated, and which were not generated in direct response to the researcher's specific research question. For example, a researcher investigating the integration of quality, health and safety and environmental management systems would consider data sources on general systems theory as a 'soft' secondary data source. In the middle section of the continuum, the primary-secondary characteristics of the data is seen as becoming blurred, and is **composite** in nature i.e. exhibiting both primary and secondary data characteristics. For example, unpublished and/or unrefereed research project reports and internal working papers which are based on *primary data* generated in direct response to the author's specific research question, but which may form *secondary sources* for the authors in connection with subsequent research questions. Again, composite data can take the form of **'hard' composite data**, which significantly address the specific research question being investigated; and **'soft' secondary data**, which addresses the research question being explored, but only to a limited degree.

Both primary and secondary data sources have their own advantages and disadvantages. Primary data has the potential to be more compatible with the research questions being investigated, as the data being collected is specific to the research domain and research questions being investigated. In contrast, secondary data can potentially be incompatible, with assumptions, categorisations and measures being inappropriate for the purpose at hand[37].

471.

[37] Stewart, D.W., (1984), **Secondary Research**, Sage: Beverly Hills: California. Page 14.; Bedeian, A.G., (1984), **Organizations: Theory and Analysis**, Holt-Saunders: New York. Page 42.

Secondary data, however, has the potential advantages of scale and scope over primary data, with all other things being equal:[38]

- Secondary data provides a broader, indepth systemic context (geographic, temporal, social) than primary data.
- Secondary data provides validation for primary data, whereby the secondary data allows the quality and consistency of the primary data to be assessed.

The hypotheses set out in this research mirror the broad and systemic nature of the parent research domain of sustainable development. It is because of the strong match between the systemic nature of the research and the systemic, contextual nature of secondary data sources, that secondary data was used.

The key research methodology challenge, once the data type being used was identified, was to ensure that the design of the data collection and data analysis maximised the advantages of secondary data, while at the same time minimising its disadvantages.

Data collection

The central task of the data collection design was the sampling strategy used to guide the data collection process. A sample is defined as "... a model of the population or a subset of the population that is used to gain information about the entire population. A good model produces good information about the population.[39]"

A non-probability sampling approach was used, which "... comprises a collection of sampling approaches that have the distinguishing characteristic that subjective judgments play a role in sample selection.[40]" For this research, a two stage sampling strategy was employed, dovetailing 'critical cases' and 'snowball' sampling approaches[41]. First, 'critical case' sampling was used to identify key or essential secondary data sources to the research domain. Second, from these critical sources,

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[38] Giddens, A., (1989), **Sociology**, Basil Blackwell: Oxford. Page 681.; Stewart, D.W., (1984), **Secondary Research**, Sage: Beverly Hills: California. Page 14.
[39] Henry, G.T., (1998), "Practical Sampling", in L. Bickman & D.J. Rog, (Eds.), **Handbook of Applied Social Research Methods**, Sage: London. Pps. 101-126. Page 102.
[40] Henry, G.T., (1998), "Practical Sampling", in L. Bickman & D.J. Rog, (Eds.), **Handbook of Applied Social Research Methods**, Sage: London. Pps. 101-126. Page 104.
[41] Henry, G.T., (1990), **Practical Sampling**, Sage: Newbury Park, California.

a 'snowballing' approach was used to identify further pertinent sources to be included in the sample.

Critical cases

The 'critical cases' for the two groups of literature: the general secondary sources on sustainable development; and construction and built environment specific literature will be discussed in turn.

The 'critical case' general secondary sources on sustainable development were chosen on their ability to cover the broad spectrum of issues shown in Figure 2.1. Two influential documents were identified as the logical starting point for the data collection because they were instrumental in developing and legitimising the international policy and research agenda on sustainable development:

- World Commission on Environment and Development, (1987), **Our Common Future** ("The Brundtland Report"), WCED: Oxford University Press: Oxford. This report, although not adding anything substantially new to the development and environment debate, popularised the term 'sustainable development', and made a significant contribution to instilling within the international community the sense of the immediate and pressing need for action.
- United Nations Conference on Environment and Development, (1992), **The Earth Summit '92**, Regency Press: London. This document is the product of the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. The conference built upon the issues raised by the Brundtland report, culminating in one hundred and eighty-two governments formally accepted the need for change by agreeing to the twenty-seven principles enshrined in the Rio Declaration on Environment and Development and adopting the global agenda for action on sustainable development represented by the forty-chapter 'Agenda 21'.

The 'critical case' built environment and construction industry specific secondary sources were chosen on their ability to cover the construction and property industries, with the built artefact or product being the link between the distinct, but closely meshed, industries. These elements, and their interaction, are shown in Figure 3.5..

along with the secondary sources selected to address them. The secondary data sources are as follows:

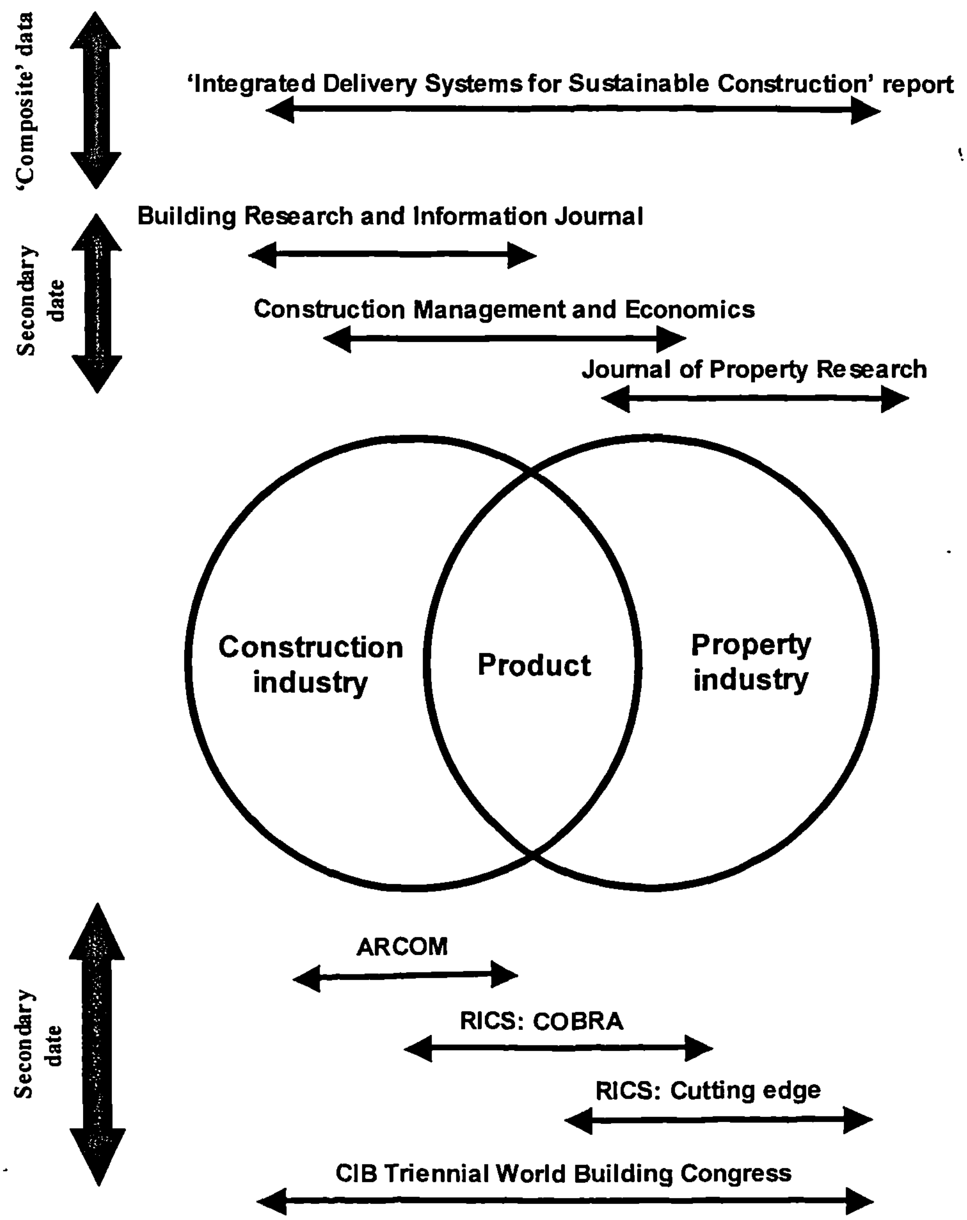


Figure 3.5.: Mapping of composite / secondary sources onto the construction and property industries

Composite data sources

A key source of literature which this thesis draws upon (particularly Sections 4.3., 4.4. and 4.5.), are the findings from the 'Integrated Delivery Systems for Sustainable

Construction' (IDS) research project[42]. The IDS project aims, along with the methodology, is summarised in Appendix A – G.

For the purposes of this thesis, the final IDS report is considered a 'hard' composite data source (see Figure 3.4.). It is secondary in nature, as the data was not generated in direct response to the investigation of the specific research question articulated in this thesis. However, the findings from the IDS project are particualy relevant to the research question being investigated in this study and thus, where appropriate, is used extensively as primary data to test the research hypotheses (to reiterate, particularly Section 4.3. – Hypothesis 1, Section 4.4. – Hypothesis 2 and Section 4.5. – Hypothesis 3).

Secondary data sources

Journals. The following journals were chosen as 'critical' cases because of their coverage of built environment and construction activity research domains:

- Building Research and Information: The International Journal of Research, Development, Demonstration & Innovation (1997-1999)

  The journal is an "... international refereed journal serving all practitioners and clients in the design, construction and property sectors ...bring[ing] together ideas, developments, projects, case studies, innovative practices, feedback and to stimulate discussion and debate across the spectrum of design, material, construction, organizational, environmental, market, user and research management topics"[43]
- Construction Management and Economics (1997- 1999)

  The journal is an "... international journal which serves all practitioners in the construction sector and researchers in academic and research organizations ... the Journal helps construction clients to find better ways of procuring, running and using their buildings and other constructed facilities"[44]
- Journal of Property Research (1997-1999)

  The journal is "... an international journal ... [with] two major areas of focus:

[42] Barrett, P.S., Sexton, M.G. & Green, L., (1998), **Integrated Delivery Systems for Sustainable Construction: Unpublished report for the Construction Sponsorship Directorate, Department of Environment Transport and the Regions**, DETR: London.
[43] Aim and scope section contained within in each edition of the journal.
[44] Aim and scope section contained within in each edition of the journal.

- Property investment portfolios. This covers topics such as the role of property as an investment class, forecasting of markets and property portfolio construction. '...
- Land development. This covers a wide range of issues surrounding the development and redevelopment of property. The focus may be financial, economic or environmental; urban or rural; public or private sector."[45]

Conferences

Further, to capture research which is often innovative and provocative, and has not been subjected to the 'editorial sterilisation' often associated with refereed journals, the following conference proceedings were chosen as 'critical' cases which covered both the built environment and construction research domains:

- Association of Researchers in Construction Management (ARCOM)
  ARCOM focuses on construction management research. Secondary data sources were drawn from their annual conference proceedings (1997, 1998 and 1999).
- Royal Institution of Chartered Surveyors (RICS)
  - Construction and Building Research Conference (COBRA) proceedings 1998 and 1999. COBRA is the annual construction and building research conference of the RICS. Topics covered include: business and markets; environment and sustainability; facilities management and maintenance; human and organisational aspects; information technology; legal and contractual matters; management; and technology and design.
  - Cutting Edge proceedings 1997, 1998 and 1999. The Cutting Edge is the annual real estate research conference of the RICS. Topics covered include: the property supply industry; property occupation, management and use; property market analysis and forecasting; property investment; pricing, valuation and decision-making; and property in a global context.
- Conseil International du Bâtiment (CIB)
  - Triennial World Building Congress (1998) The focus of this conference was 'construction and the environment'. The conference brought together all of the research activities of the CIB and channelled them into

[45] Aim and scope section contained within in each edition of the journal.

four themes: materials and technologies; indoor environment aspects; management and organisation; and procurement and legal issues. The conference focus covered the full breadth of the construction and property industries.

Snowballing

The 'critical case' sampling provided an appropriate foundation from which to identify key further key data sources for further investigation. The Holographic Dynamic PSR model (see Section 2.7.) was used as the guiding framework to determine whether further data sources should be included in the sample. The use of the model as a data collection / analysis framework is discussed in the data analysis section below.

The 'snowballing' sampling strategy was complemented by 'chaining' - defined as "following chains of citations or other forms of referential connection between material." Two types of chaining were used: forward and backward. Backward chaining involved following reference links to the source, while forward chaining describes searching for works referencing the current one[46]. An example, of a backward chaining, for example, is the exploration of Daly (1977)[47] cited in Stead and Stead (1992)[48]; while an example of a forward chain is Schumacher (1973)[49] cited in Hamilton (1993)[50] and Roszak (1992)[51]. Further, this 'chaining' is inherent to academic literature, as commentators locate and embed their work in the relevant literature.

The actual number of sources investigated was determined by saturation[52], that is, no further data sources were collected for a particular issue when all data collected was

[46] Ellis, D., (1989), "A Behavioral Model for Information Retrieval System Design", **Journal of Information Science**, 15: 4&5): 237-247.
[47] Daly, H.E., (1977), **Steady State Economics**, Freeman: San Francisco.
[48] Stead, E.W. & Stead, J.G., 1992), **Management for a Small Planet: Strategic Decision Making and the Environment**, Sage: Newbury Park.
[49] Schumacher, E.F., (1973), **Small is Beautiful: Economics as if People Mattered**, Harper & Row: New York.
[50] Hamilton, L.S., (Ed.), (1993), **Ethics, Religion and Biodiversity: Relations Between Conservation and Cultural Values**, White Horse Press: Cambridge, England.
[51] Roszak, T., (1992), **The Voice of the Earth**, Simon & Schuster: New York.
[52] Glaser, B. & Strausss, A.L., (1967), **The Discovery of Grounded Theory**, Aldine: New York. Pages 61-62.

sufficiently detailed and complete to provide a full and revealing picture of that issue[53], to the degree that the marginal utility to the researcher of each additional secondary source would be approaching zero[54].

The data collection approach used for the research has been discussed. The issue of data analysis will now be addressed.

Data analysis

The data analysis was focused on testing the hypotheses set out in Section 2.8. through a process of 'pattern-matching' – linking data with hypotheses[55]. For completeness, the systemically linked hypotheses (see Section 2.8.) are given below:

H1: Built environment and construction industry stakeholders' conceptualisation of sustainable development will be different, and will result in distinctive, potentially conflicting, focuses.

H2: Stakeholders involved in the built environment and construction industry who do not share similar worldviews on sustainable development will identify and prioritise different key sustainable development objectives.

H3: Stakeholders who are involved in the built environment and construction industry will have varying degrees of responsibility for progressing particular sustainable development objectives.

H4: Efforts to progress sustainable development objectives which do not adequately link pressures, states and responses in a systemic fashion will be unbalanced and fragmented.

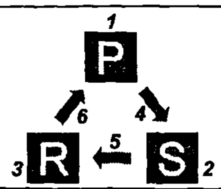
H5: Efforts to progress objectives that are contextualised in an ecological view of sustainable development will be characterised by systemically linked pressures,

[53] Becker, H.S., (1970), **Sociological Work: Method and Substance**, Transaction: New Brunswick. Page 52.
[54] Fielding, N.G. & Fielding, J.L., (1986), **Linking Data**, Sage: Beverly Hills, California.
[55] Campbell, D.T., (1974), "Degrees of Freedom and the Case Study", **Comparative Political Studies**, 8: 178-193.

states and responses, and will lead to progressive, significant and balanced sustainable development.

The analysis used the *Holographic Dynamic PSR model* (see Section 2.7.) and its constituent elements: the 'worldview' framework' (see Section 2.5.5.) and the *Dynamic PSR model* (see section 2.6.5.) to situate, integrate and systemically understand the myriad issues identified from the secondary data sources. (Table 3.1. was used as a practical tool to support the 'gap analysis' set out in Figure 2.6., making both the issue and the stakeholder explicit and so addressing the fragmentation in the literature synthesis). These frameworks benefit from being firmly located in, and developed from, the literature synthesis undertaken in Chapter 2.

Table 3.1.: Framework for change – gap analysis

Issue / objective:		***Stakeholder:***
Reference:		
Description of pressures	**Description of state**	**Description of response**
Gap 1 ***(in pressures)***	**Gap 2** ***(in state)***	**Gap 3** ***(in responses)***
Gap 4 ***(barriers to understanding)***	**Gap 5** ***(barriers to implementation)***	**Gap 6** ***(barriers to effectiveness)***
Overall commentary		

The data analysis was sequential, in that the objectives for sustainable development generated in hypotheses H1 and H2 identified the objectives which guided the investigation to test hypotheses H3 and H4, and stimulated the need to investigate an opposing position explored in H5. This integrated approach to the research provided a seamless process of enquiry (see Section 2.8.).

The data collection and data analysis rationales and procedures have been identified and discussed. The following section will discuss the procedures followed to ensure the validity of the research methodology.

3.6. Validation

Validation refers to "... whether the [research methodology] design is sufficiently rigorous to provide support for definitive conclusions and desired recommendations[56]" The validation of this research is secured in two ways: defining the degree to which the 'outputs' of the research can be generalised to the wider population; and the robustness of the 'process' used to generate these outputs. These two aspects are discussed in turn.

The generalisability of research findings

The generalisability of research findings refers to "... the probability that [the] patterns observed in the sample will also be present in the wider population from which the sample is drawn."[57] The generalisation of these research findings or outputs is limited to an analytical generalisation[58]; that is, to the general domain of the research hypothesis set out (see Section 2.8.) and the sample set (see Section 3.5.). This is in distinct contrast from a statistical generalisation, which generalises findings from the sample to the universe.

The robustness of the research 'process'

The key mechanism used to ensure validation of the data collection and analysis process was triangulation, where multiple methods and/or data sources were used to corroborate, elaborate or illuminate an issue or finding[59]. The underlying methodological premise for triangulation is that the weaknesses of a given research method or data source can be compensated by counter-balancing strengths of

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[56] Bickerman, L., Rog, D.J. & Hedrick, T.E., (1998), "Applied Research Design: A Practical Approach", in L. Bickman & D.J. Rog (Eds.), **Handbook of Applied Social Research Methods**: Pages 5-37, Sage: London. Page 11.
[57] Easterby-Smith, M., Thorpe, R. & Lowe, A., (1991), **Management Research: An Introduction,** Sage: London. Page 41.
[58] Yin, R.K., (1989), **Case Study Research: Design and Methods**, Sage: London.
[59] Rossman, G.B. & Wilson, B.L., (1985), "Numbers and Words: Combining Quantitative and Qualitative Methods in a Single Large-scale Evaluation Study", **Evaluation Review**, 9: 5: 627-643.

another[60]. Further, the level of triangulation has an influence on the generalisability of the findings. The need for methodological integration, for example, has been argued in order to achieve some confidence in the representativeness of research findings, with the "... generalisability of findings [being] enhanced by the coordination or integration of findings from studies using different research methods."[61]

Four categories of triangulation have been identified:[62]

- Triangulation of theories. Findings from one discipline are used to explain situations in another discipline.
- Data triangulation. Data is used which has been collected over different time frames and/or from different sources.
- Triangulation by investigators. The use of findings generated by different investigators researching the same situation.
- Methodological triangulation. The use of a range of data generated using a variety of research philosophies, approaches and techniques.

The research methodology used in this research satisfies the demands of all four triangulation categories in two important ways. First, the soft systems research approach of generating the research issues and hypotheses from the general literature on sustainable development, and testing them in the built environment and construction industry specific literature ensures diversity of theories, data sets, methodologies and investigator perspectives. Second, the use of secondary data sources ensures that there "... is a compilation of perspectives taken by individuals on issues and, as such, is much enriched by multiple viewpoints"[63]. Indeed, it has been observed that:

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[60] Jick, T.D., (1979), "Mixing Qualitative and Quantitative Methods: Triangulation in Action", **Administrative Science Quarterly**, 24: 602-611.; Lenard, D., Raftery, J. & McGeorge, D., (1997), "Designing a Research Methodology", **Journal of Construction Procurement**, 3: 2: 19-33.

[61] Evans, W., (1971), "Introduction: The Organisational Experiment", in W. Evans, (Ed.), **Organizational Experiments: Laboratory and Field Research**, Harper: New York. Page 26.

[62] Easterby-Smith, M., Thorpe, R. & Lowe, A., (1991), **Management Research: An Introduction**, Sage: London. Pages 133-134.

[63] Glass, G., (1993), **Meta-analysis**, Sage: London. Page 67.

"one purpose of literature reviews is to establish the "facts." These are the stubborn, dependable relationships that regularly occur despite any biases that may be present in particular studies because of the implicit theories behind the investigator's choice of measures, observation schedules, and the like."[64]

3.7. Summary and link

This chapter has discussed the methodology used for this research. First, the need for a 'nested' approach, which integrated the research philosophy, approach and techniques employed, was identified. Second, the interpretative 'preunderstanding-understanding' philosophy underpinning the research was reviewed. Second, the soft systems research approach developed for the research was examined. Finally, the literature review and synthesis research techniques used were deliberated. The chapter concluded with a discussion of how the validity of the research methodology was ensured.

The following chapter presents and analyses the research results.

[64] Stegmuller, W., (1978), **The Structure and Dynamics of Theories**, Springer-Verlag: New York.

4 Research findings

4.1. Introduction

Chapter 4 presents the results and analyses them for their relevance to the research issues set out in Section 1.2. and the hypotheses set out in Section 2.8. The data collection and analysis methods used to generate these research findings are discussed in chapter 3. Conclusions about the research hypotheses and research problem based on the results furnished in this chapter, including their place in the body of knowledge given in chapter 2, will be made in chapter 5.

The chapter is organised around the research hypotheses, with each of the hypotheses (Section 2.8. H1 – H5) being investigated in turn.

4.2. Hypothesis 1: Built environment and construction industry stakeholders' conceptualisation of sustainable development will be different, and will result in distinctive, potentially conflicting, focuses

4.2.1. Introduction

Sections 2.3. and 2.5. set out the argument that stakeholders' conceptualisation and operationalisation of sustainable development varies, and that this variety is very much a function of each of the different worldviews stakeholders possess. Worldviews are made up of ethical positions which guide, shape and legitimise firm behaviour, and the scale and form of interactions between social and ecological systems. This argument is captured in the context of the required focus and action to bring about sustainable urban development, by the observation that:

> *"The aspiration to preserve and develop cultural heritage is ... clearly articulated in broad terms, but how this aspiration is interpreted and converted into policies and implementation strategies for a city or urban settlement is very much a function of the negotiated integration and leverage of diverse (often conflicting) stakeholder perspectives and motivations."*[1]

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[1] Sexton, M.G. & Barrett, P.S., (2000), "The Need to Understand 'Worldview' Diversity in Developing Sustainable Built Environments", **Proceedings of the Millennium Conference: Cities and Sustainability – Sustaining Our Cultural Heritage**, Kandalama, Sri Lanka: 21st February – 25th February.

As with the concept of sustainable development in general (see Section 2.4.1.), sustainable urban development, for instance, has been viewed in terms of political ideology[2], vision expression[3], value change[4], social reorganisation[5] or economic reorganisation[6] towards a desired future. The range of definitions demonstrates that the construct is fundamentally infused with multiple objectives. Consequently, the goals (and thus supporting policies and measures of progress) stressed in one instance may not be the same as those emphasised in another. An international research effort, for example, observed that:

> *"Sustainable construction has different approaches and different priorities in different countries. Some of them identify economic, social and cultural as part of their sustainable construction framework, but it is raised as a major issue only in a few countries."*[7]

The argument being presented in this thesis is that the interaction and understanding (though not necessarily mutual acceptance) of worldviews is required to develop a discourse of shared terms and language that are needed in order for analysis, debate, negotiation and problem-solving to occur. The clear implication is that the current fluidity and diversity of stakeholder perceptions and motivations is unlikely to change, except in focused areas, and ideally should be appreciated and accommodated, rather than viewed as a source of debilitating confusion. Effort is needed to make the assumptions from which different stakeholder positions are built more transparent through the development and use of appropriate frameworks which provide direction, consistency and coherence in the understanding of, and linkage between, stakeholder 'worldviews' and sustainable development objectives. This will enable:

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[2] For example, see Tsenkova, S., (1999), "Sustainable Urban Development: Myth or Realty", **International Journal of Urban and Regional Research**, 23: 2: 361.
[3] President's Council on Sustainable Development, (1996), **Sustainable America: A New Consensus for Prosperity, Opportunity and a Health Environment for the Future**, PCSD: Washington, DC.
[4] For example, see Campbell, S., (1996), "Green Cities, Growing Cities, Just Cities?", **Journal of the American Planning Association**, 63: 3: 302.
[5] Irwin, A., (1995), **Citizen Science: A Study of People, Expertise and Sustainable Development**, Routledge: London.
[6] Richardson, N., (1992), "Canada", in R. Stren, R. White and J. Whitney, (Eds.), **Sustainable Cities: Urbanization and the Environment in International Perspectives**: 145-167, Westview Press: Boulder.

- different stakeholders to better understand each others' particular needs and aspirations, thereby creating;
- the necessary common foundation and language to facilitate the development of 'win-win' solutions which engage and motivate all relevant stakeholders.

4.2.2. Key findings from the literature

The literature is conspicuously devoid of the need to locate stakeholders' strategies and actions within the context of their worldviews. There are, however, some exceptions which begin to identify and scope out this issue. At a *global level*, for example, it has been suggested that the 'mechanistic', goal-orientated worldview of the northern hemisphere needs to be more in balance with the 'systemic', processual worldview of the southern hemisphere[8]. This theme is continued at an *industry level*, by the argument that there is an important link between values and industry development, and that stakeholders need to be "... aware of their own values, and the way these influence actions/behaviour."[9] Similarly, at a *professional decision-making* level, the argument has been raised that the specialisation of construction professional roles has obstructed the holistic approach needed for sustainable development[10], and that:

> *"professional decision-making is not entirely socially neutral but is influenced by an individual's perception of 'reality' as to how he ... sees the world, and images society to be. The need for the identification with the values of the construction subculture would seem to block out the entrance of both people and alternative ideas that are seen as 'different' or 'unsettling', but which may be more reflective of the needs and composition of wider society."*[11]

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[7] CIB Working Commission W82, (1998), **Sustainable Development and the Future of Construction: A Comparison of Visions from Various Countries**, CIB W82: Page 35.

[8] Du Plessis, C., (2000), "Cities and Sustainability: Sustaining Our Cultural Heritage", **Proceedings of Cities & Sustainability: Sustaining Our Cultural Heritage**, Kandalama, Sri Lanka: 22nd – 25th February.

[9] Fox, P.W., (1999), "Construction Industry Development: Exploring Values and other Factors from a Grounded Theory Approach", **Proceedings of the CIB conference – Customer Satisfaction: A Focus for Research and Practice in Construction, Volume 1: Construction Process Innovation**, 5th – 10th September, Page 127.

[10] Ngowi, A.B., (1998), "Is Construction Procurement a Key to Sustainable Development?", **Building Research and Information**, 26: 6: 340-350.

[11] Greed, C. (1988), "Cultural Change in Construction: Generic or Gendered", **Proceedings of the CIB World Building Congress – Construction and the Environment: Symposium D: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden: 7th – 12th June. Page 1822.

Further, research into the sustainable development agendas being pursued by "leading-edge" architects and engineers in the UK, revealed that there were three overlapping agendas for reducing the environmental impact of buildings: group A mainly focused on macro/global issues; group B focused on a broader agenda, encompassing both the macro/global issues and adding to them more local or site/project specific ones; finally, group C pursued the broadest agenda, adding public participation and equity dimensions to the other two groups of issues[12]. Finally, within the context of urban sustainability, it has been articulated that any assessment framework needs to accommodate the worldviews from a range of *individual* perspectives[13].

Such literature has been important in developing the contours of the problem, but they do not offer a path across the 'problem terrain' toward a possible portfolio of solutions. Findings from the 'Integrated Delivery Systems for Sustainable Construction' project are considered particularly relevant in giving some pertinent insights here, focusing as it did, in part, on developing and using a spatial-value framework to gain a clearer definition and understanding of sustainable development from different stakeholder positions[14].

The research findings are the product of a Delphi exercise supported by appropriate qualitative and quantitative analysis. The Delphi exercise consisted of an iterative process of opinion gathering and feedback, which generated insights and solutions, based on aggregated responses from two panels:

- A national panel consisting of twenty people representing a range of stakeholders perspectives from across the United Kingdom construction supply chain; and
- An international panel consisting of twenty environmental experts (from thirteen countries spanning five continents) which contributed both specialist knowledge and an international dimension to the research findings.

[12] Eclipse Research Consultants, (1996), **Environmental Initiatives in the UK Construction Industry: 1995 Survey of Current Practice**, Eclipse Research Consultants: Cambridge, England.
[13] Cole, R.J. (Ed.), (1996), **Proceedings of the CIB TG8 International Research Workshop: Linking and Prioritizing Environmental Criteria**, Toronto, Canada: 15th – 16th November.
[14] Barrett, P.S., Sexton, M.G. & Green, L., (1998), **Integrated Delivery Systems for Sustainable Construction: Unpublished report for the Construction Sponsorship Directorate, Department of Environment Transport and the Regions**, DETR: London.

To gain a clearer definition and understanding of sustainable development from different stakeholder positions represented by the Delphi panels, the panellists were asked to rank a number of sustainable development definitions which had been categorised using a sociological typology described in Section 2.5.5. (In addition, the panellists were able to offer their own definitions, to be reviewed and commented on in subsequent Delphi rounds.)

'Sustainable development' definitions, rather than 'sustainable construction' definitions, were chosen to more accurately reflect the broader, systemic nature of sustainability issues which traverse beyond the boundaries of the built environment and the construction industry. This definitional issue, for example, is consistent with the approach that:

> *"One response to the confusion inherent in the term 'sustainable construction' would be to revert to the use of the term 'sustainable development'. In applying this suggestion, one would seek to ensure, for example, that the construction of the building, house or road satisfies the principles of sustainable development."*[15]

The sustainable development definitions that were presented to the Delphi panels are given below[16]:

<u>Dominant product sustainability</u>

Definition 1:

> *"In principle, such an optimal (sustainable growth) policy would seek to maintain an "acceptable" rate of growth in per-capita real incomes without depleting the national capital asset stock or the natural environment asset stock"*[17]

Definition 2:

> *"Improving the capacity to convert a constant level of physical resource use to the increased satisfaction of human needs."*[18]

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[15] Hill, R.C. & Bowen, P.A., (1997), "Sustainable Construction: Principles and a Framework for Attainment", **Construction Management and Economics**, 15: 223-239.

[16] Barrett, P.S., Sexton, M.G. & Green, L., (1998), **Integrated Delivery Systems for Sustainable Construction: Unpublished report for the Construction Sponsorship Directorate, Department of Environment Transport and the Regions**, DETR: London. Page 7-8.

[17] Turner, R.K., (1988), **Sustainable Environment Management**, Belhaven: London.

[18] UNEP, World Wide Fund for Nature, World Conservation Union, (1991), **Caring for the World: A Strategy for Sustainability**: WCU: Gland, Switzerland.

Dependent social systems

Definition 3:

"In broad terms the concept of sustainable development encompasses:

1. *Help for the very poor because they are left with no option other than to destroy their environment;*
2. *The idea of self-reliant development, within natural resource constraints;*
3. *The idea of cost-effective development using different economic criteria to the traditional approach; that is to say development should not degrade environmental quality, nor should it reduce productivity in the long run;*
4. *The great issues of health control, appropriate technologies, food self-reliance, clean water and shelter for all;*
5. *The notion that people-centred initiatives are needed; human beings, in other words, are the resources in the concept."*[19]

Definition 4:

"The creation and responsible maintenance of a healthy built environment based on resource efficient and ecological principles."[20]

Human benefit sustainability

Definition 5:

"Sustainable development: development that is likely to achieve lasting satisfaction of human needs and improvement of the quality of human life."[21]

Definition 6:

"Sustainable development is concerned with:

- *The maintenance of a healthy economy, promoting quality of life and protecting human health and the environment, in which all pay the environmental costs of their decisions.*
- *The optimal use of non-renewable resources.*
- *The sustainable use of renewable resources.*
- *Minimising damage to the carrying capacity of the environment."*[22]

[19] Tolba, M., (1987), **Sustainable Development: Constraints and Opportunities**, Butterworth: London.
[20] Kibert,. C., (1994), **Proceedings of the First International Conference on Sustainable Construction**, Tampa, Florida: 6th – 9th November.
[21] Allen, R., (1980), **How to Save the World**, Oxford University Press: Oxford.
[22] Norton, B.G., (1992), "A New Paradigm for Environmental Management", in R. Costanza, B.G. Norton & B.D. Haskell (Eds.), **Ecosystem Health: New Goals for Environmental Management,** Washington, D.C. Pages 23-41. Page 23.

Global product sustainability

Definition 7:

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[23]

Definition 8:

"Using our natural resources in such a way that they meet our economic, social and cultural needs, but not depleting or degrading these resources to the point that they cannot meet these demands for future generations."[24]

Global niche preservation

Definition 9:

"A sustainable society is one that can persist over generations, one that is far-seeing enough, flexible enough, and wise enough not to undermine either its physical or social systems of support. In order to be socially sustainable, the contribution of population, capital, and technology in the society would have to be so configured so that the material living standard is adequate and secure for everyone. In order to be physically sustainable the society's material and energy throughputs would have to meet three conditions: its rate of use of renewable resources do not exceed their rates of regeneration; its rates of use of non-renewable resources do not exceed the rate at which sustainable renewable substitutes are developed; and its rate of pollution emission do not exceed the assimilative capacity of the environment."[25]

Definition 10:

"Sustainable development empowers individuals to adopt a lifestyle that conserves the natural system by balancing human use of resources with the rate at which these resources are replenished, so that the needs of future generations of all species are not compromised."[26]

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[23] United Nations, (1987), **Our Common Future**, OUP: Oxford.

[24] Department of Indian Affairs and Northern Development, (1997), **Towards a Sustainable Development Strategy for the Department of Indian Affairs and Northern Development**, DIAND: British Columbia.

[25] Meadows, D.H., Meadows, D.L., & Randers, J., (1992), **Beyond the Limits: Confronting Global Collapse – Envisioning a Sustainable Future**, Chelsea Green: Post Mills, VT.

[26] Engle, J.R., (199), "Introduction: The Ethics of Sustainable Development", in J. Engle & J.G. Engel, (Eds.), **The Ethics of Environment and Development**, University of Arizona Press: Tuscon. Pages 1-23. Page 10.

Ecosystem identity sustainability

Definition 11:

> *"Human beings, in their quest for economic development and enjoyment of the riches of nature, must come to terms with the reality of resource limitation and the carrying capacities of ecosystems. For if the object of development is to provide for social and ecological welfare, the object of conservation is to ensure the earth's capacity to sustain development and to support all life."*[27]

Self-sufficient sustainability

Definition 12:

> *"Managing economic development and human growth without destroying the life-supporting systems of our planet demands a fundamental shift in values and public policy. We must aspire to be less wasteful of our natural and human resources, to place greater worth on the welfare of future generations, and to take pride in maintaining a healthy, productive Earth."*[28]

Ecosystem insurance

Definition 13:

> *"Global sustainability means the indefinite survival of the human species across all regions of the world [while ensuring] the persistence of all components of the biosphere, even those with no apparent benefit to humanity."*[29]

Ecosystem benefit sustainability

Definition 14:

> *"Sustainable development is one which appreciates that the earth and its biosphere have their own intrinsic significance and value, and that human decision-making and action must have absolute respect for this."*[30]

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[27] IUCN, (1984), **World Conservation Strategy**, IUCN: Gland, Switzerland.

[28] Veidennan, S., (1993), "The Economics and Economy of Sustainability: Five Capitals and Three Pillars", **Proceedings of the Delaware Estuary Program Conference on "Preserving Our Future"**, Philadelphia: November 30th. Page 1.

[29] Worldwatch Institute, (1990), **Building a Sustainable Society**, Worldwatch Institute: Washington D.C.

[30] Barrett, P.S. & Sexton, M.G., (1998), **Unpublished Working Paper for the Project Advising on Sustainability**, University of Salford: Salford.

4.2.3. Findings from the Delphi process

After three rounds of the Delphi process, the UK Delphi panel's most favoured definition of sustainable development was identified to be[31]:

> *Using our natural resources in such a way that they meet our economic, social and cultural needs, but not depleting or degrading these resources to the point that they cannot meet these needs for future generations.*

The panellists concluded that relevant stakeholders "... [had] some chance of achieving this [definition of sustainable development] .." This was in contrast to, say, definition 1, which was described as being "... too vague [and] too human centred ...", and "... based solely on criteria of human needs. No environmental, biological or health caveats are provided"; and definition 5, which was argued to "... [make] no consideration of the impact on the environment", and "... no mention of conservation, recycling or disposal. No mention of balance between development, improvement and environmental damage. No thought for future generations. [32]"

The international Delphi panel's most favoured definition of sustainable development (generated by the panel itself) was[33]:

> *Sustainable development promotes, through societal value systems and policies, a healthy, productive Earth and social and economic quality of life for all, both now and in the future. To physically enable this, the following ecological principles need to be embraced: pollutant emission must not exceed the earth's assimilative capacity; the rate of use of renewable resources must not exceed their regeneration rate; and the rate of use of non-renewable resources must not exceed the rate at which renewable substitutes can be found.*

The panellists argued that this definition "... elaborated on the concept of matching the use of natural resources with the satisfaction of needs." The other

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[31] Barrett, P.S., Sexton, M.G. & Green, L., (1998), **Integrated Delivery Systems for Sustainable Construction: Unpublished report for the Construction Sponsorship Directorate, Department of Environment Transport and the Regions**, DETR: London. Page 24.

[32] *Op. cit.* Page 121.

[33] *Op. cit.* Page 24 – 15.

definitions were rejected as being too neo-classical in focus. Definition 4, for example, was considered[34]:

> *"... selfish – ignores those less privileged and unable to put their case, as well as other shortcomings ... [and] ... nothing to do with the built environment as enacted by those who make it happen."*

Figure 4.1. maps the aggregated scores for the top four most favoured definitions from each of the Delphi panels against the sociology typology (see Section 2.5.5.), structured to reflect a 'local' – global' spatial continuum on the vertical axis, and a 'neo-classical – ecological' value continuum on the horizontal axis[35]. (The UK Delphi panel top four definitions were definitions 4, 7, 8, 9. The International Delphi panels top definitions, with two attracting equal support to generate five definitions, were 6, 7, 8, 9, 12.)

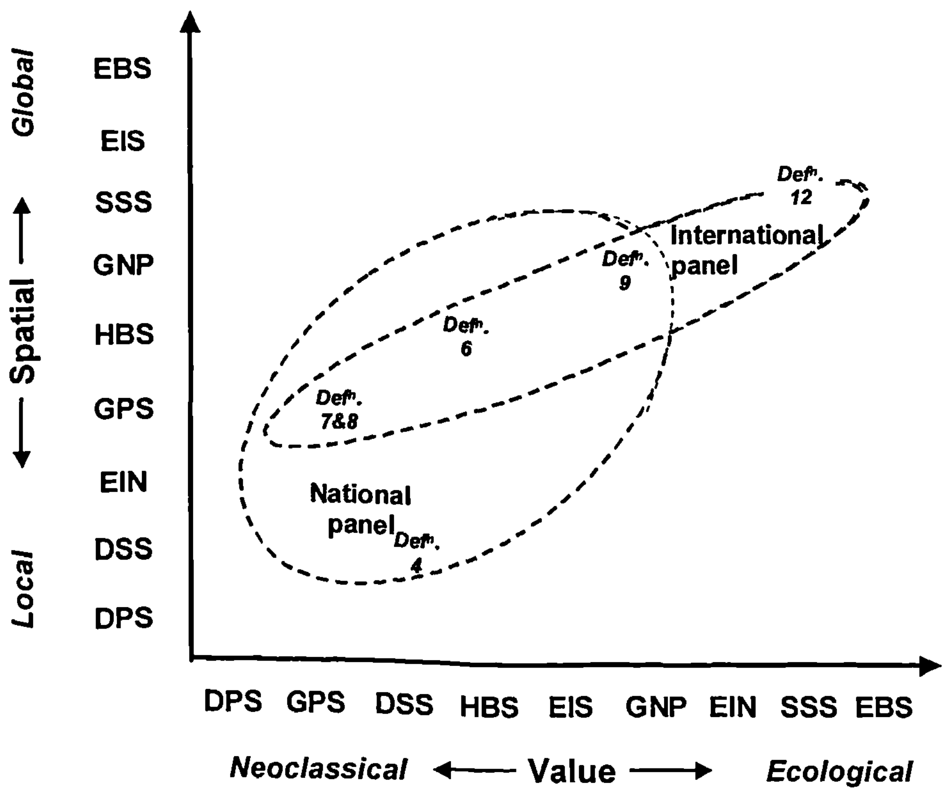

Figure 4.1. The different views of sustainable development between the two Delphi groups

[34] *Op. cit.* Page 146.
[35] Adapted from *Op. cit.* Page 25.

Figure 4.1. demonstrates that the range of definitions of sustainable development preferred were different from the national and international perspectives. The UK definition was simpler, spatially tighter and more neoclassical-focused than that of the international panel, as befits a national, industry-based viewpoint. The international definition was more complex, spatially broader and ecologically focused; in particular, making explicit the fact that social change was the essential agent through which balance in stated physical parameters could be achieved. This reflected the more strategic view of a group of internationally-located environmental experts.

It is equally transparent, however, how much the two focuses *do* overlap: although the panels held distinctive 'worldviews', there was a significant core of shared terms and language from which fertile discourses between stakeholders has the potential to spring and develop.

4.2.4. Comment on hypothesis H1 and link to hypothesis H2

The findings substantially support the first part of the hypothesis; namely, that stakeholders do possess distinctive 'worldviews'. However, the findings do not support the second part of the hypothesis; that is, that these distinctive worldviews will result in different, potentially conflicting focuses. Indeed, the findings suggest that there is the potential for significant overlap in focus between the two Delphi panels.

The 'worldview' argument suggests that where there is a significant degree of difference between stakeholders' perception of the meaning of sustainable development, there will be correspondingly different ranking by the stakeholders of the most (and least) important priority areas to progress sustainable built environments and construction activity. This is the focus of the next hypothesis, and is explored in the next section.

4.3. Hypothesis 2: Stakeholders involved in the built environment and construction industry who do not share similar worldviews on sustainable development will identify and prioritise different key sustainable development objectives

4.3.1. Introduction

Drawing upon the argument presented in Section 2.4.1., sustainable development requires strategic focus if it is to flourish, and add real value to the sustainability performance of the built environment and construction activity. A distinctive, prioritised set of objectives is required to serve as a set of guidelines for the appropriate direction and channelling of efforts and activities of relevant stakeholders. This is consistent with commentators who argue that appropriate strategic objectives assist in information gathering, direction and control[36], and facilitate stakeholder communication, cooperation and sustained strategy implementation[37]. Without direction, sustainable development objectives will always be on the barren periphery of stakeholder behaviour, because they cannot meaningfully influence it[38].

4.3.2. Key findings from the literature

The research literature is rich in proffered objectives to progress sustainable built environments and construction activity. Five distinct but intertwined areas of *industry practice* were identified to progress sustainable development in engineering and construction, for example, through a Delphi survey of representative construction industry practitioners, academics and government officials worldwide from the following areas: management and business; design technology and practices; construction methods and equipment; materials and systems; and public and government policy[39]. From a *'process-orientated'* perspective, objectives focusing on the life cycle of a building, for example, have

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[36] For example, see Langley, A., (1998), "The Roles of Formal Strategic Planning", **Long Range Planning**, 21: 3: 40-50.
[37] For example, see Akao, Y., (1991), **Policy Deployment**, Productivity Press: Cambridge.
[38] Barrett, P., Sexton, M.G. & Curando, M., (1998), "Sustainability Through Integration", **Proceedings of the CIB World Building Congress – Construction and the Environment: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden: 7th – 12th June.
[39] Civil Engineering Research Foundation, (1996), **Engineering and Construction for Sustainable Development in the 21st Century: CERF Report 96-5016A**, CERF: Washington, D.C.

been articulated as a set of twenty-four criteria, ranging from 'capability of fulfilling required function', through to 'ease of demolition' and 'removal'[40]. Similarly, fourteen environmental quality targets for building grouped into four categories have been proposed: eco-construction, eco-management, comfort and health[41]. Complementary to process-orientations are *'product-orientated'* perspectives, which focus on particular materials (for example, bitumen[42]) or product technologies (for example, energy efficient light bulbs[43]).

However, such objectives tend not to be prioritised or weighted, potentially stifling focused, integrated strategies and activities which address, for example, to stimulate high leverage, systemic areas of improvement or to address key deficiencies. It has been stressed, for example, that stakeholders in the built environment and in construction activity:

> *"... lack ... a framework in which ... dialogue can take place ... to ensure a proper balance between [sustainable development] objectives."*[44]

Findings from the 'Integrated Delivery Systems for Sustainable Construction' project is considered particularly relevant here in giving pertinent insights into this issue, focusing as it did in part, on developing a prioritised set of objectives for progressing sustainable built environments and construction activity.[45]

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[40] Angioletti, R., Gobin, C. & Weckstein, M., (1997), "Twenty-four Criteria for Designing and Constructing Buildings on Sustainable Development Principles", **CIB Task Group 8**

[41] Nibel, S., Duchêne-Marullaz, P., & Olive, G., (1998), "Environmental Book of Specifications and Qualitative Assessment Methods for Green Secondary Schools", **Proceedings of the CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden: 7th – 12th June.

[42] For example, see Cash, C.G. & Bailey, D.M., (1993), "Predictive Service Life Tests for Roofing Membranes", **USACERL Interim Report FM-94/03.**

[43] Sexton, M.G., (1993), "The Greening of Industry: The Case of Office Lighting", **Unpublished M.Sc. Dissertation**, Manchester School of Management, University of Manchester Institute of Science and Technology: Manchester, U.K.

[44] Brandon, P.S., (1998), "Sustainability in Management and Organisation: The Key Issues?", **Proceedings of the CIB World Building Congress - Construction and the Environment: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden: 7th – 12th June. Page 1746.

[45] Barrett, P.S., Sexton, M.G. & Green, L., (1998), **Integrated Delivery Systems for Sustainable Construction: Unpublished report for the Construction Sponsorship Directorate, Department of Environment Transport and the Regions**, DETR: London.

Sustainable development objectives were distilled from the relevant literature[46], and were chosen to populate all sections of the PSR model (see Section 2.6.4.) and to reflect both environmental and socio-economic dimensions, in order to capture the systemic, multidimensional aspects of sustainable development. Prospective objectives were tested against the criteria set out in Table 2.1., and were evaluated by two environmental experts and one construction expert as an initial test for their appropriateness. The objectives selected are shown in Table 4.1. and mapped against the PSR model in Figure 4.2.

Table 4.1. Selected performance objectives

Objective Number	Objective
1	Improve technology transfer from other industrial sectors
2	Increase urbanisation
3	Reduce consumption of non-renewable resources
4	Reduce global warming
5	Improve air quality
6	Conserve and improve drinking water
7	Improve quality of physical infrastructure
8	Reduce energy consumption in buildings
9	Increase recyclable material content of buildings
10	Increase level of individual disposable income
11	Improve proximity of residential areas to places of employment, shopping, education, leisure and natural areas
12	Increase amount of time available to pursue leisure interests
13	Develop clear national sustainability policy and plans
14	Improve local government implementation of the principles set out in Agenda 21
15	Improve land use planning
16	Improve environmental performance of construction supply chains
17	Increase uptake of environmental management system accreditation for firms (e.g.ISO 14000)
18	Prevalence of voluntary agreements between individuals (e.g. car sharing)

[46] For example, U.S. Interagency Working Group on Sustainable Indicators, (1998), **Sustainable Development in the United** States, IWGSI: Washington.; Schulze, I. & Colby, M., (1995), **A Conceptual Framework to Support Development and Use of Environmental Information in Decision-making**, United Nations Environmental Protection Agency: New York.; Gouzee, N., (1996), **Indicators for Sustainable Development**, United Nations Commission on Sustainable Development: New York.; DPCSD, (1996), **United Nations Work Programme on Indicators of Sustainable Development**, Commission on Sustainable Development: New York.; World Resources Institute, (1995), **Environmental Indicators: A Systemic Approach to Measuring**

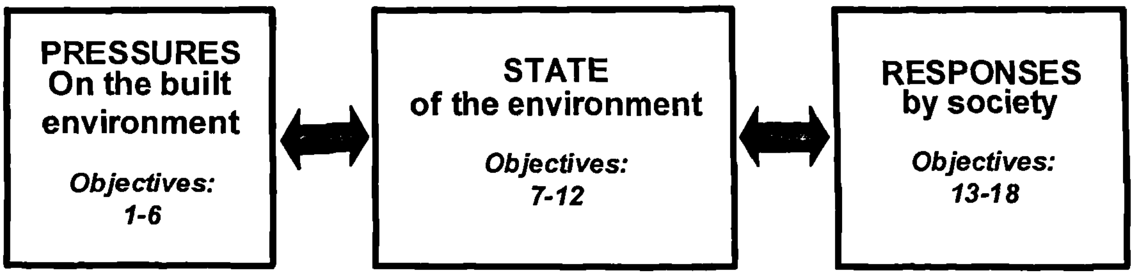

Figure 4.2. Mapping of objectives onto PSR model

The context and need for each of these objectives is briefly described below:

Objective 1: Improve technology transfer from other industrial sectors

A central strategy to elevate sustainability performance in the built environment and construction activity is to learn from other industries and/or other countries through effective technology transfer. Technology transfer is widely considered to be a potentially powerful mechanism to provide the construction industry with new technologies that can, where appropriate, transform and complement current technologies to create and sustain better levels of performance[47].

Effective technology transfer can be defined as being the application of 'out-of-industry' knowledge into use[48]. Further, a broad view of technology is taken, defining it as the know-how about the transformation[49] of operational technologies and processes; material technologies; and knowledge technologies[50]. Research

and Reporting on Environmental Policy Performance in the Context of Sustainable Development, World Resources Institute: Washington.

[47] For example, see Barrett, P.S. & Sexton, M.G., (1999), "The Transformation of 'Out of Industry' Knowledge into Construction Industry Wisdom', **Proceedings of the Linking Construction Research and Innovation to Research and Innovation in Other Sectors**, London: 24th June.; CIB W65 & Norwegian Building Research Institute, (1997), **Proceedings of the Workshop on Cultural Factors Affecting International Transfer of Construction Management Best Practice**, Oslo, Norway: June.; Ofori, G., (1994), "Construction Industry Development: The Role of Technology Transfer", **Construction Management and Economics**, 12: 5: 379-392.; Carrillo, P.M., "Technology Transfer on Joint Venture Projects in Developing Countries", **Construction Management and Economics**, 14: 1: 45-54.

[48] Eto, M., Rogers, E.M., Wierengo, D., Byrnes, P., and Allbritton, M. (1995) **Technology Transfer from Government R&D Laboratories in the United States and Japan.** Focus on New Mexico. Albuquerque: University of New Mexico, Department of Communication and Journalism, Research Report.

[49] Wilson, I., (1986), "The Strategic Management of Technology: Corporate Fad or Strategic Necessity?", **Long Range Planning**, 19: 2.

[50] Hickson, D.J., Pugh, D.S. & Pheysey, D.C., (1969), "Operations Technology and Organizational Structure: An Empirical Reappraisal", **Administrative Science Quarterly**, 14: 378-379.

which compared refurbishment in shipping and construction, for example, identified significant similarities and a number of transferable technologies of benefit to both industrial sectors[51].

The key challenge with this objective is to ensure that both the 'sender' and 'receiver' of the technology locate the transfer at an appropriate level; that is, does the receiver want to imitate the technology, adapt the technology, or innovate from the technology[52]? It has been stressed, for example, that for successful technology to occur, the obligations to the recipients need to be specifically defined[53]. This 'depth' of technology issue is captured by the argument that the transfer of environmentally friendly technologies depends on the potential receiver to adequately understand their own needs, obtain sufficient information, and to possess the knowledge and capability to implement and manage the technological change successfully[54].

Objective 2: Increase urbanisation

Urbanisation is an increasingly pervasive force, with the percentage of the world's population living in cities and towns swelling from an estimated thirty-eight percent in 1975 to forty-five percent in 1995, and projected to rise to fifty-four percent in 2015[55]. Potential economic and social advantages of urbanisation are significant and well established. It has been argued, for example, that:

> *"... cities have always played a privileged role as centres of cultural and economic activity. From their earliest origins, cities have exhibited a conspicuous capacity both to generate culture in the form of art, ideas, styles and attitudes, and to induce high levels of economic innovation and growth."*[56]

[51] Bartlett, E,V. & Clift, M.R., (1999), "Reliability and Whole Life Performance: Integrating the Supply Chain", **Proceedings of the Eighth International Conference on Durability of building Materials and Components**, Vancouver, Canada. Pages 1916-1923.

[52] Barrett, P.S. & Sexton, M.G., (1998), **Integrating to Innovate: Report for the Construction Industry Council**, Construction Industry Council: London.

[53] Carrillo, P.M., (1994), "Technology Transfer: A Survey of International Construction Companies", **Construction Management and Economics**, 12: 1: 45-51.

[54] United National Environment Programme, (1998), **Sustainable Development: Economic Development and Environmentally Sound Technologies**, United Nations Environment Programme: London. Page 39.

[55] United Nations, (1996), **World Urbanization Prospects: The 1996 Revision**, United Nations: New York.

[56] Scott, A.J., (1997), "The Cultural Economy of Cities", **International Journal of Urban and Regional Research**, 21: 2: 323-340. Page 323.

Increasingly, however, the onerous burden which cities place on the natural environment is being appreciated. The adverse externalities of cities have been analogised, for example, by the suggestion that "... every city is an ecological black hole drawing on the material resources and productivity of a vast and scattered hinterland many times the size of itself."[57]

The objective of increasing the density of urbanisation, although apparently paradoxical, offers hope for the future[58]. Cities represent both environmental problems as well as part of the solution. In contrast to the city which spreads outward at low densities, high density cities can offer "... a compact alternative to the constant invasion of open space (wilderness) represented by modern sprawl"[59]; and that environmental improvement in such issues as air and water pollution, energy use, resource depletion, occupational health, hazardous waste management and recycling, has a truly urban focus.[60]

Objective 3: Reduce consumption of non-renewable resources

The built environment and construction activity is probably the greatest consumer of natural materials, using from seventeen percent to fifty percent of the extracted resources (see section 2.3.2.). As discussed in Section 2.2.2., an important distinction can be made between exhaustible (or non-renewable) and renewable natural capital or resources, and their associated environmental impacts:

> *"Materials have widely varying environmental impacts. Some, such as oil, hardwood timber from nonsustainably managed sources and copper, are drawn from limited stocks of nonrenewable resources. Others, such as limestone or sand, are more abundant, but their extraction, processing and transport to site can cause significant environmental degradation. Others again, such as aluminium, are widely available, but consume a lot of energy in their processing. Finally, some materials, such as softwood from sustainable managed*

[57] Roseland, M., (1992), **Toward Sustainable Communities: A Resource Book for Municipal and Local Governments**, Alger Press. Page 21.
[58] For example, see Commission of the European Communities, (199), **Green Paper on the Urban Environment: EUR 12902**, Commission of the European Communities: Brussels.
[59] Colthorpe, P., (1986), "The Urban Context", in S. Van der Ryn & P. Calthorpe, (Eds.), **Sustainable Communities**: pages 1-33, Sierra Club: San Francisco. Page 1.
[60] For example, see Breheny, M., (1995), "The Compact City and Transport Energy Consumption", **Transactions of the Institute of British Geographers**, 20: 81-101.; Paehlke, R., (1996), **Myths: Towards a More Urbanist Environmentalism: Research Paper No. 159**, Centre for Urban and Community Studies. Page 1.

forests, are relatively abundant and can be used extensively and sustainably."[61]

The objective of reducing the consumption of non-renewable resources (and making more appropriate use of renewable resources, such as timber, natural fibres and animal tissue), has the potential to deliver several significant environmental and social advantages in different stages of the resources' lifecycle. For instance, renewable resources cannot be depleted if managed in a proper way, since resource sources are renewed by natural processes. In addition, the use of materials based on renewable resources is 'carbon dioxide neutral', which means that there are no net emissions of carbon dioxide across the entire lifecycle. Indeed:

> *"... not only are materials of plant origin renewable but, because they absorb carbon dioxide from the air for growth, they can help to reduce emissions of carbon dioxide which contribute to global warming."*[62]

Furthermore, using materials based on renewable resources, in principle, results in biodegradable waste, because they contain no mineral compounds.

Objective 4: Reduce global warming

The stabilisation of global concentrations of atmospheric carbon is one of the most important challenges of sustainable development faced by the world community[63]. Research indicates that emission reductions of about sixty percent may be required by 2050 if carbon concentrations are to be stabilised by 2100 and significant interference with climate systems avoided[64]. The Intergovernmental Panel on Climate Change estimates that if nothing is done to limit greenhouse gases, the global average temperature could increase by between 0.2 and 0.5 centigrade each

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[61] O'Cofaigh, E. & Lewis, O.J., (1999), "The Principles and Practice of Sustainable Architectural Design", **Sustainable and Energy Efficient Building**, James and James (Science Publishers) Ltd: London. Pages 56-62. Page 61.

[62] Atkinson, C.J. & Butlin, R.N., (1993), "Ecolabelling of Building Materials and Building Products", **Building Research Establishment Information Paper 11/93**, Watford, England. Page 3.

[63] Grubb, E., (1993), **The Earth Summit Agreements: A Guide and Assessment**, Earthscan: New York.

[64] Lowe, R.J., (1997), "Defining and Meeting the Carbon Constraints of the 21st Century", **Proceedings of the Second International Conference: Buildings and the Environment**, Centre Scientifique et Technique du Bâtiment: Paris, June.; Houghton, J.T., (1996), **Climate Change 1995: The Science of Climate Change: Contribution of Working Group 1 to the Second Assessment Report of the Intergovernmental Panel on Climate Change**, Cambridge University Press: Cambridge.

decade for the next one hundred years[65]. As discussed in Section 2.3.1, the magnitude of this potential climate change poses serious risks for human and ecosystem adaptation, with potentially large environmental and socio-economic consequences, in particular agriculture, forestry, water availability, biodiversity, energy requirements (e.g. space heating and cooling), the economy, human health and recreation.

Commentators have noted that: "as the problems of global warming become manifest, there is an increasing interest in societal systems that place relatively little load on the environment. Reducing the burden on the global environment is a vital issue that the construction industry must address in response"[66]; and that this response has significant "... implications for design and management of existing and future buildings, infrastructure and communities."[67] In particular, this objective focuses on the reduction of greenhouse emissions from the built environment and construction activity by minimising the use of fossil-based energy through appropriate material and product technologies and selection of energy efficiency systems and technology, making optimal use of daylight and natural ventilation, and using photovoltaic cells to generate electricity[68].

Objective 5: Improve indoor air quality

The quality of indoor air and its potential effects on human health is an important issue, particularly so because of the amount of time people spend indoors. Research has shown, for example, that time spent at home ranges from sixty-eight percent for fifteen to twenty-four year olds to nearly ninety percent for those over sixty-five years old[69].

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65 Intergovernmental Panel on Climate Change, (1990), **Policy-maker's Summary of the Scientific Assessment of Climate Change**, WMO & UNEP: New York.

66 Sakai, K., Nakahara, T., Fujita, T., Morioka, T., Yoshida, N., Urushizaki, N. & Takemoto, K., (1998), "Application of Life Cycle Assessment (LCA) to Urban Renewal Projects", **Proceedings of the CIB World Congress: Construction and the Environment – Symposium A: Materials and Technologies for Sustainable Construction**, Gävle, Sweden: June 7th – 12th: Page 820.

67 DETR, (1998), **Opportunities for Change: Consultation Paper on a UK Strategy for Sustainable Construction**, DETR: London. Page 7.

68 DETR, (1997), **Climate Change: DETR Newsletter**, DETR: London.

69 Langley A., Dantalis, N. & Edwards-Bert, P., (Eds.), (1992), **Environmental Health in the Home**, South Australian Health Commission, Public & Environmental Health Service: Adelaide.

Internal air quality is often more polluted than the ambient air. The quality of indoor air results from the interaction of many factors. These factors include: construction materials, furnishings and equipment, which emit odours, particles and volatile organic compounds; the infiltration of outside air and moisture through the building envelope; the type and state of ventilation systems, and the occupancy patterns of the building[70].

The objective of improving internal air quality is important to reduce the risks of adverse effects on natural ecosystems, human health and quality of life; in particular sick-building syndrome (symptoms experienced by building occupants that are generally short-term, for example, sore throats and fatigue) and building-related illnesses (clinically verifiable diseases experienced, for example Legionnaires' disease)[71].

Objective 6: Improve drinking water quality

The rationale for the sustainable development and management of freshwater resources was clearly articulated in chapter 18 of Agenda 21:

> *"Water is needed in all aspects of life. The general objective is to make certain that adequate supplies of water of good quality are maintained for the entire population of this planet, while preserving the hydrological, biological and chemical functions of ecosystems, adapting human activities within the capacity limits of nature and combating vectors of water-related diseases ... "*

However, since 1980, global water use has more than tripled and is currently estimated at four thousand, three hundred and forty cubic kilometres per year. Demand in all areas of water use – urban, industrial and agricultural – has increased, often because of mismanagement, overuse, and waste[72]. Many parts of the world are now experiencing rising water costs, seasonal shortages, and unpredictable quality and availability of supplies.

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[70] Environmental Protection Agency, (1991), **Building Air Quality: A Guide for Building Owners and Facility Managers**, GPO: Washington, DC.

[71] Hansen, S.J., (1991), **Managing Indoor Air Quality**, PrenticeHall: Englewood Cliffs, NJ. Pages 43 and 44.; McLennan, P., (1990), "Sick Building Syndrome: An Alternative View", **Facilities**, 8: 4: 21-23.

[72] Postel, S., (1993), "Facing Water Scarcity", L. Starke, (Ed.), **State of the World 1993**, Worldwatch Institute: New York. Pages 22-23.

The objective of conserving and improving drinking water quality embodies:

> *"... the fundamental objective is to establish and to maintain a constant balance between human desires and activities on one hand, and the natural processes on the other .... Water management is a combination of very complex activities, aimed at achieving the rational use and protection from water, but also protection of water against pollution."*[73]

In addition, this objective encompasses the technical innovation focusing on "... developing and promoting the use of water efficient appliances such as low flush WCs."[74]

Objective 7: Improve quality of physical infrastructure

The physical infrastructure of the built environment is viewed as the integrated network of private and public works that provides the basic services essential to maintain an appropriate built environment[75], and is often used as an umbrella term for many activities referred to as "*social overhead capital.*"[76] *Infrastructure* systems are established for the purpose of transporting people, conveying goods and services, supplying water, and providing energy generation and distribution, and therefore include the following[77]:

> *"... both specific functional modes – highways, streets, roads, and bridges; mass transit; airports and airways; water supply and water resources; wastewater management; solid-waste treatment and disposal; electric power generation and transmission; telecommunications; and hazardous waste management – and the combined system these modal elements comprise."*

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[73] Maruši, J., Širac, M. & Šturlan, S., (1996), "The Importance, Financing, Planning and Evaluation of Water Management Works and Systems in the Republic of Croatia", **Proceedings of CIB W55 Economic Management of Innovation, Productivity and Quality in Construction**: Pages 741 – 751, Zagreb, Croatia: September 4th – 7th, Page 742-743.

[74] Department of Environment, Transport and Regions, (1998), **Opportunities for Change: Consultation Paper on a UK Strategy for Sustainable Construction**, Department of Environment, Transport and Regions: London. Page 14.

[75] Drew, D.R., de la Garza, J.M. & Kim, K., "Simulation of Life-cycle Infrastructure Planning for Sustainable Development", **Proceedings of the Computer Simulation Conference**, Reno. Nevada: July 19th – 22nd.

[76] World Bank, (1994), **World Development Report 1994**, Oxford University Press: Oxford, U.K.

[77] National Research Council, (1987), **Infrastructure for the 21st Century: Framework for a Research Agenda**, Committee on Infrastructure Innovation, National Research Council, Washington, DC., US.

Research has stressed that issues such as population growth, demographic changes, and increased expectations for service from deteriorating systems are increasingly complex and difficult to manage intelligently[78]. The objective of improving the quality of the physical infrastructure, therefore, is important in progressing the creation and maintenance of an economically efficient and environmentally sound built environment.

Objective 8: Reduce energy consumption in buildings

A significant impact of the built environment and construction industry is from energy consumption, and its associated production and distribution. The built environment accounts for approximately one third of the world's energy consumption (see section 2.3.2.) and is a significant driving force behind climate change, fossil fuel consumption, and so on. Energy use in buildings, for example, accounts for the production of fifty percent of United Kingdom's carbon dioxide emissions, the main 'greenhouse gas'; whilst the production of building materials alone consumes twenty-nine percent of the United Kingdom's industrial energy[79].

At present, the nature and severity of interaction between energy-intensive built environments and construction activity is unprecedented. However, economic growth and social development depend on energy use and to meet these expanding needs, energy consumption is growing. The challenge for the built environment and construction activity, therefore, is how to meet these needs in an energy efficient fashion. It has been widely accepted for some time, for example, that energy efficiency is a key issue in reducing greenhouse gases, with a U.K. government enquiry stating that:

> *"... the most striking feature of our inquiry has been the extent to which improvements in energy efficiency – across all sectors of the economy – are almost universally seen as the most obvious and most effective response to the problem of global warming."*[80]

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[78] National Science Foundation, (1993), **Civil Infrastructure Systems Research: Strategic Issues**, National Science Foundation: Washington, D.C., U.S.A.

[79] CIRIA, (1993), **Environmental Issues in Construction: Special Report 94**, CIRIA: London.

[80] House of Commons Energy Committee, (1989), **Energy Policy Implications of the Greenhouse Effect: Volume 1, 6th Report of the House of Commons Energy Committee**, H.M.S.O., London, U.K.

Objective 9: Increase recyclable material content of buildings

Construction activity consumes a significant quantity of the world's materials. Building construction, for example, consumes forty percent of the raw stone, gravel and sand used globally each year, and twenty-five percent of the virgin wood[81].

The objective of increasing the recyclable material content of buildings is driven by the argument that once a material has completed its initial service in a building, it potentially has additional use as a resource and can be later recovered and recycled. This idea is expressed by the observation that:

> *"In a sense, the buildings of today are the forests of tomorrow – a potentially huge source for materials that can be used and recycled in future construction projects. Design for disassembly is the key to making the reuse and recycling of today's buildings economical."*[82]

At the design stage, for example, many high-performance green buildings use pre-manufactured modular structural and building enclosure systems that enable efficient assembly and disassembly. Such design approaches facilitate metal recycling, for instance[83]. Approximately fifty to seventy percent of the energy and pollution from steel production can be avoided by current recycling technology, and up to eighty-five percent of the energy and pollution from aluminium manufacturing can be avoided by remelting[84].

Objective 10: Increase level of disposable income

The objective of increasing disposal income is driven by equity considerations. The equitable distribution of wealth is central to the ideology of sustainable development, as discussed in Section 2.4.2. The rationale behind this principle is that the enormity and complexity of the poverty issue could endanger the social

[81] Rodman, D. & Lenssen, N., (1995), "A Building Revolution: How Ecology and Health Concerns Are Transforming Construction", **Worldwatch Paper 124.**

[82] Fishbein, B.K., (1998), **Building for the Future: Strategies to Reduce Construction and Demolition Waste in Municipal Projects**, INFORM: New York. Page 40.

[83] Kobet, B., Powers, W., Lee, S. & Mondor, C., (1999), **High-performance Green Buildings: A Document for Decision Makers**, Pennsylvania Department of Environmental Protection, U.S.A. Page 22.

fabric, undermine economic development and the environment, and threaten political stability. This theme is strongly embedded in Agenda 21 (Chapter 3), which decided that poverty has an adverse impact upon the environment, and that it is important to seek ways in which individuals and communities can make a living in a competitive market place which factors in considerations of economic activities that are viable, restorative and protect ecological integrity.

It has been contended, for example, that for a sustainable society, as well as reducing urban sprawl, energy demands and resource demands, there is a need for individuals and communities to have increased economic self-reliance, "... to promote 'sustainable livelihoods through the creation of jobs and resulting purchasing power ...[85]". It is within this context that the objective of increasing the level of disposable income is very much:

> *"... concerned with people's capacities to generate and maintain their means of living, enhance their well-being, and that of future generations. These capacities are contingent upon the availability and accessibility of options which are ecological, socio-cultural, economic, and political and are predicated on equity, ownership of resources and participatory decision making."*[86]

<u>Objective 11: Improve proximity of residential areas to places of employment, shopping, education, leisure and natural areas</u>

Communities that are sustainable in nature have been viewed as "... the fulfilment of human needs, the maintenance of ecological integrity, provision for social self-determination, and the achievement of equity.[87]" The objective of improving the proximity of residential areas to places of employment, shopping, education, leisure and natural areas is guiding and motivating efforts to infill and revitalise

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[84] Natural Resources Canada and Forintek Canada Corporation, (1994), **Building Materials in the Context of Sustainable Development: Summary Report and Research Guidelines**, Forintek Canada Corporation: Ottawa.

[85] Kumar, A., (1993), quoted in Gilham, A., (1998), "Strategies for Change – Understanding Sustainable Development from a Construction Industry Perspective", **Proceedings of the CIB World Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change**, 7th – 12th June: Gävle, Sweden. Page 1815.

[86] Singh, N.C., Titi, V. & Strickland, R., (1994), **Sustainable Development and the World Summit for Social Development: Conceptual and Practical Linkages Among Sustainable Development, Poverty Eradication, Productive Employment and Social Integration**, International Institute for Sustainable Development: Winnipeg, Canada. Page 38.

existing urban infrastructure with a focus on rebuilding mixed-use pedestrian neighbourhoods which integrate housing, retail space and work places[88]. It is argued that this principle is a requirement to enhance living, working and leisure environments[89].

It has been argued, for example, that the social, economic and political vitality of a community is realised, in large part, as the result of a diverse mix of people and activities[90]; and that there are essential connections:

> *"... between urban space design and forms of public and social life; between building use and the presence of persons on streets and squares; between aesthetic qualities of architecture and the attention and interest of city dwellers in their environments; between the form of city's public spaces and city dweller's social, emotional and physical well-being."*[91]

This argument is consistent across spatial levels, with it being argued at a building level, for example, that:

> *"There is no doubt that placing green building projects within easy access of public transportation, medical facilities, shopping areas, and recreational facilities decreases the need for automobiles and encourages bicycling and walking. In addition, successful green buildings blend into the community, preserving natural and historical characteristics, and will utilize existing infrastructure in order to reduce sprawl."*[92]

Objective 12: Increase amount of time available to pursue leisure interests

People are increasingly undergoing substantial lifestyle changes. Market research, for example, has revealed that people are increasingly prioritising

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87 Gardner, J. & Roseland, M., (1989), "Thinking Globally: The Role of Social Equity in Sustainable Development", **Alternatives**, 16: 26-34. Page 28.

88 Calthorpe, P., (1996), "The Next American Metropolis", J.M. Stein (Ed.), **Classic Readings in Real Estate and Development**, Urban Land Institute: Washington, DC. Pages 453-474.

89 Halliday, S.P., (1994), "BSRIA's Environmental Code of Practice for Buildings and their Services", **Proceedings of the First International Conference of CIB TG16 on Sustainable Construction**, Tampa, Florida: 6th – 9th November.

90 Jacobs, J., (1969), **The Death and Life of Great American Cities**, Modern Library: New York.

91 Lennard, S.C. & Lennard, H.L., (1997), **Livable Cities People and Places: Social and Design Principles for the Future of the City**, Centre for Urban Well-being: New York. Page 3-4.

92 Augenbroe, G.L.M. & Pearce, A.R., (2000), "Sustainable Construction in the USA: Perspectives to the Year 2000", **Proceedings of Cities and Sustainability: Sustaining Our Cultural Heritage**, Kandalama, Sri Lanka: 22nd – 25th February. Page 1/20.

environment-orientated quality of life, rather than the constant accumulation of material assets:

> *"What more material possessions do [people] want? Few, if any. Far better to take their next instalment of the good life in the form of air purified of car fumes, streets swept clean of litter."*[93]

This lifestyle change is manifesting itself in a wide variety of areas – eating healthier foods, taking more exercise, purchasing more environmentally-friendly products and increasing the quantity and quality of their leisure time[94].

A key sustainable objective is thus to maintain the quality of the built environment in which leisure takes place; thus contributing to the quality of life of those taking part in leisure activities, and maximising the economic contribution that leisure activities make, while protecting natural resources.

Objective 13: Develop clear national sustainable development policy and plans

The government has a major role in providing the appropriate contextual conditions that will stimulate sustainable development. It has been argued, for example, that "... the development of environmental legislation is singularly the most important factor influencing the behaviour of industry in the field of the environment[95]", with:

> *"... many environment-related statutes, regulations, codes and general policies [having] implications for the construction industry, affecting where constructed items are located, how they are planned and designed, the materials and components used, the techniques and equipment adopted, and how the completed facilities are maintained, altered and, ultimately, demolished."*[96]

The objective for developing clear national sustainable development policy and plans is consistent with Chapter 28 of Agenda 21 which argues that the

[93] Jacobs, E. & Worcester, R., (1990), **We British: Britain Under the Moriscope**, Weidenfeld and Nicolson. Page 114.
[94] Mintel, (1989), **The Green Consumer**, Mintel: London.
[95] Welford, R. & Gouldson, A., (1993), **Environmental Management Systems and Business Strategy**, Pitman: London. Page 18.
[96] Ofori, G., (1992), "The Environment: The Fourth Construction Project Objective?", **Construction Management and Economics**, 10: 5: 369-395. Page 369.

responsibility of bringing about changes to progress sustainable development lies with governments in partnership with the private sector and local authorities and in collaboration with national, regional and international organisations. Further, these changes should be located within an overall integrating framework of national plans, goals and objectives, rules, regulations and laws.

Objective 14: Improve local government implementation of the principles set out in Agenda 21

A key thrust of Agenda 21 is the need for action at the local level, through the establishment of Local Agenda 21s[97]. Agenda 21 asserts that a suitable framework already exists in the system of local authorities, which are a democratic level of government with the potential for partnership with all sectors of the community – public organisations, private companies, voluntary bodies and individuals – and for encouraging participation by all these groups, including local authorities themselves, in the achievement of a sustainable way of living and operating. The importance of Local Agenda 21s has been captured in the argument that[98]:

> *"It is local action that is likely to develop enduring concern and involvement, and it is local action which will be needed to secure commitment and facilitate democratic control. Moreover, it is 'the local' which can enable experimentation, and permit diversity. Although there must be international, national and regional frameworks and guidance, it is local policy and action which will ultimately deliver sustainability."*

The objective of improving the local government implementation of Local Agenda 21 is an important part of the process to enable local stakeholders to understand (and take shared ownership of), the economic, social and environmental sustainable development principles in the creation and maintenance of their own built environments and communities.

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[97] United Nations Conference on Environment and Development, (1992), **Agenda 21**, UNCED: Geneva. Chapter 28.

[98] Agyeman, J. & Evans, B., (1994), "Making Local Agenda 21 Work", **Town and Country Planning**, July/August. Page 198.

Objective 15: Improve land use planning

There is a wide range of environmental issues in connection with the interaction of land use planning and the construction industry[99]. The key sustainable development objective is to balance the competing demands for the finite quantity of land available. The main issues are to minimise the loss of rural land to development and to maintain the vitality and viability of urban areas with people living close to where they work. The indicators relevant to these issues are, for example, the reuse of urban land, and the reclamation of derelict land.

The reuse of land for urban use, particularly for housing and commercial development, contributes to reducing the pressure on the countryside to accommodate new development. Commercial and residential redevelopment within existing urban areas helps to maintain their vitality and viability. In addition, it can improve the general quality of life and also accessibility for those people without a car by increasing and widening the range of services and facilities available and thereby reducing the need for people to travel to other areas for work, shopping and leisure. Similarly, the reclamation and regeneration of derelict land in both urban and rural areas minimises the pressure to develop greenfield sites. It can also help to revitalise local environments, particularly urban areas, by removing unsightly developments and providing land suitable for housing, employment and leisure uses[100].

Objective 16: Improve environmental performance of construction supply chains

The scale and scope of innovation required to enhance the overall environmental performance of the construction industry necessitates innovation flowing through the supply chain if the full benefit is to be obtained[101]. This idea is projected in the observation that a "proactive" company will:

> *"... thrive only when it acts as a whole system that includes not just executives and workers, but customers, suppliers, and neighbors"*[102]

[99] CIRIA, (1993), **Environmental Issues in Construction: Special Publication 94**, CIRIA: London.
[100] Department of Environment, (1995), **Land Use Change in England, No.10**, DOE: HMSO.
[101] For example, Barrett, P.S. & Sexton, M.G., (1998) **Integrating to Innovate: Report for the Construction Industry Council**, CIC/DETR: London.
[102] Makower, J., (1994), **Beyond the Bottom Line**, Simon & Schuster: New York. Page 46.

This approach strongly advocates that firms wanting to generate the greatest benefits from their environmental management processes must integrate other members of the supply chain into these processes. The need for integration, for example, is stressed in the argument that:

> *"Integration is the key to environmental strategy for any business. It is therefore necessary for chartered surveying firms not only to examine every aspect of their own environmental performance but to look also at the consequences of any advice that is given to their clients."*[103]

Further, the role of supply chains in the diffusion of innovation is noted; in particular, it is argued that the role of large firms in passing on good practices to their smaller counterparts may be the key in the development of widespread environmental management:

> *"The diffusion of environmental management techniques via the supply chain is ... a very important factor influencing the improvement of industrial environmental performance."*[104]

The notion of a green supply chain is related to the broader concept of a "sustainable economy."[105] This view extends the idea of environmental performance beyond the boundaries of individual firms or supply chains, and beyond the current generation of products and services. Fundamental to developing a sustainable economy is the recognition that environmental initiatives may start as operational initiatives to reduce waste and emissions, but it is argued that these initiatives must grow to a point where the strategy and the vision of the company incorporates environmental issues.

Objective 17: Increase uptake of environmental management systems

The uptake of environmental management systems within construction firms are motivated by two concerns:

[103] Markwell, S. & Ravenscroft, N., (1996), "Sustainable Land Management and Development: The Role of the Rural Chartered Surveyor", in Y. Rydin (Ed.), **The Environmental Impact of Land and Property Management**, Wiley/RICS: London. Page 30.
[104] Lloyd, M., (1994), "How Green are My Suppliers?", **Purchasing and Supply Chain management**, CIPS: England. Age 40.

> *"... first in anticipation of increasingly stringent government legislation, both national and international, and second in response to the rising concern demonstrated by the general public for environmental issues."*[106]

Environmental management systems can offer some affirmation that relatively high environmental standards are being maintained. BS7750, for example, is defined as[107], "... a specification for an environmental management system for ensuring and demonstrating compliance with stated environmental policies and objectives." The standard requires the total organisation and process to be considered, claiming that, because all business activities interact with the environment, the environmental management system components will be:

> *"... inextricably woven with most, if not all, of the organisation's overall management system ... effective integration and co-ordination of the overall system components is essential to ensure consistent decision making."*[108]

Objective 18: Greater prevalence of voluntary agreements between individuals

Voluntary agreements between individuals do not attempt to offer material incentives involving greed or fear, but aim for higher moral ground. The motivation invoked is often called the 'norm of social responsibility"[109] The norm requires that one helps others in a situation when all are dependent upon each other. Individuals may make changes in their environmental behaviour because their actions will affect others positively.

A key focus for voluntary agreements between individuals is the increase of use of car-pooling, defined as a regular arrangement between car owners who take turns

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105 Hart, S.L., (1997), "Beyond Greening: Strategies for a Sustainable World", **Harvard Business Review**, 75: 1: 66-76.
106 Griffith, A., (1995), "The Current Status of Environmental Management Systems in Construction", **Engineering, Construction and Architectural Management**, 2: 1: 5-15. Page 5.
107 British Standards Institution, (1994), **BS 7750: 1994, Specification for Environmental Management Systems**, British Standards Institution: London. Page 2.
108 British Standards Institution, (1994), **BS 7750: 1994, Specification for Environmental Management Systems**, British Standards Institution: London. Page 11.
109 Berkowitz, L., (1972), "Social Norms, Feelings, and other Factors Affecting Helping Behavior and Altruism", in L. Berkowitz, (Ed.), **Advances in Experimental Social Psychology – Volume 6**: Pages 63-108, Academic Press.

to drive their car and give a lift to the other(s)[110]. The need for greater car-pooling is brought into sharp focus by the trend in car ownership. In 1992, it was estimated that there were some six hundred million cars worldwide, and it was predicted that by the year 2010 there would be two billion cars[111]. This trend is:

> *"... worrying to both policy makers and concerned citizens alike. There is growing concern for noise and atmospheric pollution, traffic congestion, accidents, energy use and conservation, environmental decay, etc., and all these are the result of excessive use of the motor vehicle. The ubiquitous use of motor vehicles has become a formidable threat to the natural environment and to the quality of social and economic life. There is therefore an urgent need to stop, or at the very least, reduce, this trend in growth."*[112]

The objective of increasing the greater prevalence of voluntary agreements between individuals is thus an important area for improving resource usage with associated reductions in energy use and so forth.

4.3.2. Findings from the Delphi process

The panellists from the two Delphi panels were asked to rank the performance objectives listed above as to their relevance in achieving sustainable development[113]. The panellists were given the opportunity to add their own objectives. (The objectives put forward by the panellists themselves included: international enforcement of sustainable policies; capital/technology transfer to developing countries; renewable energy sources; redevelopment of brownfield sites before greenfield sites; working from home; improvement of security/reduce crime; improvement of health services; improve communication infrastructure; and increase resources for education.) The final ranking of the objectives for the two Delphi panels were as follows:

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110 Vincent, R.A. & Wood, K., (1989), "Car Sharing and Car Pooling in Great Britain: The Recent Situation and Potential", **TRRL Laboratory Report 893**, TRRL.

111 Bleviss, D.L. & Walzer, P., (1990), "Energy for Motor Vehicles", **Scientific American**, 26th September.; Lowe, M.D., (1990), "Alternatives to the Automobile: Transport for Livable Cities", **Worldwatch Institute Paper 98/49**, Worldwatch Institute.

112 Ab Rahman, A., (1993), "Behavioural and Institutional Factors Influencing Car Ownership and Usage", **Unpublished PhD Thesis**, Texas A & M University: Texas.

113 Barrett, P.S., Sexton, M.G. & Green, L., (1998), **Integrated Delivery Systems for Sustainable Construction: Unpublished report for the Construction Sponsorship Directorate, Department of Environment Transport and the Regions**, DETR: London.

UK Delphi panel

The following issues were ranked (in descending order) as the **most** important objectives to be addressed to progress sustainable development[114]:

13. Develop clear national sustainability policy and plans
8. Reduce energy consumption in buildings
3. Reduce consumption of non-renewable resources

The panellists commented, for example, that the objective to reduce energy consumption in buildings, "... has global impact, [and] represents a long term high priority objective", although progress could be made on the short term, with reduced energy consumption being, "... an achievable target, using available technology."[115]

The objective to reduce the consumption of non-renewable resources was supported by an appreciation that "... ultimately, sustainability is about the careful use of resources in the widest sense ...", and that the "... [construction] industry is able to deliver recycling and efficiency of use by refining design standards, standardisation, pre-fabrication, and minimising wastage."[116]

Finally, the objective to develop clear national sustainability policy and plans as emphasised by the panellists through such observations as the "... overall direction given by national and local government .... must be of the required scale to bring about a significant move in the direction of attaining sustainable development", and that sustainable development "... objectives need to be determined and guided by a national plan, with clear targets and measures by which their achievement will be assessed."[117]

[114] *Op. cit.* Page 26.
[115] *Op. cit.* Page 130.
[116] *Op. cit.* Page 130.
[117] *Op. cit.* Page 130.

The following issues were ranked (in descending order) as the **least** important objectives to be addressed to progress sustainable development[118]:

10. Increase level of individual disposable income
12. Increase amount of time available to pursue leisure interests
2. Increase urbanisation

The panellists did not provide many arguments as to why these objectives were not high priority issues. On the issue of increasing the level of individual personal income, a panellist did argue that increased income "... can only lead to over-specification when applied to construction issues."[119]

A profile across all of the objectives is given in Figure 4.3[120]. (see Table 4.1. for key).

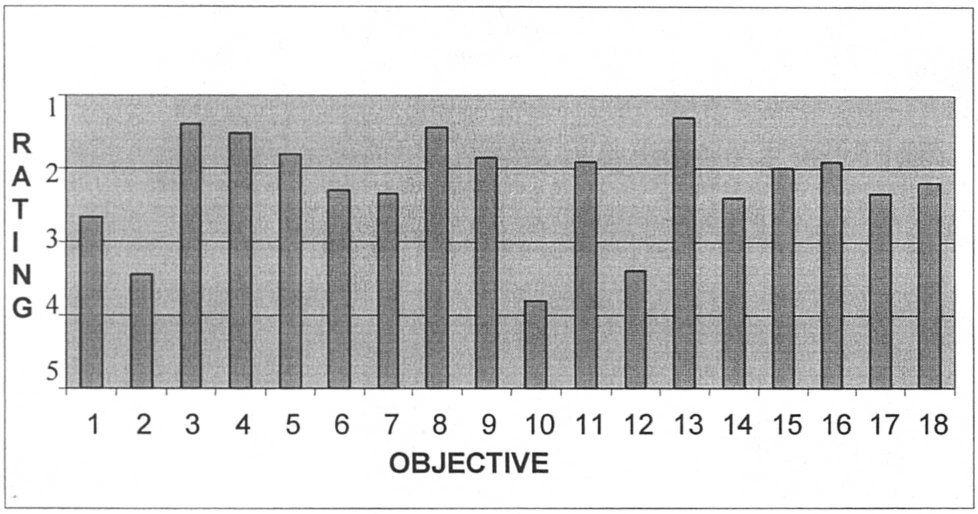

Figure 4.3. Profile of objective ratings by the UK panel
(Key: 1=Strongly agree with objective;
5=Strongly disagree with objective)

International Delphi panel

The following issues were ranked (in descending order) as the **most** important issues to be addressed to progress sustainable development[121]:

[118] *Op. cit.* Page 26.
[119] *Op. cit.* Page 131.
[120] *Op. cit.* Page 27.

8. Reduce energy consumption in buildings
3. Reduce consumption of non-renewable resources
13. Develop clear national sustainability policy and plans

The international panel argued that the objective to reduce energy consumption in buildings was[122]:

> *"... a central issue. In its broadest sense, it encompasses issues such as the depletion of the ozone layer and the destruction of scarce resources. At a less wide ranging level it deals with efficiency and waste reduction within the life cycle of a facility. As we spend much of our lives in buildings, they should be a major focus of our attention."*

An international panellist, in support of the objective to reduce consumption of non-renewable resources, argued that[123]:

> *"... central to the issue of sustainability is the retention of those resources which cannot be replaced (by regeneration or in the last resort substitution). By developing alternative processes and technologies and methods which reduce the burden on non-renewable resources, progress towards the goal can be made. Hence I see this objective as being multi facetted – it is not negative, don't use resources objective, but epitomises a drive to change and innovate in order to conserve what cannot be renewed."*

The need for clear national policy and plans was set out in the following panellist observation[124]:

> *"... sustainability is impossible if it is attempted in a piecemeal fashion; it is dependent on national and international co-operation and development of agreed standards. Hence it is essential that the groups work together to ensure sustainability. Individual efforts are futile if there are no national and international plans and policies."*

The following issues were ranked (in descending order) as the **least** important issues to be addressed to progress sustainable development[125]:

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121 *Op. cit.* Page 27.
122 *Op. cit.* Page 155.
123 *Op. cit.* Page 154.

12. Increase amount of time available to pursue leisure interests
10. Increase level of individual disposable income
2. Increase urbanisation

The international panellists did not offer reasons for giving these three issues low priority, but a panellist did comment on the lowest priority objective – increase urbanisation –by arguing that[126]:

> *"... increased urbanisation is likely to increase demand for resources of all types and so be counter-productive in terms of sustainability. Urbanisation tends to engender reliance and demand rather than self help and sustainability. Natural resources become in short supply, and due to density of population and societal issues, drive the increased consumption of resources. Big does not make for efficient."*

A profile across all of the objectives is given in Figure 4.4[127]. (see Table 4.1. for key).

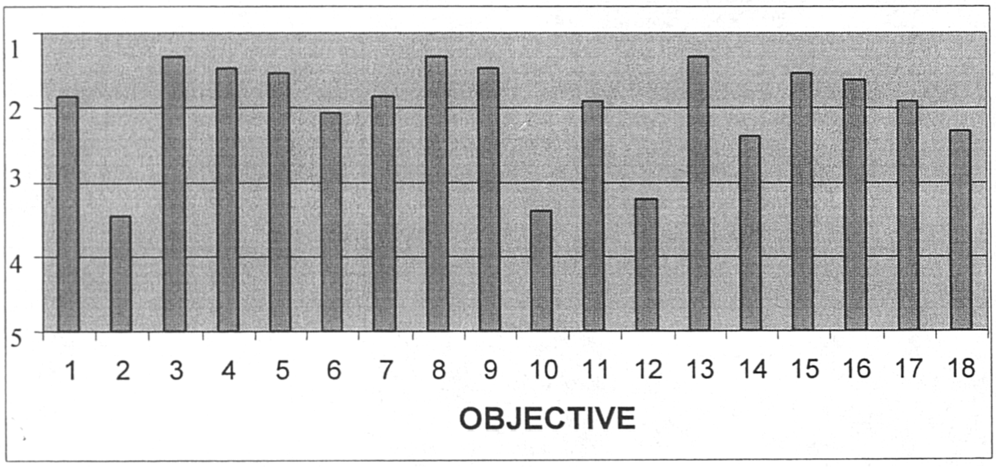

Figure 4.4. Profile of objective ratings by the international panel
(Key: 1=Strongly agree with objective;
5=Strongly disagree with objective)

4.3.3. Comment on hypothesis H2 and link to hypothesis H3

The findings from Hypothesis 1 (see Section 4.2.) emphasised the extent to which the two Delphi panels' views on what sustainable development means overlapped,

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[124] *Op. cit.* Page 155.
[125] *Op. cit.* Page 28.
[126] *Op. cit.* Page 155.
[127] *Op. cit.* Page 28.

and that there was a significant core of shared terms and language from which fertile discourses between shareholders could spring and develop. It was further argued, however, that if there was a significant degree of difference between stakeholders in their perception of the meaning of sustainable development, it would result in a correspondingly different ranking by the stakeholders of the most (and least) important priority areas to progress sustainable development.

The findings presented for the second part of the hypothesis does not support this argument, with the two Delphi panels having considerable similarity and therefore implied consensus in the main objectives chosen and also in the lower priority areas selected. These are summarised in Table 4.2.

Table 4.2.: Prioritised objectives: Comparison of UK and international Delphi panel views

Top objectives	**National panel**	**International panel**
Reduce energy consumption in buildings	Third	First
Reduce consumption of non-renewable resources	Second	Second
Develop clear national sustainable development policy/plans	First	Third
Bottom objectives		
Increase level of disposable income	Third from last	Second from last
Increase time available to pursue leisure interests	Second from last	Third from last
Increase urbanisation	Last	Last

It is interesting to note that the top two priority areas – reduce energy consumption, and reduce consumption of non-renewable resources – are very technical in focus. This is considered entirely consistent with the 'simpler, spatially lighter and more neoclassical-focus' of the UK national Delphi panel. It is not entirely consistent with the international Delphi panel, however, with its more 'complex, spatially broader and ecologically focused' view of sustainable development (see Section 4.2.3.); one would have expected some of the more socially orientated objectives to have been priority areas. Indeed, both Delphi panels considered the issues of increasing the level of individual disposal incomes and increasing the amount of time available to pursue leisure interests to be of low priority. The reason for this apparent contradiction between the espoused 'worldview' of the international Delphi panel, and its prioritisation of 'technical-orientated' objectives over 'social-orientated' objectives, might well exist not so much because the 'socially-orientated' objectives were not important, but because the stakeholders within the built environment and the construction industry were not perceived to be the right stakeholders (in terms of influence over the relevant decision-making arenas and resources) to progress these objectives. The issue of linking stakeholders to appropriate objectives is the focus of the next hypothesis.

Before investigating the next hypothesis, however, it is worth noting the importance given by both Delphi panels to clear national policies and plans for sustainable development, in order to galvanise appropriate, integrated activity. Finally, the low priority given to increasing urbanisation by both Delphi panels is, quite frankly, a surprise. The rationale for increased urbanisation, as discussed earlier in this section, is strong, and has been projected at influential, international levels.

4.4. Hypothesis 3: Stakeholders who are involved in the built environment and construction industry will have varying degrees of responsibility for progressing particular sustainable development objectives

4.4.1. Introduction

The strategic intent embodied within sustainable development objectives can only be transformed into action by appropriate stakeholders taking ownership of them, and translating and synergistically embedding them within their own objectives, decision-making processes, and activities. The need to better identify stakeholders and their roles with respect to sustainable development is emphasised in the speculation that "... typical future concerns for the industry to address will be ... who are the stakeholders in any decision making process – [and] are they partners or detractors?[128]" There are considerable barriers, however, to this ownership and integration of stakeholder roles, a position captured in the following observation, that:

> *"Within the construction industry there is a broad range of parties who are stakeholders, that is within the context of the broader built environment. We need to promote initiatives that bring these stakeholders together and promote co-operation. Many of the processes involved in construction projects, in particular contractual procedures, encourage confrontation. The confrontation, prejudice and lack of understanding between members of the design team should not be underestimated as a barrier to sustainable construction and holistic integrated design."*[129]

The argument being stressed in this thesis is that without a clear link between sustainable development objectives and stakeholders, strategic challenges might well not be addressed at all, or be taken on by inappropriate stakeholders. There is a crucial need for a shared understanding between stakeholders on not only 'what' action is required to progress sustainable built environments and construction activity, but 'who' needs to be linked with these objectives.

4.4.2. Key findings from the literature

The majority of the literature resources reviewed discuss a variety of issues and objectives relevant to sustainable development, but conspicuously do not link stakeholders with their ownership and progression. There are some literature sources which have identified key stakeholders in the built environment and construction activity, and have linked them with particular sustainable development objectives. The CIB Agenda 21 on Sustainable Construction[130], for example, has identified key stakeholders and objectives, as shown in Figure 4.5.

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[128] Gilham, A., (1998), "Strategies for Change – Understanding Sustainable Development from a Construction Industry Perspective", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change** Gävle, Sweden, 7th – 12th June. Page 1817.

[129] Construction Research and Innovation Strategy Panel, (1998), **CRISP Response to *Opportunites for Change*: Sustainable Construction**, CRISP: London. Page 7.

Figure 4.5. Sustainable development actions for stakeholders

Similarly, the BEQUEST project has usefully addressed the role and responsibilities of central 'societal actors' involved in the development, use and maintenance of the built environment (see Table 4.3.), across the spatial scale from individual buildings through to whole European Union member countries[131].

[130] CIB, (1999), **Agenda 21 on Sustainable Construction: CIB Report Publication 237**, CIB: Rotterdam: Netherlands.

[131] Curwell, S., (2000), "Building Environmental Quality Evaluation Through Time: Towards Sustainable Urban Development – The Work of the BEQUEST Network in Europe", **Proceedings of the Cities and Sustainability: Sustaining Our Cultural Heritage**, Kandalama: Sri Lanka: 22nd – 25th February.

Table 4.3.: Actors influencing the built environment

Collective interest (9 actors) • Elected representatives/administrators • Government agencies • Regional authorities • Local authorities • Research institutions and technical centres • Vocation training institutions • Consumer associations • Non-government agencies for environmental protection • Other relevant interests	*Design (5 actors)* • Designers • Technical consultants • Town planners • Landscape architects • Construction economists *Project carry-through (3 actors)* • Construction material producers and distributors • Construction contractors and managers • Development control officers
Operational decision-making (4 actors) • Development companies • Non-managing building and infrastructure • Owners managing building and infrastructure owners • Banks and other institutions	*Use (5 actors)* • Transport and utility service providers • Facilities managers • Users of builders • Users of transport and utility services • Insurers

The Construction Research and Innovation Strategy Panel identified the following key stakeholders and roles[132]:

- Clients – primarily responsible for the initial commission of the structure/design team and the payment of fees. The client has a key role in whether sustainable construction comes about.
- Investors and financiers – primarily responsible for resourcing the construction project. Investors and financiers can thus restrict the opportunity of sustainable design and construction through the imposition of preconceived ideas, such the need for air conditioning to create an acceptable internal environment.
- The design team (i.e. architects, quantity surveyors, building services engineers, etc.) – primarily responsible for the development of the brief and of

[132] Construction Research and Innovation Strategy Panel, (1998), **CRISP Response to *Opportunities for Change*: Sustainable Construction**, CRISP: London.

the design as well as the through-life commissioning of the building. The understanding of sustainable development issues and the awareness of opportunities for sustainable construction and operation/management amongst the design team will affect how the concept is realised.

- Contractors (and their suppliers) – primarily responsible for transforming the design into a physical artefact. The involvement of the contractor during the design phase can improve buildability as well as raising the awareness of the contractors as to why certain decisions have been made to achieve a sustainable solution.
- Operations/maintenance/management – primarily responsible for the operation, maintenance and management of the building in use. Their contribution to sustainable development is somewhat dependent on the original design and realisation of the building, but they can advise on how to improve the operation and management as well as reducing the maintenance requirements through good design.
- Waste services – primarily responsible for managing the waste streams generated through the life cycle of a building. These stakeholders can contribute to the industry's understanding and management of the sources and characteristics of these wastes.

The issue of linking stakeholders with objectives was also a focus for the 'Integrated Delivery Systems for Sustainable Construction' project. The panellists from both the national and international Delphi panels were presented with the list of performance objectives given in Table 4.1., and asked to identify the stakeholders with responsibility for each of them. From this data, cognitive maps were constructed depicting the major links between stakeholders and objectives, and indicating which of the stakeholders had been strongly or weakly linked to particular objectives, based upon the frequency with which they had been identified by panellists as holding responsibility. The findings for each of the Delphi panel are given below.

UK Delphi panel

Figure 4.6. shows the main stakeholder responsibilities and links[133]. Table 4.4. presents the five links between performance objectives and stakeholders which received the highest level of agreement from the national panel:

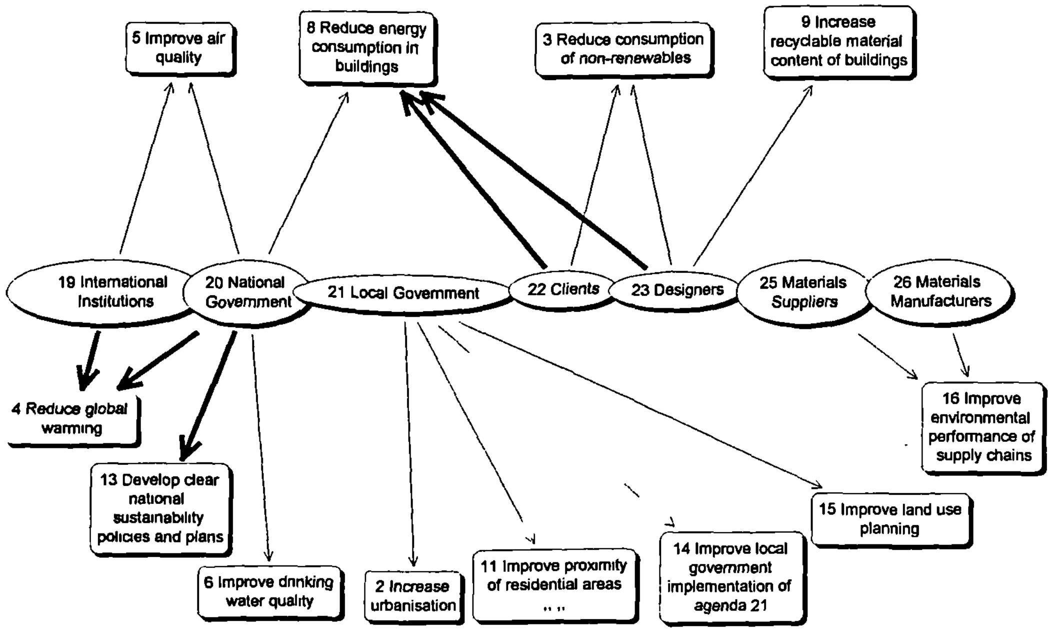

Figure 4.6. Key stakeholders and linkages identified by the UK panel

Key: The thick arrows denote strongest links

The map indicates that panellists consider international institutions and national governments hold the key responsibility for global and national sustainability issues such as air quality, drinking water quality, energy consumption and the reduction of global warming. The development of clear national sustainability policies and plans was also regarded as a major responsibility of national government. The performance objectives which panellists considered local government to hold key responsibility for were principally concerned with land use planning and implementation of Agenda 21.

Table 4.4 UK national panel's views on stakeholders to objectives

Stakeholder	Objective
International institutions	Reduce global warming
National government	Develop clear national sustainability policies and plans
Clients	Reduce energy consumption in buildings
National government	Reduce global warming
Designers	Reduce energy consumption in buildings

Clients and designers were together considered to be responsible for reducing energy consumption in buildings and the consumption of non-renewable resources, whilst designers were additionally believed to have key responsibility for increasing the recyclable material content of buildings. Material manufacturers and suppliers, although recognised as being important, were not ranked as key stakeholders.

International Delphi panel

Figure 4.7. shows the main stakeholder responsibilities and links[134]. Table 4.5. presents the four links between performance objectives and stakeholders which received the highest level of agreement from the international panel:

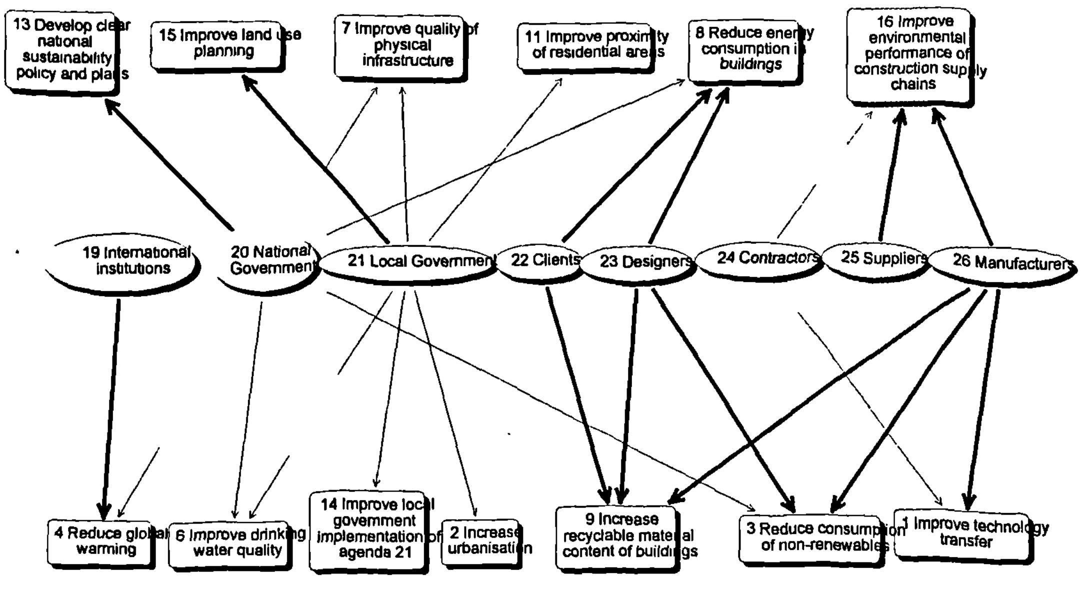

Figure 4.7. Key stakeholders and linkages of the international panel

Key: Thick arrows denote strongest links

133 *Op. cit.* Page 30.

Table 4.5 International panel's views on stakeholders to objectives

Stakeholder	Objective
National government	Develop clear national sustainability policies and plans
Designers	Reduce energy consumption in buildings
Clients	Reduce energy consumption in buildings
Materials manufacturers	Reduce consumption of non-renewable resources

The map indicates that panellists consider international institutions and national governments hold key responsibility for global and national sustainability issues such as drinking water quality, energy and non-renewable resource consumption, and the reduction of global warming. The development of clear national sustainability policies and plans and improvements in the quality of the physical infrastructure were also regarded as major responsibilities of national government. The performance objectives which panellists considered local government to hold key responsibility for were principally concerned with land use planning and implementation of Agenda 21.

Clients and designers were together considered to be responsible for reducing energy consumption in buildings and increasing the recyclable material content of buildings, whilst additionally designers were believed to have key responsibility for reducing the consumption of non-renewable resources. Contractors, material manufacturers and materials suppliers were all linked to improving the environmental performance of supply chains, although the link with contractors was less strong. Contractors and materials manufacturers were both linked to improvements in technology transfer, although again the link with contractors was less strong. In addition materials manufacturers were strongly linked to resource issues such as reducing the consumption of non-renewable resources and increasing the recyclable material content of buildings.

Cross-comparison of Delphi panels

There is a considerable similarity and therefore implied consensus in the main links between stakeholders to objectives. These are summarised in Table 4.6.

[134] *Op. cit.* Page 31.

Table 4.6. Performance objectives and stakeholders: Comparison of UK and international Delphi panel views

Top objectives	National		International	
	Priority	*Primary stakeholders*	*Priority*	*Primary stakeholders*
Reduce energy consumption in buildings	Third	• **Clients** • **Designers** • National government	First	• **Clients** • **Designers**
Reduce consumption of non-renewable resources	Second	• Clients • Designers	Second	• **Designers** • **Materials manufacturers**
Develop clear national sustainable development policy / plans	First	• **National government**	Third	• **National governments**

Notes for table:

1. Stakeholders in bold represent the strongest links.

4.4.3. Comment on hypothesis H3 and link to hypothesis H4

The literature has substantially supported the hypothesis that stakeholders within the built environment and construction activity do have varying degrees of responsibility for progressing particular sustainable development objectives.

The Delphi study findings have identified three prioritised objectives to progress sustainable development, and linked them to the key stakeholders with responsibility for them. The focus of the next hypothesis is to use the *Dynamic PSR model* to investigate the proposed efforts (contained within the relevant built environment and construction industry research literature) to progress these objectives.

4.5. Hypothesis 4: Efforts to progress sustainable development objectives which do not adequately link pressures, states and responses in a systemic fashion will be unbalanced and fragmented.

4.5.1. Introduction

The creation and maintenance of sustainable built environments and construction activity needs to appreciate and embrace the systemic nature of interaction between social and ecological systems (see Section 2.2.2.). This idea underpins the observation, for example, that:

"The pursuit of urban sustainability is a complex task requiring the analysis of the full range of urban activities both spatially and temporally. Activities and processes which merit particular study include land use patterns and built form; transport supply and demand; energy consumption; waste generation and processing; and land contamination. ***An understanding of the interactions and feedbacks between these elements is essential to the analysis of sustainability.****"*[135]

"[The need for] understanding and accepting the system relationships between [construction] industry behaviour and its impact ...This means taking responsibility for the impact of the business, so recognising that businesses do not operate in isolation to their environment."[136]

The *Dynamic PSR model* (developed in Section 2.6.5.) is used as a mechanism to investigate whether prevailing strategies articulated in the relevant research literature are adequate in their systemic contextualisation and focus. As discussed in Section 2.6.5., for the *Dynamic PSR model* to make sense, it is crucial that it is used in such a way that, at any one time, the same stakeholder's perspective is used for Pressure (P), State (S) and Response (R) and that the issue or objective in question is also kept constant. The analysis in support of this hypothesis is based on relevant secondary literature sources (see Chapter 3), and is focused on the priority issues identified in Section 4.3. It should be noted that the secondary sources were not sufficiently sensitive to allow the fixing of the stakeholder, e.g. client or contractor, and the level of resolution, e.g. city, building or component, to be done with any great degree of certainty or accuracy. This leads to some residual raggedness in the analyses of the three priority objectives, and has implications for future uses of the model, discussed in Section 5.5.

An analysis of each of the three priority objectives – development of clear national sustainable development policies and plans; reduction in the consumption of non-

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[135] May, A.D., Mitchell, G. & Kupiszewska, D., (1995), "The Development of the Leeds Quantifiable City Model", **Proceedings of the International Workshop on the Environmental Impact Evaluation of Buildings and Cities for Sustainability**, Florence, Italy,: 13th – 15th September: Paper 3: Page 1. Emphasis added.

[136] Gilham, G., (1998), "Strategies for Change – Understanding Sustainable Development from a Construction Industry Perspective", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change** Gävle, Sweden, 7th – 12th June. Page 1819.

renewable resources; and reduction in the energy consumption of buildings – using the *Dynamic PSR model* is informed by the aspirations and characteristics of sustainable development by the UK Delphi panel (see Section 4.2.):

> *"Using natural resources in such a way that they meet our economic, social and cultural needs, but not depleting these resources to the point that they cannot meet these needs for future generations."*

It is appreciated by the researcher that this is but one of a diverse range of perspectives of sustainable development (see Section 2.4.1.), but, as with the stakeholder and the issue, the *Dynamic PSR model* needs to have a fixed focus.

4.5.2. First priority objective: Develop clear national sustainable development policies and plans

Dynamic PSR model Gap 1: Pressures, in terms of drivers for change

There is very limited explicit discussion given in the literature on what the pressures or drivers stimulating the need for clear national sustainable development policies and plans actually are. What discussion there is on pressures can be usefully categorised into three distinctive, but overlapping groups: 'top down' or contextual pressures, originating from international institutions and policy agendas; 'integrating' or process pressures originating from a desire to optimally focus the internal dynamic of the built environment and construction activity; and 'specific issue' pressures to address particular, normally technically-orientated issues emerging from a variety of locations within the built environment and the construction industry. The interrelationships between these pressures are shown in Figure 4.8., and discussed below.

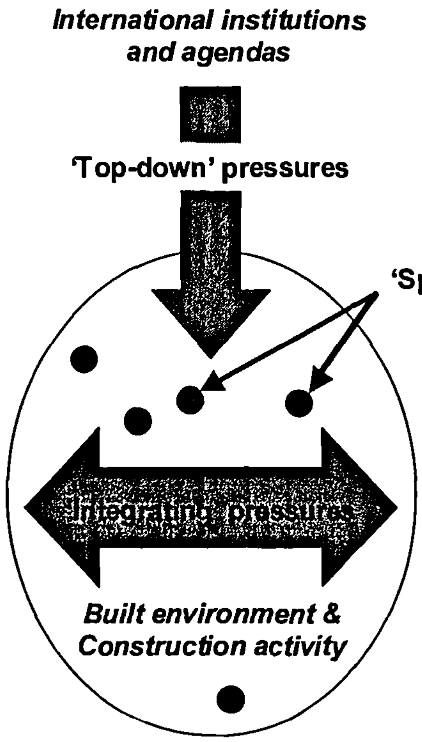

Figure 4.8.: Key pressures to develop clear sustainable development national policies and plans

'Top down' pressures from international institutions and their reports and research agendas encourage national governments to generate appropriate policies and plans. It is commented, for example, that the Human Settlement Committee of the United Nations Economic Commission for Europe had a significant influence in the development of the French building regulations.[137]

Similarly, the genesis for Dutch sustainable development policy has been described:

> *"As one of the reactions on the Brundtland report the Dutch National Environmental Policy was published in 1989. In this document ... intentions and guidelines were formulated with the aim to anchor the concept of sustainability into, amongst others, the Dutch building industry."*[138]

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[137] Blachère, G., (1998), "Tentative Application of the ECE Compendium of Model Provisions for Building Regulations", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change** Gävle, Sweden, 7th – 12th June. Page 1962.

[138] Pietersen, H.S. & Fraay, A.L.A., (1998), "Performance of Concrete with Recycled Aggregates", **CIB World Building Congress: Construction and the Environment – Symposium A:**

The aspiration for the Korea national government's integrated approach to the design and operation of sustainable human settlements is apparently made transparent, with the comment that[139]:

> *"The Korean government is proposing to establish the Korean Habitat Agenda including policies and institutional systems which deliver development objectives that are compatible with the aims of sustainable development."*

The Korean government has used the guiding and integrating nature of the Habitat Agenda to develop, and begin implementing, conservation laws for natural resources in residential developments; environmentally-friendly transport systems; and planning regulations to encourage ecological corridors in urban areas.

'Integrating' pressures for clear national policies and plans are identified in the need for strategies to optimally design and manage the internal dynamic of stakeholders' objectives and activities within the built environment and the construction industry. These pressures, for example, underpin the argument that there is an expressed need to promote interdisciplinary collaborations and multiple-stakeholder partnerships between government, industry, consultants, contractors, non-government organisations and the general public[140], as:

> *"... sustainable design and construction can not be pursued as an autonomous task. It is part of the more comprehensive context of sustainable development.*
>
> *This brings the issue into national and international policies and as a consequence it touches with the tension between environment and economy. Economic growth and a reduction of the pressure on the environment is a dilemma at first sight but it can definitely be*

Materials and Technologies for Sustainable Constructionlity – Endurance Through Change Gävle, Sweden, 7th – 12th June. Page 1751.

[139] Lee, K.I., (1998), "The Direction of Policies and Systems for the Development of Sustainable Human Settlements in Korea", **CIB World Building Congress: Construction and the Environment – Symposium C: Legal and Procurement Practices – Right for Environment**, Gävle, Sweden, 7th – 12th June. Page 1566.

[140] Gardner, J.E., (1989), "Decision making for Sustainable Development: Selected Approaches to Environmental Assessment and Management", **Environmental Impact Assessment Review**, 9: 4: 337-366.

successfully combined through changes in production, process, taxation and government policy."[141]

'Specific issue' pressures focus on particular areas which stimulate national polices and plans. For example:

- The UK's policy on contaminated land was developed in response to growing pressure on development land resources and greater environmental awareness[142].
- The Kuwaiti Ministry of Electricity and Water code of practice for energy conservation is in response to air-condition power consumption accounting for seventy percent of the energy generated from April to October when temperatures are in the region of fifty degrees Celsius[143].
- Standards for paint[144] in Japan were in direct response to a report by the Environment Protection Agency which reported that around thirty percent of the total amount of organic carbons which were emitted into the air due to human activities came from paint[145].
- Landfill Tax in the UK was developed in response to increasing pressures on finite landfill sites to dispose of construction waste[146].

In summary, there is a general dearth of discussion in the literature on what the explicit pressures for clear national sustainable development polices and plans are. The sources that are available tend to consider pressures as falling into three groups: 'top-down', 'integrating' and 'specific issues.' The focus of attention is predominantly on the 'specific issue' pressures, which raises the real danger of such pressures being considered in isolation, rather than being appropriately contextualised into the broader, systemically meshed stream of pressures.

[141] Ang, G.K.I., (1998), "Sustainable Design Construction and the Performance Concept", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change** Gävle, Sweden, 7th – 12th June. Page 1751.
[142] CIRIA, (1995), **Remedial Treatment for Contaminated Land: Special Report 103**, CIRIA: London.
[143] Almudhaf, H. & Al-Ragom, F., (1998), "Autoclaved Aerated Concrete for Construction in Hot Regions", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change** Gävle, Sweden, 7th – 12th June.
[144] For example, Japanese Standard Association, (1992), **Japanese Industrial Standard: K 5659-1992 – Fluoro Resin Paint for Steel Structures**, Japanese Standard Association: Japan.
[145] Sakamaki, F., (1986), "Hydrocarbons in the Global Troposphere", **Research Report National Institute Environmental Studies**, 102: 31-42.

Further, indicators to measure the force and direction of these pressures are not established, or the systemic implications identified, critically assessed and used to continuously improve the design and/or delivery of appropriate responses within potentially changing contextual pressures.

Dynamic PSR model Gap 2: States, in terms of the relevant stakeholders' level of understanding and willingness to act

The stakeholders identified in the literature for having primary responsibility for clear national policies and plans are national governments. This is consistent with hypothesis 3 which firmly established national governments as being the central stakeholders for this objective (see Section 4.4.2.)

In the literature reviewed, there was little discussion about the motivation and ability of national governments to formulate and implement national sustainable development policies and plans. The one notable exception is the UK's policy for sustainable construction. The Department of the Environment, Transport and the Regions set out to develop a national strategy for sustainable construction, motivated by the belief that:

> *"The built environment provides the context for most human activities and has a huge impact on the quality of life in our communities. Construction also provides the delivery mechanisms for many aspects of Government policy aimed at the provision and modernisation of the nation's infrastructure – transport, housing, schools, hospitals etc. The benefits which could flow from a more efficient and sustainable construction industry are potentially immense. Further, the construction process lends itself to detailed measurement and sustainable construction can therefore act as a case study for developing a quantified framework for sustainable development more generally."*[147]

Further, the ability of the government to better understand the needs of industry within the context of sustainable development was enhanced through a consultation process which encouraged feedback from a range of stakeholders[148].

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146 Department of Environment, (1994), **Planning Policy Guidance Note 23: Planning and Pollution Control**, H.M.S.O.: London.

147 Department of Environment, Transport and the Regions, (1998), **Opportunities for Change: Consultation Paper on a UK Strategy for Sustainable Construction**, DETR: London. Page 4.

148 For example, see Construction Research and Innovation Strategy Panel, (1998), **CRISP Response to *Opportunities for Change*: Sustainable Construction, CRISP: London.**

Appropriate indicators to measure the level of understanding and willingness of national governments to act are not established, and systemic implications are not identified, critically assessed and used to close gaps in understanding or to stimulate the motivation within relevant stakeholders to act.

Dynamic PSR model Gap 3: Responses, in terms of actions taken by relevant stakeholders

In the literature, the responses discussed tended to focus on particular, generally technical, issues. This is considered consistent with the UK definition of sustainable development which is neo-classically focused, and emphasises technical and economic considerations over social ones (see Section 4.2.3.). The majority of responses are not explicitly linked to pressures, for example:

- The Standard Assessment Procedure is a statutory 'home energy rating' methodology included as part of the UK Building Regulations[149]. The link to energy resources and global warming is, at best, implicit.
- The New Zealand Building Code which sets out to regulate buildings with respect to the protection of neighbouring properties, the safety of fire-fighting personnel and energy efficiency[150]. The link, again, to broader pressures for energy efficiency is implicit.

There are a number of responses which are better linked to pressures, although these responses tend to address only the technical aspects of these pressures. For example:

- The UK's policy on contaminated land was developed to stimulate the reclaiming or recycling of contaminated land (land which represents an actual or potential hazard to health or the environment as a result of current or previous use)[151].

[149] The Standard Assessment Procedure, (1994), **The Government's Standard Assessment Procedure for Energy Rating of Dwellings**, BRECSU, HMSO: London.
[150] Building Industry Authority, (1992), **The New Zealand Building Code Handbook and Approved Documents**, Building Industry Authority: Wellington, New Zealand.
[151] Department of Environment, (1994), **Planning Policy Guidance Note 23: Planning and Pollution Control**, H.M.S.O.: London.

- The Kuwaiti Ministry of Electricity and Water code of practice for energy conservation encourages design and technological solutions by setting peak load limits for space cooling[152].
- Landfill tax is a financial instrument aimed at stimulating an integrated approach to waste management which locates waste solutions higher up in the waste hierarchy. The waste hierarchy indicates that waste reduction is the most effective environmental solution. Failing that, reuse, recycling or energy recovery from waste should be considered. Only wastes which are not suitable for any of the above treatments should be disposed of[153].

In summary, the responses are generally focused on technical issues, and are inadequately meshed to pressures. Further, responses for 'integrating' pressures identified in Gap 1 appeared absent in the literature. This lack of focus and integration, again, exposes the collective response to the systemic challenges of sustainable development as debilitating fragmentation and potential conflicting activity. This situation is further exacerbated by appropriate indicators not being established, performance not measured and systemic implications not identified, critically assessed, and used to feed into a continuous process of response review and improvement.

Dynamic PSR model Gap 4: The relationship between Pressures and States – Barriers to understanding

In the literature reviewed, there is a conspicuous lack of comment on the level of understanding between pressures and states. The issue of brownfield planning policy in the U.K. was an exception. Promoting development on brownfield sites is a key government policy but, at the same time, the government has introduced more stringent legislation of waste management and environmental protection. It has been argued that there is a distinct tension here, as the development of brownfield sites generally requires the removal and disposal of waste material:

[152] Almudhaf, H. & Al-Ragom, F., (1998), "Autoclaved Aerated Concrete for Construction in Hot Regions", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change** Gävle, Sweden, 7th – 12th June.
[153] For example, see Symonds Travers Morgan / ARGUS, (1995), **Construction and Demolition Waste Project in the Framework of the Priority Waste Stream Programme of the European**

"This means that on the one hand developers are being encouraged to redevelop urban and brownfield sites, while on the other it appears they are being penalised for doing so."[154]

This adverse tension certainly gives weight to the observations that responses (Gap 3) lack focus and integration, potentially resulting, as in the case with brownfield sites and waste management, in conflicting policies.

Appropriate indicators to track such tensions between policies are not measured, and systemic implications are not identified, critically assessed and used to close gaps in understanding within relevant stakeholders.

Dynamic PSR model Gap 5: The relationship between States and Responses – Barriers to implementation

In the literature reviewed there is little discussion on the relationship between states and responses. It is noted, for example, in a survey of companies in the UK commercial property management sector, that although almost all respondents were aware of the growing impact of environmental legislation, over one third did not routinely assess new projects for potential environmental costs and risks[155]. The research did not address *why* this was the case.

Appropriate indicators to measure drivers / barriers for the implementation of national policies and plans are not established, and from such data systemic implications are not identified, critically assessed, and used to improve the design and/or delivery of strategies that both amplify the drivers, and reduce/eliminate the barriers.

Dynamic PSR model Gap 6: The relationship between Responses and Pressures – Barriers to effectiveness

In the literature reviewed, there is little discussion on the relationship between national policy and plan responses and pressures. There is an absence of

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Commission: Report of the Project Group to The European Commission, European Commission: Brussels.

[154] McCarty, J.; Pottinger, K.G. & Dixon, T.J., (1999), **Waste Not, Want Not? Brownfield Development and the Effects of the Landfill Tax**, College of Estate Management: Reading.

[155] Lizieri, C., Palmer, S., Charlton, M., Wilson, C. & Finlay, L., (1996), "Valuation Methodology and Environmental Legislation: A Study of the UK Commercial Property Industry", **RICS Research Paper Series: Volume 2: Number 3**, RICS: London.

comprehensive, longitudinal statistics and case studies to support (or invalidate) national policies being pursued. A partial exception is the discussion on the effectiveness of the Landfill Tax. The Landfill Tax can be considered 'effective' in one sense, in that it has been a substantial influence in reducing the percentage of construction waste disposed of in landfill sites from eighty percent in 1994[156], to forty three percent in 1997[157]. However, this 'output' result has not been brought about by the intended aim of the Landfill Tax, of encouraging industry to develop waste reduction, reuse or recycling solutions; rather, a significant proportion of the reduction in landfill has come about through waste being diverted to unregulated activities such as golf course landscaping and land spreading on farms[158].

Appropriate indicators to measure the effectiveness of national policies and plans on reducing/eliminating pertinent pressures are not established, and systemic implications are not identified, critically assessed and used to improve the design and/or delivery of responses which are more effective.

Summary

The national government is considered as being the primary stakeholder to progress this objective. Further, the discussions are consistent with the neo-classical focus of the UK definition of sustainable development.

There is very limited explicit discussion given in the relevant literature on the nature and role of national sustainable development policies and plans. The pressures for clear sustainable development policy and plans (*Dynamic PSR model* Gap 1), when identified, are categorised into 'top-down' pressures, 'integrating' pressures and 'specific issue' pressures. Appropriate indicators are not adequately established, trends measured and systemic implications identified, critically assessed and appropriately used.

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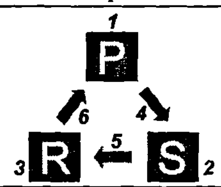
[156] Friedman, A. & Cammalleri, V., (1994), "Reducing Energy, Resources and Construction Waste Through Effective Residential Unit Design", **Building Research and Information,** 21: 1: 103-108.
[157] Reeds, J., (1997), "No Time to Waste", **Construction Manager,** 3: 5: 19-21.
[158] Reeds, J., (1997), "No Time to Waste", **Construction Manager,** 3: 5: 19-21.

Similarly, the current effectiveness of national policies and plans is inadequately identified, appropriate indicators are not established, performance is not measured and systemic implications are not identified, critically assessed and appropriately used (*Dynamic PSR model* Gaps 2 and 3). Responses tend to address particular, generally technical, issues. Further, responses tend to place too much emphasis on the economic and resource aspects of sustainability, with little focus on developing and integrating the social and cultural needs, and resource degradation issues.

Finally, the relationship between the pressures, states and responses pertaining to national sustainable development policies and plans is inadequately identified, appropriate integrative indicators are not established, causal responsiveness is not measured and systemic implications are not identified and critically assessed (*Dynamic PSR model* Gaps, 4, 5 and 6). Table 4.7. summarises the current position on national sustainable development policy and plans.

Table 4.7. Summary of current position on national sustainability policy and plans

Issue / objective: Develop clear national sustainable development		*Stakeholder:* National government
Description of pressures Patchy. Categorised into 'top-down', 'integrating' and 'specific issue' pressures.	***Description of state*** Little explicit discussion.	***Description of response*** Responses generally linked to 'specific issue' pressures and are technical in focus.
Gap 1 *(in pressures)* Detailed, systemic understanding of *what* interactive social, economic and environmental pressures shape national sustainability policies.	**Gap 2 *(in state)*** Detailed understanding of the social, economic and environmental states of the built environment.	**Gap 3 *(in responses)*** Detailed description and analysis of national policies, particularly those addressing 'top-down' and 'integrating' pressures.
Gap 4 *(barriers to understanding)* Detailed, systemic understanding of *how* pressures interact with the built environment.	**Gap 5 *(barriers to implementation)*** Detailed, systemic understanding of how changes in the condition of the built environment shape the focus, design and implementation of national policies.	**Gap 6 *(barriers to effectiveness)*** Detailed, systemic understanding of how the outcomes from national policies shape underpinning social, economic and environmental pressures.
Overall commentary The gap analysis has revealed significant deficiencies in the understanding and application of national sustainability policies and plans.		

4.5.3. Second priority objective: Reduce consumption of non-renewable resources

<u>*Dynamic PSR model* Gap 1: Pressures, in terms of drivers for change</u>

There is very limited explicit discussion in the literature on what the pressures for reducing the consumption of non-renewable resources actually are. Further, the distinction between renewable and non-renewable materials is not made in much of the literature. The discussion on pressures tend to be couched in very broad, terms that, arguably, lack the fine-grained body of knowledge to locate and focus 'state' analysis of key issues, and, based on this, appropriate, integrated 'responses'.

The pressures for reducing non-renewable resources, where discussed, is generally discussed from economic perspectives. A representative example of such perspectives is captured in the economic argument that approximately one-tenth of the global economy is dedicated to the creation, management and operation of the built environment, and that the construction activity component of this accounts for around forty percent of the materials flow entering the world economy, with much of the rest allocated for the physical infrastructure of the built environment[159]. The implications of this are substantial:

> *"... because of the building industry's significant impact on the national economy, even modest changes that promote resource efficiency in building construction and operations can make major contributions to economic prosperity and environmental improvement."*[160]

Appropriate 'pressure' indicators are not adequately established to measure the force and direction of these pressures, systemic implications from such data are not identified, critically assessed, and used to inform/align responses to potentially changing pressures.

Dynamic PSR model Gap 2: States, in terms of the relevant stakeholders' level of understanding, willingness to act

The stakeholders identified in the literature as having primary responsibility for reducing the consumption of non-renewable resources are designers and contractors. This is only partially consistent with the findings presented for hypothesis 3, which identified stakeholders from both the supply side (designers) and the demand side (clients) (see Section 4.4.2.).

The literature reviewed had little explicit discussion on the level of relevant stakeholders' understanding and willingness to act to reduce the consumption of non-renewable materials. Stakeholders' motivations to act are usually framed from a cost benefit analysis perspective, which is consistent with the economic pressures which are emphasised in Gap 1. This argument is presented in the comment that:

[159] Roodman, D.M. & Lennssen, N., (1995), "A Building Revolution: How Ecology and Health Concerns are Transforming Construction", **Worldwatch Paper 124**, Worldwatch Institute: Washington, D.C.
[160] Public Technology, Inc., (1996), **Sustainable Building Technical Manual: Green Building Design, Construction and Operations**, Public Technology, Inc. Chapter 1, Page 1.

"... selecting environmentally preferable building materials is one way to improve a buildings performance. To be practical, however, environmental performance must be balanced against economic performance. Even the most environmentally conscious building designer or building materials manufacturer will ultimately want to weigh environmental benefits against economic costs. They want to identify building materials that improve environmental performance with little or no cost."[161]

Appropriate state indicators are not established to measure the ability and motivation of relevant stakeholders to act, and systemic implications from such data is not identified, critically assessed or used to close gaps in understanding and to stimulate the motivation of relevant stakeholders to act.

Dynamic PSR model Gap 3: Responses, in terms of actions taken by relevant stakeholders

The responses contained in the literature to the reduction of non-renewable resources are very much shaped by a technical-economic view of sustainable construction. Again, this is consistent with the similar thrusts emphasised in pressures (Gap 1) and states (Gap 2), and is considered consistent with the UK definition of sustainable development which is neo-classically focused, and emphasises technical and economic considerations over social ones (see Section 4.2.3.).

Representative views which emphasise the reduction of resources include the argument that sustainable construction is the creation of a healthy built environment and needs to adopt resource-efficient, ecologically-based principals[162]; and sustainable construction needs to be centred around a 'cradle to grave' approach to reduce the waste streams from construction activity[163]. Under this directional umbrella, responses to reduce the consumption of resources (as argued above, the literature generally does not distinguish between renewable, and

[161] Norris, G.A. & Marshall, H.E., (1995), **Multiattribute Decision Analysis: Recommended Method for Evaluating Buildings and Building Systems: Report 5663 for the National Institute of Standards and Technology**, NISIR: Gailhersburg. Page 64.
[162] Kibert, C.J., (1994), Final Session of the **First International Conference of CIB TG 16 on Sustainable Construction**, Tampa, Florida: 6th – 9th November.
[163] Wyatt, D.P., (1994), "Recycling and Serviceability: The Twin Approach to Securing Sustainable Construction", **Proceedings of the First International Conference of CIB TG16 on Sustainable Construction**, Tampa, Florida: 6th – 9th November.

non-renewable resources), tend to focus on better design through life cycle assessment methodologies and improved waste management.

The fundamental idea underpinning life cycle assessment methodologies is that to enhance the environmental performance of a given 'system' (for example, a building, a product or a material), a systematic and comprehensive understanding of all the environmental impacts that occur throughout the system's life cycle is required. This approach, when applied to a building for example, seeks to identify and evaluate all environmental impacts of that building from the acquisition of all materials, energies and natural resources that ultimately go into a building to the time when the building has completed its useful life and is demolished. The espoused benefit of this approach is that equipped with the knowledge and understanding provided by the life cycle methodology, relevant stakeholders are able to make the properly contextualised and informed decisions that can lead to genuine improvement in a building's environmental performance.

The majority of the life cycle methodologies discussed in the research literature focuses on buildings, products and materials as their unit of analysis. The Building Research Establishment Environmental Assessment Method (BREAAM), for example, is an approach for the environmental labelling of buildings. BREAAM, "... in the interests of clarity and to aim for a broad and balanced approach to the environment ...[164]", groups environmental issues under three main headings: global issues, local issues, and indoor issues. Of interest here, is that under 'global issues', natural resources and the recycling of materials are taken into consideration. Similarly, the Building Environmental Performance Assessment Criteria (BEPAC) is an environmental assessment approach which, of its five principal assessment issues, focuses on resource conservation. More specifically, under this issue, BEPAC encourages the reduction of resource use, the reuse and recycling of resources, and the purchase of products with lower

[164] Yates, A., Bartlett, P. & Baldwin, R., (1994), "Assessing the Environmental Impact of Buildings in the UK", **Proceedings of the First International Conference: Buildings and the Environment**, 16^{th} – 20^{th} May: Building Research Establishment, Watford, U.K. Paper 1, Page 2.

initial "environmental cost", such as those with recycled content[165]. While the Systematic Evaluation and Assessment of Building Performance model, "... addresses the need for comprehensive performance evaluation and assessment based on the life cycle assessment, comparative risk assessment, and industrial ecology." It assesses the environmental burden of a building, weighing, amongst others, resource consumption issues on a global scale, and on a local or project scale and establishes targets based on different sustainability criteria[166].

The life cycle assessment methodology, as discussed earlier, can be usefully applied to other units of analysis. Researchers have commented, for example, that materials require:

> *"... an adapted life cycle assessment process suitable for comparing many different materials with varied lives and applications, coming from a variety of sources and processes."*[167]

With this aim in mind, the idea of comparing different materials in terms of embodied energy has emerged. Embodied energy is defined as, "... the total primary energy that has to be sequestered from a stock within the earth in order to produce a product or service[168]", and needs to include the embodied energy of the materials used in the repair, maintenance and refurbishment of the element or building, as well as the energy to dismantle them and dispose of the materials from which they were composed[169]. The need to reduce the level of embodied energy is stimulating the concept of 'ecomaterials' or environmentally-friendly materials,

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[165] Cole, R.J., (1994), "Assessing the Environmental Performance of Office Buildings", **Proceedings of the First International Conference: Buildings and the Environment**, 16th – 20th May: Building Research Establishment, Watford, U.K.

[166] Levin, H., (1997), "Systematic Evaluation and Assessment of Building Environmental Performance (ASEABEP)", **Proceedings of the CSTB & CIB Second International Conference on Buildings and the Environment**, Paris: June.

[167] Edwards, S. & Hobbs, S., (1998), "Data Collection and Handling for Environmental Assessment of Building Materials by Architects and Specifiers", **Proceedings of the CIB World Building Congress: Construction and the Environment – Symposium A: Materials and Technologies for Sustainable Construction**, 7th – 12th June: Gävle, Sweden.

[168] Chapman, P.F. & Roberts, F., (1983), **Metal Resources and Energy**, Butterworths. Page 34.

[169] Howard, N.P., (1996), "Embodied Energy and Consequential CO_2 in Construction", **Proceedings of the International Symposium on Energy and Mass Flow in the Life Cycle of Buildings**, August: Vienna, Austria.

to try and make an effective contribution from the materials side to sustainable development[170].

Similarly, appropriate and robust life cycle methodologies to assess building products are viewed as being an important:

> *"... tool to achieve product improvement [and its role] is broadly recognised by the building industry, designers, commissioners and governments."*[171]

Life cycle assessment methodologies, for example, are used by lighting manufacturers to both improve and communicate the environmental performance of their products. Research, for instance, has provided evidence that incandescent lamps produce twice as much mercury as fluorescent technologies because of their higher energy consumption over their life cycle, even though incandescent lamps themselves contain mercury and fluorescent lamps do not[172].

Waste management is concerned with an integrated 'waste hierarchy' approach to resource reduction. As discussed in the 'National Policies and Plans' analysis above, the waste hierarchy indicates that waste reduction is the most effective environmental solution. Failing that reuse, recycling or energy recovery should be considered. Only wastes which are not suitable for any of the above treatments should be disposed of. This waste hierarchy approach is summarised in the emphasis that:

> *"Extra attention should be given to the 3Rs (Reduce, Reuse, Recycle) when considering the use of non-renewable resources. While non-renewable resources cannot be used sustainably, their 'life' can be extended by reducing their use in product manufacture, reusing a product a number of times rather than discarding after using once,*

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[170] Research Development Bureau of Science and Technology of Japan, (1993), **Ecomaterials for the Preservation of the Global Environment: Report of Fundamental Research**, Research Development Bureau of Science and Technology of Japan: Tokyo: Japan.

[171] Schuurmans-Stehmann, A. & Meijr, J.P.R., (1998), "Environmental Relevant Product Information in the Dutch Building Industry", **Proceedings of the CIB World Building Congress: Construction and the Environment – Symposium A: Materials and Technologies for Sustainable Construction**, 7th – 12th June: Gävle, Sweden. Page 643.

[172] Sexton, M.G., (1993), "The Greening of Industry: The Case of Office Lighting", **Unpublished M.Sc. Dissertation**, University of Manchester Institute of Science and Technology: Manchester, UK.

recycling of the resource at the end of the usable life of the product and switching to renewable substitutes where possible."[173]

Resource reduction through waste management centres around selecting materials and components that have low environmental impact through their life cycles (see discussion on life cycle assessment methodologies in Gap 3 of this section), and on proper initial briefing to ensure use requirements are met in a resource efficient manner. This briefing orientation to the resource reduction debate is summarised in the assertion that:

"... a building that is oversized for its designed purpose, or has oversized systems, will excessively consume materials ... The client's present and future space needs must be carefully studied to ensure that the resulting building and systems are sized correctly."[174]

Post building lifecycle responses for reuse of materials includes the reuse of roofing tiles[175], and the salvaging of doors, cabinets, architectural ironwork and glass, and so on[176]. The concept of reuse includes the renovation of existing buildings for new purposes. For optimal effectiveness, this requires that the buildings are designed and constructed with reuse in mind[177]. Where demolition is absolutely necessary, this principle requires design solutions which facilitate disassembly or deconstruction, for example, through appropriate fixing details which allow for the non-destructive separation of different materials at the end of the life of the building[178].

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[173] Hill, R.C. & Bowen, P.A., (1997), "Sustainable Construction: Principles and Framework for Attainment", **Construction Management and Economics**, 15: 223-239. Page 230.

[174] Kim, J. & Rigdon, B., (1998), **Introduction to Sustainable Design**, National Pollution Centre for Higher Education: Ann Arbor. Page 21.

[175] Tolstoy, N., Bjötklund, K. & Carlson, P.O., (1998), "Material Flows in the Construction Industry and Heavy Engineering Sector", **Proceedings of the CIB World Building Congress: Construction and the Environment – Symposium A: Materials and Technologies for Sustainable Construction**, 7th – 12th June: Gävle, Sweden.

[176] American Institute of Architects on the Environment, (1992), **Environmental Resource Guide**, American Institute of Architects: Washington, D.C.

[177] Roodman, D.M. & Lenssen, N., (1994), "Our Buildings, Ourselves", **World Watch**, 7: 6: 21-29.

[178] Wyatt, D.P. & Gilleard, J.G., (1994), "Deconstruction: An Environmental Response for Construction Sustainability", **Proceedings of the First International Conference of CIB TG16 on Sustainable Construction**, Tampa: Florida: 6th – 9th November.

Recycling responses include the use of recycled mineral fines from aggregate quarrying to improve the thermal properties of wood composite concretes[179], and recycled aggregates in precast concrete blocks[180].

Appropriate indicators are not established to measure the direction and uptake of responses by relevant stakeholders, and systemic implications from such data are not identified, critically assessed and used to improve the design and diffusion of the appropriate responses.

Dynamic PSR model Gap 4: The relationship between Pressures and States – Barriers to understanding

In the literature reviewed, there is patchy discussion on the level of understanding between pressures and states. In the case of life cycle assessment methodology, for example, the complexity of the issues involved means that often the data generated is not thoroughly understood or utilised by relevant stakeholders. As a consequence, the application of some well intended sustainable development principles can be misguided. Often materials or products are compared and decisions made on the basis of isolated environmental attributes without consideration of the full array of environmental impacts and implications present in the total life cycle[181]. This argument is presented in the observation that:

> *"... if 'product A' is manufactured from a certain recycled material and 'product B' incorporates no recycled material, the assumption usually is that A is a better choice than B. Or if A is made of natural materials and B is not, A is usually assumed to be the preferred environmental choice. Sound science and [life cycle assessment] may reject such a choice; making the proper decision requires a more thorough analysis."*[182]

[179] Queneudec, M., Legarrec, M.J., Alfim, K. & Bouguerra, A., (1996), **Concrete for Environmental Enhancement and Protection**, E&FN Spon: London.
[180] Collins, R.J. & Sherwood, P., (1995), **The Use of Waste and Recycled Materials in Aggregates: Standards and Specifications**, H.M.S.O.: London.
[181] For example, see Beetstra, F., (1997), "Beyond Life Cycle Assessment: Building Related Environmental Decisions", **Proceedings of the CSTB & CIB Second International Conference on Buildings and the Environment**, Paris: June.
[182] Tshady, J.A., (1996), "Material and Specifications", **Sustainable Building Technical Manual: Green Building Design, Construction and Operations**, Public Technology, Inc.

Appropriate indicators to measure the level of understanding between pressures and states are not established, and systemic implications are not identified, critically assessed, and used to close any gaps in understanding within relevant stakeholders.

Dynamic PSR model Gap 5: The relationship between States and Responses – Barriers to implementation

The development of new solutions to reduce the consumption of non-renewable resources does not automatically equate to their adoption. It has been noted, for example, that that the majority of design practices have been slow to change their behaviour towards more sustainable objectives, preferring to continue with well known design solutions and familiar products[183].

Such barriers, in part, are arguably due to many response reduction strategies not adequately meshing into the prevailing decision-making rationales and processes. As discussed in Gap 2 of this analysis, the predominant motivating factor for relevant stakeholders to meaningfully engage in strategies to reduce resource consumption is that it must be economically viable. This dimension, for example, is often not adequately captured in life cycle assessment methodologies, with the environmental considerations not being integrated and balanced with traditional issues that affect decisions; for example, function, performance, aesthetics and cost.

Appropriate indicators to measure drivers / barriers for implementation are not established, and from such data systemic implications are not identified, critically assessed, and used to improve the design and/or delivery of responses that both amplified the drivers, and reduce/eliminate the barriers.

[183] Emmitt, S., (1997), "The Diffusion of Environmentally Responsible Ideals and Practices", in M. Gray (Ed.), **Evolving Environmental Ideals: Changing Ways of Life, Values and Design Practices**, Royal Institute of Technology: Stockholm, Sweden . Pages 41-49.

Dynamic PSR model Gap 6: The relationship between Responses and Pressures – Barriers to effectiveness

In the literature reviewed there is a deficiency of comprehensive and longitudinal statistics and case studies to evaluate how effective resource reduction strategies actually are. It has been noted, for example, that there is a dearth of reliable statistics on demolition materials which are crushed and reused on site, with the comment that:

> *"... the lack of data on materials which are crushed and re-used on the original site is of some concern, because this can amount to a significant proportion of the most voluminous single material flow: crushed concrete, bricks, tiles, ceramics and gypsum-based materials."*[184]

The benefits of such data are illustrated in the case of the Landfill Tax example discussed in the 'National Policies and Plans' analysis above. Data demonstrated that stakeholders appear to misunderstand, or choose to ignore, the actual purpose of the Landfill Tax (namely, to encourage optimal waste reduction, reuse and recycling solutions) and treat it as a taxation burden to be avoided through disposing of construction waste in other, unregulated, ways.

Appropriate indicators to measure the effectiveness of responses on reducing / eliminating pertinent pressures are not established, and systemic implications from such data are not identified, critically assessed, and used to improve the design and/or delivery of appropriate responses which are more effective.

Summary

The pressures to reduce the consumption of non-renewable resources (Dynamic PSR model Gap 1) are not sufficiently or clearly identified, appropriate indicators are not established, trends are not measured and systemic implications are not identified and critically assessed. Inadequate distinction is made between renewable and non-renewable resources.

[184] Symonds Group Ltd., (1999), **Construction and demolition Waste Management Practices, and Economic Impacts: Report to DGXI European Commission**, European Commission: Brussels. Page 47.

The level and type of resources consumed at built environment, construction industry and building units of analysis (Dynamic PSR model Gap 2) are not comprehensively identified, appropriate indicators are not established, quantities and types of resources are not measured and systemic implications are not identified and critically assessed.

Responses to the reduction of non-renewable resources (Dynamic PSR model Gap 3) predominantly focus on better design through life cycle methodologies for buildings, materials and components, and better production processes through waste reduction, recycling and management.

The methodologies described concentrate almost entirely on techno-economic considerations at a project/building level of analysis. Construction industry and built environment levels of analysis and socio-economic considerations are underdeveloped. This situation is shown in Figure 4.9. In addition, it is noted that the 'response' knowledge and practice is geared towards the designer and contractor stakeholders. The demand-side role of the client in reducing consumption of non-renewable resources (a key stakeholder identified by the UK Delphi group) is not adequately considered.

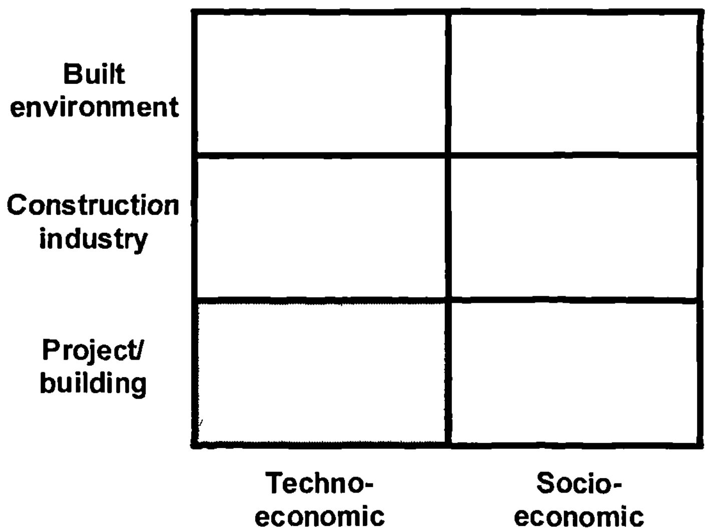
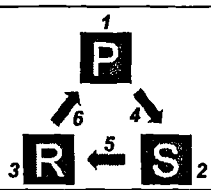


Figure 4.9.: Main focus of response methodologies to reduce consumption of non-renewable resources

Responses do resonate with the advocated definition of sustainable development, . but this view of sustainable development is found to be inadequate, in that too much emphasis is given to the economic and resource depletion aspects of sustainable development, with little focus on developing and integrating the social and cultural needs, and resource degradation issues.

Finally, the relationships between the pressures, states and responses pertaining to the reduction in consumption of non-renewable resources are inadequately identified, appropriate integrative indicators established, causal responsiveness measured and systemic implications identified and critically assessed (Dynamic PSR model Gaps 4, 5 and 6). Table 4.8. summarises the current position on the objective to reduce the consumption of non-renewable resources.

Table 4.8.: Summary of current position on non-renewable resource consumption

Issue / objective: Reduction consumption of non-renewable resources		***Stakeholder:*** Designers, contractors
Description of pressures Techno-economic pressures emphasised.	***Description of state*** Little discussion	***Description of response*** Fragmented responses focusing predominately on techno-economic considerations at a project level.
Gap 1 ***(in pressures)*** Detailed, systemic understanding of what pressures shape the scale and type of non-renewable resource consumption.	**Gap 2** ***(in state)*** Detailed understanding of the ability or motivation of relevant stakeholders to engage in resource reduction strategies.	**Gap 3** ***(in responses)*** Responses which address and integrate the social aspects of non-renewable resource consumption.
Gap 4 ***(barriers to understanding)*** Detailed, systemic understanding of *how* pressures shape the scale and type of non-renewable resource consumption in the built environment.	**Gap 5** ***(barriers to implementation)*** Detailed, systemic understanding of how changes in the level and type of non-renewable resource consumption influences the focus, design and implementation of responses.	**Gap 6** ***(barriers to effectiveness)*** Detailed, systemic understanding of how the outcomes from relevant responses shape underpinning non-renewable resource consumption pressures.
Overall commentary Knowledge and practice pertaining to reduction of consumption in non-renewable resources is not informed by an understanding of the pressures to use such resources and the present resource usage and reserves.		

4.5.4. Third priority objective: Reduce energy consumption in buildings

Dynamic PSR model Gap 1: Pressures, in terms of drivers for change

There is limited discussion in the literature reviewed on what the pressures for reducing energy consumption in building explicitly are. As with the pressures for the reduction of non-renewable resources (see Section 4.5.3.), pressures are generally discussed from an economic perspective; namely, that approximately ten percent of the global economy is dedicated to the creation, management and operation of the built environment[185], and that the energy consumption resulting from this activity accounts for between fifty-five percent[186] and sixty-five percent[187] of the total energy consumption of the global economy. The argument, as with non-renewable resources, is that even a modest improvement in energy efficiency can translate into significant enhancements in economic prosperity and environmental performance.

Appropriate indicators are not adequately established to measure the force and direction of the pressures related specifically to energy consumption, and systemic implications from such data are not identified, critically assessed, and used to inform/align responses to potentially changing pressures.

Dynamic PSR model Gap 2: States, in terms of the relevant stakeholders' level of understanding, willingness to act

The stakeholder identified in the literature as having primary responsibility for reducing energy consumption is the designer. This is only partially consistent with the findings presented for hypothesis 3, which identified stakeholders from both the supply side (designers) and the demand side (clients). The literature reviewed has little explicit discussion on the level of relevant stakeholders' understanding and willingness to act to reduce energy consumption. Stakeholders' motivation to act are usually framed from a cost benefit analysis

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[185] Roodman, D.M. & Lennssen, N., (1995), "A Building Revolution: How Ecology and Health Concerns are Transforming Construction", **Worldwatch Paper 124**, Worldwatch Institute: Washington, D.C.

[186] Bonini, C. & Anink, D., (1997), **Handbook of Sustainable Building**, James and James: London.

perspective, which is consistent with the economic pressures which are emphasised in Gap 1.

Appropriate 'state' indicators are not established to measure the ability and motivation of relevant stakeholders to act, and systemic implications from such data are not identified, critically assessed and used to guide appropriate responses to improve the level of understanding and stimulate motivation within relevant stakeholders to act.

Dynamic PSR model Gap 3: Responses, in terms of actions taken by relevant stakeholders

In the literature reviewed, the majority of the responses to reduce energy consumption in buildings tend to be technical in focus and are underpinned by an energy conservation principle: namely, to reduce 'input' energy into the building. This is considered consistent with the UK definition of sustainable development which is neo-classical in focus, and emphasises technical and economic considerations over social ones (see Section 4.2.3.).

The dominant response themes can be fruitfully categorised into construction site planning, passive solar design, insulation, alternative sources of energy, daylighting and energy-efficient equipment. Representative examples of these overlapping and interactive responses are given below.

Appropriate *site planning* allows the designer to make best use of natural resources. Strategies include:

- orientating buildings to take advantage of shade and airflows for cooling in summer, and passive solar energy for heating and wind protection in winter. Research has shown, for example, that the process of refreshment (increasing the air exchange rate during the unoccupied period of the night in order to eliminate the heat stored in the building mass during the day) was more conducive to some types of site configurations that others[188]. Similarly, the

[187] Vale, R. & Vale, B., (1991), **Towards a Green Architecture**, RIBA Publications: London.
[188] Douzane, O., Roucoult, J.M. & Langlet, T., (1998), "Natural Night Ventilation and Thermal Inertia", **CIB World Building Congress: Construction and the Environment – Symposium B:**

orientation and shape of the building was determined to have an effect on the thermal performance of fenestration[189].

- minimise solar shadows for southern orientations, through appropriate positioning of landscape areas, open spaces and so forth, to avoid cold spots.
- use of existing vegetation to moderate weather conditions through the provision of shade and transpiration in the summer and winter. Research in the United Kingdom, for example, indicates that planted roof systems deliver, amongst other things, the benefit of reducing external and internal building temperatures[190].

Passive solar design emphasises architectural design approaches that minimise building energy consumption by integrating conventional energy-efficient devices, such as mechanical and electric pumps, fans, lighting fixtures, and other equipment, with passive design elements, such as an efficient building envelope, appropriate amounts of fenestration, increased daylighting design and thermal mass. The passive solar design concept is summarised in the statement:

> *"... passive solar design balances all aspects of the energy use in a building: lighting, cooling, heating, and ventilation. It achieves this by combining, in a single concept, the use of renewable resources and conventional, energy-efficient strategies."*[191]

Research has indicated that passive solar buildings use forty-seven percent less energy than conventional buildings and sixty percent less than comparable older buildings[192].

Indoor Environment and Sustainable Development – Are they Compatible?, Gävle, Sweden, 7th – 12th June.

189 Tovil, A. & Özkan, E., (1998), "The Effects of Fenestration on the Thermal Performance of Retrofitted Residential Buildings in Istanbul", **CIB World Building Congress: Construction and the Environment – Symposium B: Indoor Environment and Sustainable Development – Are they Compatible?**, Gävle, Sweden, 7th – 12th June.

190 Murdoch, L., Fewkes, A., & O'Rouke, A., (2000), "The Performance of Planted Roof Systems in the UK", **Proceedings of the Millennium Conference - Cities and Sustainability: Sustaining Our Cultural Heritage**, Kandalma, Sri Lanka: 22nd –25th February.

191 Passive Solar Industries Council and National Renewable Energy Laboratory, (1997), **Designing Low Energy Buildings – Integrating Daylighting, Energy-efficient Equipment, and Passive Solar Strategies**, Passive Solar Industries Council and National Renewable Energy Laboratory: Washington, D.C. Page 10.

192 Passive Solar Industries Council and National Renewable Energy Laboratory, (1997), **Designing Low Energy Buildings – Integrating Daylighting, Energy-efficient Equipment, and**

Appropriate *insulation systems and technologies* reduce both the heating and cooling loads of a building, thus reducing energy consumption. This argument is emphasised in the observation that:

> *"... the majority of environmental burdens come from the energy use for heating of building spaces and water during the service life of the building. Based on this, the most important environmental property of a house is the U-value of the building envelope."*[193]

The retrofitting of houses with wall and roof insulation, for example, was found to reduce energy consumption by up to thirty-eight percent[194].

Daylighting is the practice of bringing light into a building interior in a more effective manner, thus reducing the need for artificial lighting[195]. Research findings indicate that electrical lighting accounts for approximately fifty percent of total energy consumption of a building, and that daylighting can reduce lighting energy consumption by between fifty and eighty percent[196]. Design solutions include the use of curved ceiling planes to distribute light into spaces and the incorporation of light shelves where appropriate to reflect light on to the ceiling, and then into the internal space[197].

Energy-efficient equipment and appliances can significantly reduce the energy consumption during the operational phase on a building's life cycle. Research has indicated, for example, that desiccant cooling technology for air conditioning, "...

Passive Solar Strategies, Passive Solar Industries Council and National Renewable Energy Laboratory: Washington, D.C. Page 2 and 7.

193 Häkkinen, T. & Saam, M., (1998), "Ecological Building Design", **Proceedings of the CIB World Building Congress: Construction and the Environment – Symposium A: Materials and Technologies for Sustainable Construction,** 7th – 12th June: Gävle, Sweden. Page 731.

194 Al-Ragom, F.A. & Al-Ghimlas, F., (1998), "Assessment of Energy Conservation Measures Suitable for Retrofitting Residential Buildings in Kuwait", **CIB World Building Congress: Construction and the Environment – Symposium B: Indoor Environment and Sustainable Development – Are they Compatible?**, Gävle, Sweden, 7th – 12th June.

195 Romm, J. & Browning, W., (1994), **Greening the Building and the Bottom Line: Increasing Productivity Through Energy-efficient Design**, Rocky Mountain Institute: Snowmass, Colorado.

196 McCluney, R., (1994), **The Case for Daylighting**, Solar Energy Centre: Cape Canaveral, Florida.

197 Hastings, S.R., (1994), **Passive Solar Commercial and Institutional Buildings: A Sourcebook of Examples and Design Insights**, Wiley & Sons: West Sussex.

can lead to significant savings in primary energy consumption and associated CO_2 emissions ....[198]"

Appropriate indicators are not established to measure the direction and uptake of responses to reduce energy consumption by relevant stakeholders, and systemic implications from such data are not identified, critically assessed and used to improve the design and/or delivery of appropriate responses.

Dynamic PSR model Gap 4: The relationship between Pressures and States – Barriers to understanding

In the literature reviewed there is patchy discussion on the barriers to understanding of the pressures from the relevant stakeholders. A notable exception is the strong argument that increases in energy efficiency may actually result in increased energy consumption[199]. This apparent paradox that as energy efficiency increases so does energy consumption is known as the Khuzzoom-Brookes postulate, which argues that an increase in energy efficiency lowers the unit cost of energy, thereby stimulating increased demand for energy[200].

Arguments of this nature suggest that there are real barriers to understanding, in that the literature appears to advocate solely technical solutions to energy consumption, without injecting responses with the needed social dimension to accommodate human behaviour. This position is emphasised in the following observation:

> *"... all we need to do is to implement the cost effective measures and watch energy consumption and carbon emissions fall in line with the technological improvements. It is, of course, not that simple. Many of the measures available have been known about for decades and their cost effectiveness well established, yet they are not applied in significant volume and although improvements have taken place, the pace of change is slow. The complexity of technological, economic*

198 Halliday, S.P. & Beggs, C.B., F., (1998), "The Potential for Solar Powered Desiccant Cooling", **CIB World Building Congress: Construction and the Environment – Symposium B: Indoor Environment and Sustainable Development – Are they Compatible?**, Gävle, Sweden, 7th – 12th June. Page 720.

199 Herring, H., (1990), **Does Energy Efficiency Save Energy: The Economists Debate: EERU Report No. 074**, The Open University: Milton Keynes, UK.

200 Sanders, H.D., (1992), "The Khazzoom-Brookes Postulate and Neoclassical Growth", **Energy Journal**, 13: 4: 131-148.

and social systems is great and there is no simple link between efficiency and consumption."[201]

This complexity, and the way there is a tendency to try and unravel it from a purely technical perspective, is stimulating commentators to move from framing and trying to solve energy problems in technical terms, towards a socio-technical perspective which considers the problem in a more holistic, people-orientated fashion[202].

Appropriate indicators to measure the level of understanding between pressures and states are not established, and systemic implications from such data are not identified, critically assessed and used to close gaps of understanding within relevant stakeholders.

Dynamic PSR model Gap 5: The relationship between States and Responses – Barriers to implementation

The barriers to implementation of energy consumption reduction responses are similar to those for non-renewable resources discussed earlier; namely, that any proposed solution must have demonstrable cost benefit. This economic imperative is emphasised in the steps needed to encourage the retrofitting of energy efficiency insulation:

> *"the retrofitting cases payback periods for the customer were over 30 years, which is very long. Therefore, the building owner must be encouraged to retrofit his building by offering initial cost subsidisation and restricting the renovation loan acceptance with a condition that the building owner must retrofit his building with the most suitable option for his building."*[203]

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[201] Bell, M. & Lowe, R.J., (1999), "Sustainability and the Development of an Energy Efficient Housing Stock: A Review of the Theoretical Issues", **Proceedings of the RICS Construction and Building Research Conference – The Challenge of Change: Construction and Buildings for the New Millennium**, Salford, UK: 1st – 2nd September. Page 193.

[202] Shove, E., (1998), "Gaps, Barriers and Conceptual Chasms: Theories of Technology Transfer and Energy in Buildings", **Energy Policy**, 26: 5: 1105-1112.

[203] Al-Ragom, F.A. & Al-Ghimlas, F., (1998), "Assessment of Energy Conservation Measures Suitable for Retrofitting Residential Buildings in Kuwait", **CIB World Building Congress: Construction and the Environment – Symposium B: Indoor Environment and Sustainable Development – Are they Compatible?**, Gävle, Sweden, 7th – 12th June. Page 1074.

Appropriate indicators to measure drivers/barriers are not established, and from such data systemic implications are not identified, critically assessed and used to improve the design and/or delivery of responses that both amplify the drivers and reduce/eliminate the barriers.

Dynamic PSR model Gap 6: The relationship between Responses and Pressures – barriers to effectiveness

There is a deficiency in the literature reviewed of comprehensive and longitudinal statistics and case studies to evaluate how effective energy consumption strategies actually are.

Appropriate indicators to measure the effectiveness of responses on reducing/eliminating pressures are not established, and systemic implications from such data are not identified, critically assessed, and capitalised on to further improve the design and/or delivery of appropriate responses which are more effective.

Summary

The pressures to reduce the energy consumption in buildings (*Dynamic PSR model* Gap 1) are not adequately identified, appropriate indicators established, trends measured and systemic implications identified and critically assessed.

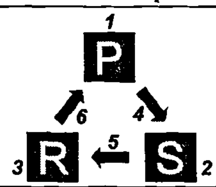
The level of energy usage consumed at built environment, construction industry and building units of analysis (*Dynamic PSR model* Gap 2) are not sufficiently identified, appropriate indicators established, quantities/types measured and systemic implications identified and critically assessed.

Responses to the reduction of energy consumption in buildings (*Dynamic PSR model* Gap 3) focus predominantly on better design information through life cycle assessment methodologies measuring energy usage at a building level. To a lesser extent, methodologies to assess energy usage for housing stock were discussed. In addition, it is noted that the 'response' knowledge and practice is geared towards the designer stakeholder. The demand-side role of the client in reducing energy consumption in buildings (a key stakeholder identified by the UK Delphi group) is not considered.

Responses do consistently resonate with the advocated definition of sustainable development, but this view of sustainable development is found to be inadequate in that it has been noted that although there is a substantial body of technologies and processes to reduce energy consumption, this information has had a marginal effect on design activity. In particular, too much emphasis is given to the economic and resource depletion aspects of sustainability, with little focus on developing and integrating the social and cultural needs, and resource degradation issues.

Finally, the relationship between the pressures, states and responses pertaining to the reduction in energy consumption in buildings is inadequately identified, appropriate integrative indicators established, causal responsiveness measured and systemic implications identified and critically assessed (*Dynamic PSR model* Gaps 4, 5 and 6). Table 4.9. summarises the current position on the objective of reducing energy consumption in buildings.

Table 4.9.: Summary of current position on energy consumption reduction in buildings

Issue / objective: Reduce energy consumption in buildings		*Stakeholder:* Designers
Description of pressures Techno-economic focus.	*Description of state* Little explicit discussion.	*Description of response* Fragmented technically-focused life cycle assessment methodologies and construction technology solutions
Gap 1 *(in pressures)* Detailed, systemic understanding of *what* interactive social, economic and technological pressures shape energy consumption patterns and levels in buildings.	Gap 2 *(in state)* Detailed understanding of the ability or motivation of relevant stakeholders to engage in energy consumption reduction strategies.	Gap 3 *(in responses)* Responses which address and integrate the social aspects of energy consumption in buildings.
Gap 4 *(barriers to understanding)* Detailed, systemic understanding of *how* pressures shape energy consumption patterns and levels in buildings.	Gap 5 *(barriers to implementation)* Detailed, systemic understanding of how changes in the pattern and level of energy consumption in buildings shapes the focus, design and implementation of responses.	Gap 6 *(barriers to effectiveness)* Detailed, systemic understanding of how the outcomes from energy consumption reduction in buildings responses shape the underpinning social, economic and environmental pressures.
Overall commentary The issue of energy reduction is predominantly considered from a technical perspective at the building level.		

4.5.5. Comment on hypothesis H4 and link to hypothesis H5

The key generic findings from the analysis of the current approaches to the three priority objectives to progress sustainable built environments and construction activity using the *Dynamic PSR model* are shown in Figure 4.10., and are described below:

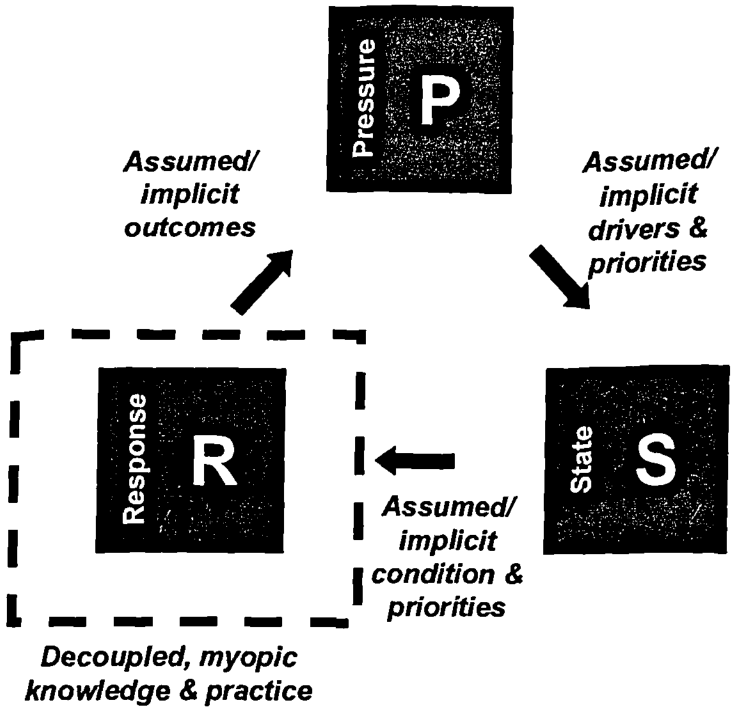


Figure 4.10. Current approach to the three priority objectives to progress sustainable built environments and construction activity

- Current knowledge and practice is focused on responses which are seriously decoupled from a systemic understanding of pressures and states. Rather, they are informed and guided by assumed or vaguely implied economic, social and environmental pressures shaping (and being shaped by) the built environment; and on the economic, social and environmental conditions or states of the built environment. This lack of causal understanding can generate responses which unwittingly amplify unwanted pressures or deplete or degrade desired states.
- Responses are being directed at a range of (generally technological) issues which are not directed, integrated and prioritised by clearly defined sustainable development national policies and plans which are shaped by articulated definitions of sustainable development. This lack of direction manifests itself in a myriad of disjointed, myopic initiatives. Again, this lack of uniform, integrated action can generate responses which address inappropriate issues and/or are in conflict with each other.

The findings presented to test Hypothesis 4 substantially support the argument that in the case of the three priority areas identified in Section 4.3., stakeholders' objectives and activities are not sufficiently integrated to progress stable and significant sustainable development. The analyses made clear that, despite the fact these are very familiar areas in which a large volume of work has been done, the work tends to be focused mainly in only one area of the model, typically the "response" part. As a consequence of other aspects being ignored, the causal links between the areas do not get explicit treatment either. As a result local action is often recommended without an explicit strategic context, or any certainty that the desired environmental impact will actually result. The idea of "thinking globally and acting locally" is far from being achieved.

It is contended that the findings of Hypothesis 4 (rather than from the general sustainable development literature) indicate that the top three priority objectives are treated from a neo-classical position, whose emphasis on technology and economics encourages the fragmented, unbalanced bodies of knowledge found. The implication of this argument is that where a sustainable development objective is approached from a more ecological view of sustainable development (see Section 4.2.), the body of knowledge will be characterised by a greater degree of systemic integration, allowing a more progressive, significant and balanced sustainable development to take place. This is the focus of the next hypothesis discussed in the following section.

4.6. Hypothesis 5: Efforts to progress objectives that are contextualised in an ecological view of sustainable development will be characterised by systemically linked pressures, states and responses, and will lead to progressive, significant and balanced sustainable development.

4.6.1. Introduction

The focus of this hypothesis is to test whether sustainable development objectives that are contextualised in an ecological view of sustainable development will be characterised as a systemically integrated body of knowledge, and will lead to progressive, significant and balanced sustainable development.

The objective of bringing about sustainable urban development has been identified in the literature as usefully testing the arguments contained in this hypothesis, and will be discussed below.

4.6.2. Sustainable urban development

Dynamic PSR model Gap 1: Pressures, in terms of drivers for change

The key 'umbrella' pressure on sustainable urban development featuring in the literature reviewed is that of urbanisation. As discussed in Section 4.3.2., urbanisation is an increasing pervasive force, with the percentage of the world's population living in cities and towns swelling from an estimated thirty-eight percent in 1975 to forty-five percent in 1995, and projected to rise to fifty-four percent in 2015[204]. The potential economic and social advantages of urbanisation are significant and well established. It has been argued, for example, that:

> *"... cities have always played a privileged role as centers of cultural and economic activity. From their earliest origins, cities have exhibited a conspicuous capacity both to generate culture in the form of art, ideas, styles and attitudes, and to induce high levels of economic innovation and growth."*[205]

Increasingly, however, the onerous burden which cities place on the natural environment is being appreciated. The Brundtland Commission indicates that cities "... account for a high share of the world's resource use, energy consumption and environmental pollution ..." and that they "... draw their resources and energy from distant lands with enormous aggregate impacts on those lands.[206]" The adverse environmental impacts of cities has been analogised, for example, by the suggestion that:

> *".. every city is an ecological black hole drawing on the material resources and productivity of a vast and scattered hinterland many times the size of itself."* [207]

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[204] United Nations, (1996), **World Urbanization Prospects: The 1996 Revision**, United Nations: New York.

[205] Scott, A.J., (1997), "The Cultural Economy of Cities", **International Journal of Urban and Regional Research**, 21: 2: 323-340. Page 323.

[206] World Commission on Environment and Development, (1987), **Our Common Future**, Oxford University Press: Oxford. Page 241.

[207] Roseland, M., (1992), **Toward Sustainable Communities: A Resource Book for Municipal and Local Governments**, Alger Press. Page 21.

Appropriate indicators to measure the force and direction are established at an international level, and are used to inform and align responses to changing contextual pressures[208]. Urban environmental quality indicators, for example, focus on such issues as the degree of urbanisation (measured through percentage of population living in cities with more than one million inhabitants) and the quality of urban air, drinking water, ambient surface and ground water[209]. These indicator sets are increasingly being used by individual nations, culminating in national environmental performance reviews which monitor, amongst other areas, urban quality. Such data are being critically assessed, and are being used to inform/align responses to any changes in contextual pressures. The literature acknowledges that there is still a substantial way to go with the development of urban sustainability indicators generally[210], but it does appear that there is general consensus on the broad focus and scope required[211].

Dynamic PSR model Gap 2: States, in terms of the relevant stakeholders' level of understanding, willingness to act

There is a real appreciation in the literature that the broad range of pressures impinging on the urban environment, and the social contexts which shape, and are shaped by, urban environments, require that a correspondingly broad range of stakeholders need to be involved and have shared understanding and ownership of the myriad of issues. The stakeholders identified in the literature for bringing about urban sustainability are usefully summarised in Table 4.2. (see Section 4.4.2.).

In reality, however, the focus in the literature is predominantly on national and local government stakeholders. For example, there is significant discussion on the

[208] Organisation for Economic Co-operation and Development, (1997), **Better Understanding Our Cities: The Role of Urban Indicators**, Organisation for Economic Co-operation and Development: Paris.
[209] Organisation for Economic Co-operation and Development, (1993), **OECD Core Set of Indicators for Environmental Performance Reviews: A Synthesise Report by the Group on the State of the Environment: Environment Monograph No. 83**, Organisation for Economic Co-operation and Development: Paris.
[210] Lombardi, P. & Basden, A., (1997), "Environmental Sustainability and Information Systems", **Systems Practice**, 10: 4: 473-489.
[211] Organisation for Economic Co-operation and Development, (1997), **Better Understanding Our Cities: The Role of Urban Indicators**, Organisation for Economic Co-operation and Development: Paris.

level of relevant national governments' understanding and willingness to act with respect to urban sustainable development. The OECD State of the Environment reporting gives a clear indication at a national level that the issue of urban sustainability is being addressed in a systemic way. Similarly, at local government levels, the development and implementation of Local Agenda 21 plans is demonstration of the ability and willingness to act (see Section 4.3.2. Objective 14).

Appropriate indicators are not, however, being adequately established to measure the ability and motivation of the wide range of stakeholders to act, and systemic implications from such data are not identified, critically assessed and used to close gaps in understanding, and to stimulate the motivation of these stakeholders.

Dynamic PSR model Gap 3: Responses, in terms of actions taken by relevant stakeholders

In the context of this expanding urbanisation and associated environmental, social and economic pressures on the environment, there has been, and is, considerable international discussion on the required focus and action to bring about sustainable urban development[212]. The resultant agendas for change from these internationally based and owned discussions can be summarised in the assertion that urban sustainable development concerns:

> *"... the continuing maintenance, adaptation, renewal, and development of a city's physical structure and systems and its economic base in such a way as to enable it to provide a satisfactory human environment with minimal adverse effects on the natural environment."*[213]

Further, the responses to urban sustainable development can be usefully grouped into the six sustainable urban development principles developed in Habitat II[214]:

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212 For example, United Nations Conference on Environment and Development, (1992), **Agenda 21**, UNCED: Rio de Janeiro: 3rd – 14th June.; United Nations Centre for Human Settlement, (1996), **Habitat Agenda**, Istabal.

213 Richardson, N., (1992), "Canada", in R. Stren, R. White and J. Whitney, (Eds.), **Sustainable Cities: Urbanization and the Environment in International Perspective**, Westview Press: Boulder. Page 148.

214 United Nations Centre for Human Settlement, (1996), **Habitat Agenda II**, Istabal.

- The institutional dimension of urban development (enabling strategies, subsidiarity, human rights etc.)
- The cultural dimension of urban development (the need to appreciate and accommodate culture etc.)
- The ethical dimension of urban development (the need to eliminate poverty, unemployment etc.)
- The environmental dimension of urban development (resource consumption etc.)
- The economic dimension of urban development (eco-industry etc.)
- The spiritual dimension of urban development (The promotion of a different relationship between spiritual development and material development etc.)

The 'top-down' pressures of the international agendas for sustainable urban development (see Section 4.5.2.), combined with an ecological worldview interpretation of sustainable development - which emphasises environmental, economic, technological and social dimensions appears to provide a robust and integrating focus for the body of research concentrating on urban sustainability.

Responses to the *institutional* dimension of urban sustainable development in the literature focus on strategies to achieve social determination where "... locally identified needs are addressed through locally determined strategies.[215]" The concept of self-determination is viewed as requiring greater community involvement and participation in decision-making[216]. Organisational frameworks to guide and facilitate participation and consultation between stakeholders form a significant research focus[217]. In addition, technological tools to facilitate participation are offered in the literature. Virtual reality technologies, for

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[215] Wismer, S., (1990), "Planning for Sustainable Development: A Community-based Approach", **Unpublished PhD Thesis**, University of Waterloo: Waterloo. Page 32.

[216] For example, see Brandon, P.S., Lombardi, P. & Bentivegna, V., (Eds.), ***Evaluation of the* Built Environment for Sustainability**, Chapman & Hall: London.

[217] For example, see Iyer-Ranigal, U. & Treloar, G., (2000), "Participative Management Techniques for Sustainable Development", **Proceedings of the Millennium Conference - Cities and Sustainability: Sustaining Our Cultural Heritage**, Kandalma, Sri Lanka: 22nd –25th February.

example, are being harnessed to improve communication and participation in the urban planning process[218].

The need to preserve and develop the *cultural* dimension of urban development is a focal and recurring element in the literature. The United Nations Convention Concerning the Protection of the World Cultural and Natural Heritage highlight, for example, that natural and cultural capital are complementary[219]; with the Habitat Agenda stressing the importance of the cultural, scientific, symbolic, spiritual and religious value of cultural heritage[220]; and Local Agenda 21 emphasises the need to value and protect local distinctiveness[221]. Strategies are proposed, for example, that are geared towards integrating and emphasising topography and other features which are unique to an urban settlement[222]. Similarly, conservation strategies are being articulated, with building conservation being defined as the "... process which leads to the prolongation of the life of cultural property ... for its utilisation now and in the future.[223]"

Responses to the *ethical* dimension of urban sustainable development tend to focus on the interrelated issues of equity and accessibility, which advocate that urban settlements should be characterised by an equality of access by people of all ages and in all economic levels with varying life styles, physical abilities, racial background, cultural heritage and religious preference[224]. Indeed, it is argued that the ethical health of urban settlements rests on the ability of an urban settlement "... to satisfy divergent needs ....[225]"

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218 Hamilton, A. & Fernando, T., (2000), "Participation in Urban Planning: A Visual Approach", **Proceedings of the Millennium Conference - Cities and Sustainability: Sustaining Our Cultural Heritage,** Kandalma, Sri Lanka: 22nd –25th February.
219 United Nations Educational, Scientific and Cultural Organization, (1972), **Convention Concerning the Protection of the World Cultural and Natural Heritage,** United Nations Educational, Scientific and Cultural Organization: Paris.
220 United Nations Centre for Human Settlement, (1996), **Habitat Agenda,** Istabal.
221 Council of European Municipalities and Regions, (1997), **Local Agenda 21: Basic Guide,** Council of European Municipalities and Regions: Brussels
222 Giddings, R.D., (2000), "Sustaining Cultural Heritage of City Centre Buildings in Northern Europe", **Proceedings of the Millennium Conference - Cities and Sustainability: Sustaining Our Cultural Heritage,** Kandalma, Sri Lanka: 22nd –25th February.
223 Fielden, B., (1994), **Conservation of Historic Buildings,** Butterworth: Oxford. Page vii.
224 von Eckardt, W., (1978), **Back to the Drawing Board! Planning Livable Cities,** New Republic Books: Washington, D.C.

Responses to the *environmental* dimension of urban sustainable development predominantly focus on resource depletion and degradation issues. The literature is at its weakest here, in that it draws upon the type of fragmented strategies and issues highlighted in the discussion of the 'reduce non-renewable resources consumption' priority objective (see Section 4.3.2.). This literature tends to focus on individual buildings, and the utility and application of these ideas and methodologies for urban settlements is not discussed or demonstrated to any meaningful depth. Research into 'compact' cities (high density cities), although embryonic, appears to be a potentially useful way of bridging 'micro' resource efficient buildings, with 'macro' urban settlement considerations.

The *economic* dimension of urban development is a key emphasis in the property management orientated literature, with efforts being made to mesh neoclassical ideas and methodologies with sustainable development. This need, and the ongoing journey, is embodied in the argument that:

> *"... economic analysis of the financial benefits of 'green design' is critical to the environmental push. Nevertheless, such analysis remains in an embryonic state in terms of quantification and economic evaluation .... The next stage ... is the development of robust and effective quantitative techniques and tools that will provide economically reliable financial forecasts of the net benefits of green design."*[226]

The adaptation and use of discounted techniques in the evaluation and appraisal of land use, building obsolescence and building depreciation is being developed within the context of urban settlements[227].

Technology is also being applied to assist in the economic aspects of urban sustainability with, for example, IT-enabled simulations that "...model economic,

[225] Calthorpe, P., (1986), "The Urban Context", in S. van der Ryn & P. Calthorpe, (Eds,), **Sustainable Communities**, Sierra Club: San Francisco. Page 9.
[226] Smith, P.V., (2000), "Ecologically Sustainable Development and Facility Economics: The Critical Connection", **Proceedings of the Millennium Conference - Cities and Sustainability: Sustaining Our Cultural Heritage**, Kandalma, Sri Lanka: 22nd –25th February. Section 4, Page 90.
[227] Deakin, M., (1995), "An Economic Evaluation and Appraisal of the Effects Land Use, Building Obsolescence and Depreciation have on the Environment of Cities", **Proceedings of the**

environmental and social factors of life .... so that the regeneration can be analysed and projections into the future can be made, which will inform planning and policy making" [228]; and sustainable community development modelling discussions which draw attention to the problem of too much reliance on the economic aspects of urban planning[229].

The *spiritual* dimension of urban development is developed in the literature, with commentators asserting that there is a need "... to arrive at an integrative state of well-being in both ecosystem and human terms.[230]" Though ecosystem health is requisite for urban sustainability, so is the satisfaction of human needs and aspirations since urban settlements arose in order to fulfil many of these needs. This argument is embodied in the observation that there are essential connections in the urban environment:

> *"... between urban space design and forms of public and social life; between building use and the presence of persons on streets and squares; between aesthetic qualities of architecture and the attention and interest of city dwellers in their environments, between the form of the city's public places and city dweller's social, emotional and physical well-being ..."*[231]

Appropriate indicators are established for a variety of responses, but are deficient in the area of resource depletion and degradation. On the whole, national and local governments are identifying systemic implications from these indicators, and are using them to improve the design and/or delivery of appropriate responses.

International Workshop on the Environmental Impact Evaluation of Buildings and Cities for Sustainability, Florence, Italy: 13th – 15th September.

[228] Hamilton, A., Curwell, S. & Davies, T., (1998), "A Simulation of the Urban Environment in Salford", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden, 7th – 12th June.

[229] Deakin, M. & Hine, J., (1998), "Modelling Sustainable Community Development in Edinburgh's South East Wedge", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden, 7th – 12th June.

[230] Pell, D. & Wismer, S., (1990), **Social Implications of a Sustainable City**, Development Initiatives Inc.: Guelph.

Dynamic PSR model Gap 4: The relationship between Pressures and States – Barriers to understanding

The leading international agendas for urban sustainable development, in particular that Habitat and Agenda 21 agendas, provide a fruitful focus and framework for debate, negotiation, mediation and consensus building. Collectively, this fertile environment is stimulating better, and shared, understanding of the relationships between the pressures and states.

The Korean national government, for example, adopted and adapted the Habitat II agenda as an integrated approach to the design and operation of sustainable human settlements[232]. This agenda is complemented by discussions on the economic, environmental, social, cultural, political and institutional pressures for sustainability[233]; and future scenario development which indicate "... the kind of cities and settlements which will be developed .. "[234]

Finally, Agenda 21-informed, and internationally accepted guidance on the relationship between the pressures, states and responses pertaining to sustainable urban settlements is given in the Habitat II agenda. This agenda (in unison with other influential agendas for urban settlements[235]) provides powerful, systemic sustainability indicators.

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231 Lennard, S.C. & Lennard, H.L., (1987), **Livable Cities People and Places: Social and Design Principles for the Future of the City**, Centre of Urban Well-being: New York. Page 3-4.

232 Leė, K.I., (1998), "The Direction of Policies and Systems for the Development of Sustainable Human Settlements in Korea", **CIB World Building Congress: Construction and the Environment – Symposium C: Legal and Procurement Practices – Right for Environment**, Gävle, Sweden, 7th – 12th June.

233 Lewis, T.M., (1998), "The Concept and Context of Sustainable Development in the Caribbean", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden, 7th – 12th June.; Baba, K., (1998), "Necessity of common Understanding of Sustainability in Construction in Asia", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden, 7th – 12th June.

234 Bourdeau, L., Huovila, P. & Lanting, R., (1998), "Sustainable Development and the Future of Construction, a CIB W82 Project", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden, 7th – 12th June.

235 European Commission, (1994), **The Aalborg Charter of European Cities and Towns Towards Sustainability**, European Commission; Council of European Municipalities and Regions, (1997), **Local Agenda 21 Guide**, CEMR: Brussels.; United Nations Conference on Human Settlements, (1994), **Report of the Expert Group Meeting on Urban Indicators for Country Reporting (Habitat II)**, UNCHS: Geneva.

Dynamic PSR model Gap 5: The relationship between States and Responses – Barriers to implementation

The barriers to implementation in the literature reviewed generally focus on two areas: the intrinsic physical nature of the urban environment and the social aspects of implementation.

The literature identified the temporal tension between policy aspirations for sustainable urban development, and the longer time spans which are embedded in the physical artefacts of the built environment. This issue is explored in the observation that:

> "... *[the difficulty of achieving sustainable development is] compounded by other factors ... [including] ... the longevity of buildings and city infrastructure – 60 to 100 years is not unusual for individual buildings.*"[236]

The need for effective management of the social aspects of the required change and innovation for sustainable urban development is emphasised in the literature. It is argued, for example, that participation is also directly linked with equity; and that many urban development programmes, although initiated on the basis of consultation and participation of all stakeholders, fail to monitor equity aspects. This results in urban development management and benefits being usurped by elite sections of the community and in the majority losing interest[237].

Appropriate indicators to measure drivers/barriers for the 'outputs' of the implementation are established, but not so much the 'process' of implementation (for example, participation in the urban planning process). The systemic implications from the 'output' data are generally critically assessed, and used to improve the design and/or delivery of strategies that both amplify the drivers, and reduce/eliminate the barriers.

[236] Curwell, S., (2000), "Building Environmental Quality Evaluation Through Time: Towards Sustainable Urban Development – The Work of BEQUEST Network in Europe", **Proceedings of the Millennium Conference - Cities and Sustainability: Sustaining Our Cultural Heritage,** Kandalma, Sri Lanka: 22nd –25th February. Section 4, Page 82.

[237] Shah, P., (1994), "Institutional Participation", **Proceedings of the Workshop on Strategies for Sustainability,** IUCN General Assembly: Buenos Aires.

Dynamic PSR model Gap 6: The relationship between Responses and Pressures – barriers to effectiveness

There is a considerable body of comprehensive, longitudinal statistics and case studies (usually as part of the Local Agenda 21 process) to support (or invalidate) the sustainable urban development strategies being pursued. This data is used to identify systemic implications and to improve the design and/or delivery of responses which are more effective.

Summary

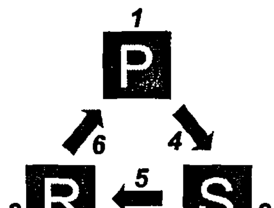
The pressures to bring about sustainable urban development are adequately identified, and embrace and integrate environmental, social and economic dimensions which are more consistent with a more ecological worldview of sustainable development (*Dynamic PRS model* Gap 1).

The understanding and willingness of relevant stakeholders to act is stimulated and enabled by nested international and national focuses and frameworks. The roles of national and local government stakeholders are emphasised over the other myriad of stakeholders involved in sustainable urban development (*Dynamic PRS model* Gap 2).

The systemic flow from a firm, systemic understanding of the pressures, along with comprehensive and meaningful data sets of statistics and case studies, allows responses offered to be meaningfully integrated and focused, although technology responses are still fragmented and at an inappropriate, individual building level of resolution (*Dynamic PRS model* Gap 3).

Finally, the international and national frameworks offer robust guidance on the relationship between the pressures, states and responses pertaining to sustainable urban development (*Dynamic PRS model* Gaps 4, 5 and 6). Table 4.10. summarises the current position of the objective of sustainable urban development.

Table 4.10.: Summary of current position on sustainable urban settlements

Issue / objective: Sustainable urban development		***Stakeholder:*** Wide variety of stakeholders, but emphasis on national and local governments
Description of pressures Detailed discussion of the social, economic and social pressures shaping sustainable urban settlements.	***Description of state*** Detailed sustainability indicators for urban settlements contained within Habitat II and associated agendas.	***Description of response*** Range of responses addressing and integrating social, economic and environmental aspects of sustainable urban settlements.
Gap 1 ***(in pressures)*** Further development and honing.	**Gap 2** ***(in state)*** Further development and interpretation to meet the particular characteristics and needs of UK urban settlements.	**Gap 3** ***(in responses)*** Further integration of different levels of resolution, in particular with respect to technological solutions for resource depletion and degradation issues. For example, how urban settlement responses inform and integrate responses to achieve sustainable buildings and sustainable building components.
Gap 4 ***(barriers to understanding)*** Detailed, systemic understanding of *how* pressures shape urban settlement configuration and scale.	**Gap 5** ***(barriers to implementation)*** Detailed, systemic understanding of how changes in the configuration and scale of urban settlements shape the focus, design and implementation of relevant responses.	**Gap 6** ***(barriers to effectiveness)*** Detailed, systemic understanding of how the outcomes from sustainable urban settlement responses shape the underpinning social, economic and environmental pressures.
Overall commentary The issue of sustainable urban development is fairly comprehensively and systemically addressed at the planning level, but does not adequately engage with the lower levels of resolution, such as the building and the building component units of analysis.		

4.6.2. Comment on hypothesis H5

The findings presented to test Hypothesis 5 substantially support the argument that sustainable development objectives which have the benefit of being contextualised within an ecological worldview will be characterised by a greater degree of systemic integration of pressures, states and responses. This allows a more progressive, significant and balanced sustainable development to take place –

which is being particularly evidenced by the integrating focus of Local Agenda 21 initiatives. Important gaps were still identified, however, in particular the deficiency in systemic technology responses at an urban settlement level of resolution (*Dynamic PSR model* Gap 3).

4.7. Summary and link

This chapter has presented key findings from the built environment and construction research literature to test the hypotheses developed in Chapter 2, using the appropriate research methodology set out in Chapter 3. The next, and final, chapter summarises this research, and draws implications from the study for both general, and built environment and construction activity theory, and for built environment and construction activity practice.

5. Conclusions

5.1. Introduction

The aim of this chapter is to summarise the findings of this research. Conclusions for each of the hypotheses and the overall research problem are set out. Lessons and recommendations are given for both the general sustainable development domain, and more specifically for built environment and construction activity. Lastly, possible future research trajectories are articulated.

5.2. Conclusions about each research hypothesis

5.2.1. Hypothesis 1: Built environment and construction industry stakeholders' conceptualisation of sustainable development will be different, and will result in distinctive, potentially conflicting, focuses

In general, the literature is conspicuously devoid of the need to locate stakeholders' strategies and actions with the context of their worldviews (see Section 4.2.2.) Relevant findings, however (see Section 4.2.3.), substantially support the first hypothesis part of the hypothesis; namely, that stakeholders do possess distinctive 'worldviews.' The findings, however, do not support the second part of the hypothesis; that is, that these distinctive worldviews will result in different, potentially conflicting focuses. Indeed, the findings suggest that there is the potential for significant overlap in focus between stakeholder positions.

The 'worldview' argument developed from the literature (see Section 2.5.) suggested that where there is a significant degree of difference between stakeholders' perception of the meaning of sustainable development, there will be correspondingly different ranking by the stakeholders of the most (and least) important priority areas to progress sustainable built environments and construction activity. This is the focus of the Hypothesis 2.

5.2.2. Hypothesis 2: Stakeholders involved in the built environment and construction industry who do not share similar worldviews on sustainable development will identify and prioritise different key sustainable development objectives

The research literature offers a variety of objectives to progress sustainable built environments and construction activity. However, such objectives tend not to be prioritised or weighted, potentially stifling focused, integrated strategies and activities (see Section 4.3.2.) Literature which did address the hypothesis did not support the hypothesis, and thus were discordant with the prevailing position of the literature (see Section 2.5.). The findings demonstrated considerable similarity between the national and international Delphi panels, and therefore implied consensus in the *prioritisation of objectives to progress sustainable development* (see Table 4.2.)

In commenting on hypothesis 2 (see Section 4.3.3.) it was contended that the apparent contradiction between the espoused 'worldview' of the international Delphi panel, and its prioritisation of 'technical-orientated' objectives over 'social-orientated' objectives, might well exist not so much because the social-orientated' objectives were not important, but because the stakeholders within the built environment and the construction industry were not perceived to be the right stakeholders (in terms of influence over the relevant decision-making arenas and resources) to progress these objectives. This argument resonated strongly with Hypothesis 3.

5.2.3. Hypothesis 3: Stakeholders who are involved in the built environment and construction industry will have varying degrees of responsibility for progressing particular sustainable development objectives

The literature was found to support the hypothesis that stakeholders within the built environment and construction activity do have varying degrees of responsibility for progressing particular sustainable development objectives (see Section 4.4.).

The Delphi study findings identified three prioritised objectives to progress sustainable development, and linked them to the key stakeholders with responsibility for them. The focus of Hypothesis 4 was to use the Dynamic PSR model to investigate the proposed efforts (contained within the relevant built environment and construction industry research literature) to progress these objectives.

5.2.4. Hypothesis 4: Efforts to progress sustainable development objectives which do not adequately link pressures, states and responses in a systemic fashion will be unbalanced and fragmented

The findings presented to test Hypothesis 4 substantially support the argument, in the case of the three priority areas identified in Section 4.3., that research efforts are not sufficiently integrated to support the progress of stable and significant sustainable development. The analyses made clear that, despite the fact these are very familiar areas in which a large volume of work has been done, the work tended to be focused mainly in only one area of the model, typically the "response" part. As a consequence of other aspects being ignored, the causal links between the areas do not get explicit treatment either. As a result local action is often recommended without an explicit strategic context, or any certainty that the desired environmental impact will actually result. The Agenda 21 idea of "thinking globally and acting local" is far from being achieved.

It is contended that the top three priority objectives are treated from a neo-classical position, whose emphasis on technology and economics encourages the fragmented, unbalanced bodies of knowledge found. The implication of this argument is that where a sustainable development is objective approached from a more ecological view of sustainable development (see Section 4.2.), the body of knowledge will be characterised by a greater degree of systemic integration, allowing a more progressive, significant and balanced sustainable development to take place. This is the focus of Hypothesis 5.

5.2.5. Hypothesis 5: Efforts to progress objectives which are contextualised in an ecological view of sustainable development will be characterised by systemically linked pressures, states and responses, and will lead to progressive, significant and balanced sustainable development

Hypothesis 5 very much came in response to the findings of Hypothesis 4, rather than from the literature. The purpose of Hypothesis 5 was to further test and Hypothesis 4 by demonstrating that where there is an appropriate understanding of the context, and a clear, integrating focus, the body of research knowledge would be more balanced and integrated.

The findings presented to test Hypothesis 5 substantially support the argument that the objective of sustainable urban development, in this case, which has the benefit of being contextualised within an ecological worldview is characterised by a greater degree of systemic integration of pressures, states and responses. This has allowed a more progressive, significant and balanced sustainable development to take place – which is being particularly evidenced by the integrating focus of Local Agenda 21 initiatives. Important gaps were still identified, however, in particular the deficiency in systemic technology responses at an urban settlement level of resolution (*Dynamic PSR model* Gap 3).

5.3. Conclusions about the research problem

The research problem which formed the starting point of this study (see Section 1.2.) was that although there was a considerable body of knowledge on sustainable issues in the built environment and construction activity, this research is unfocused, fragmented and developed from particular, potentially conflicting or restricted, research perspectives or 'worldviews.'

The findings from this thesis generally validated this concern in the three key areas investigated (see Section 4.5.), and have clarified key problems being experienced because of it. Figure 5.1. directs and synthesises the findings for Hypotheses 1 to 4 in support of this statement.

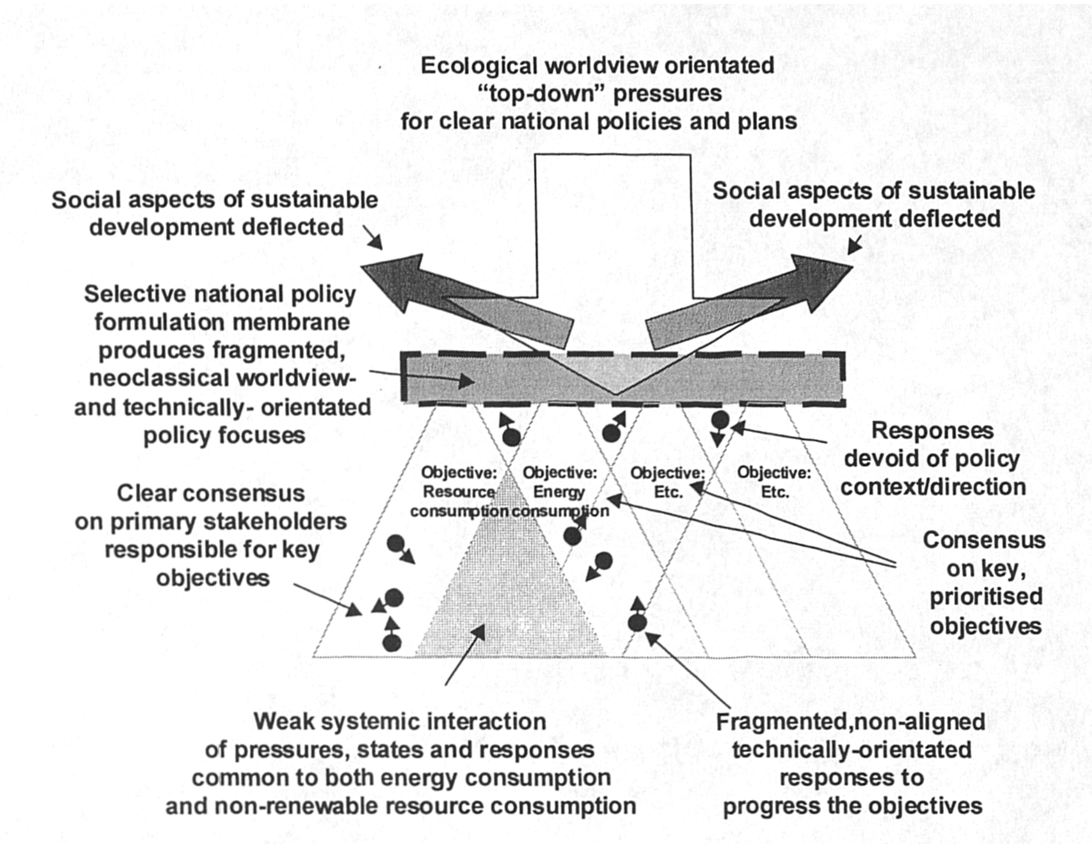


Figure 5.1.: Current state of built environment and construction activity body of knowledge addressing key sustainable development issues

Starting off at the top of the diagram:

- The espoused integrating focus for the body of knowledge was viewed as the call for "top-down" pressures via clear national plans and policies (see Section 4.5.2.). These pressures took the form of generally ecological worldview orientated international bodies and research agendas (see Section 4.5.2.). The need for clear national policies and plans was identified as a prioritised objective (see Section 4.3.2.).
- These pressures were interpreted and filtered through selective national policy membranes. The social aspects of sustainable development tended to be filtered or 'deflected', leaving the policies and plans neoclassical worldview in orientation, fragmented and technically focused (see Section 4.5.2.)
- Along with the need for clear national policies and plans, the need to reduce the consumption of non-renewable resources and reduce energy consumption in buildings were identified as prioritised objectives, receiving consensus support from the two Delphi panels (see Section 4.3.2.). Further, the responsibility for

delivering these objectives were clearly linked to primary stakeholders (see Section 4.4.2.).

- The lack of balanced, integrating focus was viewed as resulting in responses which were not adequately meshed in with appropriate pressures and hence were fragmented, non-aligned to each other, and technically orientated (see Section 4.5.3., 4.5.4. and 4.5.5.).
- Objectives tended to be treated in isolation, rather than appreciating and promoting systemic interaction of pressures, states and responses common to both energy consumption and non-renewable resource consumption (see Section 4.5.3., 4.5.4. and 4.5.5.).

In contrast, Hypothesis 5 demonstrated the benefits of efforts which are focused and integrated. Figure 5.2. presents this situation for sustainable urban development.

Starting off at the top of the diagram:

- The integrating focus for the body of knowledge was viewed as the "top-down" pressures for sustainable urban development. These pressures took the form of generally ecological worldview orientated international bodies and research agendas.
- These pressures were interpreted and filtered through selective national and local government membranes. The broader social, economic and environmental dimensions of sustainable development were captured to create appropriate, integrating focuses.
- The balanced, integrating focus was viewed as resulting in responses which were adequately meshed in with appropriate pressures and hence were more comprehensive in their coverage of the issues, cohesive and addressed social, environmental and economic aspects of sustainable development.

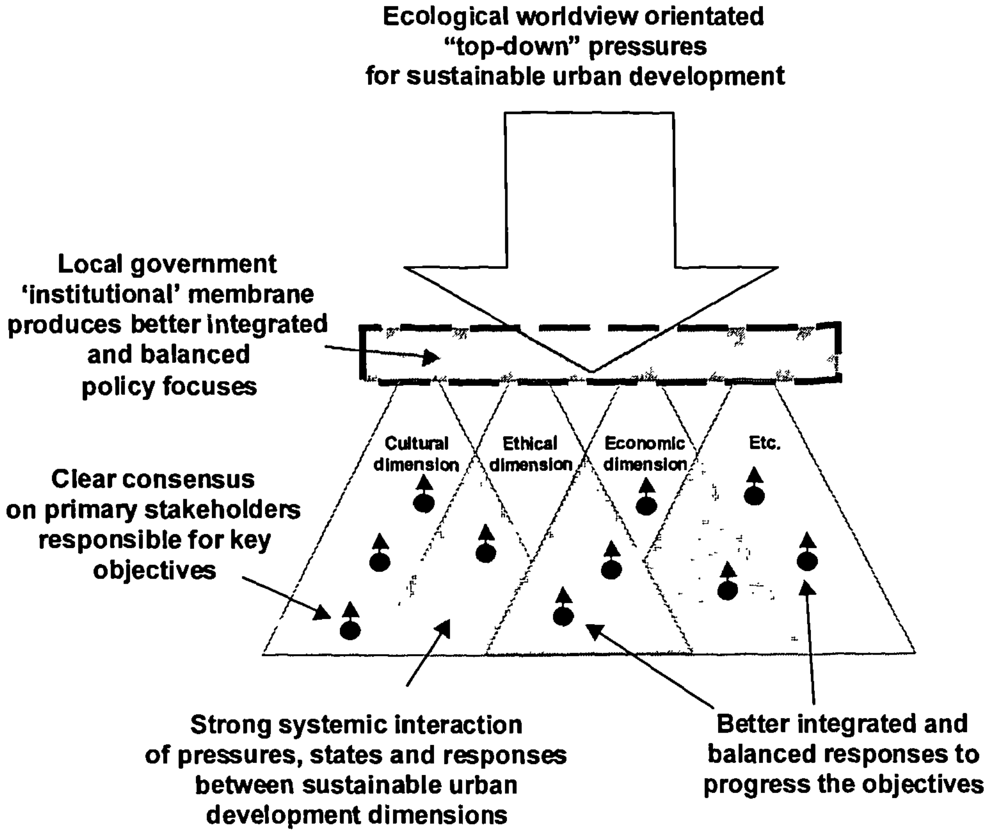


Figure 5.2.: Current state of built environment and construction activity body of knowledge addressing sustainable urban development issues

- Efforts to progress the various dimensions of sustainable urban development (cultural, ethical, economic, spiritual, etc.), were viewed as appreciating and promoting systemic interaction of pressures, states and responses common to these dimensions.

It can be seen that there is a significant contrast between the unfocused and fragmented bodies of knowledge for the top three key objectives to progress sustainable development identified by the Delphi panels, and the more focused and integrated body of knowledge to support sustainable urban development. The point here is that the *key objectives* are not being addressed adequately; while sustainable urban development, an objective which is being addressed more adequately, is not perceived as a key objective. Indeed, urbanisation, which is closely linked to sustainable urban development, attracted the least support as a key objective by the Delphi panels (see Table 4.2.).

Thus, the predominantly unfocused and fragmented research agenda and resultant body of knowledge demonstrates that at best, interactions between different bodies of knowledge supporting particular objectives only occur at the margins or are restricted to specialised, environmentally orientated subdisciplines at the margins of these bodies of knowledge. There is a real need to generate dynamic, prioritised research agendas that focus and integrate knowledge, and include at its core the needs and constraints imposed by sustainable development. This need, along with other lessons and recommendations, is discussed in the following sections.

5.4. General sustainable development lessons and recommendations

5.4.1. Introduction

The precise interpretation and operationalisation of sustainable development was described in Section 2.4.1. as being:

> *"... at once vague and complex, stimulating, "... a wide range of potential definitions which can be used to support divergent objectives" directed at envisioning what to sustain and what to develop."*

The findings of this study do not fully support the "interpretation" of sustainable development problems articulated in the general sustainable development literature. Conclusions from Hypothesis 1 suggest that there is the potential for significant overlap in focus between stakeholder positions; while Hypothesis 2 and 3 demonstrate strong consensus on what the key objectives to progress sustainable built environments and construction activity should be, and which stakeholders should have primary responsibility for them. The findings do support, however, the difficulty in "operationalisation" of sustainable development, with Hypothesis 4 revealing the unfocused and fragmented body of knowledge to progress these key objectives through the stakeholders identified.

The key recommendations which can be fed back into the general sustainable development arena thus focus on the clarification and linkage between the interpretation and operationalisation dimensions of sustainable development.

5.4.2. Dynamic, prioritised research agenda development framework

This study has developed and utilised the *Holographic Dynamic PSR model* to critically evaluate the focus and integration of the bodies of knowledge which support sustainable built environments and construction activity. This process employed in this study is considered sufficiently robust to provide a generic framework for developing dynamic, prioritised research agendas in other areas of activity, and is shown diagrammatically in Figure 5.3[1]. The framework will be discussed by working through the steps.

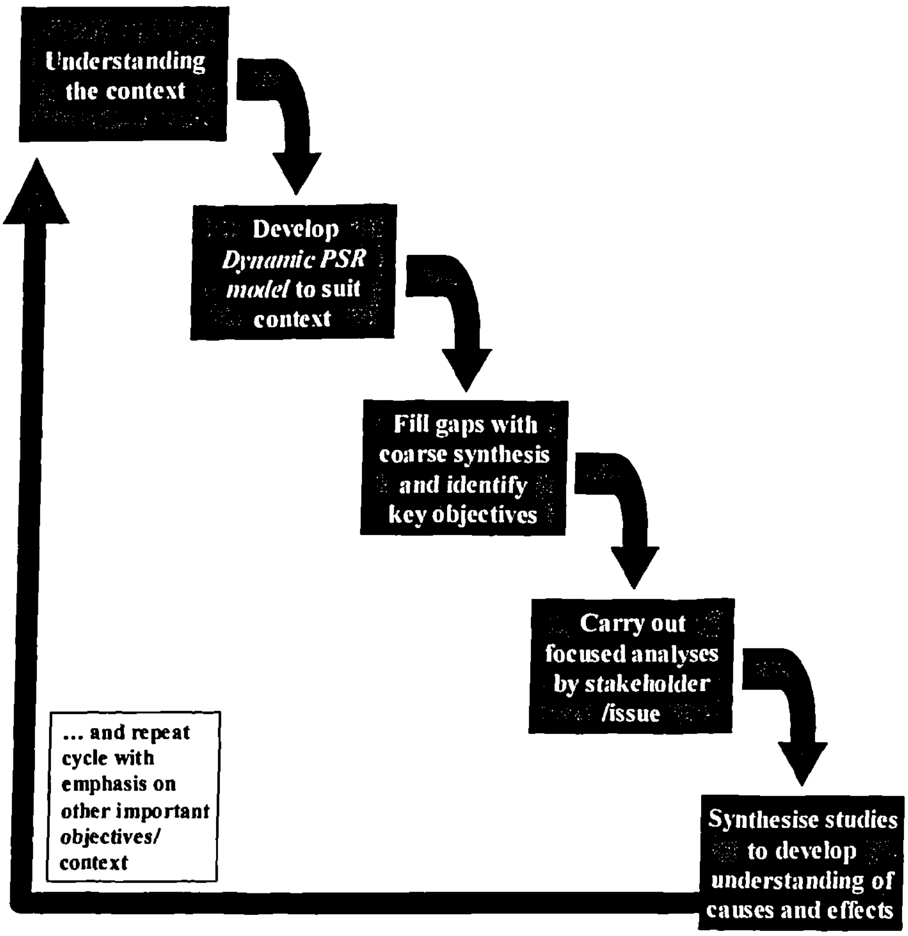


Figure 5.3.: Proposed generic framework for developing dynamic, prioritised research agendas

[1] Adapted from Barrett, P.S., Sexton, M.G. & Green, L., (1998), **Integrated Delivery Systems for Sustainable Construction: Unpublished report for the Construction Sponsorship Directorate, Department of Environment Transport and the Regions,** DETR: London. Page iv.

Step 1: Understand the context

Research agendas need to provide integrating focus for research efforts. Key stakeholders need to first of all make explicit their worldviews and their perceptions of what sustainable development means, in order to provide the discourse of shared terms and language that is required for fruitful analysis, debate, negotiation and problem-solving to occur.

It should be stressed that the clear focus advocated here should not be equated with a heavy, prescriptive 'top-down' strategy; but rather a 'soft focus' approach which embraces and emphasises the commonality between stakeholder views. This allows inclusive, integrating direction, with the flexibility to be interpreted and internalised by stakeholders to reflect their particular worldview. In effect, the 'soft focus' style encourages and facilitates a synergistic mutual crafting of 'top-down' integrating visions and 'bottom-up' interpretation, fleshing out and progression of that vision.

This approach is entirely consistent with the *Holographic Dynamic PSR model* (see Section 2.7.) which:

> *"... provides an explicit link with the ever changing environmental, economic and social context to provide sustainable development with a 'reality' with its intrinsic multi-dimensional, multi-causal, mutually implicated and constantly changing knowledge base."*

Step 2: Develop *Dynamic PSR model* to suit context

The next step is to develop the *Dynamic PSR model* to provide a robust, common analytical framework characterised by the capability to create a continuous learning cycle.

This model enables explicit action to bring together the work on sustainable development, and firmly locate it in the broad context established in Step 1, providing a real sense of direction. The practical tool given in Table 2.6. enables a gap analysis to be carried out, making both the issue and the stakeholder explicit at a given level of resolution, providing a way to overcome the fragmentation found in the literature synthesis.

Step 3: Fill gaps with coarse synthesis and identify key objectives

There are many other objectives, but to make progress it is important to concentrate somewhere to start with. In any event, any objectives identified are likely to be so systemic in nature that they are likely to lead to many connected areas. Thus, the proposal is that a coarse synthesis should be carried out to map the state of knowledge about the objectives in all three areas of the model, namely pressure, state and response. At this stage differences in perspectives would not be worried about, but a powerful effort would be made to identify systemic indicators. It is very possible that gaps in knowledge around the *Dynamic PSR Model* will be found and work to fill these should be instituted.

Step 4: Carry out focused analyses for stakeholder/issue

Given a broad overview of the state of the art in the chosen areas, and the identification of systemic indicators, the third step is to carry out focussed analyses taking the particular views of the key stakeholders. This would involve a particular study for each relevant stakeholder for each topic. Using the same model from multiple directions emphasises the holographic nature of the framework (see Section 2.6.). These studies would each investigate the whole *Dynamic PSR model.* As they are consistent in the viewpoint they hold, they can and will include analyses of the linkages between the parts, namely Gaps 4, 5 and 6 of the model. Impacts of alternatives would be assessed using the agreed systemic indicators.

Step 5: Synthesis studies to develop understanding of causes and effects

These studies will then open up a wholly new opportunity in the fourth step, namely to synthesize several studies on the same topic using a common, broad framework, with an explicit focus on causal links, but studied from the different points of view of the key stakeholders. This will enable each of the areas to be much better understood and, by comparison across the findings in the identified priority objectives, generic lessons will be exposed. This is consistent with the holographic notion of the broader *Holographic Dynamic PSR model* (see Section 2.7.) which "... allows sustainable development to be considered from a range of possible stakeholder and issue perspectives..." but still be located in, and infused with, the broader systemically characterised sustainable development landscape.

Step 6: Feeding lessons forward

At this point the lessons learnt will be fed into a renewed investigation and understanding of the changing context (Step 1). Further, the lessons learnt will inform that *Dynamic PSR Model* in two ways. First, the structure of the model will be reassessed having been rigorously tested by the five steps described above. It is not expected that significant change in the broad framework will emerge, but an open mind in principle is necessary. Development of the model is more likely to occur in the second way, namely in terms of filling in the detail. This will involve: clarification of the boundaries between parts of the model, clearer classification of the generic aspects of each area and an elaboration of the nature of the linkages between the parts.

Second and subsequent rounds

Having completed a full cycle, the strength of the process is that it starts again, supported by an increased understanding of the framework and the reality it seeks to reflect, and reinvigorated by the selection of new objectives (which are going to emerge due to the systemic nature of sustainable development) to provide focus. This resonates strongly with the holographic nature of the overall *Holographic Dynamic PSR model* (see Section 2.7.) in that this 'learning-to-learn' dynamic stimulates and enables the research agenda development framework "... to learn by its own experience, and to modify its structure and design to reflect what it has learned."

It should be emphasised that the framework should be viewed as a generic framework, rather than a 'unifying' framework. Thus, the conflict between a unifying framework and the plurality of theoretical and methodological approaches need not necessarily arise. On the contrary, the generic framework can even promote and strengthen methodological pluralism, by structuring a wide range of questions and suggesting stimulating new methodological and theoretical accesses. In this way, the proposed framework has real utility in guiding and shaping research agendas towards the required transdisciplinary modes of enquiry needed to significantly progress sustainable development.

The proposed framework was developed and used in a study focused on sustainable built environments and construction activity, and it is to this specific area that the next section turns.

5.5. Specific built environments and construction activity lessons and recommendations

5.5.1. Introduction

The key lesson generated from this study, as discussed in Section 5.3., is that the body of knowledge supporting the progression of sustainable built environments and construction activity is unfocused, fragmented and driven by particular research perspectives.

It is argued that there are:

- Nested definitions of sustainable development at national and international levels (see Section 4.2. Hypothesis 1) - in which context;
- Consensus key objectives (see Section 4.3. Hypothesis 2) and related stakeholders (see Section 4.4. Hypothesis 3) showing extraordinary consistency between national industry level and international environmental experts level – which provided the focus for;
- A literature synthesis using the *Dynamic PSR model*, showing that taken together the studies reported only partial coverage of the subject area and in addition the studies individually have variable and only implicit perspectives (see Section 4.5. Hypothesis 4) – this stimulated the need to demonstrate;
- The benefit of a more focused and integrated body of knowledge in supporting sustainable development objectives (see Section 4.6. Hypothesis 5).

It is this focused process of investigation in itself that forms a potentially useful contribution; namely, the dynamic, prioritised research agenda development framework, discussed in generic form in Section 5.4.2. The application of this framework for sustainable built environments and construction activity is presented in the next section.

5.5.2. Prioritised UK research agenda for sustainable built environments and construction activity

The proposed prioritised UK research agenda for sustainable built environments and construction activity follows the same steps as described in Section 5.4., and is shown in Figure 5.4.

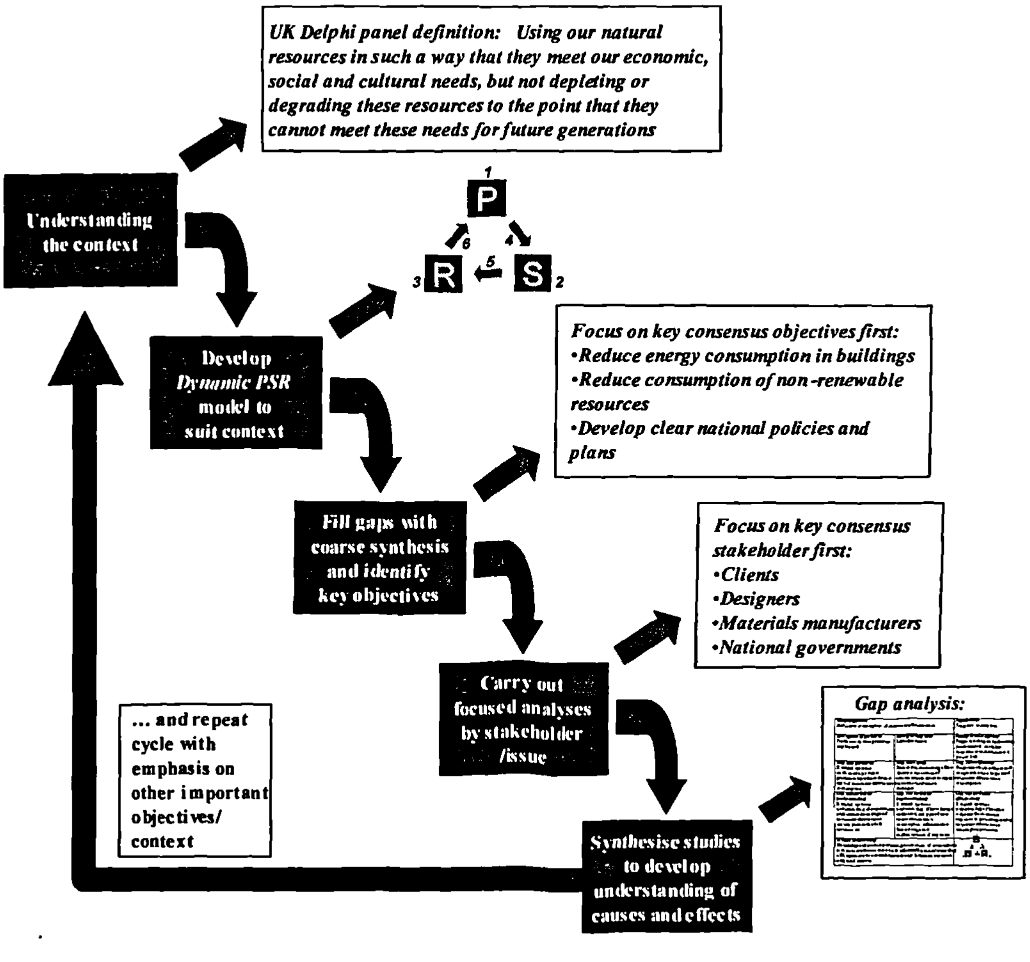


Figure 5.4. Proposed prioritised UK research agenda for sustainable built environments and construction activity

This prioritised agenda is underpinned by, and provides strongly developed consensus views on the nature of sustainable development for the built environment and construction activity, together with a broad improvement-orientated model. The consensus view of sustainable development is considered to be sufficiently 'soft focused' in nature (see Section 5.4. Step 1) to encourage stakeholders from the 'bottom-up' to positively support its progression from their particular perspectives; but still be adequately distinctive to give clear, 'top-down' integrating direction.

The consensus view and improvement-orientated model is infused with carefully identified priorities to give an iterative agenda for action. The *Dynamic PSR model* proved its utility in highlighting gaps in research scope and dynamics. More importantly, it provides a clear indication of where additional research effort should be focused. This could be in terms of new work or making efforts to integrate the work from relevant disciplines. There are some initiatives to support the latter at present, but if progress is to be made a strong effort is needed to provide a transdisciplinary response to a multifaceted issue. Simply expecting existing disciplines to provide the breadth of experience and thinking needed is very unlikely to work.

However, it is also apparent that, because of the secondary data sources used, it is not always possible at this stage to fix the stakeholder view taken and so, to some extent, the level of analysis. This leads to some residual raggedness in the analyses and has implications for future uses of the model, described next.

Much of the potential for the proposed research agenda is as a design tool for managed research programmes, research projects, programmes, networks and events. Filling gaps is one thing, but creating projects or events that are well balanced, but focus on a specific stakeholder perspective and/or issue is offered as a powerful way forward. If a managed programme of studies, for example, maintained a fixed issue approached from a variety of stakeholder positions and a wide portfolio of research disciplines, a synthesis of these studies providing transdisciplinary, multiple stakeholder perspectives of a particular issue will be achievable. This approach can also be seen to have great potential for the design of events and networks. In addition, the systemic, integrating focus of the dynamic research agenda framework could be usefully applied to the development of not only more effective environmental regulation (that address pressures, states and responses), but also to the creation of regulations which can be more easily combined with other issues (such as health and safety, and quality) to deliver integrated management systems[2].

Overall, the dynamic, prioritised research agenda, and its underpinning development and continuous improvement process, allows gaps in existing well-worked areas to be identified, it enables disparate work to be brought together synergistically within a generic framework and it can provide a robust design tool to create balanced research programmes, projects and events.

This study has approached the articulated research problem from a particular perspective, but the opportunity cost is that the problem was not approached from a different angle:

> *"Use a different lens and you see different things; you ask different questions, you find different answers. What you see through any lens is in fact there, although it is never all that there is. It's important to remember, whatever lens you use, that it lets you see some things, but it prevents you from seeing others."*[3]

Using the approach presented in this thesis has allowed for certain issues to be explored, yet there is certainly more to the research problem articulated in Section 1.3. In the next section, ideas for further research are presented.

5.6. Further research

With respect to the quote which ends the previous section, further research can be seen as one of two classes – that which enhances this study with the same lens or that which enhances this study with a different lens. A few areas with potential from each category are introduced in this section.

From the same perspective as this thesis, the following is listed as an area for further research:

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[2] For example, see Barrett, P.S. & Sexton, M.G., (1995), "Integrated Management Systems", **Proceedings of the COBRA '95 RICS Construction Research Conference**, Edinburgh: 8th – 9th September.

[3] Meadows, D., (1996), "Who Causes Environmental Pollution", **ISEE Newsletter**, 6: 3: 1-8. Page 8.

- Iterations of the research agenda framework utilising secondary data sources would be useful in testing and developing the framework further, and focusing and integrating the bodies of knowledge which support and progress identified key objectives.
- Use of the research agenda framework in non-sustainable development domains of the built environment and construction activity field using secondary data sources would be useful in producing prioritised research agenda for other issues, and would further test the generic robustness of the framework.

When examined with a different lens than in this thesis, sustainable built environments and construction activity have many avenues with fruitful potential. The following areas for further research which utilise primary data are listed.

- Use of the *Holographic Dynamic PSR model* to investigate and integrate findings from primary data. For example, fixing a key objective (say, the reduction of energy consumption in buildings), and looking at this issue from a number of case studies from different stakeholder perspectives (say, clients, designers, etc.). Similarly, a stakeholder position could be fixed (say, the designer), and a case study or action research approach could be usefully employed to see how the stakeholder addresses a range of key objectives.
- Cross-industry comparisons using the *Holographic Dynamic PSR model* could potentially crystallise best practice and novel solutions which could be adapted and transferred in the built environment and construction industry. Similarly, cross-country comparisons of fixed stakeholder or issue positions could yield interesting insights and sharing of knowledge and best practice. The CIB research network, for example, would be an appropriate vehicle to progress this type of research.

In the next section, the thesis is related to Section 1.1., in which the sustainability of current trajectories of human activity was brought into question. The role of this thesis in altering the trajectory of built environments and construction activity is examined.

5.7. Final comments

Section 1.1. located this research in the global concern that current trajectories of human activity (in which the built environment and construction activity is a significant contributor), are unsustainable; in that they are exceeding the carrying capacity of the Earth's resource base, and that the resultant waste and pollution streams are exceeding the Earth's assimilative capacity.

The focus of this study was to contribute to the challenge of guiding and shaping the bodies of research knowledge to adequately support and progress sustainable built environments and construction activity. The findings from this research have revealed that these bodies of knowledge tend to be unfocused and fragmented. In consequence, sustainable development in this area is being addressed in an unbalanced, suboptimal fashion. This study, however, has found common ground which contributed to the sustainable development challenge by proposing a robust, prioritised UK research agenda for sustainable built environments and construction activity characterised by transdisciplinary focus, integration and continuous improvement. Further, this research agenda development framework is sufficiently generic to be useful to sustainable development efforts in other areas of human activity.

Appendix A: Summary of the aims and research methodology of the 'Integrated Delivery Systems for Sustainable Construction Project'

A.1. Project background and aims

The 'Integrated Delivery Systems for Sustainable Construction" (IDS) project was originally motivated by the Civil Engineering Research Foundation Conference on sustainability in construction, which set out thirty-eight recommendations for action and formed the basis for six projects[1]. The IDS project is one of those six, and was funded by the Department of Environment, Transport and the Regions in the United Kingdom and was adopted by the Couseil International du Bâtiment for ongoing development.

The project was supported by the Construction Sponsorship Directorate of the Department of Environment, Transport and the Regions' research programmes in the following areas[2]:

- To give a clear definition and understanding of sustainability and, in particular, in relation to construction industry best practice and innovation.
- To identify connections within construction and between construction and other environmental issues to include any benefits, synergies and possible linkages.
- In terms of construction, to recommend priority areas for future research in the sustainable development area.

The research was carried out in terms of, and in liaison with, the interests of the construction industry and includes an international dimension.

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[1] Civil Engineering Research Foundation, (1996), **Engineering and Construction for Sustainable Development in the Twenty-first Century: An International Research Symposium and Technology Showcase**, Washington, D.C.

[2] Construction Sponsorship Directorate of the Department of Environment Transport and the Regions, (1997), **Tender Specification Requirements for a Project to Advise on Sustainability**, Construction Sponsorship Directorate of the Department of Environment Transport and the Regions,: London.

A.2. Research methodology

A.2.1. Introduction

This section presents first an overview of the Delphi method as the main fieldwork approach used, a justification of its use, and a description of its application in this project.

A.2.2. The Delphi method

A.2.2.1. Description of Delphi method

The Delphi method is a technique to develop consensus within a group of people. Each member of the panel does not know the identity of the other panel members. The aim is to combine expert opinion, by facilitating the exchange of ideas and information but enabling each participant to have an equal input by preventing bias due to position, status or dominant personalities. As initial responses are made separately, new ideas may be introduced by individuals which other members of the panel have not previously considered. The aim of each round or iteration is to gradually produce / consolidate consensus within the panel, or at least identify significant areas of disagreement.

A.2.2.2. Justification for the methodology

The Delphi method was used because of its strengths in developing consensus on issues and its ability to draw together wide ranging expert opinion effectively and efficiently – a key requirements to accomplishing the research objectives within the time constraints set.

A.2.2.3. Composition of Delphi panels

Two Delphi panels were set up:

- A **national** panel of approximately twenty people from the UK construction industry representing key stakeholders throughout the construction supply chain.
- An **international** panel of approximately twenty people from a number of countries representing environmental expert opinion.

The quality of the results is highly dependent on the quality of the Delphi panels, both in terms of their standing and the energy devoted to the exercise. The panellists who took part are given in Tables A.1 and A.2. It should be apparent that they are very solid representatives of the national and international perspectives sought. From the evaluation exercise carried out at the end of the project, it is also clear that a high level of commitment and thought went into their responses. Thus, the research team is confident that the results represent important views that should be given due weight.

Table A.1. UK Delphi panel members

Panel member	Institution/Company	Firm size[3]	Principal business / focus
Tony Aindow	Owens Corning Building Products (UK) Ltd, St.Helens, Merseyside	Large	Manufacturer of glass fibre based material and products.
William Bordass	Bordass Associates, London	SME	Design practice focusing on heating, ventilation and air conditionings issues.
Peter Clegg	Fielden Clegg Design, Bath	SME	General architectural practice.
John Conaughton	Davis Langdon Consultancy, London	Large	Project managers for construction and property research.
Mike Downing	Trent Concrete Limited, Colwich, Nottingham	SME	Specialist pre-cast concrete design, manufacture and installer
Brian Edwards	Department of Architecture, University of Huddersfield	Not applicable	Academic specialising in architecture and sustainable development.
Ron German	Stanhope Properties plc, London	Large	Property development and estate management firm
Sandy Haliday	GAIA Research, Edinburgh, Scotland	SME	Professional consultancy specialising in renewable technologies, passive solar, benign materials and design guidance.
Frank Hennessy	Nuffield Hospitals, Surbiton	Large	Private health care group
Richard Lorch	Richard Lorch Associates, London	SME	Architecture practice.
Jan Masat	Taywood Engineering, Southall, Middlesex	Large	Professional consultancy specialising in construction processes, materials and structural performance.
John Maxwell	Barclays Property Holdings Ltd, Reading, Berkshire	Large	Professional service firm specialising in property and estate development and management.
Angus McIntosh	Richard Ellis, Leeds, West Yorkshire	Large	Professional service firm specialising in general and commercial surveying.
Bill Middleton	Parkman, Salford	SME	Professional consultancy specialising in civil engineering and structural design.
David Owen	Department of	Not	Academic specialising in facilities

[3] Key: Small to medium (SME): <250 staff; Large: >250 staff

	Construction Management and Engineering, University of Reading	applicable	management.
Darren Patterson	WSP Environmental Limited, Middlesbrough, Cleveland	Large	Professional service firm specialising in sustainability, environmental management systems and geotechnics.
David Robertson	Ernest Ireland Construction, Bath	Large	General contracting firm involved in all types of construction and property work.
Karen Sieracki	Kaspar Associates, London	SME	Professional service firm specialising in property management and investment.
Peter Smith	School of Environment and Development, Sheffield Hallam University	Not applicable	Academic specialising in sustainable construction
Richard Stebbing	Hunter and Partners Limited, Chichester, West Sussex	SME	Professional service firm specialising in building surveying.
Alan Taylor	Bovis Construction Limited, Harrow, Middlesex	Large	General contracting firm involved in all types of construction and property work.
Martin Wade	Currie & Brown, London	Large	Professional service firm specialising in project and cost management.
Bernard Williams	Bernard Williams Associates, Leeds, West Yorkshire	SME	Professional service firm specialising in facilities management and property management.

Table A.2. International Delphi panel members

Panel member	Institution/Company	Principal business / focus
George Ang	Government Building Agency, Netherlands	Deputy Director of Government Building Agency with, amongst others, responsibility of the biannual 'sustainable building action plan.'
Colin Davidson	Faculty of Management, University of Montreal, IF Research Corporation, Canada	Academic specialising in information and knowledge management in construction and property.
Luis Alves Dias	Department of Civil Engineering and Architecture, IST (Istituto Superior Tecnico), Lisbon, Portugal	Academic specialising in environmental engineering and technology.
F. de Troyer	Department of Architecture, Urban and Regional Planning, Catholic University of Leuven, Belgium	Academic specialising in sustainable architecture, city planning and physical planning
Ian Eilenberg	Construction Management Unit, RMIT (Royal Melbourne Institute of Technology), Australia	Academic specialising in best practice for sustainable construction.
Lena Hackzell	SBK (Svensk Byggtjänst), (The Swedish Building Centre), Stockholm, Sweden	Academic specialising in healthy buildings and sustainable construction.
Bob Hindle	African Centre for Strategic Studies in Construction, University of Cape Town, Republic of South Africa	Academic specialising in sustainable construction.

Brooke Hill	DAIS (Department of Administrative and Information Services), Australia	Public sector manager specialising in sustainable construction and urban environments
Maria Katavic	Department of Construction Management, University of Zagreb, Croatia	Academic specialising in building economics.
Stephen Kendal	School of Arts and Sciences, Marymount University, Virginia, USA	Academic specialising in open building implementation.
Charles Kibert	College of Design, Construction and Planning, University of Florida, USA	Academic specialising in sustainable construction.
Tapio Koivu	VTT - Valtion Teknillinen Tutkimuskeskus (Technical Research Centre of Finland), Finland	Research manager for a number of projects investigating issues across the construction and property industries.
Patrizia Lombardi	Casa Citta Department, Polytechnic of Turin, Italy	Academic specialising in sustainable architecture and urban planning
Mathijs. Prins	Department of Technology Management, Eindhoven University of Technology, Netherlands	Academic specialising in architectural management.
Steve Rowlinson	Department of Construction Management, University of Hong Kong	Academic specialising in procurement issues in the construction industry.
Bengt Rystedt	School of Technology, University College Gavle-Sandviken, Sweden	Academic specialising in sustainable construction
Aska Sarja	VTT - Valtion Teknillinen Tutkimuskeskus (Technical Research Centre of Finland), Finland	Academic specialising in systems building and environmental construction technologies.
Miguel Sattler	Department of Civil Enginnering, UFRGS (Universidade Federal do Rio Grande do Sul), Brazil	Academic specialising in sustainable architecture and urban planning.
Dik Spekkink	EGM Onderzoek BV, Amsterdam, Netherlands	Academic specialising in architectural management.
John Staus	BKH Consulting Engineers, Amsterdam, Netherlands	Professional service firm specialising in toxicology and geohydrology impact assessments

A.2.2.4. Delphi process

The research operated around a cyclical process of input, evaluation, synthesis and reevaluation. Input into each round consisted of a questionnaire developed by the University of Salford research team. The questionnaires were completed by the panellists. Data from the questionnaires was synthesised by the University of Salford research team before being fed back to the panellists for re-evaluation, together with the new input for the current round. In this way, consensus was reached, providing a basis for progression to other issues. Panellists had two opportunities to respond to each of the issues: once during the initial input to the cycle and once during the re-evaluation stage. Figure A.1. shows the key research issues dealt with in the three rounds undertaken.

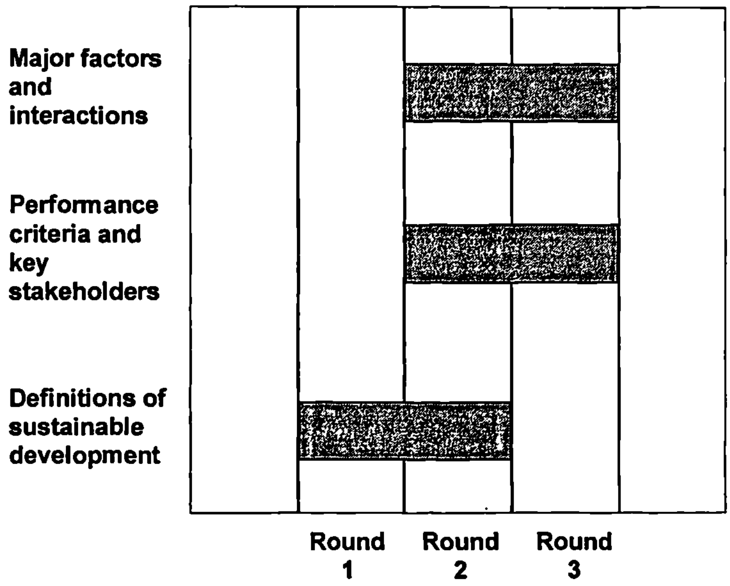

Figure A.1. Delphi research programme

A.2.2.5. Summary of iterations

The first iteration

The aim of the first iteration was to find consensus on a definition of sustainable development, and to identify and clarify the underlying rationale for preferred definitions.

Fourteen definitions were given in the first questionnaire. Panellists were asked to indicate their level of agreement with each of the definitions using a five point Likert scale. In the event of panellists demonstrating broad agreement or disagreement with the definitions, they were also asked to specify their three most favoured definitions and the one which they considered to be the least helpful to enable some refinement of the data to be achieved. Opportunity was provided for panellists to offer their own definition if they wished. The second section of the questionnaire required panellists to suggest general performance criteria which they considered to be important for progress towards sustainable development.

The second iteration

The analysis of data from the first round was used to reduce the fourteen original definitions of sustainable development to four for the national panel and five for the international panel. The concepts contained in these core definitions were used to construct a synthesised definition. This then allowed panellists to rank the synthesised definition alongside the most favoured definitions in the second round. Opportunity was also provided for the panellists to suggest modifications to the synthesised definition in order to improve its position in the ranking exercise and provide further indication of their perceptions of what the key issues were.

Part two of the questionnaire was based on the pressure / state / response (PSR) model. Panellists were provided with a list of eighteen performance objectives drawn from each of the categories in the PSR model. They were asked to rate the objectives.

The third iteration

Analysis of the second round data identified the front-running objectives and the overall most favoured definition. The analysis also included the construction of cognitive maps to identify the high leverage stakeholder/ objective relationships.

The third round questionnaire required panellists to reassess the listed objectives, and to indicate which were their three most favoured and single least favoured objective, and to rate their level of agreement with the stakeholders included in the cognitive map holding key responsibility for each of the objectives which they had been linked to.

A.3. Conclusion

The Delphi method has been briefly described and its use justified for the project. The process undertaken, along with a summary of each round was presented.

Appendix B: IDS Questionnaire 1 – UK Delphi Panel

INTEGRATED DELIVERY SYSTEMS FOR SUSTAINABLE CONSTRUCTION

THE IDS PROJECT

Further to my recent e-mail inviting you to participate in the IDS project, we are now starting the first iteration.

We have included you on a short list of thirty experts and hope you will be able to complete the following simple questionnaire.

If you have not yet had a chance to respond to our recent invitation we would still very much like you to be a part of this study.

Should you decide not to participate, however I would be grateful if you could confirm this.

With Compliments,

Peter S. Barrett

Delphi round 1:
DEFINITION OF SUSTAINABLE DEVELOPMENT

Introduction:

The purposes of this phase of the Delphi process are:
I) to begin to develop a consensus on a definition of sustainable development by seeking your views upon a variety of definitions;
II) to identify what in your view are the key performance measures of sustainable development.

Please paste the content of this file into your text editor, preferentially Word for Windows.
Use your text editor to introduce your answers and comments. Alternatively use the reply command on your e-mail programme.

Once you have finished answering the questionnaire please e-mail us the resulting file by 30/01/98.
The e-mail address is: idsuk@geocities.com

Should you have any difficulty e-mailing the file, please contact us for assistance on tel. +44.161.2953176 or fax the file to +44 161 295 3862.

This file is also included in the Web Site supporting the project.
You can find it at:
http://www.surveying.salford.ac.uk/idsuk/

The Web Site will be updated regularly, allowing the panellists to follow the progress of the project.

Panellist name:______________________________

____

I - Some definitions of sustainable development:

In the context of construction, seen as a change agent for the environment, please record your level of agreement (from strongly agree to strongly disagree) for each of the definitions given below.

Please indicate your choice by inserting an "x" next to your chosen level of agreement, e.g.:

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree X
e. Strongly Disagree

1. "Sustainable development - development that is likely to achieve lasting satisfaction of human needs and improvement of the quality of human life."

a. Strongly Agree
b. Agree

c. Neutral
d. Disagree
e. Strongly Disagree

2. "Using our natural resources in such a way that they meet our economic, social and cultural needs, but not depleting or degrading these resources to the point that they cannot meet these needs for future generations."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

3. "*In broad terms the concept of sustainable development* encompasses:

Help for the very poor because they are left with no option other than to destroy their environment;

The idea of *self-reliant development, within* natural resource constraints;

The idea of cost-effective development using different economic criteria to the traditional approach; that is to say development should not degrade environmental quality, nor should it reduce productivity in the long run;

The great issues of health control, appropriate technologies, food self-reliance, clean water and shelter for all;

The notion that people-centred initiatives are needed."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

4. "The creation and responsible maintenance of healthy built environment based on resource efficient and

ecological principles."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

5. "Human beings, in their quest for economic development and enjoyment of the riches of nature, must come to terms with the reality of resource limitation and the carrying capacities of ecosystems. For if the object of development is to provide for social and ecological welfare, the object of conservation is to ensure the Earth's capacity to sustain development and to support all life."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

6. "Sustainable development is concerned with:

The maintenance of a healthy economy, promoting quality of life and protecting human health and the environment, in which all pay the environmental costs of their decisions.

The optimal use of non-renewable resources.

The sustainable use of renewable resources.

Minimising damage to the carrying capacity of the environment."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

7. "In principle, … optimal (sustainable growth) policy would seek to maintain an "Acceptable" rate of growth in per-capita real incomes without depleting the national capital asset stock or the natural environment asset stock."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

8. "Improving the capacity to convert a constant level of physical resource use to the increased satisfaction of human needs."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

9. "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

10. "Managing economic development and human growth without destroying the life-support systems of our planet demands … a fundamental shift in values and public policy. We must aspire to be less wasteful of our natural and human resources, to place greater worth on the welfare of future generations, and to take pride in maintaining a healthy, productive Earth."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

11. "Sustainable development is one which appreciates that the Earth and its biosphere have their own intrinsic significance and value, and that human decision-making and action must have absolute respect for this."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

12. "A sustainable society is one that can persist over generations, one that is far-seeing enough, flexible enough, and wise enough not to undermine either its physical or social systems of support. In order to be socially sustainable, the combination of population, capital, and technology in the society would have to be configured so that the material living standard is adequate and secure for everyone. In order to be physically sustainable the society's material and energy throughputs would have to meet … three conditions: Its rates of use of renewable resources *do not exceed* their rates of regeneration; its rates of use of non-renewable resources do not exceed the rate at which sustainable renewable substitutes are developed; and its rate of pollution emission do not exceed the assimilative capacity of the environment."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

13." Sustainable development empowers individuals to adopt a lifestyle that conserves the natural system by balancing human use of resources with the rate at which these resources are replenished, so that the needs of future generations of all species are not compromised. "

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

14. "Global sustainability means the indefinite survival of the human species across all regions of the world [while ensuring] the persistence of all components of the biosphere, even those with no apparent benefit to humanity."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

15. If you feel that these definitions are inadequate please give your own definition of sustainable development below (if you are quoting a definition please include details on the source):

____
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In the context of construction, seen as a change agent for the environment, please indicate the numbers of the quotations that constitute in your opinion the best three definitions of sustainable development.
Please rank them in order of preference and indicate the reasons for your selection.

First definition: No. ___
Reasons for selection:__________________________
____
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Second definition: No. ___
Reasons for selection:__________________________
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Third definition: No. ___
Reasons for selection:______________________________

In the context of construction, seen as a change agent for the environment, which of the above definitions in your opinion is the least helpful.
Please give the reasons for your selection.

Definition: No. ___
Reasons for selection:__________________________

Note: the sources of the above definitions will be supplied at a later stage.
This takes into account that indication of provenance may bias the evaluation.

II - General measures

Irrespective of the way you scored the individual definitions, please list what you feel the key performance measures of sustainable development should be.

Thank you very much for completing this questionnaire.
Please return it to idsuk@geocities.com
Following the receipt and synthesis of the responses to the first iteration, the panellists will receive feedback, which will form the basis for the next round.

Appendix C: IDS Questionnaire 2 – UK Delphi Panel

INTEGRATED DELIVERY SYSTEMS FOR SUSTAINABLE CONSTRUCTION

National Delphi Round 2:
SUSTAINABLE DEVELOPMENT: PERFORMANCE OBJECTIVES AND MEASURES

Introduction

The purposes of the second round of the Delphi process are:

- To further define a consensus on a definition of sustainable development by seeking your views on the definitions which attracted the most support from Round 1;
- To develop a consensus on performance objectives and measures by seeking your views on a range of proposed objectives.

The first six pages of this document contain the second questionnaire and explanatory notes. The remainder (Appendix A) consists of a feedback report on the findings of the first round. We strongly advise that you read the Round 1 feedback report before completing the questionnaire.

In view of the technical difficulties experienced associated with e-mailing questionnaires and responses, following completion of this questionnaire please either e-mail us the resulting file or alternatively, fax your response to us by Friday 13/03/98. In the event that you decide to fax your response, please could you complete the questionnaire in black ink. The fax number is +44.161.2953233. The attached file is MS Word 6.

Should you have any difficulty faxing us, please contact us for assistance on tel. +44.161.2953176

The project is supported by a Web Site which will be updated regularly, allowing the panellists to follow the progress of the project. You can find it at: http://www.surveying.salford.ac.uk/idsin/

Panellist name:__________________________
Panellist institution / firm:______________________

I) Core definitions of sustainable development: re-evaluation

The aim of this section of the questionnaire is to obtain data relating to the re-evaluation of the core definitions and a synthesised definition, in the light of the quantitative and qualitative responses gained during the first round.

The two definitions attracting the most support from the national panel were:

Definition No. 2

"Using our natural resources in such a way that they meet our economic, social and cultural needs, but not depleting or degrading these resources to the point that they cannot meet these needs for future generations."

Definition No. 4

"The creation and responsible maintenance of an healthy built environment based on resource efficient and ecological principles."

In addition to the above two definitions for which greatest levels of agreement was demonstrated by the panel, a further definition has been assembled from the component parts of the four core definitions which achieved the highest aggregate scores, in order to produce a synthesised definition representing the concepts which the national panel collectively considered to be important.

Synthesised definition:

"Sustainable development embraces ecological principles to balance present and future economic, social and cultural human and built environment needs with the ongoing security of resource stocks and minimisation of resource degradation"

Please could you complete the table below by ranking the definitions (1 – first choice, 2 – second choice and 3 – third choice).

Definition number	Ranking
Definition 2	
Definition 4	
Synthesised definition	

Please describe any modifications to the synthesised definition which would make it your first choice (or, if already your first choice, improve it).

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II) Some proposed performance objectives for sustainable development

Can you please complete the matrix below:

Column A lists a number of performance objectives. (Objectives are defined as a desired state of affairs which the relevant stakeholder is trying to bring about.) The objectives listed represent recurring key issues distilled from the relevant literature.

Please rate the relevance of each objective to accomplishing the kind of sustainable development described by the core definitions. Please record your rating in ***Column B*** and your views regarding which stakeholder (s) you feel have *key* responsibility for each objective in **Column C** using the following keys:

Column B			***Column C***
1	- Strongly agree	A	- International institutions
2	- Agree	B	- National government
3	- Neutral	C	- Local government
4	- Disagree	D	- Clients
5	- Strongly disagree	E	- Designers
		F	- Contractors
		G	- Material / component suppliers
		H	- Material / component manufacturers

For example, if you strongly agree that a given objective is relevant to achieving sustainable development, and that clients and local government are the key stakeholders, record "1" in column B and record "C" and "D" in column C.

If you feel that the objectives listed are inadequate please give your own performance objectives in the spaces provided. (Please note that in the second part of this section, you will be asked to identify and rank what you feel are the most important / relevant objectives, along with what you feel is the objective that least supports sustainable development.)

In ***Column D*** please suggest appropriate measures to monitor the performance level of each objective.

Column A Objective	Col. B Rate	Column C Relevant stakeholder (s)	Column D Relevant measure (s)
Example: ***Increase environmental taxes***	***2***	***B, C***	***Revenue generated from taxes***
1) Improve technology transfer from other industrial sectors			
2) Increase urbanisation			
3) Reduce consumption of non-renewable resources			
4) Reduce global warming			
5) Improve air quality			
6) Improve drinking water quality			
7) Improve quality of physical infrastructure			

Column A Objective	Col. B Rate	Column C Relevant stakeholder (s)	Column D Relevant measure (s)
Example: ***Increase environmental taxes***	*2*	***B, C***	***Revenue generated from taxes***
8) Reduce energy consumption in buildings			
9) Increase recyclable material content of buildings			
10) Increase level of individual disposable income			
11) Improve proximity of residential areas to places of employment, shopping, education and leisure			
12) Increase amount of time available to pursue leisure interests			
13) Develop clear national sustainability policy and plans			
14) Improve local government implementation of the principles set out in Agenda 21			
15) Improved land use planning			
16) Improve environmental performance of construction supply chains			
17) More widespread uptake of environmental management system accreditation for firms (e.g. IS0 14000)			
18) Greater prevalence of voluntary agreements between individuals (e.g. *car sharing*)			

Column A Objective	**Col. B Rate**	**Column C Relevant stakeholder. (s)**	**Column D Relevant measure (s)**
Example: Increase environmental taxes	*2*	*B, C*	*Revenue generated from taxes*
19) Your choice:			
20) Your choice:			
21) Your choice:			
22) Your choice:			
23) Your choice:			

In the context of construction, please indicate the numbers of the objectives that in your opinion are the most relevant for progress towards sustainable development. Please rank them in order of preference and indicate the reasons for your selection.

First objective: No. _____
Reasons for selection:

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Second objective: No. _____
Reasons for selection:

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Third objective: No. _____

Reasons for selection:

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In the context of construction, please indicate the objective that in your opinion is the least relevant for progress towards sustainable development. Please indicate the reasons for your selection.

First objective: No. _____
Reasons for selection:

____
____
____
____
____

Thank you very much for completing this questionnaire.
Please return it by fax to +44.161.2953233. Following the receipt and synthesis of the responses to the second iteration, the panellists will receive feedback, which will form the basis for third round.

Appendix D: IDS Questionnaire 3 – UK Delphi Panel

INTEGRATED DELIVERY SYSTEMS FOR SUSTAINABLE CONSTRUCTION

National Delphi Round 3:
SUSTAINABLE DEVELOPMENT: MAJOR FACTORS AND INTERACTIONS

Introduction
Due to the better than expected progress in the analysis, we anticipate only one further round after this one. Please respond promptly and stay with us for the final phase of this study - your input is greatly appreciated.

The purposes of the third round of the Delphi process are:

- To further define a consensus on performance objectives.
- To rate the relationships between the performance objectives and the key stakeholders

Before completing the questionnaire, we strongly advise that you read the Round 2 feedback report in Appendix A.
Only the first 5 pages of this document contain the third questionnaire and explanatory notes. The remainder (Appendix A) consists of the feedback report on the findings of the second round.

Following completion of the five pages of this questionnaire please either e-mail or alternatively, fax them to us by Wednesday 29/04/98. In the event that you decide to fax your response, please complete the questionnaire in black ink. The fax number is 0161.2953233. The attached file is in MS Word 6.0.

Should you have any difficulty responding, please contact us for assistance on tel. 0161.2953176

The project is supported by a Web Site, which will be updated regularly, allowing the panellists to follow the progress of the project. You can find it at: http://www.surveying.salford.ac.uk/idsuk/

Panellist name:____________________________
Panellist institution / firm:______________________

Part I - Some proposed performance objectives for sustainable development

In appendix A we have included the evaluation by the panellists of 18 proposed performance objectives for sustainable development. (Objectives were defined as a desired state ofaffairs which the relevant stakeholder is trying to bring about.).

Bearing this evaluation in mind, please reassess the relevance of each objective to accomplishing the kind of sustainable development described by the definition emerging from the previous round. Please record your rating next to each objective.
Note :- Graph 2 in Appendix A may be a useful summary of the responses from the second round to have to hand when answering this question. Please also note rephrasing of objective 2.

1 - Strongly agree
2 - Agree
3 - Neutral
4 - Disagree
5 - Strongly disagree

Objective	Rating
1) Improve technology transfer from other industrial sectors	
2) **Increase urban densities** = Increase urbanisation	
3) Reduce consumption of non-renewable resources	
4) Reduce global warming	
5) Improve air quality	
6) Improve drinking water quality	
7) Improve quality of physical infrastructure	
8) Reduce energy consumption in buildings	
9) Increase recyclable material content of buildings	
10) Increase level of individual disposable income	
11) Improve proximity of residential areas to places of employment, shopping, education, leisure and natural areas.	
12) Increase amount of time available to pursue leisure interests	
13) Develop clear national sustainability policy and plans	
14) Improve local government implementation of the principles set out in Agenda 21	
15) Improved land use planning	
16) Improve environmental performance of construction supply chains	
17) Increase uptake of environmental management system accreditation for firms (e.g. IS0 14000)	
18) Greater prevalence of voluntary agreements between individuals (e.g. car sharing)	

Objective	Rating
Panellists Suggestions	
19) International enforcement of sustainable policies	
20) Capital/knowledge transfer to developing countries	
21) Renewable energy sources (wind/water...)	
22) Redevelop (brownfield sites before greenfield sites)	
23) Working at home	

In the context of construction, please indicate the numbers of the objectives that in your opinion are the most relevant for progress towards sustainable development. Please rank them in order of preference

Note :- Graph 3 in Appendix A may be a useful summary of the responses from the second round to have to hand when answering this question.

First objective	
Second objective	
Third objective	

In the context of construction, please indicate the objective that in your opinion is the least relevant for progress towards sustainable development :
Objective: No. _____

Part II - Rate importance of links between stakeholders and performance objectives

The previous round identified the major links between performance objectives and stakeholders.

These links, illustrated in the following two pages derive from your responses to the second round questionnaire. Only the major links are shown - the thick solid arrows represent the strongest of the major links and the broken thin arrows represent the weaker of the major links. Please use the empty box on each link to rate your level of agreement for that particular stakeholder holding key responsibility for the relevant performance objective, using the following scale:

1 - Strongly agree
2 - Agree
3 - Neutral
4 - Disagree
5 - Strongly disagree

Please use the space below to add any further comments which you may wish to make:

____
____
____

Thank you very much for completing this questionnaire. Please return it by fax to +44.161.2953233. Following the receipt and synthesis of the responses to the third iteration, the panellists will receive feedback, which will form the basis for the fourth round.

N

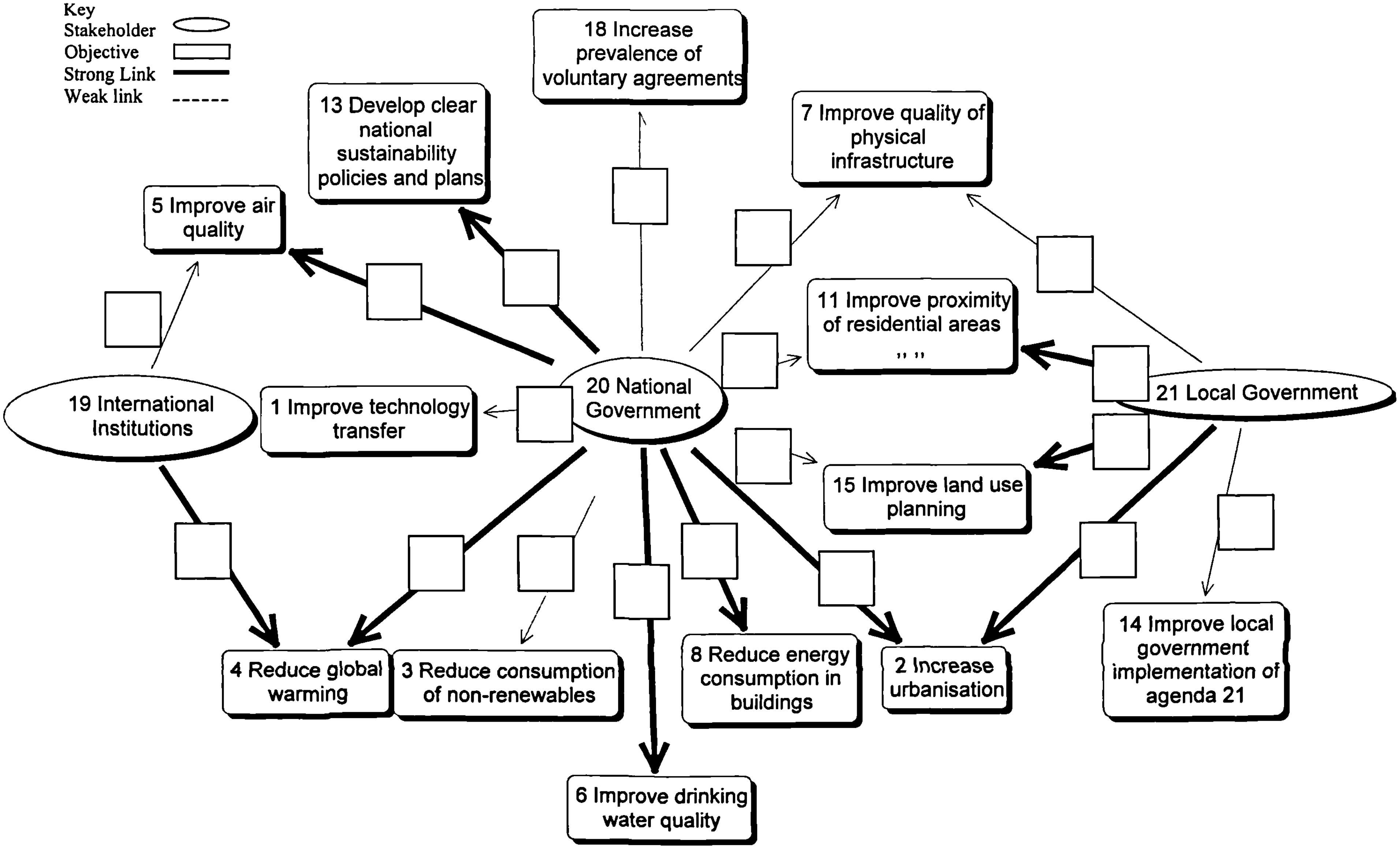

Figure 1: View of links between performance objectives and stakeholders (part 1)

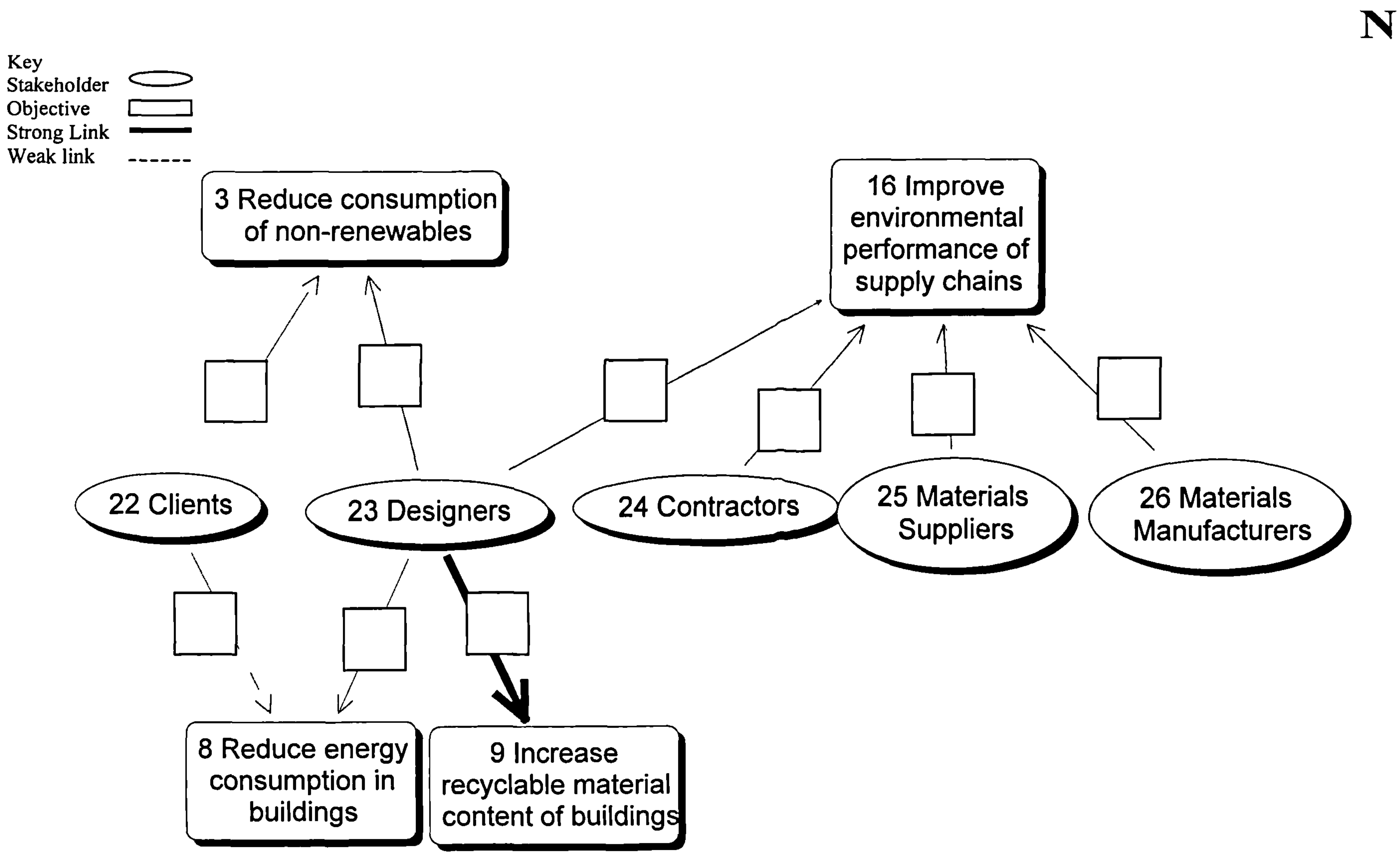

Figure 2: View of links between performance objectives and stakeholders (part 2)

Appendix E: IDS Questionnaire 1 – International Delphi Panel

INTEGRATED DELIVERY SYSTEMS FOR SUSTAINABLE CONSTRUCTION

THE IDS PROJECT

Further to my recent e-mail inviting you to participate in the IDS project, we are now starting the first iteration.

We have included you on a short list of thirty experts and hope you will be able to complete the following simple questionnaire.

If you have not yet had a chance to respond to our recent invitation we would still very much like you to be a part of this study.

Should you decide not to participate, however I would be grateful if you could confirm this.

With Compliments,

Peter S. Barrett

Delphi round 1:
DEFINITION OF SUSTAINABLE DEVELOPMENT

Introduction:

The purposes of this phase of the Delphi process are:
I) to begin to develop a consensus on a definition of sustainable development by seeking your views upon a variety of definitions;
II) to identify what in your view are the key performance measures of sustainable development.

Please paste the content of this file into your text editor, preferentially Word for Windows.
Use your text editor to introduce your answers and comments.
Alternatively use the reply command on your e-mail programme.

Once you have finished answering the questionnaire please e-mail us the resulting file by 30/01/98.
The e-mail address is: idsin@geocities.com

Should you have any difficulty e-mailing the file, please contact us for assistance on tel. +44.161.2953176 or fax the file to +44 161 295 3862.

This file is also included in the Web Site supporting the project.
You can find it at:
http://www.surveying.salford.ac.uk/idsin/

The Web Site will be updated regularly, allowing the panellists to follow the progress of the project.

Panellist name: ______________________________

____

I - Some definitions of sustainable development:

In the context of construction, seen as a change agent for the environment, please record your level of agreement (from strongly agree to strongly disagree) for each of the definitions given below.

Please indicate your choice by inserting an "x" next to your chosen level of agreement, e.g.:

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree X
e. Strongly Disagree

1. "Sustainable development - development that is likely to achieve lasting satisfaction of human needs and improvement of the quality of human life."

a. Strongly Agree
b. Agree

c. Neutral
d. Disagree
e. Strongly Disagree

2. "Using our natural resources in such a way that they meet our economic, social and cultural needs, but not depleting or degrading these resources to the point that they cannot meet these needs for future generations."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

3. "In broad terms the concept of sustainable development encompasses:

Help for the very poor because they are left with no option other than to destroy their environment;

The idea of self-reliant development, within natural resource constraints;

The idea of cost-effective development using different economic criteria to the traditional approach; that is to say development should not degrade environmental quality, nor should it reduce productivity in the long run;

The great issues of health control, appropriate technologies, food self-reliance, clean water and shelter for all;

The notion that people-centred initiatives are needed."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

4. "The creation and responsible maintenance of healthy built environment based on resource efficient and ecological principles."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

5. "Human beings, in their quest for economic development and enjoyment of the riches of nature, must come to terms with the reality of resource limitation and the carrying capacities of ecosystems. For if the object of development is to provide for social and ecological welfare, the object of conservation is to ensure the Earth's capacity to sustain development and to support all life."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

6. "Sustainable development is concerned with:

The maintenance of a healthy economy, promoting quality of life and protecting human health and the environment, in which all pay the environmental costs of their decisions.

The optimal use of non-renewable resources.

The sustainable use of renewable resources.

Minimising damage to the carrying capacity of the environment."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

7. "In principle, … optimal (sustainable growth) policy would seek to maintain an "Acceptable" rate of growth in per-capita real incomes without depleting the national capital asset stock or the natural environment asset stock."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

8. "Improving the capacity to convert a constant level of physical resource use to the increased satisfaction of human needs."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

9. "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

10. "Managing economic development and human growth without destroying the life-support systems of our planet demands … a fundamental shift in values and public policy. We must aspire to be less wasteful of our natural and human resources, to place greater worth on the welfare of future generations, and to take pride in maintaining a healthy, productive Earth."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

11. "Sustainable development is one which appreciates that the Earth and its biosphere have their own intrinsic significance and value, and that human decision-making and action must have absolute respect for this."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

12. "A sustainable society is one that can persist over generations, one that is far-seeing enough, flexible enough, and wise enough not to undermine either its physical or social systems of support. In order to be socially sustainable, the combination of population, capital, and technology in the society would have to be configured so that the material living standard is adequate and secure for everyone. In order to be physically sustainable the society's material and energy throughputs would have to meet … three conditions: Its rates of use of renewable resources do not exceed their rates of regeneration; its rates of use of non-renewable resources do not exceed the rate at which sustainable renewable substitutes are developed; and its rate of pollution emission do not exceed the assimilative capacity of the environment."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

13." Sustainable development empowers individuals to adopt a lifestyle that conserves the natural system by balancing human use of resources with the rate at which these resources are replenished, so that the needs of future generations of all species are not compromised. "

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

14. "Global sustainability means the indefinite survival of the human species across all regions of the world [while ensuring] the persistence of all components of the biosphere, even those with no apparent benefit to humanity."

a. Strongly Agree
b. Agree
c. Neutral
d. Disagree
e. Strongly Disagree

15. If you feel that these definitions are inadequate please give your own definition of sustainable development below (if you are quoting a definition please include details on the source):

____
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In the context of construction, seen as a change agent for the environment, please indicate the numbers of the quotations that constitute in your opinion the best three definitions of sustainable development.
Please rank them in order of preference and indicate the reasons for your selection.

First definition: No. ___
Reasons for selection:_________________________
____
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Second definition: No. ___
Reasons for selection:_________________________
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Third definition: No. ___
Reasons for selection:_____________________________
____
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____

In the context of construction, seen as a change agent for the environment, which of the above definitions in your opinion is the least helpful.
Please give the reasons for your selection.

Definition: No. ___
Reasons for selection:___________________________

Note: the sources of the above definitions will be supplied at a later stage.
This takes into account that indication of provenance may bias the evaluation.

II - General measures

Irrespective of the way you scored the individual definitions, please list what you feel the key performance measures of sustainable development should be.

Thank you very much for completing this questionnaire.
Please return it to idsin@geocities.com
Following the receipt and synthesis of the responses to the first iteration, the panellists will receive feedback, which will form the basis for the next round.

Appendix F: IDS Questionnaire 2 – International Delphi Panel

INTEGRATED DELIVERY SYSTEMS FOR SUSTAINABLE CONSTRUCTION

International Delphi Round 2:
SUSTAINABLE DEVELOPMENT: PERFORMANCE OBJECTIVES AND MEASURES

Introduction

The purposes of the second round of the Delphi process are:

- To further define a consensus on a definition of sustainable development by seeking your views on the definitions which attracted the most support from Round 1;
- To develop a consensus on performance objectives *and measures* by seeking your views on a range of proposed objectives.

We strongly advise that you read the Round 1 feedback report before completing the questionnaire. The first six pages of this document contain the second questionnaire and explanatory notes. The remainder (Appendix A) consists of a feedback report on the findings of the first round.

In view of the technical difficulties experienced associated with e-mailing questionnaires and responses, following completion of this questionnaire please either e-mail us the resulting file or alternatively, fax your response to us by Friday 13/03/98. In the event that you decide to fax your response, please could you complete the questionnaire in black ink. The fax number is +44.161.2953233. The attached file is MS Word 6.0.

Should you have any difficulty faxing us, please contact us for assistance on tel. +44.161.2953176

The project is supported by a Web Site which will be updated regularly, allowing the panellists to follow the progress of the project. You can find it at: http://www.surveying.salford.ac.uk/idsin/

Panellist name:__________________________
Panellist institution / firm:______________________

I) Core definitions of sustainable development: re-evaluation

The aim of this section of the questionnaire is to obtain data relating to the re-evaluation of the core definitions and a synthesised definition, in the light of the quantitative and qualitative responses gained during the first round.

The two definitions attracting the most support from the international panel were:

Definition No. 10

"Managing economic development and human growth without destroying the life-support systems of our planet demands a fundamental shift in values and public policy. We must aspire to be less wasteful of our natural and human resources, to place greater worth on the welfare of future generations, and to take pride in maintaining a healthy, productive Earth."

Definition No. 12

"A sustainable society is one that can persist over generations, one that is far-seeing enough, flexible enough, and wise enough not to undermine either its physical or social systems of support. In order to be socially sustainable, the contribution of population, capital, and technology in the society would have to be configured so that the material living standard is adequate and secure for everyone. In order to be physically sustainable the society's material and energy throughputs would have to meet three conditions: its rate of use of renewable resources do not exceed their rates of regeneration; its rates of use of non-renewable resources do not exceed the rate at which sustainable renewable substitutes are developed; and its rate of pollution emission does not exceed the assimilative capacity of the environment."

In addition to the above two definitions for which greatest levels of agreement was demonstrated by the panel, a further definition has been assembled from the component parts of the four core definitions which achieved the highest aggregate scores, in order to produce a synthesised definition representing the concepts which the international panel collectively considered to be important.

Synthesised definition:

"Sustainable development promotes, through societal value systems and policies, a healthy, productive Earth and social and economic quality of life for all, both now and in the future. To physically enable this, the following ecological principles need to be embraced: pollutant emission must not exceed the Earth's assimilative capacity; the rate of use of renewable resources must not exceed their regeneration rate; and the rate of use of non-renewable resources must not exceed the rate at which renewable substitutes can be found."

Please could you complete the table below by ranking the definitions (1 – first choice, 2 – second choice and 3 – third choice).

Definition number	Ranking
Definition 10	
Definition 12	
Synthesised definition	

Please describe any modifications to the synthesised definition which would make it your first choice (or, if already your first choice, improve it).

____

____

II) **Some proposed performance objectives for sustainable development**

Can you please complete the matrix below:

Column A lists a number of performance objectives. (Objectives are defined as a desired state of affairs which the relevant stakeholder is trying to bring about.) The objectives listed represent recurring key issues distilled from the relevant literature.

Please rate the relevance of each objective to accomplishing the kind of sustainable development described by the core definitions. Please record your rating in ***Column B*** and your views regarding which stakeholder (s) you feel have *key* responsibility for each objective in **Column C** using the following keys:

Column B			***Column C***
1	- Strongly agree	A	- International institutions
2	- Agree	B	- National government
3	- Neutral	C	- Local government
4	- Disagree	D	- Clients
5	- Strongly disagree	E	- Designers
		F	- Contractors
		G	- Material / component suppliers
		H	- Material / component manufacturers

For example, if you strongly agree that a given objective is relevant to achieving sustainable development, and that clients and local government are the key stakeholders, record "1" in column B and record "C" and "D" in column C.

If you feel that the objectives listed are inadequate please give your own performance objectives in the spaces provided. (Please note that in the second part of this section, you will be asked to identify and rank what you feel are the most important / relevant objectives, along with what you feel is the objective that least supports sustainable development.)

In ***Column D*** please suggest appropriate measures to monitor the performance level of each objective.

Column A Objective	Col. B Rate	Column C Relevant stakeholder (s)	Column D Relevant measure (s)
Example: ***Increase environmental taxes***	**2**	***B, C***	***Revenue generated from taxes***
1) Improve technology transfer from other industrial sectors			
2) Increase urbanisation			
3) Reduce consumption of non-renewable resources			
4) Reduce global warming			
5) Improve air quality			
6) Improve drinking water quality			
7) Improve quality of physical infrastructure			
8) Reduce energy consumption in buildings			
9) Increase recyclable material content of buildings			
10) Increase level of individual disposable income			
Improve proximity of residential areas to places of employment, shopping, education, leisure and natural areas.			

Column A Objective	Col. B Rate	Column C Relevant stakeholder (s)	Column D Relevant measure (s)
Example: ***Increase environmental taxes***	*2*	*B, C*	*Revenue generated from taxes*
11) Increase amount of time available to pursue leisure interests			
12) Develop clear national sustainability policy and plans			
13) Improve local government implementation of the principles set out in Agenda 21			
14) Improved land use planning			
15) Improve environmental performance of construction supply chains			
16) Increase uptake of environmental management system accreditation for firms (e.g. IS0 14000)			
17) Greater prevalence of voluntary agreements between individuals (e.g. car sharing)			
18) Your choice:			
19) Your choice:			
20) Your choice:			
21) Your choice:			

Column A Objective	Col. B Rate	Column C Relevant stakeholder (s)	Column D Relevant measure (s)
Example:* *Increase environmental taxes	***2***	***B, C***	***Revenue generated from taxes***
22) Your choice:			

In the context of construction, please indicate the numbers of the objectives that in your opinion are the most relevant for progress towards sustainable development. Please rank them in order of preference and indicate the reasons for your selection.

First objective: No. _____
Reasons for selection:

____
____
____
____
____

Second objective: No. _____
Reasons for selection:

____
____
____
____
____

Third objective: No. _____
Reasons for selection:

____
____
____
____
____

In the context of construction, please indicate the objective that in your opinion is the least relevant for progress towards sustainable development. Please indicate the reasons for your selection.

First objective: No. _____
Reasons for selection:

____
____
____

Thank you very much for completing this questionnaire.
Please return it by fax to +44.161.2953233. Following the receipt and synthesis of the responses to the second iteration, the panellists will receive feedback, which will form the basis for the third round.

Appendix G: IDS Questionnaire 3 – International Delphi Panel

INTEGRATED DELIVERY SYSTEMS FOR SUSTAINABLE CONSTRUCTION

International Delphi Round 3:
SUSTAINABLE DEVELOPMENT: MAJOR FACTORS AND INTERACTIONS

Introduction
Due to the better than expected progress in the analysis, we anticipate only one further round after this one. Please respond promptly and stay with us for the final phase of this study - your input is greatly appreciated.
The purposes of the third round of the Delphi process are:

- To further define a consensus on performance objectives;
- To rate the relationships between the performance objectives and the key stakeholders.

Before completing the questionnaire, we strongly advise that you read the Round 2 feedback report in Appendix A.

Only the first 5 pages of this document contain the third questionnaire and explanatory notes. The remainder (Appendix A) consists of a feedback report on the findings of the second round.

Following completion of the five pages of the questionnaire please either e-mail them to us or alternatively, fax them by Wednesday 29/04/98. In the event that you decide to fax your response, please complete the questionnaire in black ink. The fax number is +44.161.2953233. The file attached to our e-mail is in MS Word 6.0.

Should you have any difficulty responding, please contact us for assistance on tel. +44.161.2953176

The project is supported by a Web Site, which will be updated regularly, allowing the panellists to follow the progress of the project. You can find it at: http://www.surveying.salford.ac.uk/idsin/

Panellist name:______________________________
Panellist institution / firm:________________________

Part I - Some proposed performance objectives for sustainable development

In appendix A we have included the evaluation by the panellists of 18 proposed performance objectives for sustainable development. (Objectives were defined as a desired state of affairs which the relevant stakeholder is trying to bring about.)

Bearing this evaluation in mind, please *reassess* the relevance of each objective to accomplishing the kind of sustainable development described by the definition emerging from the previous round. Please record your rating next to each objective using the following scale :

1 - Strongly agree
2 - Agree
3 - Neutral
4 - Disagree
5 - Strongly disagree

Note :- Graph 2 in Appendix A may be a useful summary of the responses from the second round to have to hand when answering this question. Please also note rephrasing of objective 2.

Objective	Rating
1) Improve technology transfer from other industrial sectors	
2) Increase urban densities = Increase urbanisation	
3) Reduce consumption of non-renewable resources	
4) Reduce global warming	
5) Improve air quality	
6) Improve drinking water quality	
7) Improve quality of physical infrastructure	
8) Reduce energy consumption in buildings	
9) Increase recyclable material content of buildings	
10) Increase level of individual disposable income	
11) Improve proximity of residential areas to places of employment, shopping, education, leisure and natural areas.	
12) Increase amount of time available to pursue leisure interests	
13) Develop clear national sustainability policy and plans	
14) Improve local government implementation of the principles set out in Agenda 21	
15) Improved land use planning	
16) Improve environmental performance of construction supply chains	
17) Increase uptake of environmental management system accreditation for firms (e.g. ISO14000)	
18) Greater prevalence of voluntary agreements between individuals (e.g. car sharing)	
Panellists Suggestions :	
19) Improve security/reduce crime	
20) Improve health services	

Objective	Rating
21) Improve communication infrastructure	
22) Increase involvement by communities	
23) Increase availability of food from sustainable agriculture	
24) Increase resources for education (particularly health education)	

In the context of construction, please indicate the numbers of the objectives that in your opinion are the most relevant for progress towards sustainable development. Please rank them in order of preference

Note :- Graph 3 in Appendix A may be a useful summary of the responses from the second round to have to hand when answering this question.

First objective	
Second objective	
Third objective	

In the context of construction, please indicate the objective that in your opinion is the least relevant for progress towards sustainable development :
Objective: No. _____

Part II - Rate importance of links between stakeholders and performance objectives

The previous round identified the major links between performance objectives and stakeholders.

These links, illustrated in the following two pages derive from your responses to the second round questionnaire. Only the major links are shown - the thick solid arrows represent the strongest of the major links and the broken thin arrows represent the weaker of the major links. Please use the empty box on each link to rate your level of agreement for that particular stakeholder holding key responsibility for the relevant performance objective, using the following scale:

1 - Strongly agree
2 - Agree
3 - Neutral
4 - Disagree
5 - Strongly disagree

Please use the space below to add any further comments which you may wish to make:

____
____
____
____
____

Thank you very much for completing this questionnaire. Please return it by fax to +44.161.2953233. Following the receipt and synthesis of the responses to the third iteration, the panellists will receive feedback, which will form the basis for the fourth round.

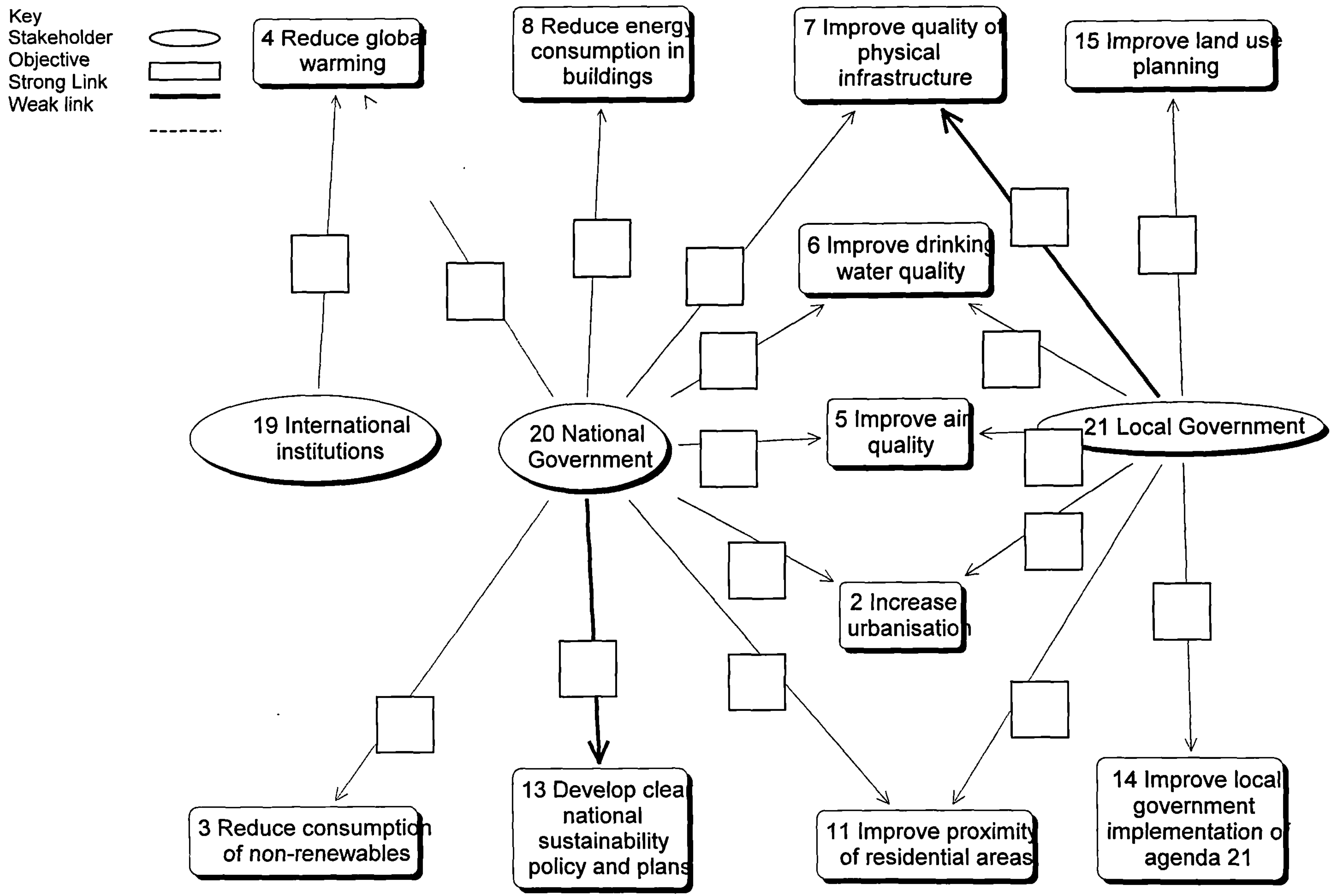

Figure 1: View of links between performance objectives and stakeholders (part 1)

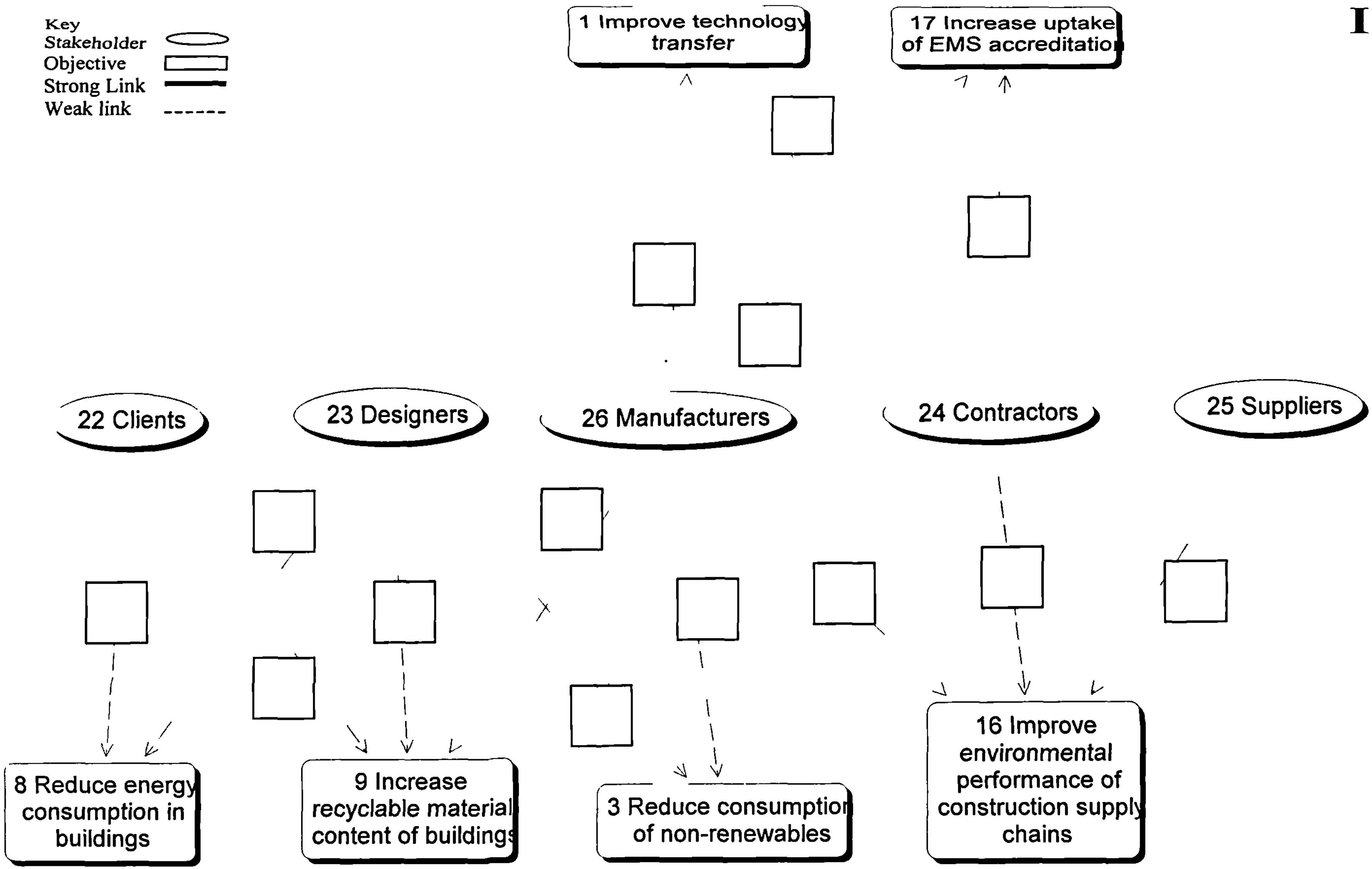

Figure 2: View of links between performance objectives and stakeholders (part 2)

BIBLIOGRAPHY

Ab Rahman, A., (1993), "Behavioural and Institutional Factors Influencing Car Ownership and Usage", **Unpublished PhD Thesis,** Texas A & M University: Texas.

Adam, B., (1990), **Time and Social Theory,** Polity Press: Cambridge.

Adams. D.K., (Ed.), (1993), **Facing the Energy Challenge: Perspectives in Canada and the United Kingdom,** Ryburn: Keele.

Adams. D.K., (Ed.), (1993), **Environmental Issues: The Response of Industry and Public Authorities,** Ryburn: Keele.

Adriaanse, A., (1993), **Environmental Policy Performance Indicators: A Study of Indicators for Environmental Policy in the Netherlands,** The Hague: Sdu Uitgeverji Koninginnegracht.

Aerts, D., Apostel, L., De Moor, B., Hellemans, S., Maex, E., van Belle, H., & van der Veken, J., (1994), **Worldviews: From Fragmentation to Integration,** VUB Press: Brussels.

Agyeman, J. & Evans, B., (1994), "Making Local Agenda 21 Work", **Town and Country Planning,** July/August. Page 198.

Akao, Y., (1991), **Policy Deployment,** Productivity Press: Cambridge.

Alfsen, K.H. & Saebo, H.V., (1993), "Environmental Quality Indicators: Background, Principles and Examples from Norway", **Environmental and Resource Economics,** 3: 415-435.

Allen, P.M., (1982), "Evolution, Modeling, and Design in a Complex World", **Environment and Planning,** 9: 583-597.

Allen, R., (1980), **How to Save the World,** Oxford University Press: Oxford.

Allen, T.F.H., Bandurski, B.L. & King, A.W., (1993), **The Ecosystem Approach: Theory and Ecosystem Integrity: Report to the Great Lakes Science Advisory Board,** IJC: Ottawa and Washington.

Almudhaf, H. & Al-Ragom, F., (1998), "Autoclaved Aerated Concrete for Construction in Hot Regions", **CIB World Building Congress: Construction and**

the Environment – Symposium D: Managing for Sustainability – Endurance Through Change Gävle, Sweden, 7th – 12th June.

Al-Ragom, F.A. & Al-Ghimlas, F., (1998), "Assessment of Energy Conservation Measures Suitable for Retrofitting Residential Buildings in Kuwait", **CIB World Building Congress: Construction and the Environment – Symposium B: Indoor Environment and Sustainable Development – Are they Compatible?**, Gävle, Sweden, 7th – 12th June.

American Institute of Architects on the Environment, (1992), **Environmental Resource Guide**, American Institute of Architects: Washington, D.C.

Anderson, T.L. & Leal, D.R., (1991), **Free Market Environmentalism**, Pacific Research Institute for Public Policy, Westview Press: San Francisco, CA.

Ang, G.K.I., (1998), "Sustainable Design Construction and the Performance Concept", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change** Gävle, Sweden, 7th – 12th June.

Angioletti, R., Gobin, C. & Weckstein, M., (1997), "Twenty-four Criteria for Designing and Constructing Buildings on Sustainable Development Principles", **CIB Task Group 8**

Arbnor, I. & Bjerke, B., (1997), **Methodology for Creating Business Knowledge**, Sage: Lund, Sweden.

Arnold, S.J. & Fischer, E., (1994), "Hermeneutics and Consumer Research", **Journal of Consumer Research**, 21: June: 55-70.

Arrow, K., Bolin, R., Costanza, P., Dasgupta, C., Folke, C.S., Holling, B.O., Janssen, S., Levein, K., Mäler, C., Perrings, C. & Pimentel, D., (1995), "Economic Growth, Carrying Capacity, and the Environment", **Science**, 268: 520-521.

Atkinson, C.J. & Butlin, R.N., (1993), "Ecolabelling of Building Materials and Building Products", **Building Research Establishment Information Paper 11/93**, Watford, England.

Augenbroe, G.L.M. & Pearce, A.R., (2000), "Sustainable Construction in the USA: Perspectives to the Year 2000", **Proceedings of Cities and Sustainability: Sustaining Our Cultural Heritage**, Kandalama, Sri Lanka: 22nd – 25th February.

Avison, K & Fitzgerald, L., (1994), **Methodological Concepts and Approaches**, Free Press: New York.

Axlerod, L.J., (1994), "Balancing Personal Needs with Environmental Preservation: identifying Values that Guide Decisions in Ecological Dilemmas", **Journal of Social Issues**, 50: 3: 85-104.

Baba, K., (1998), "Necessity of Common Understanding of Sustainability in Construction in Asia", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden, 7th – 12th June.

Bakkes, J.A., van der Born, G.J., Helder, J.C., Swart, R.J., Hope, C.W. & Parker, J.D., (1994), **An Overview of Environmental Indicators: Sate of the Art and Perspectives: UNEP/EATR-94-01**, UNEP: Nairobi, Kenya.

Banathy, B.H., (1992), **A Systems View of Education: Concepts and Principles for Effective Practice**, Educational Technology Publications: Englewood Cliffs, NJ. Page 191.

Barbier, E.B., (1987), "The Concept of Sustainable Development", **Environmental Conservation**, 14: 2: 101-110.

Barbier, E.B., (1989), **Economics, Natural Resource Scarcity and Development: Conventional and Alternative Views**, Earthscan: London.

Barnett, H.J. & Morse, C., (1963), **Scarcity and Growth**, John Hopkins University Press: Baltimore.

Barrett, P., Sexton, M.G. & Curando, M., (1998), "Sustainability Through Integration", **Proceedings of the CIB World Building Congress – Construction and the Environment: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden: 7th – 12th June.

Barrett, P.S. & Sexton, M.G., (1995), "Integrated Management Systems", **Proceedings of the COBRA '95 RICS Construction Research Conference**, Edinburgh: 8th – 9th September.

Barrett, P.S. & Sexton, M.G., (1998), **Integrating to Innovate: Report for the Construction Industry Council**, Construction Industry Council: London.

Barrett, P.S. & Sexton, M.G., (1998), **Unpublished Working Paper for the Project Advising on Sustainability**, University of Salford: Salford.

Barrett, P.S. & Sexton, M.G., (1999), "The Transformation of 'Out of Industry' Knowledge into Construction Industry Wisdom', **Proceedings of the Linking Construction Research and Innovation to Research and Innovation in Other Sectors**, London: 24th June.

Barrett, P.S., Bootland, J., Cooper, I., Gilham, A. & Jenkins, O., (1998), **Report for the Construction Research and Innovation Strategy Panel – Sustainable Construction Theme Group: Research and Innovation for Sustainable Construction**, CRISP: London.

Barrett, P.S., Sexton, M.G. & Green, L., (1998), **Integrated Delivery Systems for Sustainable Construction: Report for the Construction Sponsorship Directorate, Department of Environment Transport and the Regions**, DETR: London.

Bartlett, E,V. & Clift, M.R., (1999), "Reliability and Whole Life Performance: Integrating the Supply Chain", **Proceedings of the Eighth International Conference on Durability of Building Materials and Components**, Vancouver, Canada. Pages 1916-1923.

Bateson, G., (1972), **Steps to an Ecology of Mind**, Ballantine: New York.

Bauman, Z., (1978), **Hermeneutics and Social Sciences**, Hutchinson: London.

Beatley, T., (1995), "Planning and Sustainability: The Elements of a New (Improved?) Paradigm", **Journal of Planning Literature**, 9: 4: 383-395.

Becker, H.S., (1970), **Sociological Work: Method and Substance**, Transaction: New Brunswick.

Beckerman, W., (1994), "Sustainable Development: Is it a Useful Concept?" **Environmental Values**, 3: 3: 191-209.

Bedeian, A.G., (1984), **Organizations: Theory and Analysis**, Holt-Saunders: New York. Page 42.

Beetstra, F., (1997), "Beyond Life Cycle Assessment: Building Related Environmental Decisions", **Proceedings of the CSTB & CIB Second International Conference on Buildings and the Environment,** Paris: June.

Bell, M. & Lowe, R.J., (1999), "Sustainability and the Development of an Energy Efficient Housing Stock: A Review of the Theoretical Issues", **Proceedings of the RICS Construction and Building Research Conference – The Challenge of Change: Construction and Buildings for the New Millennium,** Salford, UK: 1st – 2nd September. Page 193.

Bell, S. & Morse, S., (1999), **Sustainable Indicators: Measuring the Immeasurable,** Earthscan: London. Page 25.

Bentley, F., (1984), "Why Protect Agricultural Land?", **Journal of Soil and Water Conservation,** 39: Page 295.

Berger, P.L. & Luckman, T., (1966), **The Social Construction of Reality,** New York. Page 1.

Berkowitz, L., (1972), "Social Norms, Feelings, and other Factors Affecting Helping Behavior and Altruism", in L. Berkowitz, (Ed.), **Advances in Experimental Social Psychology – Volume 6**: Pages 63-108, Academic Press.

Bernstein, R.J., (1983), **Beyond Objectivism and Relativism: Science, Hermeneutics, and Praxis,** University of Pennsylvania Press: Philadelphia.

Berreby, D., (1995), "Unabsolute Truths: Clifford Geertz", **New York Times Magazine,** April 9th: 44-47.

Bhaskar, V. & Glyn, A., (Eds.), (1995), **The North and South: Ecological Constraints and the Global Economy,** United Nations University Press: Tokyo.

Bickerman, L., Rog, D.J. & Hedrick, T.E., (1998), "Applied Research Design: A Practical Approach", in L. Bickman & D.J. Rog (Eds.), **Handbook of Applied Social Research Methods**: Pages 5-37, Sage: London.

Blachère, G., (1998), "Tentative Application of the ECE Compendium of Model Provisions for Building Regulations", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change** Gävle, Sweden, 7th – 12th June.

Bleicher, J., (1980), **Contemporary Hermeneutics: Hermeneutics as Method, Philosophy and Critique**, Routledge: London.

Bleviss, D.L. & Walzer, P., (1990), "Energy for Motor Vehicles", **Scientific American**, 26th September.

Blowers, A., 1993), "Preface", in A. Blowers, (Ed.), **Planning for a Sustainable Environment: A Report by the Town and Country Planning Association**, Earthscan: London.

Bohm, D., (1978), "The Implicate of Enfolded Order: A New Order for Physics", in J.B. Cobb & D.R. Griffin, (Eds.), **Mind in Nature: Essays on the Interface of Science and Philosophy**, University Press of America: Washington.

Bohm, D., (1980), **Wholeness and the Implicate Order**, Routledge & Kegan Paul: London.

Bonini, C. & Anink, D., (1997), **Handbook of Sustainable Building**, James and James: London.

Bossell, H., (1999), **Indicators for Sustainable Development: Theory, Method, Applications: A Report to the Balaton Group**, International Institute for Sustainable Development: Winnipeg, Canada.

Bossink, B.A.G. & Brouwers, H.J.H., (1996), "Construction Waste: Quantification and Source Evaluation", **Journal of Construction and Engineering Management**, 122: 1.

Botkin, D.B., (1990), **Discordant Harmonies: A New Ecology for the Twenty-first Century**, Oxford University Press: Oxford.

Bottom, C.W., McGreed, W.S., & Heaney, G., (1999), "Appraising the Functional Performance of Office Buildings", **Journal of Property Research**, 16: 4: 339-358.

Bourdeau, L., (1999), "Sustainable Development and the Future of Construction: A Comparison of Visions from Various Countries", **Building Research and Information**, 27: 6: 355-367.

Bourdeau, L., Huovila, P. & Lanting, R., (1998), "Sustainable Development and the Future of Construction, a CIB W82 Project", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden, 7th – 12th June.

Boureron, P.S. & Jensen, M.E., (1994), "An Overview of Ecological Principles for Ecosystem Management", in M.E. Jensen & P.S. Bourgeron, (Eds.), **Ecosystem Management: Principles and Applications**, Pacific Northwest Research Station.

Brandon, P.S., (1998), "Sustainability in Management and Organisation: The Key Issues?", **Proceedings of the CIB World Building Congress - Construction and the Environment: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden: 7th – 12th June.

Brandon, P.S., Lombardi, P. & Bentivegna, V., (Eds.), **Evaluation of the Built Environment for Sustainability**, Chapman & Hall: London.

Breheny, M., (1995), "The Compact City and Transport Energy Consumption", **Transactions of the Institute of British Geographers**, 20: 81-101.

Brekke, K.A., (1997), **Economic Growth and the Environment: On the Measurement of Income and Welfare**, 24: 231-240.

British Standards Institution, (1994), **BS 7750: 1994, Specification for Environmental Management Systems**, British Standards Institution: London.

Brown, G.M. & Swierzbinski, J., (1992), "An Ecological Economy: Notes on Harvest and Growth", **Beijer Discussion Paper Series 12**, Biejer International Institute of Ecological Economics: Stockholm, Sweden.

Brown, L.R *et al.*, (1991, 1992, 1993, 1994, 1995, 1996, 1997. 1998), **State of the World**, Earthscan Publications: London.

Brown, L.R., (1991), "Bridging Organizations and Sustainable Development", **Human Relations**, 44: 8: 807-831.

Brown, L.R., (1994), **State of the World 1994: A Worldwatch Institute Report on Progress Toward a Sustainable Society**, Norton: New York.

Buchanan, A., (1985), **Ethics, Efficiency, and the Market**, Rowman & Littlefield: Totowa, New Jersey.

Buchholz, R., (1993), **Principles of Environmental Management: The Greening of Business**, Prentice-Hall: Englewood Cliffs, NJ.

Building Industry Authority, (1992), **The New Zealand Building Code Handbook and Approved Documents**, Building Industry Authority: Wellington, New Zealand.

Burayidi, M., (1997), "Environmental Sustainability of Third World Economic Development: Constraints and Possibilities", **Environmental Sustainability**, 9: 2: 31-42.

Bureau of Territorial Planning and Regional Economics, China National Planning Commission, Planning Bureau, China National Environmental Protection Agency, and Chinese Academy of Geological Information, (1994), "Major Environmental Problems in China", **Chinese Environment and Development**, 4: 4: 18-52.

Bryld, B., (1997), "CSD Working List of Indicators of Sustainable Development", in Moldan (Ed,), **Sustainability Indicators: A Report on the Project on Indicators of Sustainable Development**, Wiley: New York. Pages 142-147.

Cairns, J., McCormick, P. & Neiderlehner, N., (1993), "A Proposed Framework for Developing Indicators of Ecosystem Health", **Hydrobiologica**, 263: 1-44.

Callenbach, E., (1993), **EcoManagement – The Elmwood Guide to Ecological Auditing and Sustainable Business**, Berret-Koehler: San Francisco.

Calthorpe, P., (1986), "The Urban Context", in S. van der Ryn & P. Calthorpe, (Eds,), **Sustainable Communities**, Sierra Club: San Francisco.

Calthorpe, P., (1996), "The Next American Metropolis", J.M. Stein (Ed.), **Classic Readings in Real Estate and Development**, Urban Land Institute: Washington, DC. Pages 453-474.

Campbell, D.T., (1974), "Degrees of Freedom and the Case Study", **Comparative Political Studies**, 8: 178-193.

Campbell, S., (1996), "Green Cities, Growing Cities, Just Cities?", **Journal of the American Planning Association**, 63: 3: 302.

Carley, M. & Christie, I., (1993), **Managing Sustainable Development**, Earthscan: London.

Carpenter, S.R., (1991), "Inventing Sustainable Technologies", in J. Pitt & E. Lugo, (Eds.), **The Technology of Discovery and the Discovery of Technology: Proceedings of the Sixth International Conference of the Society for Philosophy and Technology**, Society for Philosophy and Technology: Blacksburg.

Carpenter, S.R., (1993), "When are Technologies Sustainable?", in L.A. Hickman & C.F. Porter (Eds.), **Technology and Society**: 202-214., Society for Philosophy and Technology: Carbondale, Ill.

Carrillo, P.M., (1994), "Technology Transfer: A Survey of International Construction Companies", **Construction Management and Economics**, 12: 1: 45-51.

Carrillo, P.M., "Technology Transfer on Joint Venture Projects in Developing Countries", **Construction Management and Economics**, 14: 1: 45-54.
Cash, C.G. & Bailey, D.M., (1993), "Predictive Service Life Tests for Roofing Membranes", **USACERL Interim Report FM-94/03.**

CERF, (1996), **Proceedings of the Engineering and Construction for Sustainable Development in the Twenty-first Century: An International Research Symposium and Technology Showcase**, Washington, D.C.

Cernea, M., (1993), "The Sociologists Approach to Sustainable Development", **Finance and Development**, 30: 4: 6-10.

Chapman, P.F. & Roberts, F., (1983), **Metal Resources and Energy**, Butterworths. Page 34.

Checkland, P. & Scholes, J., (1990), **Soft Systems Methodology in Action**, Wiley: Chichester.

Checkland, P. & Tsouvalis, C., (1997), "Reflecting on SSM: The Link Between Root Definitions and Conceptual Models", **Systems Research and Behavioral Science**, 14: 3: 153-166.

Checkland, P., (1988), "The Case for 'Holon'", **Systems Practice**, 1: 3: 235-238.

Checkland, P.B., (1981), **Systems Thinking, Systems Practice**, Wiley: Chichester.

Checkland, P.B., (1992), "From Framework Through Experience to Learning: The Essential Nature of Action Research", **Proceedings of the Second World Congress on Action Learning,** 14th – 17th July.

Churchman, W., (1968), **The Systems Approach,** Dell: New York.

CIB W65 & Norwegian Building Research Institute, (1997), **Proceedings of the Workshop on Cultural Factors Affecting International Transfer of Construction Management Best Practice,** Oslo, Norway: June.

CIB Working Commission W82, (1998), **Sustainable Development and the Future of Construction: A Comparison of Visions from Various Countries,** CIB W82.

CIB, (1999), **Agenda 21 on Sustainable Construction: CIB Report Publication 237,** CIB: Rotterdam: Netherlands.

CIRIA, (1993), **Environmental Issues in Construction: Special Report 94,** CIRIA: London.

CIRIA, (1995), **Remedial Treatment for Contaminated Land: Special Report 103,** CIRIA: London.

Civil Engineering Research Foundation, (1996), **Engineering and Construction for Sustainable Development in the 21st Century: CERF Report 96-5016A,** CERF: Washington, D.C.

Clark, M., (1989), **Ariadne's Thread,** St. Martin's Press: New York.

Clark, W.C., (1989), "Managing Planet Earth", **Scientific America,** 261: 3: 47-54.

Clayton, A.M. & Radcliffe, N.J., (1996), **Sustainability: A Systems Approach,** Earthscan: London.

Cole, R.J. (Ed.), (1996), **Proceedings of the CIB TG8 International Research Workshop: Linking and Prioritizing Environmental Criteria,** Toronto, Canada: 15th – 16th November.

Cole, R.J., (1994), "Assessing the Environmental Performance of Office Buildings", **Proceedings of the First International Conference: Buildings and the Environment,** 16th – 20th May: Building Research Establishment, Watford, U.K.

Collins, R.J. & Sherwood, P., (1995), **The Use of Waste and Recycled Materials in Aggregates: Standards and Specifications**, H.M.S.O.: London.

Colthorpe, P., (1986), "The Urban Context", in S. Van der Ryn & P. Calthorpe, (Eds.), **Sustainable Communities**: pages 1-33, Sierra Club: San Francisco.

Commission of the European Communities, (199), **Green Paper on the Urban Environment: EUR 12902**, Commission of the European Communities: Brussels.

Common, M. & Perrings, C., (1992), "Towards an Ecological Economics of Sustainability", **Ecological Economics**, 6: 7-34.

Common, M., (1995), **Sustainability and Policy: Limits to Economics**, Cambridge University Press: Cambridge.

Conca, K., Alberty, M. & Dabelko, G., (Eds.), **Green Planet Blues: Environmental Politics from Stockholm to Rio**, Westview Press: Boulder.

Construction Research and Innovation Strategy Panel Sustainable Construction Group, (1998), **Research and Innovation for Sustainable Construction: Report for the Construction Research and Innovation Strategy Panel**, CRISP: London.

Construction Research and Innovation Strategy Panel, (1998), **CRISP Response to *Opportunities for Change*: Sustainable Construction**, CRISP: London.

Coomer, J., (1979), "The Nature of the Quest for a Sustainable Society", in J. Coomer (Ed.), **Quest for a Sustainable Society**, Pergamon Press: Oxford.

Cooper, H.M., (1988), "Organizing Knowledge Syntheses: A Taxonomy of Literature Reviews", **Knowledge in Society**, 1: 104-126.

Cooper, H.M., (1989), **Integrating Research: A Guide for Literature Reviews**, Sage: Newbury Park.

Cooper, H.M., (1984), **The Integrative Research Review: A Systematic Approach**, Sage: Newbury Park.

Corn, L.M., (1993), **Ecosystems, Biomes, and Watersheds: Definitions and Use – Report for Congress**, The Committee for the National Institute for the Environment: Washington.

Corson, W.H., (1994), "Changing Course: An Outline of Strategies for a Sustainable Future", **Futures**, 26: 206-223.

Costain Environmental Policy. [Online] Available http://www.costain.com/environm/envifrnt.htm, August 4th, 1999.

Costanza, R., Daly, H.E. & Bartholomew, J.A., (1991), "Goals, Agenda and Policy Recommendations for Ecological Economics", in R. Costanza (Ed.), **Ecological Economics: The Science and Management of Sustainability**: Pages 1-20. Columbia University Press: New York.

Costanza, R., Sklar, F.H. & White, M.L., (1990), "Modelling Coastal Landscape Dynamics", **BioScience**, 40: 91-107.

Costanza, R., Wainger, L., Folke, C. & Maler, K., (1993), "Modelling Complex Ecological Economic Systems", **BioScience**, 43: 8: 545-556.

Council of European Municipalities and Regions, (1997), **Local Agenda 21: Basic Guide**, Council of European Municipalities and Regions: Brussels.

Conseil du Bâtiment, (1998), **Proceedings of the CIB World Building Congress: Construction and the Environment**, CIB: Gälve, Sweden: 7th – 12th June.

Conseil du Bâtiment, (1999), **CIB Agenda 21 on Sustainable Construction: CIB Report 237**, Counseil du Bâtiment: Rotterdam, Netherlands.

Courtney, R. (1999), "CIB Agenda 21 and the Building Research Community", **Building Research and Information**, 27: 6: 374-378.

Curwell, S., (2000), "Building Environmental Quality Evaluation Through Time: Towards Sustainable Urban Development – The Work of the BEQUEST Network in Europe", **Proceedings of the Cities and Sustainability: Sustaining Our Cultural Heritage**, Kandalama: Sri Lanka: 22nd – 25th February.

Daily, G.C., (1997), "Valuing and Safeguarding Earth's Life Support Systems", in G. Daily, (Ed.), **Natures Services: Societal Dependence on Natural Ecosystems**: pages 365-374. Island Press: Washington, DC.

Daly, H., (1977), **Steady State Economics: The Economics of Biophysical Equilibrium and Moral Growth**, W.H. Freeman.

Daly, H.E. & Cobb, J.B., (1990), **For the Common Good: Redirecting the Economy Towards Community, the Environment and a Sustainable Future,** Greenprint: London.

Daly, H.E. & Cobb, J.B., (1994), **For the Common Good** (2nd edition), Beacon Press: Boston.

Daly, H.E. & Townsend, K.N., (1993), **Valuing the Earth: Economics, Ecology, Ethics**, The MIT Press: Cambridge.
Daly, H.E., (1977), **Steady State Economics**, Freeman: San Francisco.

Daly, H.E., (1989), "Steady-state versus Growth Economics: Issues for the Next Century", **Proceedings of the Hoover Institute Conference on Population, Resources and Environment**, Stanford University: 1st – 3rd February.

Darling, F.F. & Dasmann, R.F., (1969), "The Ecosystem View of Human Society", **Impact of Science on Society**, 19: 109-121.

Dasgupta, P., (1993), **An Inquiry into Well-being and Destitution**, Oxford University Press: Oxford.

Dasgupta, P.S., (1982), **The Control of Resources**, Basil Blackwell: Oxford.

Dasguta, P.S. & Heal, G.M., (1979), **Economic Theory and Exhaustible Resources**, Cambridge University Press: Cambridge.

Davis, J., (1991), **Greening Business**, Basil Blackwell: Oxford, England.

Deakin, M. & Hine, J., (1998), "Modelling Sustainable Community Development in Edinburgh's South East Wedge", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden, 7th – 12th June.

Deakin, M., (1995), "An Economic Evaluation and Appraisal of the Effects Land Use, Building Obsolescence and Depreciation have on the Environment of Cities", **Proceedings of the International Workshop on the Environmental Impact Evaluation of Buildings and Cities for Sustainability**, Florence, Italy: 13th – 15th September.

Deetz, S., (1985), "Critical-cultural Research: New Sensibilities and Old Realities", **Journal of Management**, 11: 2: 121-126.

Department of Environment, (1994), **Planning Policy Guidance Note 23: Planning and Pollution Control**, H.M.S.O.: London.

Department of Environment, (1995), **Land Use Change in England, No.10**, DOE: HMSO.

Department of Environment, Transport and Regions, (1998), **Opportunities for Change: Consultation Paper on a UK Strategy for Sustainable Construction**, Department of Environment, Transport and Regions: London.

Department of Environment, Transport and the Regions, (1998), **Opportunities for Change: Sustainable Construction**, DETR: London.

Department of Indian Affairs and Northern Development, (1997), **Towards a Sustainable Development Strategy for the Department of Indian Affairs and Northern Development**, DIAND: British Columbia.

Department of the Environment Transport and the Regions, (1998), "Developing a Framework for Sustainable Construction", **CIRM Business Plans**, Page 1.

DETR, (1997), **Climate Change: DETR Newsletter**, DETR: London.

DETR, (1998), **Opportunities for Change: Consultation Paper on a UK Strategy for Sustainable Construction**, DETR: London.

Development Watch, (1994), **Sustainable Development Indicators**, UNDP: New York.

DiMaggio, P. & Powell, W.W., (1983), "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields", **American Sociological Review**, 19: 252-284.

Dobson, A., (1990), **Green Political Thought**, Harper Collins: London.

Dolan, D.F., (1979), **The British Construction Industry: An Introduction**, MacMillan Press: London.

Dorcey, A.H.J., (1986), **Bargaining in the Governance of Pacific Coastal Resources: Research and Reform**, Westwater Research Centre, University of British Columbia: Vancouver.

Douzane, O., Roucoult, J.M. & Langlet, T., (1998), "Natural Night Ventilation and Thermal Inertia", **CIB World Building Congress: Construction and the Environment – Symposium B: Indoor Environment and Sustainable Development – Are they Compatible?**, Gävle, Sweden, 7th – 12th June.

Dowie, M., (1995), **Losing Ground: American Environmentalism at the Close of the Twentieth Century**, The MIT Press: Cambridge, MA.

DPCSD, (1996), **United Nations Work Programme on Indicators of Sustainable Development**, Commission on Sustainable Development: New York.

Drew, D.R., de la Garza, J.M. & Kim, K., "Simulation of Life-cycle Infrastructure Planning for Sustainable Development", **Proceedings of the Computer Simulation Conference**, Reno. Nevada: July 19th – 22nd.

Dryzek, J.S., (1997), **The Politics of the Earth: Environmental Discourses**, Oxford University Press: Oxford.

Du Plessis, C., (2000), "Cities and Sustainability: Sustaining Our Cultural Heritage", **Proceedings of Cities & Sustainability: Sustaining Our Cultural Heritage**, Kandalama, Sri Lanka: 22nd – 25th February.

Dunlap, R.E. & Catton, W.R., (1993), "The Development, Current Status, and Probable Future of Environmental Sociology: Toward an Ecological Sociology", **Annuals of the International Institute of Sociology**: 3.

Dyck, R., (1998), "Integrating Planning and Sustainability Theory for Local Benefit", **Local Environment**, 3: 1: 27-41.

Easterby-Smith, M., Thorpe, R. & Lowe, A., (1991), **Management Research: An Introduction**, Sage: London.

Eckersley, R., (1992), **Environmentalism and Political Theory**, University of New York Press: Albany.

Eclipse Research Consultants, (1996), **Environmental Initiatives in the UK Construction Industry: 1995 Survey of Current Practice**, Eclipse Research Consultants: Cambridge, England.

Editors, (1996), "The Construction Industry: Building for Sustainability?, **Industry and Environment**, 19: 2: 3.

Edwards, S. & Hobbs, S., (1998), "Data Collection and Handling for Environmental Assessment of Building Materials by Architects and Specifiers", **Proceedings of the CIB World Building Congress: Construction and the Environment – Symposium A: Materials and Technologies for Sustainable Construction**, 7th – 12th June: Gävle, Sweden.

Ehrenfeld, D., (1993), "Ecosystem Health", **Orion**, Winter: 12-15.

Ehrlich, P.R., (1986), **The Machinery of Nature**, Simon & Schuster: New York.

Ehui, S.K. & Spencer, D.S.C., (1993), "Measuring the Sustainability and Economic Viability of Tropical Farming Systems: A Model from Sub-Saharan Africa", **Agricultural Economics**, 9: 279-296.

El Serafy, S., (1992), "Sustainability, Income Measurement, and Growth', in R. Goodland, H.E. Daly & S. El Serafy (Eds.), **Population, Technology, and Lifestyle: The Transition to Sustainability**: 63-79. Island Press: Washington, DC.

Elgin, D., (1994), "Building a Sustainable Species-civilization", **Futures**, 26: 2: 234-245.

Ellis, D., (1989), "A Behavioral Model for Information Retrieval System Design", **Journal of Information Science**, 15: 4&5): 237-247.

Elliot, R., (Ed.), (1995), **Environmental Ethics**, Oxford University Press: New York.

Elliot, R. & Gare, A., (Eds.), (1983), **Environmental Philosophy**, Open University Press: Milton Keynes.

Emmitt, S., (1997), "The Diffusion of Environmentally Responsible Ideals and Practices", in M. Gray (Ed.), **Evolving Environmental Ideals: Changing Ways of Life, Values and Design Practices**, Royal Institute of Technology: Stockholm, Sweden . Pages 41-49.

Energy Information Administration, U.S. Department of Energy, (1995), **International Energy Outlook, 1995, Report No. DOE/EIA-0484(95)**, U.S. Government Printing Office: Washington, D.C.

Engel, J.R., (1990), "Introduction: The Ethics of Sustainable Development", in J. Engel & J.G. Engel, (Eds.), **The Ethics of Environment and Development**: 1-23, University of Arizona Press: Tucson.

Environmental Protection Agency Science Advisory Board, (1990), **Reducing Risk: Setting Priorities and Strategies for Environmental Protection**, Environmental Protection Agency: Washington, DC.

Environmental Protection Agency, (1991), **Building Air Quality: A Guide for Building Owners and Facility Managers**, GPO: Washington, DC.

Environmental Resources Management, (1995), **Background Paper to the OECD Workshop: Sustainable Consumption and Production – Clarifying the Concepts**, Rosendal, Norway: July 2nd – 4th.

Eto, M., Rogers, E.M., Wierengo, D., Byrnes, P., and Allbritton, M. (1995) **Technology Transfer from Government R&D Laboratories in the United States and Japan.** Focus on New Mexico. Albuquerque: University of New Mexico, Department of Communication and Journalism, Research Report.

European Commission, (1994), **The Aalborg Charter of European Cities and Towns Towards Sustainability**, European Commission; Council of European Municipalities and Regions, 1997), **Local Agenda 21 Guide**, CEMR: Brussels.

Evans, W., (1971), "Introduction: The Organisational Experiment", in W. Evans, (Ed.), **Organizational Experiments: Laboratory and Field Research**, Harper: New York.

Evered, R. & Louis, M.R., 1981), "Alternative Perspectives in the Organizational Sciences: Inquiry from the Inside, and Inquiry from the Outside", **Academy of Management Review**, 6: 385-395.

Faber, M. & Proops, J., (1990), **Evolution, Time, Production and the Environment**, Springer-Verlag: Berlin.

Feldman, K.A., (1971), "Using the Work of Others: Some Observations on Reviewing and Integrating", **Sociology of Education**, 4: 86-102.

Feyerabend, P., (1981), **Realism, Rationalism and Scientific Method**, Cambridge University Press: Cambridge.

Fielden, B., (1994), **Conservation of Historic Buildings**, Butterworth: Oxford.

Fielding, N.G. & Fielding, J.L., (1986), **Linking Data**, Sage: Beverly Hills, California.

Fishbein, B.K., (1998), **Building for the Future: Strategies to Reduce Construction and Demolition Waste in Municipal Projects**, INFORM: New York.

Flood, R.L. & Carson, E.R., (1988), **Dealing with Complexity: An Introduction to the Theory and Application of Systems Science**, Plenum: New York.

Forrester, J.W., (1973), **World Dynamics**, Wright-Allen Press: Cambridge, MA.

Fox, P.W., (1999), "Construction Industry Development: Exploring Values and other Factors from a Grounded Theory Approach", **Proceedings of the CIB conference – Customer Satisfaction: A Focus for Research and Practice in Construction, Volume 1: Construction Process Innovation,** 5th – 10th September.

Fresco, L.O. & Kroonenberg, S.B., (1992), "Time and Spatial Scales in Ecological Sustainability", **Land Use Policy,** 9: 155-168.

Friedman, A. & Cammalleri, V., (1994), "Reducing Energy, Resources and Construction Waste Through Effective Residential Unit Design", **Building Research and Information,** 21: 1: 103-108.

Friedman, M., (1963), **Capitalism and Freedom**, Phoenix Books, University of Chicago Press: Chicago.

Friend, A.M., (1992), "Economics, Ecology and Sustainable Development: Are they Compatible?", **Environmental Values,** 1: 157-170.

Funtowicz, S. & Ravetz, J.R., (1994), "Emergent Complex Systems", **Futures,** 26: 6: 568-582.

Gadamer, H., (1989), **Truth and Method,** Crossrod: New York.

Gadamer, H-G., (1976), "The Historicity of Understanding," in P. Connerton, (Ed.), **Critical Sociology: Selected Readings**, Penguin Books Ltd, Harmondsworth. Pages 117-133.

Gallopin, G.C., Gutman, P. & Maletta, H., (1989), "Global Impoverishment Sustainable Development and the Environment: A Conceptual Approach", **International Social Science Journal**, 121: 375-397.

Gardner, J. & Roseland, M., (1989), "Thinking Globally: The Role of Social Equity in Sustainable Development", **Alternatives**, 16: 26-34.

Gardner, J.E., (1989), "Decision making for Sustainable Development: Selected Approaches to Environmental Assessment and Management", **Environmental Impact Assessment Review**, 9: 4: 337-366.

Gary, R. & Belbington, K.J., (1993), "The Global Environment and Economic Choice", D.K. Adams (Ed.), **Environmental Issues: The Response of Industry and Public Authorities**: 21-35, Ryburn: Halifax, England.

Gatto, M., (1995), "Sustainability: Is it a Well Defined Concept?", **Ecological Applications**, 5: 4: 1181-1184.

Georgescu-Roegen, N., (1993), "The Entropy Law and the Economic Problem", in H.E. Daly & K.N. Townsend, (Eds.), **Valuing the Earth: Economics, Ecology, Ethics**, The MIT Press: Cambridge.

Giddens, A., (1989), **Sociology**, Basil Blackwell: Oxford.

Giddings, R.D., (2000), "Sustaining Cultural Heritage of City Centre Buildings in Northern Europe", **Proceedings of the Millennium Conference - Cities and Sustainability: Sustaining Our Cultural Heritage,** Kandalma, Sri Lanka: 22nd – 25th February.

Gilham, A., (1998), "Strategies for Change – Understanding Sustainable Development from a Construction Industry Perspective", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change** Gävle, Sweden, 7th – 12th June.

Gladwin, T.N., (1993), "The Meaning of Greening: A Pleas for Organizational Theory", in K. Fisher & J. Schot (Eds.), **Environmental Strategies for Industry**: 37-61. Island Press: Washington, DC.

Glaser, B. & Strausss, A.L., (1967), **The Discovery of Grounded Theory**, Aldine: New York.

Glass, G., (1993), **Meta-analysis,** Sage: London.

Glass, G.V., (1976), "Primary, Secondary, and Meta-analysis of Research", **Education Research,** 5: 10: 3-8.

Goldberg, M., (1989), **On Systemic Balance – Flexibility and Stability in Social, Economic and Environmental Systems,** Praeger: New York.

Goodland, R. & Ledec, G., (1987), "Neoclassical Economics and Principles of Sustainable Development", **Ecological Modelling,** 38: 19-46.

Goodland, R., (1991), "The Case that the World has Reached Limits: More Precisely that Current Throughput Growth in the Global Economy Cannot be Sustained", in R. Goodland, H.E. Daly & El Serafy, (Eds.), **Environmentally Sustainable Development: Building on Brundtland,** The World Bank: Washington, DC.

Goodland, R., Daly, H. & Kellenberg, J., (1994), "Burden Sharing in the Transition to Environmental Sustainability", **Futures,** 26: 2: 146-155.

Gore, A., (1992), **Earth in Balance: Ecology and the Human Spirit,** Houghton Mifflin: New York.

Gough, J. & Ward, J., (1996), "Environmental Decision-making and Lake Management", **Journal of Environmental Management,** 48: 1: 1-16.

Goulet, D., (1993), "Biological Diversity and Ethical Development", in L.S. Hamilton, (Ed.), **Ethics, Religion and Biodiversity: Relations Between Conservation and Cultural Values**: pages 17-39, White Horse Press: Cambridge, England.

Gouzee, N., (1996), **Indicators for Sustainable Development,** United Nations Commission on Sustainable Development: New York.

Graham-Tomasi, T., (1991), "Sustainability: Concepts and Implications for Agricultural Research Policy", in P.G. Pardy, J. Roseboom & J.R. Anderson (Eds.), **Agricultural Research Policy, International Quantitative Perspectives,** Cambridge University Press: Cambridge.

Grant, J., Manuel, P. & Joudrey, D., (1996), "A Framework for Planning Sustainable Residential Landscapes", **Journal of the American Planning Association,** 63: 3: 331.

Greed, C. (1988), "Cultural Change in Construction: Generic or Gendered", **Proceedings of the CIB World Building Congress – Construction and the Environment: Symposium D: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden: 7th – 12th June.

Griffith, A., (1995), "The Current Status of Environmental Management Systems in Construction", **Engineering, Construction and Architectural Management**, 2: 1: 5-15.

Group of Seven, (1989), **Summit of the Arch: Economic Declaration**, Paris: 16th July.

Group on the State of the Environment, (1993), "OECD Cores Set of Indicators for Environmental Performance Reviews", **Environment Monograph No. 83: OCDE/DG(93)179**, OECD: Paris.

Grubb, E., (1993), **The Earth Summit Agreements: A Guide and Assessment**, Earthscan: New York.

Grundy, K., (1994), "Sustainable Development: An Emerging Paradigm", **Proceedings of the 17th New Zealand Geographical Society** Conference, Christchurch, New Zealand.

Guinomet, I., (1997), "Approaches to Indicators of Sustainable Development in the European Commission", in B. Moldan & Billharz, S., (Eds.), **Sustainability Indicators**, Wiley: New York.

Haas, P.M., Levy, M.A. & Parson, E.A., (1992), "Appraising the Earth Summit: How Should We Judge UNCED's Success?", **Environment**, 34: 8: 6-33.

Hadfield, L. & Seaton, R.A.F., (1999), "A Co-evolutionary Model of Change in Environmental Management", **Futures**, 31: 6: 577-591.

Hajer, M., (1995), **The Politics of Environmental Discourses: Ecological Modernisation and the Policy Process**, Oxford University Press: London.

Häkkinen, T. & Saam, M., (1998), "Ecological Building Design", **Proceedings of the CIB World Building Congress: Construction and the Environment – Symposium A: Materials and Technologies for Sustainable Construction**, 7th – 12th June: Gävle, Sweden.

Hall, C.A.S., (1988), "An Assessment of Several of the Historically Most Influential Theoretical Models Used in Ecology and of the Data Provided in their Support", **Ecological Modelling,** 43: 5-31.

Hall, C.A.S., (1991), "An Idiosyncratic Assessment of the Role of Mathematical Models in Environmental Sciences", **Environment International,** 17: 507-517.
Hall, S., (1988), **The Hard Road to Renewal,** Verso: London.

Halliday, S.P. & Beggs, C.B., F., (1998), "The Potential for Solar Powered Desicvant Cooling", **CIB World Building Congress: Construction and the Environment – Symposium B: Indoor Environment and Sustainable Development – Are they Compatible?,** Gävle, Sweden, 7th – 12th June.

Halliday, S.P., (1994), "BSRIA's Environmental Code of Practice for Buildings and their Services", **Proceedings of the First International Conference of CIB TG16 on Sustainable Construction**, Tampa, Florida: 6th – 9th November.

Hamilton, A. & Fernando, T., (2000), "Participation in Urban Planning: A Visual Approach", **Proceedings of the Millennium Conference - Cities and Sustainability: Sustaining Our Cultural Heritage,** Kandalma, Sri Lanka: 22nd – 25th February.

Hamilton, A., Curwell, S. & Davies, T., (1998), "A Simulation of the Urban Environment in Salford", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change,** Gävle, Sweden, 7th – 12th June.

Hamilton, L.S., (Ed.), (1993), **Ethics, Religion and Biodiversity: Relations Between Conservation and Cultural Values,** White Horse Press: Cambridge, England.

Hammond, A., (1995), **A Systematic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development,** World Resources Institute.

Hannon, B. & Joiris, C., (1987), "A Seasonal Analysis of the Southern North Sea Ecosystem", **Ecology,** 70: 1916-1934.

Hansen, S.J., (1991), **Managing Indoor Air Quality,** PrenticeHall: Englewood Cliffs, NJ.

Haque, M.M., (1991), "Sustainable Development and Environment: A Challenge to Technology Choice Decision-making", **Project Appraisal**, 6: 3: 149-157.

Hardi, P. & Zdan, T., (1997), **Assessing Sustainable Development: Principles in Practice**, International Institute for Sustainable Development: Winnipeg, Manitoba.

Harlen, W. & Malcolm, H. (1997), **Setting and Streaming: A Research View**, Scottish Council for Research in Education: Edinburgh.

Harrison, P., (1992), **The Third revolution: Population, Environment and a Sustainable World**, Penguin: New York.

Hart, S.L., (1997), "Beyond Greening: Strategies for a Sustainable World", **Harvard Business Review**, 75: 1: 66-76.

Harvey, D., (1996), **Justice, Nature and the Geography of Difference**, Blackwell: Cambridge, MA.

Hastings, S.R., (1994), **Passive Solar Commercial and Institutional Buildings: A Sourcebook of Examples and Design Insights**, Wiley & Sons: West Sussex.

Haywood, T., (1995), **Ecological Thought: An Introduction**, Polity Press.

Held, D., (1980), **Introduction to Critical Theory: Horkheimer to Habermas**, Polity Press: Oxford.

Henry, G.T., (1990), **Practical Sampling**, Sage: Newbury Park, California.

Henry, G.T., (1998), "Practical Sampling", in L. Bickman & D.J. Rog, (Eds.), **Handbook of Applied Social Research Methods**, Sage: London. Pps. 101-126.

Herring, H., (1990), **Does Energy Efficiency Save Energy: The Economists Debate: EERU Report No. 074**, The Open University: Milton Keynes, UK.

Hickson, D.J., Pugh, D.S. & Pheysey, D.C., (1969), "Operations Technology and Organizational Structure: An Empirical Reappraisal", **Administrative Science Quarterly**, 14: 378-379.

Hill, R.C. & Bowen, P.A., (1997), "Sustainable Construction: Principles and a Framework for Attainment", **Construction Management and Economics**, 15: 223-239.

Hirschheim, R., (1992) "Information Systems Epistemology: An Historical Perspective," in R. Galliers (Ed.), **Information Systems Research: Issues, Methods and Practical Guidelines**, Blackwell Scientific Publications: Oxford. Pp. 28-60.

Holling, C.S., (1964), "The Analysis of Complex Population Processes", **Canadian Entomology**, 96: 335-347.

Holling, C.S., (1992), "Cross-scale, Morphology, Geometry, and Dynamics of Ecosystems", **Ecological Monographs**, 64: 24: 447-502.

Holmberg, J., (1992), **Making Development Sustainable: Redefining Institutions, Policy, and Economics**, Washington, DC.

Houghton, J.T., (1996), **Climate Change 1995: The Science of Climate Change: Contribution of Working Group 1 to the Second Assessment Report of the Intergovernmental Panel on Climate Change**, Cambridge University Press: Cambridge.

House of Commons Energy Committee, (1989), **Energy Policy Implications of the Greenhouse Effect: Volume 1, 6th Report of the House of Commons Energy Committee**, H.M.S.O., London, U.K.

Howard, N.P., (1996), "Embodied Energy and Consequential CO_2 in Construction", **Proceedings of the International Symposium on Energy and Mass Flow in the Life Cycle of Buildings**, August: Vienna, Austria.

Howe, C., (1979), **Natural Resource Economics**, Wily: New York.

Hufschmidt, M.M., James, D.E., Meister, A.D., Bower, B.T. & Dixon, J.A., (1983), **Environment, Natural Systems and Development: An Economic Valuation Guide**, John Hopkins University Press: Baltimore.

Inglehart, R., (1977), **The Silent Revolution: Changing Values and Political Styles Among Western Publics**, Princeton University Press: Princeton, NJ.

Intergovernmental Panel on Climate Change, (1990), **Policy-maker's Summary of the Scientific Assessment of Climate Change**, WMO & UNEP: New York.

Intergovernmental Panel on Climate Change, (1992), **Climate Change 1992: The Supplementary Report to the IPCC Scientific Assessment**, Cambridge University Press: Cambridge, UK.

Intergovernmental Panel on Climate Change, Radiative Forcing of Climate Change: The 1994 Report of the Scientific Assessment Working Group of IPCC (World Meteorological Organization/United Nations Environment Programme, Geneva, 1994), p. 5, 11, 14.

International Energy Agency, (1996), **World Energy Outlook 1996**, IEA: London.
Irwin, A., (1995), **Citizen Science: A Study of People, Expertise and Sustainable Development**, Routledge: London.

Irwin, A., (1995), **Citizen Science: A Study of People, Expertise and Sustainable Development**, Routledge: London.

IUCN, (1984), **World Conservation Strategy**, IUCN: Gland, Switzerland.

IUCN, WWF & UNEP, (1980), **The World Conservation Strategy**, IUCN, WWF & UNEP: Gland Switzerland.

Iyer-Ranigal, U. & Treloar, G., (2000), "Participative Management Techniques for Sustainable Development", **Proceedings of the Millennium Conference - Cities and Sustainability: Sustaining Our Cultural Heritage,** Kandalma, Sri Lanka: 22nd –25th February.

Jacobs, E. & Worcester, R., (1990), **We British: Britain Under the Moriscope**, Weidenfeld and Nicolson.

Jacobs, J., (1969), **The Death and Life of Great American Cities**, Modern Library: New York.

James, D.E., (1989), "Achieving Sustainable development: Applications of Economic Techniques", Milieu, 4: 129-133.

Jansson, A., Hammer, M., Folke, C. & Costanza, R., (Eds.), (1994), **Investing in Natural Capital: The Ecological Economics Approach to Sustainability**, Island Press: Washington, D.C.

Japanese Standard Association, (1992), **Japanese Industrial Standard: K 5659-1992 – Fluoro Resin Paint for Steel Structures**, Japanese Standard Association: Japan.

Jesinghaus, J., (1995). "Green Accounting and Environmental Indicators: The Pressure Indices Project", **SCOPE Workshop on Indicators of Sustainable Development**, EUROSTATE / Commission of the European Communities: Wuppertal.

Jick, T.D., (1979), "Mixing Qualitative and Quantitative Methods: Triangulation in Action", **Administrative Science Quarterly**, 24: 602-611.

Jolly, J., Reynolds, T. & Slocum, J., (1988), "Application of the Means-end Theoretical for Understanding the Cognitive Bases of Performance Appraisal", **Organizational Behavior and Human Decision Processes**, 41: 153-179.

Juniper, T., (1997), "Hard Work to Bridge a Gap", **The Financial Times**, September 3rd: Page 24.

Kaplan, R.D., (1994), "The Coming Anarchy", **Atlantic Monthly**, 273: 2: 43-76.

Karr, J.R. & Dudley, D.R., (1981), "Ecological Perspective on Water Quality Goals", **Environmental Management**, 5: 55-68.

Kibert, C.J., (1994), Final Session of the **First International Conference of CIB TG 16 on Sustainable Construction**, Tampa, Florida: 6th – 9th November.

Kibert, C.J., Eilenberg, I. & Huovila, P., (1997), "Implementation of Best Practice for Sustainable Construction", **CIB Coordinators' Trend Reports: An Anthology for Future Perspectives: CIB Report 211**, CIB. Page 5.

Kibert,. C.J., (1994), **Proceedings of the First International Conference on Sustainable Construction**, Tampa, Florida: 6th – 9th November.

Kim, J. & Rigdon, B., (1998), **Introduction to Sustainable Design**, National Pollution Centre for Higher Education: Ann Arbor.

Kitson, A. & Campbell, R., (1996), **The Ethical Organisation: Ethical Theory and Corporate Behaviour**, MacMillan: Basingstoke, Hampshire.

Klaassen, G.A.J. & Opschoor, J.B., (1991), "Economics of Sustainability or the Sustainability of Economics: Different Paradigms", **Ecological Economics**, 115: 93-115.

Kobet, B., Powers, W., Lee, S. & Mondor, C., (1999), **High-performance Green Buildings: A Document for Decision Makers**, Pennsylvania Department of Environmental Protection, U.S.A.

Kraus, M., (1987), "Energy Forecasting: The Epistemological Context", **Futures**, 19: 3: 254-276.

Kuhn, T.S., (1962), **The Structure of Scientific Revolutions**, University of Chicago Press: Chicago.

Kuhn, T.S., (1970), **The Structure of Scientific Revolutions** (2nd edition), University of Chicago Press: Chicago.

Kumar, A., (1993), quoted in Gilham, A., (1998), "Strategies for Change – Understanding Sustainable Development from a Construction Industry Perspective", **Proceedings of the CIB World Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change**, 7th – 12th June: Gävle, Sweden.

Langley A., Dantalis, N. & Edwards-Bert, P., (Eds.), (1992), **Environmental Health in the Home**, South Australian Health Commission, Public & Environmental Health Service: Adelaide.

Langley, A., (1998), "The Roles of Formal Strategic Planning", **Long Range Planning**, 21: 3: 40-50.

Lave, L., (1990), "Comments: Tax Policy to Combat Global Warming", in R. Dornbusch & J. Poterba, (Eds.), **Global Warming: Economic Policy Responses**, MIT Press: Cambridge. Pages 98-104.

Lazarus, M. & von Hippel, D., (1995), **A Guide to Environmental Analysis for Energy Planners**, Stockholm Environment Institute: Boston, MA.

Lee, K.I., (1998), "The Direction of Policies and Systems for the Development of Sustainable Human Settlements in Korea", **CIB World Building Congress: Construction and the Environment – Symposium C: Legal and Procurement Practices – Right for Environment**, Gävle, Sweden, 7th – 12th June.

Lee, K.N., (1993), "Greed, Scale Mismatch and Learning", **Ecological Applications**, 3: 4: 560-564.

Lenard, D., Raftery, J. & McGeorge, D., (1997), "Designing a Research Methodology", **Journal of Construction Procurement**, 3: 2: 19-33.

Lennard, S.C. & Lennard, H.L., (1987), **Livable Cities People and Places: Social and Design Principles for the Future of the City**, Centre of Urban Well-being: New York.

Lenssen, N. & Roodman, D.M., (1995), "Making Better Buildings", in L.R. Brown (Ed.), **State of the World 1995**, Earthscan: London.Pages 95-112.

Levin, H., (1997), "Systematic Evaluation and Assessment of Building Environmental Performance (ASEABEP)", **Proceedings of the CSTB & CIB Second International Conference on Buildings and the Environment**, Paris: June.

Levin, S.A., (1993), "Science and Sustainability", **Ecological Applications**, 3: 4: 1-2.

Levin, S.A., (1996), "Forum on Economic Growth and Environmental Quality", **Ecological Applications**, 6: 12-31.

Levins, R., (1966), "The Strategy of Model Building in Population Biology", **American Science**, 54: 421-431.

Lewis, T.M., (1998), "The Concept and context of Sustainable Development in the Caribbean", **CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change**, Gävle, Sweden, 7th – 12th June.

Light, R.J. & Pillemer, D.B., (1984), **Summing Up: The Science of Review in Research**, Harvard University Press: London.

Light, R.J. & Smith, P.V., (1971), "Accumulating Evidence: Procedures for Resolving Contradictions Among Different Research Studies", **Harvard Education Review**: 41: 429-471.

Lindblom, C.E. & Cohen, D.K., (1979), **Usable Knowledge**, Yale University Press: New Haven.

Lindfors, L.G., Christiansen, K., Hoffman, L., Virtanen, Y., Juntilla, V., Hanssen, O.J., Rønning, A., Ekvall, T. & Finnveden, G., (1995), **Nordic Guidelines on Life-cycle Assessment**, Nordic Council of Ministers: Copenhagen.

Linstone, H.A., (1978), "The Delphi Technique", in J. Fowles, (Ed.), **Handbook of Futures Research**, Greenwood Press: London.

Little, D., (1993), "Evidence and Objectivity in the Social Sciences", **Social Research**, 60: 2: 363 – 396.

Lizieri, C., Palmer, S., Charlton, M., Wilson, C. & Finlay, L., (1996), "Valuation Methodology and Environmental Legislation: A Study of the UK Commercial Property Industry", **RICS Research Paper Series: Volume 2: Number 3**, RICS: London.

Lloyd, M., (1994), "How Green are My Suppliers?", **Purchasing and Supply Chain Management**, CIPS: England. Page 40.

Lombardi, P. & Basden, A., (1997), "Environmental Sustainability and Information Systems", **Systems Practice**, 10: 4: 473-489.

Lovelock, J., (1988), **The Ages of Gaia**, W.W. Norton: New York.

Lowe, M.D., (1990), "Alternatives to the Automobile: Transport for Livable Cities", **Worldwatch Institute Paper 98/49**, Worldwatch Institute.

Lowe, R.J., (1997), "Defining and Meeting the Carbon Constraints of the 21st Century", **Proceedings of the Second International Conference: Buildings and the Environment**, Centre Scientifique et Technique du Bâtiment: Paris, June.

Lyle, J.T., (1994), **Regenerative Design for Sustainable Development**, Wiley: New York.

Maguire, P., (1987), **Doing Participatory Research: A Feminist Approach**, Centre for International Education: Amherst.

Makower, J., (1994), **Beyond the Bottom Line**, Simon & Schuster: New York.

Markwell, S. & Ravenscroft, N., (1996), "Sustainable Land Management and Development: The Role of the Rural Chartered Surveyor", in Y. Rydin (Ed.), **The**

Environmental Impact of Land and Property Management, Wiley/RICS: London.

Maruši, J., Širac, M. & Šturlan, S., (1996), "The Importance, Financing, Planning and Evaluation of Water Management Works and Systems in the Republic of Croatia", **Proceedings of CIB W55 Economic Management of Innovation, Productivity and Quality in Construction**: Pages 741 – 751, Zagreb, Croatia: September 4th – 7th.

May, A.D., Mitchell, G. & Kupiszewska, D., (1995), "The Development of the Leeds Quantifiable City Model", **Proceedings of the International Workshop on the Environmental Impact Evaluation of Buildings and Cities for Sustainability**, Florence, Italy,: 13th – 15th September.

McCarty, J.; Pottinger, K.G. & Dixon, T.J., (1999), **Waste Not, Want Not? Brownfield Development and the Effects of the Landfill Tax**, College of Estate Management: Reading.

McCluney, R., (1994), **The Case for Daylighting**, Solar Energy Centre: Cape Canaveral, Florida.

McLennan, P., (1990), "Sick Building Syndrome: An Alternative View", **Facilities**, 8: 4: 21-23.

McNeill, J., (1989), "Strategies for Sustainable Development", **Scientific American**, September: 155-165.

McNeill, P., (1990), **Research Methods**, Routledge: London.

Meadows, D., (1996), "Who Causes Environmental Pollution", **ISEE Newsletter**, 6: 3: 1-8.

Meadows, D., 1998), **Indicators and Information Systems for Sustainable Development**, The Sustainability Institute: Hartford Four Corners.

Meadows, D.H., (1972), **The Limits to Growth: A Report to the Club of Rome's Project on the Predicament of Mankind**, Universe Books: New York.

Meadows, D.H., Meadows, D.L., & Randers, J., (1992), **Beyond the Limits: Confronting Global Collapse – Envisioning a Sustainable Future**, Chelsea Green: Post Mills, VT.

Merchant, C., (1992), **Radical Ecology: The Search for a Liveable World,** Routledge: New York.

Midgley, M., (1994), "The End of Anthropocentrisn?", in R. Attfield & A. Belsey, (Eds.), **Philosophy and the Natural Environment - Royal Institute of Philosophy Supplement: 36**: Pages 103-112, Press Syndicate: Cambridge.

Mintel, (1989), **The Green Consumer,** Mintel: London.

Mishan, E.J., (1973), "The Growth of Affluence and the Decline of Welfare", in H.E. Daly, (Ed.), **Economies, Ecology, Ethics: Essays Toward a Steady-state Economy,** Freeman: pages 267-281.

Mitlin, D. & Satterthwaite, D., (1991), "Sustainable Development and Cities", Prepared for **How Common is Our Future?,** Global NGO Forum.

Morgan, G. & Ramirez, R., (1983), "Action Learning: A Holographic Metaphor for Guiding Social Change", **Human Relations,** 37: 1: 1-28.

Morgan, G. & Smircich, L., (1980), "The Case for Qualitative Research", **Academy of Management Review,** 5: 491-500. Page 491.

Morgan, G.,(1986), **Images of Organization,** Sage: Newbury Park.

Morin, E., (1992), "The Concept of System and the Paradigm of Complexity", in M. Maruyama (Ed.), **Context and Complexity: Cultivating Contextual Understanding**: 125-136, Springer-Verlag: New York.

Municipality of Metropolitan Toronto, (1995), **The State of the Environment Report: Metropolitan Toronto,** Metropolotan Toronto Planning Department: Toronto.

Murcott, S., (1997), "Sustainable Systems: Definitions, Principles, Criteria, and Indicators", **Proceedings of the American Association for the Advancement of Science Annual Meeting and Science Innovation Exposition,** Seattle: 13th – 18th February.

Murdoch, L., Fewkes, A., & O'Rouke, A., (2000), "The Performance of Planted Roof Systems in the UK", **Proceedings of the Millennium Conference - Cities and**

Sustainability: Sustaining Our Cultural Heritage, Kandalma, Sri Lanka: 22nd – 25th February.

Murray, C.J.L., (1991), **Development Data Constraints and the Human Development Index**, United Nations Research Institute for Social Development: Geneva.

Myerson, G. & Rydin, Y., (1996), **The Language of the Environment: A New Rhetoric**, University College London Press.

National Academy of Sciences, (1976), **Renewable Resources for Industrial Materials,** NAS: Washington, DC, USA.

National Research Council, (1987), **Infrastructure for the 21st Century: Framework for a Research Agenda**, Committee on Infrastructure Innovation, National Research Council, Washington, DC., USE.

National Science Foundation, (1993), **Civil Infrastructure Systems Research: Strategic Issues**, National Science Foundation: Washington, D.C., U.S.A.

Natural Resources Canada and Forintek Canada Corporation, (1994), **Building Materials in the Context of Sustainable Development: Summary Report and Research Guidelines**, Forintek Canada Corporation: Ottawa.

Ngowi, A.B., (1998), "Is Construction Procurement a Key to Sustainable Development?", **Building Research and Information,** 26: 6: 340-350.

Nibel, S., Duchêne-Marullaz, P., & Olive, G., (1998), "Environmental Book of Specifications and Qualitative Assessment Methods for Green Secondary Schools", **Proceedings of the CIB World Building Congress: Construction and the Environment – Symposium D: Managing for Sustainability – Endurance Through Change,** Gävle, Sweden: 7th – 12th June.

Nordhaus, W., (1992), "An Optimal Transition Path for Controlling Greenhouse Gases", **Science,** 258: 20.

Norgaard, R., (1994), **Development Betrayed: The End of Progress and a Coevolutionary Revisioning of the Future**, Routledge: New York.

Norgaard, R., (1992), "Sustainability of the Economics of Assuring Assets for Future Generations", **World Bank, Working Paper Series No. 832**, World Bank: New York.

Norgaard, R., (1988), "Sustainable development: A Co-evolutionary View", **Futures**, December: 606-620.

Norgaard, R., (1985), "Environmental Economics: An Evolutionary Critique and a Plea for Pluralism", **Journal of Environmental Economics and Management**, 12: 382-394.

Norris, G.A. & Marshall, H.E., (1995), **Multiattribute Decision Analysis: Recommended Method for Evaluating Buildings and Building Systems: Report 5663 for the National Institute of Standards and Technology**, NISIR: Gailhersburg.

Norton, B.G., (1991), **Toward Unity Among Environmentalists**, Oxford University Press: New York.

Norton, B.G., (1992), "A New Paradigm for Environmental Management", in R. Costanza, B.D. Haskell & B.G. Norton, (Eds.), **Ecosystem Health: New Goals for Environmental Management**: Pages 23-41, Island Press.

Nui, W-Y, Lu, J.J. & Khan, A.A., (1993), "Spatial Systems Approach to Sustainable Development: A Conceptual Framework", **Environmental Management**, 17: 2: 179-186.

O'Cofaigh, E. & Lewis, O.J., (1999), "The Principles and Practice of Sustainable Architectural Design", **Sustainable and Energy Efficient Building**, James and James (Science Publishers) Ltd: London. Pages 56-62.

O'Riordan, T., (1995), "Frameworks for Choice: Core Beliefs and the Environment", **Environment**, 37: 8: 5.

Odman, P., (1985), "Hermeneutics", in T. Husen & N.T. Postlewaite, (Eds.), **The International Encyclopaedia of Education**: 2162-2169, Pergamon: Oxford.

Odum, E., (1971), **Fundamentals of Ecology**: 3rd edition, Saunders: Philadelphia.

Odum, E.P., (1993), **Ecology and Our Endangered Life Support Systems**: 2nd edition, Sinauer: Sunderland, Massachusetts.

OECD, (1991), **Environmental Indicators: A Preliminary Set**, Organization for Economic Co-operation and Development: Paris.

OECD, (1993), **OECD Core Set of Indicators for Environmental Performance Reviews – Environmental Monograph No. 83**, Organization for Economic Co-operation and Development: Paris.

OECD, (1997), **Sustainable Consumption and Production: Clarifying the Concepts**, OECD: Paris.

Oelschlaeger, M., (1991), **The Idea of Wilderness: From Prehistory to the Age of Ecology**, Yale University Press: New York.

Ofori, G., (1992), "The Environment: The Fourth Construction Project Objective?", **Construction Management and Economics**, 10: 5: 369-395.

Ofori, G., (1994), "Construction Industry Development: The Role of Technology Transfer", **Construction Management and Economics**, 12: 5: 379-392.

Ohmae, K., (1990), **The Borderless World: Power and Strategy in the Interlinked Economy**, Harper: New York.

Ontario Institute for Studies in Education, (1994), **Awakening Sleepy Knowledge: Transformative Learning in Action: Final Report of the Transformative Learning Through Environmental Action Report**, OISE: Toronto.

Organisation for Economic Co-operation and Development, (1993), **OECD Core Set of Indicators for Environmental Performance Reviews: A Synthesise Report by the Group on the State of the Environment: Environment Monograph No. 83**, Organisation for Economic Co-operation and Development: Paris.

Organisation for Economic Co-operation and Development, (1997), **Better Understanding Our Cities: The Role of Urban Indicators**, Organisation for Economic Co-operation and Development: Paris.

Organisation for Economic Co-operation and Development, (1997), **OECD Environmental Performance Reviews: A Practical Introduction**, OCDE: Paris.

Oriens, G.H., (1990), "Ecological Concepts of Sustainability", **Environment**, 32: 9: 10-39.

Orlikowski, W.J. & Baroudi, J.J. (1991), "Studying Information Technology in Organizations: Research Approaches and Assumptions", **Information Systems Research**, 2: 1-28.

Ornstein, R. & Ehrlich. P., (1990), **New World, New Mind**, Touchstone: New York.

Orr, D.W., (1994), **Earth in Mind: On Education, Environment, and the Human Prospect**, Island Press: Washington, D.C.

Paehlke, R., (1996), **Myths: Towards a More Urbanist Environmentalism: Research Paper No. 159**, Centre for Urban and Community Studies.

Page, T., (1982), "Intragenerational Justice as Opportunity", in D, Maclean & P. Brown, (Eds.), **Energy and the Future**, Rowman & Littlefield: Totowa.

Pannell, D.J. & Schilizzi, S., (1997), "Sustainable Agriculture: A Question of Ecology, Economics, Ethics or Expedience?, **Proceedings of the 41st Annual Conference of the Australian Agriculture and Resource Economics** Society, Gold Coast, Queensland, 21st 23rd January.

Passive Solar Industries Council and National Renewable Energy Laboratory, (1997), **Designing Low Energy Buildings – Integrating Daylighting, Energy-efficient Equipment, and Passive Solar Strategies**, Passive Solar Industries Council and National Renewable Energy Laboratory: Washington, D.C.

Pauchant, T. & Fortier, J., (1990), "Antropocentric Ethics in Organizations, Strategic Management and the Environment", in P. Shrivastava & R. Lamb (Eds.), **Advances in Strategic Management**, Volume 6: 99-114, Jai Press: Greenwich.

Pearce, D,W. & Atkinson, G., (1995), "Measuring Sustainable Development", in D.W. Bromley (Ed.), **The Handbook of Environmental** Economics, Blackwell: Oxford.

Pearce, D., (1988), "Optimal Prices for Sustainable Development", in D. Collard, D. Pearce & D. Ulph, (Eds.), **Economics, Growth and Sustainable Environments**, St. Martin's Press: New York. Page 58.

Pearce, D., (1998), "Measuring Sustainable Development", in the **Proceedings of the Sustainable Development Indicators OECD Expert Workshop**, 8th – 9th October: Paris.

Pearce, D., (1998), "Measuring Sustainable Development", **Sustainable Development Indicators: OECD Expert Workshop**, OECD: Paris, 8th – 9th October.

Pearce, D., Markandya, A. & Barbier, E.B., (1989), **Blueprint for a Green Economy**, Earthscan Publications: London.

Pearce, D.W. & Atkinson, G., (1992), "Are National Economies Sustainable? – Measuring Sustainable Development", **CSERGE GEC Working Paper 92-11**, University College London.

Pearce, D.W. & Atkinson, G., (1995), "Measuring Sustainable Development", in D.W. Bromley (Ed.), **The Handbook of Environmental Economics**, Blackwell: Oxford.

Pell, D. & Wismer, S., (1990), **Social Implications of a Sustainable City**, Development Initiatives Inc.: Guelph.

Peterson, F.M. & Fischer, A.C., (1977), "The Exploitation of Extractive Resources: A Survey", **Economics Journal**, 87: 681-721.

Pezzy, J., (1989), "Economic Analysis of Sustainable Growth and Sustainable Development", **World Bank Environment: Working Paper 15**, Washington, D.C.

Pezzy, J., (1992), "Sustainable Development Concepts: An Economic Analysis, **World Bank Environment Paper No.2**, World Bank: Washington, DC.

Phillips, N. & Brown, J.L., (1993), "Analyzing Communication In and Around Organizations: A Critical Hermeneutic Approach", **Academy of Management Journal**, 38: 6: 1547-1576. Page 1573.

Pietersen, H.S. & Fraay, A.L.A., (1998), "Performance of Concrete with Recycled Aggregates", **CIB World Building Congress: Construction and the Environment – Symposium A: Materials and Technologies for Sustainable Constructionlity – Endurance Through Change** Gävle, Sweden, 7th – 12th June.

Pimms, S.L., (1991), **The Balance of Nature?**, University of Chicago Press: Chicago, Illinois.

Posal, S., (1994), "Carrying Capacity: Earth's Bottom Line", in L.R. Brown *et al.*, (Eds.), **State of the World: 1994**, Worldwatch Institute, Norton: New York.

Postel, S., (1993), "Facing Water Scarcity", L. Starke, (Ed.), **State of the World 1993**, Worldwatch Institute: New York.

Postel, S.L., Daily, G.C. & Ehrlich, P.R., (1996), "Human Appropriation of Renewable Fresh Water", **Science**, 271: 785-788.

President's Council on Sustainable Development, (1996), **Sustainable America: A New Consensus for Prosperity, Opportunity, and a Healthy Environment for the Future**, PCSD: Washington, DC.

Public Technology, Inc., (1996), **Sustainable Building Technical Manual: Green Building Design, Construction and Operations**, Public Technology, Inc.

Queneudec, M., Legarrec, M.J., Alfim, K. & Bouguerra, A., (1996), **Concrete for Environmental Enhancement and Protection**, E&FN Spon: London.

Radnitzky, G., (1970), **Contemporary Schools of Metascience**, Scandinavian University Books: Goteborg.

Rahman, A., (1993), **People's Self-development: Perspectives on Participation Action Research – A Journey Through Experience**, Zed Books: London.

Rath, A. & Herbert-Copley, B., (1993), **Green Technologies for Development: Transfer, Trade and Cooperation**, International Development Research Agency: Ottawa.

Redclift, M., (1989), **Sustainable Development**, Routledge: London.

Redclift, M.R., (1987), **Sustainable development: Exploring the Contradictions**, Methuen: London.

Reeds, J., (1997), "No Time to Waste", **Construction Manager**, 3: 5: 19-21.

Rees, J., (1990), **Natural Resources: Allocation, Economics and Policy**: 2nd edition, Routledge: London.

Rees, W.E., (1995), "Achieving Sustainability: Reform or Transformation", **Journal of Planning Literature**, 9: 4: 343-361.

Rees, W.E. & Wackernagel, M., (1994), "Ecological Footprints and Appropriated Carry Capacity: Measuring the Natural Capital Requirements of the Human Economy", in A.M. Jannsson, M. Hammer, C. Folke & R. Costanza, (Eds.), **Investing in Natural Capital: The Ecological Economics Approach to Sustainability**, Washington Island Press: Washington D.C.

Rees, W.E., (1991), **Understanding Sustainable Development**, School of Community and Regional Planning: University of British Columbia, Vancouver.

Regan, T., (1983), **The Case for Animal Rights**, University of California Press: Berkley.

Reichman, O.J. & Pulliam, H.R., (1996), "The Scientific Basis for Ecosystem Management", **Ecology Applications**, 6: 3: 694-696.

Reiger, H.A., (1994), **The Notion of Natural and Cultural Integrity: Ecological Integrity and the Management of Ecosystems**, St. Lucie Press.

Rennings, K. & Wiggering, H., (1997), "Steps Towards Indicators of Sustainable Development: Linking Economic and Ecological Concepts", **Ecological Economics**, 20: 25-36.

Research Development Bureau of Science and Technology of Japan, (1993), **Ecomaterials for the Preservation of the Global Environment: Report of Fundamental Research**, Research Development Bureau of Science and Technology of Japan: Tokyo: Japan.

Richardson, N., (1992), "Canada", in R. Stren, R. White and J. Whitney, (Eds.), **Sustainable Cities: Urbanization and the Environment in International Perspectives**: 145-167, Westview Press: Boulder.

Roberts, P., (1995), **Environmentally Sustainable Business: A Local and Regional Perspective**, Paul Chapman: London. Pages 14-15.

Robertson, M., (1993), "The Response of Industry to Environmental Concern", in D.K. Adams (Ed.), **Environmental Issues: The Response of Industry and Public Authorities**: Pages 93-102, Rayburn: Halifax, England. Page 101.

Rolston, H., (1994), **Conserving Natural Value**, Columbia University Press: New York.

Rolston, H., (1996), "Earth Ethics: A Challenge to Liberal Education", in J.B. Callicot, F.J.R. da Rocha, (Eds.), **Earth Summit Ethics: Towards a Reconstructive Postmodern Philosophy of Environmental Education**, State University of New York Press: Albany, New York. Page 162.

Romm, J. & Browning, W., (1994), **Greening the Building and the Bottom Line: Increasing Productivity Through Energy-efficient Design**, Rocky Mountain Institute: Snowmass, Colorado.

Roodman, D.M. & Lennssen, N., (1995), "A Building Revolution: How Ecology and Health Concerns are Transforming Construction", **Worldwatch Paper 124**, Worldwatch Institute: Washington, D.C.

Roodman, D.M. & Lenssen, N., (1994), "Our Buildings, Ourselves", **World Watch**, 7: 6: 21-29.

Rose, G., (1982), **Deciphering Social Research**, MacMillan: London.

Roseland, M., (1992), **Toward Sustainable Communities: A Resource Book for Municipal and Local Governments**, Alger Press.

Rosenhead, J., (1989), **Rational Analysis of a Problematic World**, Wiley: Chichester.

Rosenthal, R., (1978), "Combining Results of Independent Studies", **Psychological Bulletin,** 85: 185-193.

Rossman, G.B. & Wilson, B.L., (1985), "Numbers and Words: Combining Quantitative and Qualitative Methods in a Single Large-scale Evaluation Study", **Evaluation Review**, 9: 5: 627-643.

Roszak, T., (1992), **The Voice of the Earth**, Simon & Schuster: New York.

Roughgarden, R.M. May & S.A. Levins, (Eds.), (1997), **Perspectives in Ecological Theory**, Princeton University Press: Princeton, N.J.

Ruben, B.D., (1972), "General System Theory: An Approach to Human Communication", in R.W. Budd & B.D. Ruben (Eds.), **Approaches to Human Communication**: 120-144, Hayden: Rochelle Park, NJ.

Rudestam, K.E. & Newton, R.R., (1992), **Surviving Your Dissertation: A Comprehensive Guide to Content and Process**, Sage: California.

Rydin, Y., (1992), "Environmental Impacts and the Property Market", in M.J. Breheny, M.J., (Ed.), **Sustainable Development and the Built Form**, Pion.

Sakai, K., Nakahara, T., Fujita, T., Morioka, T., Yoshida, N., Urushizaki, N. & Takemoto, K., (1998), "Application of Life Cycle Assessment (LCA) to Urban Renewal Projects", **Proceedings of the CIB World Congress: Construction and the Environment – Symposium A: Materials and Technologies for Sustainable Construction**, Gävle, Sweden: June 7th – 12th.

Sakamaki, F., (1986), "Hydrocarbons in the Global Troposphere", **Research Report National Institute Environmental Studies**, 102: 31-42.

Sanders, H.D., (1992), "The Khazzoom-Brookes Postulate and Neoclassical Growth", **Energy Journal**, 13: 4: 131-148.

Sartori, G., (1970), "Concept Misinformation in Comparative Politics", **American Political Science**, 64: 1033-1053.

Schoderbek, P.P., Schoderbek, C.G. & Kefalas, A.G., (1985), **Management Systems: Conceptual Considerations**, Business Publications: Plano, Texas. Page 292.

Schulze, I. & Colby, M., (1995), **A Conceptual Framework to Support Development and Use of Environmental Information in Decision-making**, United Nations Environmental Protection Agency: New York.

Schumacher, E.F., (1973), **Small is Beautiful: Economics as if People Really Mattered**, Abacus: London.

Schuurmans-Stehmann, A. & Meijr, J.P.R., (1998), "Environmental Relevant Product Information in the Dutch Building Industry", **Proceedings of the CIB World Building Congress: Construction and the Environment – Symposium A: Materials and Technologies for Sustainable Construction**, 7th – 12th June: Gävle, Sweden.

Schwartz, M. & Thompson, M., (1990), **Divided We Stand: Redefining Politics, Technology and Social Choice**, Harvester Wheatsheaf: New York.

Scott, A.J., (1997), "The Cultural Economy of Cities", **International Journal of Urban and Regional Research**, 21: 2: 323-340.

Seaden, G., (1997), "The Future of National Construction Research Organizations: Scenarios for the Changing Roles, Functions, Research Agendas and Funding", **Building Research and Information,** 25: 5: 250-256.

Sederberg, P.C., (1972), "Subjectivity and Typification: A Note on Method in the Social Sciences", **Philosophical Society of Science,** 2: 167-176.

Sexton, M.G. & Barrett, P.S., (2000), "The Need to Understand 'Worldview' Diversity in Developing Sustainable Built Environments', **Proceedings of the Millennium Conference: Cities and Sustainability – Sustaining Our Cultural Heritage**, Dambulla, Sri Lanka: 21st – 26th February.

Sexton, M.G., (1993), "The Greening of Industry: The Case of Office Lighting", **Unpublished M.Sc. Dissertation**, Manchester School of management, University of Manchester Institute of Science and Technology: Manchester, U.K.

Sexton, M.G., (1998), "Is There a Sustainable Definition of Sustainable Development?", **Unpublished Working Paper for the Integrated Delivery Systems for Sustainable Construction Project**, University of Salford, England.

Sexton, M.G., (1998), "Sustainability Indicators: Context, Process and Content", **Working Paper for the Integrated Delivery Systems for Sustainable Construction Project**, University of Salford: Salford.

Shah, P., (1994), "Institutional Participation", **Proceedings of the Workshop on Strategies for Sustainability**, IUCN General Assembly: Buenos Aires.

Shiklomanov, I., (1993), "World Fresh Water Resources", in P.H. Gleick, (Ed.), **Water in Crisis: A Guide to the World's Fresh Water Resources**, Oxford University Press: New York.

Shiva, V., (1992), **Staying Alive: Women, Ecology, and Development**, Zed: London.

Shove, E., (1998), "Gaps, Barriers and Conceptual Chasms: Theories of Technology Transfer and Energy in Buildings", **Energy Policy**, 26: 5: 1105-1112.

Shrivastava, P., (1994), "Castrated Environment: Greening Organizational Studies", **Organization Studies**, 15: 5: 7-5-726.

Shrivastava, P., (1995), "Ecocentric Management for a Risk Society", **Academy of Management Review**, 20: 118-137.

Shue, H., (1980), **Subsistence, Affluence, and U.S. Foreign Policy**, Princeton University Press: Princeton, New Jersey.

Siebert, H., (1995), **Economics of the Environment: Theory and Policy**, Springer-Verlag: Berlin.

Silver, C.S. & DeFries, R.S., (1990), **One Earth/One Future: Our Changing Global Environment**, National Academy Press: Washington, D.C.

Simmons, I.G., (1993), **Interpreting Nature: Cultural Constructions of the Environment**, Routledge: New York.

Singh, N.C., Titi, V. & Strickland, R., (1994), **Sustainable Development and the World Summit for Social Development: Conceptual and Practical Linkages Among Sustainable Development, Poverty Eradication, Productive Employment and Social Integration**, International Institute for Sustainable Development: Winnipeg, Canada.

Sjöström, C. & Bakens, W., (1999), "CIB Agenda 21 for Sustainable Construction: Why, How and What", **Building Research and Information**, 27: 6: 348-354.

Slaughter, R.A., (1996), "Long-term Thinking and the Politics of Reconceptualisation", **Futures**, 28: 1: 75-86.

Slavin, R.E., (1987), "Best-evidence Synthesis: An Alternative to Meta-analytic and Traditional Reviews", **Educational Researcher**, 15: 9: 5-11.

Slocombe, D.S., (1993), "Environmental Planning, Ecosystem Science, and Ecosystem Approaches for Integrating Environment and Development", **Environmental Management**, 17: 3: 289-303.

Smith, D., (1992), **Business and the Environment**, Chapman: London.

Smith, P.V., (2000), "Ecologically Sustainable Development and Facility Economics: The Critical Connection", **Proceedings of the Millennium Conference**

- **Cities and Sustainability: Sustaining Our Cultural Heritage,** Kandalma, Sri Lanka: 22nd –25th February.

Solow, R.M., (1974), "Intergenerational Equity and Exhaustible Resources", **Review of Economic Studies,** 41: 29-45.

Solow, R.M., (1991), **Sustainability: An Economist's Perspective,** Marine Policy Center: Woods Hole, Massachusetts, USA.

Solow, R.M., (1992), "Sustainability: Our Debt to the Future", **USA Today,** September: page 40.

Stallworth, H., (1996), "The Economics of Sustainability", **Office of Sustainable Ecosystems and Communities Issue Brief,** U.S. Environmental Protection Agency.
Stanners, D. & Bourdeau, P., (Ed.), (1995), "Europe's Environment", **The Dobrís Assessment,** European Environmental Agency.

Stead, E.W. & Stead, J.G., 1992), **Management for a Small Planet: Strategic Decision Making and the Environment,** Sage: Newbury Park.

Stegmuller, W., (1978), **The Structure and Dynamics of Theories,** Springer-Verlag: New York.

Stern, P., Young, O. & Druckman, D., (1992), **Global Environmental Change: Understanding the Human Dimensions,** World Wildlife Fund: Washington. Page 167.

Stern, P.C. & Dietz, T., (1994), "The Value Basis of Environmental Concern", **Journal of Social Issues,** 50: 3: 65-84.

Stewart, D.W., (1984), **Secondary Research,** Sage: Beverly Hills: California.

Subsidiary Body of Scientific, Technical & Technological Advice, (1997), **Convention on Biological Diversity: Recommendations for a Core Set of Indicators of Biological Diversity,** United Nations Environmental Protection: New York.

Swart, R.J. & Bakkes, J., (1995), **Scanning the Global Environment: A Framework and Methodology for Integrated Environmental Reporting and Assessment,** RIVM: Bilthoven, Netherlands.

Swimme, B. & Berry, T., (1992), **The Universe Story**, Harper Collins: New York.

Symonds Group Ltd., (1999), **Construction and Demolition Waste Management Practices, and Economic Impacts: Report to DGXI European Commission**, European Commission: Brussels.

Symonds Travers Morgan / ARGUS, (1995), **Construction and Demolition Waste Project in the Framework of the Priority Waste Stream Programme of the European Commission: Report of the Project Group to The European Commission**, European Commission: Brussels.

Taylor, P., (1986), **Respect for Nature: A Theory of Environmental Ethics**, Princeton University Press: Princeton, N.J.

Tchirley, J., (1996), **Environment Protection Analysis: Indicators**, Sustainable Development, Environment and Natural Resources Service, FAO Research, Extension and Training Division.

The Building Services Research and Information Association, (1998), **Sustainable Construction: The UK Viewpoint**, BSRIA: Bracknell, Berkshire.

The President's Council on Sustainable Development, (1999), **Towards a Sustainable America: Advancing Prosperity, Opportunity, and a Healthy Environment for the 21st Century**, PCSD: Washington.

The Standard Assessment Procedure, (1994), **The Government's Standard Assessment Procedure for Energy Rating of Dwellings**, BRECSU, HMSO: London.

Thompson, M., Ellis, R. & Wildavsky, A., (1990), **Culture Theory**, Westview Press: Boulder, USA.

Thurow, L., (1980), **The Zero-sum Society**, Basic Books: New York.

Tietenberg, T., (1996), **Environmental and Natural Resource Economics**, Harper Collins: New York.

Tinker, T., (1991), "Falling Down the Hole in the Middle of the Road: Political Quietism in Corporate Social Reporting", **Accounting, Auditing and Accountability Journal**, 4: 2: 28-54.

Tolba, M., (1987), **Sustainable Development: Constraints and Opportunities**, Butterworth: London.

Tolstoy, N., Bjötklund, K. & Carlson, P.O., (1998), "Material Flows in the Construction Industry and Heavy Engineering Sector", **Proceedings of the CIB World Building Congress: Construction and the Environment – Symposium A: Materials and Technologies for Sustainable Construction**, 7th – 12th June: Gävle, Sweden.

Tovil, A. & Özkan, E., (1998), "The Effects of Fenestration on the Thermal Performance of Retrofitted Residential Buildings in Istanbul", **CIB World Building Congress: Construction and the Environment – Symposium B: Indoor Environment and Sustainable Development – Are they Compatible?**, Gävle, Sweden, 7th – 12th June.

Townsend, K.N., (1993), "Steady State Economics and the Command Economy", in H.E. Daly, H.E. & K.N. Townsend, (Eds.), **Valuing the Earth: Economics, Ecology, Ethics**, The MIT Press: Cambridge.

Trist, E.L., (1981), "The Sociotechnical Perspective: The Evolution of Sociotechnical Systems as a Conceptual Framework and an Action Research Program", in A,H, Van de Ven & W.F. Joyce (Eds.), **Perspective on Organization Design and Behavior**: 19-75, Wiley: New York.

Tromp, O., (1997), **Sustainable Use of Renewable Resources for Material Purposes: A Conceptual Approach**, United Nations Environment Programme Working Group in Sustainable Product Development: Amsterdam, Netherlands.

Tsenkova, S., (1999), "Sustainable Urban Development: Myth or Reality", **International Journal of Urban and Regional Research**, 23: 2: 361.

Tshady, J.A., (1996), "Material and Specifications", **Sustainable Building Technical Manual: Green Building Design, Construction and Operations**, Public Technology, Inc.

Turner, N., Bennet, L. & Prescott, G., (1994), "Assessing and Managing the Environmental Risk of Property Ownership", **Property Management**, 12: 2: 4-15.

Turner, K.R., Pearce, D.W. & Bateman, I., (1994), **Environmental Economics: An Elementary Introduction**, Harvester Wheatsheaf: London.

Turner, R.K., (1988), **Sustainable Environment Management**, Belhaven: London.

Tyteca, D, (1996), "On the Measure of the Environmental Performance of Firms" **Journal of Environmental Management**

U.S. Department of Energy, Energy Information Administration, (1994), **Annual Energy Review 1993**, U.S. Department of Energy, Energy Information Administration: Washington, DC.

U.S. Interagency Working Group on Sustainable Indicators, (1998), **Sustainable Development in the United** States, IWGSI: Washington.

UNEP, World Wide Fund for Nature, World Conservation Union, (1991), **Caring for the World: A Strategy for Sustainability**: WCU: Gland, Switzerland.

United Nation System-wide Earthwatch Cordination, (1999), **Discussion Document: Earthwatch Strategic Framework for Environmental Observing, Assessment and Reporting**, UNEP: Geneva. Page 3.

United National Environment Programme, (1998), **Sustainable Development: Economic Development and Environmentally Sound Technologies**, United Nations Environment Programme: London. Page 39.

United Nations Centre for Human Settlement, (1996), **Habitat Agenda II**, Istabal.

United Nations Conference on Environment and Development, (1992), **Rio Declaration**, United Nations: New York.

United Nations Conference on Environment and Development, (1992), **Agenda 21**, UNCED: Rio de Janeiro, 3-14th June.

United Nations Conference on Human Settlements, (1994), **Report of the Expert Group Meeting on Urban Indicators for Country Reporting (Habitat II)**, UNCHS: Geneva.

United Nations Development Programme, (1990/1994/1996), **Human Development Report Series**, Oxford University Press: New York.

United Nations Development Programme, (1992), **Human Development Report 1992**, Oxford University Press: New York.

United Nations Development Programme, (1993), **Human Development Report**, Oxford University Press: New York.

United Nations Economic and Social Council, Commission on Sustainable Development, (1994), **Freshwater Resources: Report of the Secretary-General**, United Nations: New York.

United Nations Economic and Social Council, Committee on Natural Resources, (1994), **Water Resources: Progress in the Implementation of the Mar del Plata Action Plan and of Agenda on Water-related Issues**, United Nations: New York.

United Nations Educational, Scientific and Cultural Organization, (1972), **Convention Concerning the Protection of the World Cultural and Natural Heritage**, United Nations Educational, Scientific and Cultural Organization: Paris.

United Nations Environment Programme, (1994), **Environmental Data Report 1993**, UNEP: Nairobi, Kenya.

United Nations Environment Programme, (1995), **Global Biodiversity Assessment**, Cambridge University Press: Cambridge, UK.

United Nations Population Fund, (1998), **The State of World Population 1998**, UNFPA: New York.

United Nations, (1996), **Work Programme on Indicators of Sustainable Development of the Commission on Sustainable Development**, UN-DPCSD.

United Nations, (1996), **World Urbanization Prospects: The 1996 Revision**, United Nations: New York.

United States Interagency Working Group on Sustainable Development Indicators, (1998), **Sustainable Development in the United States: An Experimental Set of Indicators**, USIWGSDI: Washington, DC.

Vale, B. & Vale, R., (1991), **Green Architecture: Design for an Energy-conscious Future**, Bulfinch Press: Boston.

Vale, R. & Vale, B., (1991), **Towards a Green Architecture**, RIBA Publications: London.

Van Pelt, M.J.F., Kuyvenhaven, A. & Nijkamp, P., (1990), "Project Appraisal and Sustainability: Methodological Challenges", **Project Appraisal,** 5: 3: 139-158.

Vernadsky, V., (1945), "The Biosphere and the Noosphere", **American Scientist,** 33: 1: 1-12.

Viederman, S., (1994), "The Economics of Sustainability: Challenges", **Paper presented at the Workshop: The Economics of Sustainability**, Fundacao Joaquim Nabuco, Recife, Brazil.

Veidennan, S., (1993), "The Economics and Economy of Sustainability: Five Capitals and Three Pillars", **Proceedings of the Delaware Estuary Program Conference on "Preserving Our Future"**, Philadelphia: November 30th.

Vincent, R.A. & Wood, K., (1989), "Car Sharing and Car Pooling in Great Britain: The Recent Situation and Potential", **TRRL Laboratory Report 893**, TRRL.

Von Bertalanffy, L., (1975), **Perspectives on General Systems Theory**, Braziller: New York.

von Eckardt, W., (1978), **Back to the Drawing Board! Planning Livable Cities**, New Republic Books: Washington, D.C.

Vreis, H.J.M. de (1989), **Sustainable Resource Use: An Inquiry into Modelling and Planning**, University Press: Groningen,.The Netherlands.

Wackernagel, M. & Rees, W., (1996), **Our Ecological Footprint: Reducing Human Impact on the Earth**, New Society Publishers: Gabriola Island.

Walley N. & Whitehead B. (1996), "It's Not Easy Being Green", **Harvard Business Review**, May-June.

Waltz, C. & Bausell, R.B., (1981), **Research: Design, Statistics and Computer Analysis**, MacMillan: New York.

Weick, K.E., (1969), **The Sociology of Organising**, Addison-Wesley: Reading.

Weiss, E.B., (1989), **In Fairness to Future Generations: International Law, Common Patrimony, and Intergenerational Equity**, United Nations University: Tokyo.

Welford, R., (1995), **Environmental Strategy and Sustainable Development: The Corporate Challenge for the Twenty-first Century**, Routledge: London. Pages 2-3.

Welford, R.J. & Gouldson, A.P., (1993), **Environmental Management and Business Strategy**, Pitman: London.

Wilbush, J., (1990), "Impact Management, Worse Scenario: Possible Technological Strategic Options"" **Technology Analysis & Strategic Management**, 2: 1: 27-38.

Williams, B., (1985), **Ethics and the Limits of Philosophy**, Harvard University Press: Cambridge, MA.

Wilson, I., (1986), "The Strategic Management of Technology: Corporate Fad or Strategic Necessity?", **Long Range Planning**, 19: 2.

Wiltshaw, D.G. (1998), "Stigma, Perception and the Remediation of Contaminated Land", **Journal of Property Research**, 15: 4: 285-304.

Wismer, S., (1990), "Planning for Sustainable Development: A Community-based Approach", **Unpublished PhD Thesis**, University of Waterloo: Waterloo.

World Bank, (1992), **World Development Report 1992: Development and the Environment**, Oxford University Press: New York.

World Bank, (1994), **World Development Report 1994**, Oxford University Press: Oxford, U.K.

World Bank, (1995), **Monitoring Environmental Progress**, World Bank: Washington, DC.

World Business Council for Sustainable Development, (1998), **Trade and Environment: A Business Perspective**, WBCSD: Geneva, Switzerland.

World Commission on Environment and Development, (1987), **Our Common Future**, Oxford University Press: New York.

World Conservation Monitoring Centre, (1992), **Global Biodiversity: Status of the Earth's Living Resources**, IUCN, UNEP, WWF and WRI: Chapman Hall: London.

World Conservation Union, United Nations Environment Programme and World Wide Fund for nature, (1991), **Caring for the Earth: A Strategy for Sustainable Living**, WCU, UNEP and WWFN: Gland, Switzerland.

World Resources Institute, (1995), **Environmental Indicators: A Systemic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development**, World Resources Institute: Washington.

Worldwatch Institute, (1990), **Building a Sustainable Society**, Worldwatch Institute: Washington D.C.

Wyatt, D.P. & Gilleard, J.G., (1994), "Deconstruction: An Environmental Response for Construction Sustainability", **Proceedings of the First International Conference of CIB TG16 on Sustainable Construction**, Tampa: Florida: 6th – 9th November.

Wyatt, D.P., (1994), "Recycling and Serviceability: The Twin Approach to Securing Sustainable Construction", **Proceedings of the First International Conference of CIB TG16 on Sustainable Construction**, Tampa, Florida: 6th – 9th November.

Yashiro, T., (1996), "Global Perspectives in Construction for Global Environment", **Proceedings of the CIB W55 Building Economics 7th International Symposium: Economic Management of Innovation, Productivity and Quality in Construction**, Zagrb, Croatia: 4th – 7th September.

Yates, A., Bartlett, P. & Baldwin, R., (1994), "Assessing the Environmental Impact of Buildings in the UK", **Proceedings of the First International Conference: Buildings and the Environment**, 16th – 20th May: Building Research Establishment, Watford, U.K.

Yin, R.K., (1989), **Case Study Research: Design and Methods**, Sage: London.

Young, J.W.S., (1997), "A Framework for the Ultimate Environmental Index – Putting Atmospheric Change into Context with Sustainability", **Environmental Monitoring and Assessment**, 46: 135-149.

Ytterhus, BE, (1996), **SME's and Environmental Management,** Norwegian School of Management: Sandvika.