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ZEMCH: Toward the Delivery of Zero Energy Mass Custom Homes

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Masa Noguchi
Editor

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Springer

Editor
Masa Noguchi
Melbourne School of Design
The University of Melbourne
Melbourne
Australia

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Preface

Housing needs and demands are dynamic having been changed in the course of time. The shifts in socio-demographics highlight the emergence of non-traditional households and influence housing configurations and performances. Homes need to be *customisable* in order to raise the level of social sustainability in accommodating users' individual requirements, desires and expectations. In the light of fuel poverty issues arising in various countries in which the drastic hike of energy cost is a serious concern, the notion of housing affordability has been extended to encompass both initial and operating costs. In view of economic sustainability at macro and micro levels, homes need to be *affordable*. Global warming accelerated with excessive carbon dioxide (CO_2) emission is becoming conspicuous. Generally, a house consumes a significant amount of energy before and after occupancy, and the associated CO_2 emission is contributing partially to the climate change. Towards securing environmental sustainability, housing needs to be net carbon neutral (or *zero energy*) in consideration of CO_2 emission derived from the overall energy use.

In response to market needs and demands for social, economic and environmental sustainability of housing in developed and developing countries, the *zero energy mass custom home* (ZEMCH) integrated lean design and construction concept was envisaged and discussed globally. Towards the ZEMCH delivery, an emerging notion of *mass customisation* was scrutinised initially. It emerged in the same year as the general concept of *sustainable development* was widespread in 1987. The oxymoron was recognised eventually as a means to lessen housing design and construction costs whilst achieving the customisability through economies of scope rather than economies of scale.

In order to crystallise a wide spectrum of hopes and fears around the design, production and marketing approaches to the ZEMCH delivery in global contexts, *ZEMCH Network* was established in 2010. Today, the R&D collaboration network consists of over 500 partners from nearly 40 countries and the enrolment is constantly on the rise. Originally, the ZEMCH Network was formed by a group of

academics, who participated in the 2010 industry-academia knowledge transfer technical visits to production and sales facilities of low to zero energy mass customised housing manufacturers in Japan. The technical tour, later called *ZEMCH Mission to Japan*, dates back to the 2006 operation and it celebrates the 10th anniversary in 2016.

This book is the collective knowledge gained through global ZEMCH R&D activities, consisting of 12 chapters that packaged essential engineering design, construction, and commercialisation techniques and strategies applicable to the ZEMCH delivery: Chapter 1 identifies the general notion of sustainable development as a start to consider how ZEMCH practice can meet global housing market needs and demands; Chap. 2 revisits mass housing developments with the aim to articulate the necessity for enhancement of production efficiency without sacrificing design customisability; Chap. 3 introduces prefabrication seen as a means to standardise housing products and processes for construction efficiency; Chap. 4 summarises the origin of mass customisation and its application to the delivery of quality affordable homes; Chap. 5 crystallises a new notion of mass personalisation applicable to affordable housing developments; Chap. 6 summarises inclusive design techniques that aim to accommodate housing users' changing needs and demands over their lifetime; Chap. 7 clarifies how energy is used in housing before and after occupancy; Chap. 8 recaps various passive design approaches being applied to lessening energy demands of housing; Chap. 9 showcases a variety of active systems available for supplementing energy use in housing with mechanical innovations; Chap. 10 introduces the global movement and practice of zero energy homes; Chap. 11 demonstrates the significance of building energy and environmental performance simulation; and Chap. 12 unveils Japan's successful business operation essential for the ZEMCH delivery.

ZEMCH movement came to life and emerged from the grass roots needs and demands of housing in developed and developing countries. First, I would like to express my sincere gratitude to all authors, who contributed to the development of this book, which is indeed the first of this kind. Their expertise and experience streamlined ZEMCH technical knowledge and made the multidisciplinary contexts comprehensive to a wide range of audience. Second, I am thankful to all chapter leaders of this book, Sara Wilkinson, Kheira Anissa Tabet Aoul, Arman Hashemi, Victor Bunster, Karim Hadjri, Haşim Altan, Jun-Tae Kim and Laura Aelenei, for not only their first authorship, but also their dedication to the team management and leadership that helped secure the quality outcomes.

Lastly, I would like to thank all ZEMCH Network's global partners and regional experts centre directors for their generous, constructive support and cooperation. So far, ZEMCH Network established four regional centres in Brazil, Italy, UAE and UK, being responsible for the organisation and operation of annual industry-academia knowledge transfer events—i.e. ZEMCH Mission to Japan, ZEMCH International Conference and ZEMCH Design Workshop. The success is rooted in the network partners' individual efforts and collaborative actions.

ZEMCH R&D activities have been thriven for continuous improvement of the built environments in developed and developing countries, budding out the global movement for people and society.

Melbourne, Australia Masa Noguchi

Contents

Chapter 1
Sustainable Development

Sara Wilkinson, Mona Hajibandeh and Hilde Remoy

Abstract The continuous increase in the number and size of urban regions across the world pose great challenges for sustainable development. Given the connection between energy use, greenhouse gas emissions and climate change and the reality that the built environment emits around half of total emissions, the construction industry has considerable potential to reduce emissions and a key role in mitigating global warming. Other local challenges include for example loss of species and habitats, social degradation of neighborhoods, and an overall erosion of sustainability. Urbanisation patterns and the lifestyles of urban dwellers also affect the planet on wider scales and contribute to shaping bio-physical processes on planetary scales and affect how humans mentally connect with the Biosphere. However there is evidence our current understanding of the concept of sustainability, and thus sustainable development, is fragmented and unclear. There are a plethora of terms used to cover sustainable buildings, such as ecological, green, Gaian, zero energy, eco-friendly and environmental; all of which come in, and out, of fashion over time; *do they mean the same thing or are they different?* Furthermore, do the stakeholders within the built environment demonstrate a clear understanding of the concept of sustainability or; are they muddled and confused? The consequence of unclear thinking and a lack of understanding is that ultimately the built environment stakeholders are unlikely to deliver 'sustainability' efficiently or even at all, with the broader and more onerous consequences for society as a whole. In addition what are

S. Wilkinson (✉)
The University of Technology Sydney, Sydney, Australia
e-mail: Sara.Wilkinson@uts.edu.au

M. Hajibandeh
Erasmus University Rotterdam, Rotterdam, The Netherlands
e-mail: Monahaji@gmail.com

M. Hajibandeh
Tehran University of Art, Tehran, Iran

H. Remoy
Delft University of Technology, Delft, The Netherlands
e-mail: h.t.remoy@tudelft.nl

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the implications for education and should academics be broadening the debate? This lecture examines the environmental, economic, social, political and philosophical thinking underpinning the concept of sustainable development and shows how different perspectives reflect very different ways of thinking about sustainability and sustainable development. It aims to create a better understanding while offering creative solutions.

1.1 Introduction

The continuous increase in population and, in the number and size of urban regions across the world, pose great challenges for sustainable development especially in the built environment. Given the connection between energy use, greenhouse gas emissions and climate change and the reality that the built environment emits around half of total emissions, the construction industry has considerable potential to reduce emissions and a key role in mitigating global warming (UNEP 2007). Other local challenges include for example loss of species and habitats, social degradation of neighbourhoods, and an overall erosion of sustainability. At the time of writing, 'sustainability' and 'sustainable development' is the preferred term and typically embraces economic, environmental and social considerations identified by Elkington (1997); though the term sustainability was first defined a decade earlier in the Brundtland Report (WCED 1987).

Urbanisation patterns, as well as the lifestyles of urban dwellers, affect the planet on wider scales and contribute to shaping bio-physical processes on planetary scales and affect how humans mentally connect with the Biosphere. However there is evidence our current understanding of the concept of sustainability, and thus sustainable development, is fragmented and unclear.

There are a plethora of terms used to cover sustainable buildings, such as ecological, green, Gaian, zero energy, eco-friendly and environmental; all of which come in, and out, of fashion over time; *do they mean the same thing or are they different?* Furthermore, do the stakeholders within the built environment demonstrate a clear understanding of the concept of sustainability or; are they muddled and confused? The consequence of unclear thinking and a lack of understanding is that ultimately the built environment stakeholders are unlikely to deliver 'sustainability' efficiently or even at all, with the broader and more onerous consequences for society as a whole. In addition what are the implications for education and should academics be broadening the debate?

This chapter examines the environmental, economic, social, political and philosophical thinking underpinning the concept of sustainable development and shows how different perspectives reflect very different ways of thinking about sustainability and sustainable development. It aims to create a better understanding while offering creative solutions. The chapter starts with a discussion of the history

of sustainable development and how it is defined. The Brundtland Report (WCED 1987) is described and gives context to subsequent evolution in thinking about sustainable development as posited by Elkington (1997) in the Triple Bottom Line concept. The chapter moves on to explain the different levels of sustainability and the attributes and perspectives that inform the different viewpoints. A quiz is provided for readers to self-assess their own conceptual understanding of sustainability in Sect. 1.6. Section 1.3 describes sustainable urbanism and notion of the compact city, before the issues of high tech versus low tech approaches are described. The challenges of measuring sustainability form the content of Sect. 1.5 of the chapter as illustrate the risks and benefits of a focus on absolute measurement paradigms in the built environment. Penultimately, there is a discussion that endeavours to summarise what sustainable development in the context of this book. The aim of the chapter is to set the context for the following chapters and to appraise readers of the essentials of, and a framework for, the conceptual understanding of sustainable development and sustainability.

1.2 An Introduction to and History of Sustainable Development

The theoretical framework for sustainable development evolved between 1972 and 1992 through a series of international conferences and initiatives. The United Nations (UN) Conference on the Human Environment, held in Stockholm in 1972, was the first major international gathering to discuss sustainability at the global scale. The conference created considerable momentum, and a series of recommendations led to the establishment of the UN Environment Programme (UNEP) as well as the creation of numerous national environmental protection agencies at the national level. The recommendations from Stockholm were further elaborated in the 1980 World Conservation Strategy which was a collaboration between the International Union for the Conservation of Nature, the World Wildlife Fund (WWF) and UNEP—which aimed to advance sustainable development by identifying priority conservation issues and key policy options (Drexhage and Murphy 2010).

The term, sustainable development, was promoted in Our Common Future, a report published by the World Commission on Environment and Development (WCED) in 1987. It is also known as the Brundtland report, after Gro Harlem Brundtland the chair of the commission. Our Common Future defined sustainable development as: “development which meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987: 43). This definition introduced two important principles; those of inter-generational and intra-generational equity—that is consideration of the generations to come and also those less fortunate and already here. Acceptance of the report by the United

Nations (UN) General Assembly gave the term political credence; and in 1992 leaders set out the principles of sustainable development at the UN Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil, which is also known as the Rio Summit or the Earth Summit. The Earth Summit adopted the Rio Declaration on Environment and Development and Agenda21, a global plan of action for sustainable development (Kates et al. 2005).

Three seminal instruments of environmental governance were established at the Rio Summit: the UN Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity (CBD), and the non-legally binding Statement of Forest Principles. Following a recommendation in Agenda21, the UN General Assembly officially created the Commission on Sustainable Development (CSD) in 1992.

Since that time a number of important international conferences on sustainable development have been held—including the 1997 Earth Summit+5 in New York and the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg. These meetings were primarily reviews of progress; and reported that a number of positive results had been achieved, but implementation efforts largely had been unsuccessful at the national and international level. The negotiations at the WSSD in 2002 demonstrated a major shift in the perception of sustainable development—away from environmental issues toward social and economic development. This shift, which was driven by the needs of the developing countries and strongly influenced by the Millennium Development Goals (MDGs),[1] is but one example of how sustainable development has been pulled in various directions over its 25-year plus history. Defining and implementing sustainable development has had to deal with the tensions between the so-called three pillars of sustainability (economic, environmental and social), and the prevailing political and economic influences at different points in time (Drexhage and Murphy 2010).

At, and since the Rio Summit, sustainable development has found its most prominent hook, at least in terms of media and political attention, around the issue of climate change. Responses to address climate change, in terms of both mitigation and adaptation, are linked to sustainable development. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2007; Chap. 12.1.1) pointed out the iterative relationship between climate change and sustainable development, and that the two can be mutually reinforcing.

[1]The UN Millennium Declaration was adopted in 2000 and committed countries to reach eight Millennium Development Goals by 2015. The eight goals included: halving extreme poverty, halting the spread of HIV/AIDS, providing universal primary education, eliminating gender disparity in education, reducing the under-five mortality rate, reducing the maternal mortality rate and achieving universal access to reproductive health, developing a global partnership (to address the needs of the poorest countries, to further an open non-discriminatory trade system, and to deal with developing country debt); and ensuring environmental sustainably (by integrating sustainable development into country policies and programs, reducing biodiversity loss, improving access to safe drinking water and sanitation, and improving the lives of slum dwellers) (UN 2010).

1.3 Definitions of Sustainable Development

Since the Brundtland Commission first defined sustainable development in 1987 (WCED 1987), dozens, if not hundreds, of scholars and practitioners have articulated and promoted their own alternative definition; yet a clear, fixed, and immutable meaning remains elusive. Cook and Golton (1994) and Wilkinson (2012) have claimed it is a contested concept, that it is means all things to all men. That is, depending on ones worldview, various interpretations are possible. Further more these interpretations have varying degrees of action and consequently, sustainability (Wilkinson 2012; Washington 2015).

Despite this ambiguity and openness to interpretation, sustainable development has evolved a core set of guiding principles and values, based on the Brundtland Commission's standard definition to meet the needs, now and in the future, for human, economic, and social development within the restraints of the life support systems of the planet. Further, the connotations of both of the phrase's root words, "sustainable" and "development" are generally quite positive for most people, and their combination imbues this concept with the notion that sustainability is a worthwhile value and goal—a powerful feature in diverse and conflicted social contexts.

Sustainable development requires the participation of diverse stakeholders who hold diverse perspectives, with the ideal of reconciling different and sometimes opposing values and goals toward a new synthesis and subsequent coordination of mutual action to achieve multiple values simultaneously and even synergistically. As real-world experience has shown, however, achieving agreement on sustainability values, goals, and actions is often difficult and painful work, as different stakeholder values are forced to the surface, compared and contrasted, criticised and debated. Sometimes individual stakeholders find the process too difficult or too threatening to their own values and either reject the process entirely to pursue their own narrow goals or critique it ideologically, without engaging in the hard work of negotiation and compromise (Washington 2015). Critique is nonetheless a vital part of the conscious evolution of sustainable development—a concept that, in the end, represents diverse local to global efforts to imagine and enact a positive vision of a world in which basic human needs are met without destroying or irrevocably degrading the natural systems on which we all depend (Kates et al. 2005).

1.4 The Brundtland Report

In 1984, the UN General Assembly created the World Commission on Environment and Development, an independent committee of twenty-two members, headed by Gro Harlem Brundtland, the Prime Minister of Norway. Designed to examine global environment and development to the year 2000 and beyond, the Commission sought to reassess critical problems, to formulate realistic proposals for solving them, and to

raise the level of understanding and commitment to the issues of environment and development, on the basis of what was called "Sustainable Development". In 1987 the Commission published the report titled Our Common Future. This report was instrumental in preparing the UN Conference on Environment and Development held in Rio de Janeiro in 1992 (Schubert and Lang 2005).

Our Common Future gave impetus to global, regional and national environmental policies, and took a very technocentric approach rather than presenting a negative report about the destruction of finite natural resources, it offered an agenda advocating economic growth based on policies that do not harm, and they advocated can even enhance, the environment. Ecocentrics of course take a different perspective with regards to economic growth and sustainable development (Wilkinson 2012). The Commission recognised, through the definition adopted, that economy and ecology had a symbiotic relationship, and human progress through development should not bankrupt resources for future generations.

The paradox of the Brundtland Report is that it supports ecological sustainability and capitalist development at the same time. The Brundtland Report stated that "The satisfaction of human needs and aspirations is the major objective of development." (WCED 1987). However the development that economic growth spawns increases the profits of those in control of that development, and the inequitable distribution of wealth increases (Washington 2015). Profit is the mechanism by which economics makes decisions and the satisfaction of human needs and aspirations is not.

Brundtland (WCED 1987) concluded that the cause of environmental destruction is lack of economic growth. It did this because it identified poverty as the only cause of environmental destruction and identified economic growth as the only solution to poverty. The obvious conclusion was that growth in the developing world was necessary to reduce poverty to help the environment. Furthermore all developing countries needed high export growth for rapid development (The Brundtland Report 1996). The conclusion drawn was, to stop environmental destruction, make developing countries increasingly dependent on foreign trade, make them increasingly westernised, and encourage corporate growth (Kates et al. 2005). The report's focus on economic growth obscures the solution to environmental destruction and social injustices. Brundtland should promote sustainable use, and not sustainable development; an activity is sustainable if it can be continued indefinitely. A sustainable use is an activity that will not affect its resource base to the point, where that resource can no longer be used for that activity.

1.5 Elkington and the Triple Bottom Line Concept

John Elkington wrote 'Cannibals With Forks: The Triple Bottom Line of 21st century Business in 1997 nearly two decades ago. In this book he posited that everyone benefits if a paradigm of sustainable business is adopted. Significantly Elkington (1997) broadened the concept from environmental quality to embrace

Fig. 1.1 Elkington's triple bottom line

social justice and economic prosperity, the so-called three pillars of sustainability or the triple bottom line (Fig. 1.1). The notion posited by Elkington was that when the three pillars align, true sustainability is achieved.

The three bottom lines are connected, interdependent and partly in conflict. In order to deliver the triple bottom line, businesses are required to think and act in seven dimensions or 7D. These dimensions are markets, values, transparency, life cycle technology, partnerships, time-perspective and corporate governance. Elkington (1997) argues that although capitalism and sustainability do not make easy bedfellows, he believes capitalism can be part of the solution. Evidence to date of effective environmental action does not particularly bear out his belief. This, we shall see in Sect. 2.3, is a technocentric perspective. Elkington (1997) proposes ways in which to think and act in 7D in the book. He sees opportunity for entrepreneurial businesses to get ahead of others by adopting the three pillars. To some extent many of his predictions regarding accountability of performance through corporate social responsibility (CSR) and global reporting of sustainability has come to pass (Wilkinson et al. 2004), though at the same time the environmental footprint of businesses has grown, as has social and economic inequality (Washington 2015). The major contribution of the book was a framework is presented in which to discuss and act on sustainability issues. The message is positive and Elkington (1997) believes humankind has the capacity to avert global disaster, without changing our prevailing economic paradigm, it is a position that not everyone concurs with (Washington 2015).

1.6 The Spectrum of Sustainability

There is a plethora of terms used to encompass the concept of sustainability, especially within the built environment. Green, green, greener, ecological, natural, sustainable, environmentally sensitive, zero energy, Gaian, and environmentally

conscious design or building are some of the terms adopted by stakeholders and actors. Such varieties of terms beg the questions; do concepts overlap or are they the same? Are there some shared aspects between concepts and if so, what are they? Is the 'sustainability' embedded within some concepts questionable? Furthermore is it possible to conceive of a sustainable building in an absolute or a relative form? By this it is meant can a building be genuinely sustainable when considering the earth's total resources (absolute) or, is it simply more sustainable than a building to which is it contrasted (relative)? Currently with building rating systems such as BREEAM, LEED and Green Star they are conceived as being sustainable in an absolute sense. This section of the chapter seeks to elucidate some of these questions.

At the time of writing, 'sustainability' is the preferred term and typically embraces economic, environmental and social considerations identified by Elkington (1997); though the term sustainability was first defined a decade earlier in the Brundtland Report (WCED 1987). Additionally the concept is informed by political and philosophical thought, and all aspects were taken into account within a literature review. The literature revealed that there are distinct characteristics and sub groups within the concept of sustainability which needed to be de-constructed and ordered to clarify shared characteristics and those which were separate.

1.6.1 The Concept of Ecocentrism

A key division between the groups is ecocentrism and anthropocentrism (Pepper 1984; Dobson 1990; Brown 1995). In summary, an ecocentric worldview perceives ecosystems as part of an integrated environmental system with organisms, biological communities and ecosystems creating the mantle of life surrounding the planet. Ecocentrism is advocated by an environmental movement known as Deep Ecology (Naess 1990; Brown 1995) and is grounded in seeking the common good of the human and non-human world (Purser and Montuori 1995). Within the ecocentric worldview, three groups exist; transpersonal ecologists, deep ecologists and moderate ecologists. The transpersonal group subscribe to the most extreme views whilst the moderate ecologists hold the least extreme views and ideals within ecocentrism. In some instances views are shared but to differing degrees, whereas on other issues some groups subscribe to a view whilst others do not. The list of key views are summarised for all groups in Table 1.1.

In addition ecocentrics are radically egalitarian where entities such as animals, humans, rivers, seas and lakes are all believed to have equal and intrinsic value. Ecocentrics' argue that only when this worldview is adopted will we substitute environmentally destructive policies for more benign policies. Paradoxically in asking humankind to take responsibility for whole of the ecosphere eccentrics' are expressing anthropocentrism. Furthermore in reality, the egalitarian ecocentric world would collapse into nihilism if no distinctions of value are made where for

Table 1.1 Ecocentric and anthropocentric standpoints (Wilkinson 2012)

Stand-point	Trans-personal ecology	Deep ecology	Moderate ecology	Accommodating environmentalism	Cornucopian environmentalism
Belief system	Religious level of belief	Bio-ethics and intrinsic value	Primary value of ecosystems	Intra and inter-generational equity	Support for traditional ethical reasoning
				Instrumental value in nature	Rights of humans
		Accepts 'carrying capacity' of earth argument	Accepts 'carrying capacity' of earth argument		
	Emotional and irrational			Rational and pro science	
		Lacks faith in technology			Faith in science and technology
Population	Population cull	Reduce population	Zero population growth	Silent	
Resource consumption		Extreme preservationist	Resource preservation	Resource conservationist	Resource exploitative
World view	Ecocentric			Anthropocentric	
	Lacks faith in technology				Faith in technology
Waste	Reuse, repair and then recycle			Recycle	
Economic	Capitalism is not sustainable Rejects consumerism	Heavily regulated economy Capitalism is not sustainable Do not favour overseas trade 'eco'nomics. Rejects consumerism Little overseas trade.	Zero economic growth. Capitalism is not sustainable Do not favour overseas trade 'eco'nomics. Rejects consumerism. Little overseas trade	Managed growth. Capitalism is sustainable. Consumerism is acceptable Overseas trade is acceptable.	Maximise growth Capitalism is sustainable Substitution theory prevails Laissez faire economics Green consumerism is accepted Promotes consumerism Promote foreign trade/agreements
Energy	Preservationist	Preservationist	Conservationist	Conservationist	Nuclear is acceptable, conserve and increase consumption
	Very strong sustainability		Strong sustain-ability	Weak sustainability	Very weak sustainability

example the value of a child in a ghetto tenement is equal to that of a family of rats (Brown 1995).

Taken to the extreme, there is a concern that ecocentrism lends itself to an ideology of domination, where eco police enforce eco policy (Dobson 1990). Whilst some reduction in mankind's interference with the ecosphere is desirable, it is argued that some forms of ecocentrism would lead to the rejection of human rights in favour of the ecosphere, for example propositions of a human population cull advocated by the transpersonal ecology group (Naess 1990). Within social and political systems, ecocentrics tend to dislike centralised systems and materialism (Cook and Golton 1994) and this is a stance, which puts them at odds with current prevailing paradigms.

1.6.2 The Concept of Anthropocentrism and Technocentrism

The dominant world view has been anthropocentric, where mankind is perceived to have a dominant role, only humans possess intrinsic value, and are the rightful masters of 'nature' as well as being the origin and source of all values (Cook and Golton 1994). As such, anthropocentrism is a very different worldview to ecocentrism (Brown 1995). It is contended that to deliver sufficient sustainability to avert overwhelming levels of climate change, it is necessary "to persuade civil society to make a break from the anthropocentric perspective where the environment affects and benefits humans" (Salinger 2010). Within the anthropocentric paradigm resources are extracted without replenishment and non-reusable materials such as plastics and nuclear waste accumulate. Some argue that anthropocentrism is based in the positivist, objective-thinking characteristics in our scientific, mechanistic and technological world view which emerged from the 17th century onwards (Brown 1995). Anthropocentrism is held by ecocentrics to be the root cause of the ecological crisis (Cook and Golton 1994). Anthropocentrics believe that mankind is able to provide a technological fix to the environmental problems and another term for this approach is technocentric (Cook and Golton 1994).

However it is too simplistic to see a clear divide between ecocentrism and anthropocentrism, as in real life the boundaries are blurred and the issues are complex (Pepper 1984). One issue between an ecocentric worldview as opposed to an anthropocentric one is; where does the line between fair use and abuse lie (Purser and Montuori 1996)? Or where does economic development become exploitative? Furthermore authors such as Pearce (1993) and Pepper (1984) perceived further sub groups or categories within ecocentrism and anthropocentrism.

1.6.3 The Concepts of Accommodating and Cornucopian Environmentalism

Within anthropocentrism those on the left, known as 'accommodating environmentalists' tend to be gradual reformers believing in careful economic and environmental management but without radical change to social economic and political structures (Cook and Golton 1994). Those on the right are known as 'cornucopian environmentalists' believe in unfettered economic growth and humankind's right to utilise the worlds resources as they see fit. Within the ecocentric camp there is a divide between those on the right; 'deep ecologists', who put a greater emphasis on the limits to growth or carrying capacity of the earth, and those on the left 'moderate ecologists' who believe in decentralised political and social institutions. Deep ecologists believe in compulsory restraints on human population growth and on resource consumption.

Economically anthropocentrics belong to the neo classical school, believing that economic growth is possible, they reject intervention in the economy to tax or incentivise sustainability measures. There is evidence that this stance is beginning to change and evolve in capitalist economies with an increase in the scope of environmental legislation. For example, in 2010 the disclosure of energy consumption in commercial buildings in Australia became mandatory (Warren and Huston 2011) and in the UK similar legislation, known as Energy Performance Certificates (EPCs), was mandated in 2007 (DirectGov 2012). A more contentious legislation in Australia is the introduction of a carbon pricing mechanism which was commence in July 2012, the notion of 'taxing' carbon pollution met with significant resistance in the Australian parliament during 2011. There was concern about the potential impact on the economy and the amount of the carbon price compared to other countries; it remains to be seen how the policy is accepted by the electorate in the forthcoming 2013 election. To date the Australian government has largely offset the potential negative political and economic impacts of the pricing mechanism with generous government assistance to households. It is hard to say whether there is a temporary or permanent shift in the neo classical economic philosophy adopted by cornucopian environmentalists towards an economic outlook more attuned to accommodating environmentalism. In Australia, it is possible that this carbon pricing policy has resulted from a coalition government of the Labour and the Green party and represents the compromise Labour were prepared to make for political leadership. What is a concern is that within the built environment improved economic performance through a perceived increase in capital value is the main argument used to persuade property owners and investors to adopt sustainability (Eichholtz et al. 2009; Fuerst and McAllister 2011; Newell 2008).

In summary a spectrum of ideas and values exists within the concept of sustainability which goes from dark green to light green, or as some have suggested to grey; implying that the pursuit of weak sustainability does not deliver sustainable outcomes (Söderbaum 2011; Cooper 1994). The range of standpoints identified in the literature is expressed in Table 1.1. Five distinct groups were identifiable with

two classified as anthropocentric (accommodating and cornucopian environmentalism) and three being ecocentric (transpersonal, deep and moderate ecology).

In Table 1.1 it is apparent that the most radical group, the 'transpersonal ecologists' are so embroiled in 'eco-sophical' arguments and debate that they are unable to form a coherent group who are capable of action (Dobson 1990). The 'deep ecologists' and 'moderate ecologists' share a number of beliefs but also have distinct and separate positions on some issues, for example, both groups believe capitalism is not sustainable. However 'deep ecologists' believe in bio-ethics and in the intrinsic value of nature whereas 'moderate ecologists' believe in the primary value of ecosystems; a less extreme view. A similar situation prevails for the anthropocentrics, the environmentalists. The two anthropocentric groups share views on the value of science and rational thought. They differ on the 'rights of humans' which dominate for the 'cornucopian environmentalists' however for the 'accommodating environmentalists' there is instrumental value in nature. Another way of presenting these beliefs and standpoints figuratively is shown in Fig. 1.2 as the spectrum of sustainability concepts.

Figure 1.2 illustrates the disconnect between transpersonal ecology and anthropocentrism/environmentalism. Elsewhere there is some overlap between the groups in their value systems and beliefs. There is a broader divide between ecocentrism and anthropocentrism where one is considered to deliver strong sustainability and the other weak sustainability. The question is: is weak and very weak

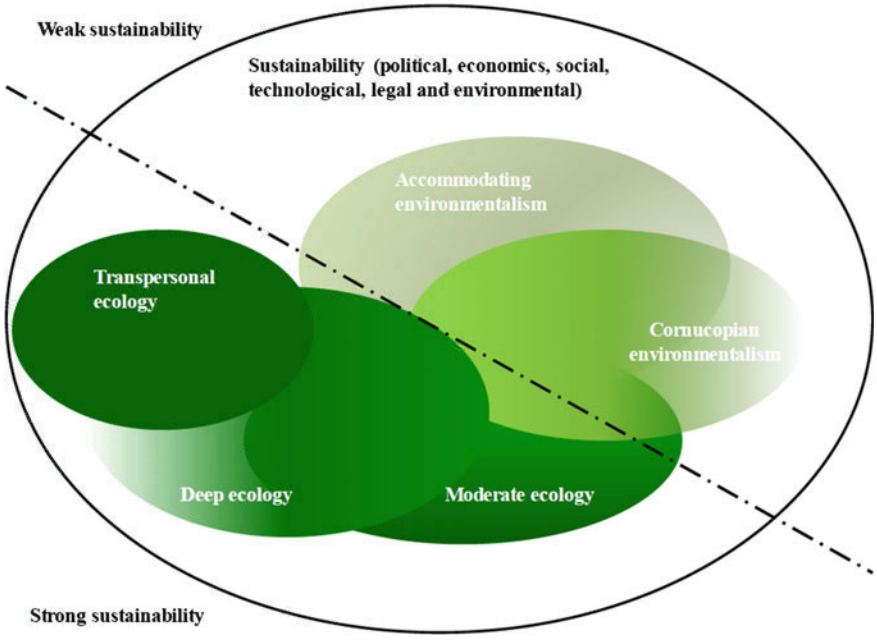

Fig. 1.2 The spectrum of sustainability concepts (Wilkinson 2013)

sustainability going to deliver sufficient changes for the generations to come and those already here? Brown (1995) asserts this level of sustainability will fall short of what is needed.

1.7 The Relationship of Built Environment to the Conceptual Model

The built environment is responsible for significant environmental impacts. Buildings use resources during construction with the extraction of resources, energy and water resources are used in the transport and manufacturing of construction materials and components. Considerable amounts of waste are also created at this stage. During the building's operational phase energy resources are used in lighting, heating and cooling and water is used in building services. Occupant or building user health is also impacted by the materials used during construction. At the end of the building lifecycle, unless materials are re-used or recycled, they will be transported to landfill where the resources are lost in perpetuity.

Within the built environment, construction companies are a sub group who have an impact on the sustainability of the buildings that they construct, design and sometimes operate and in this regard their conceptual understanding of sustainability is very important. It has become a current practice for many organisations, and not just construction companies, to adopt 'corporate social responsibility' or CSR as a means of organising, structuring, managing and reporting their environmental impact (Wilkinson et al. 2004). As a requirement of CSR companies provide information about their sustainability targets, policies and strategies, usually on their websites. This information is deemed to be an accurate and unbiased account of their respective stance and attitudes towards sustainability.

Figure 1.3 adapts Fig. 1.2 and shows construction companies as a sub set of built environments. Other actors within the built environment include designers, building users, owners and policy makers however their conceptual understanding, though important and collectively significant, is outside the scope of this study.

There is variance in the conceptual understanding of sustainability; and that it is, as Cook and Golton noted; 'an essentially contestable concept' (Cook and Golton 1994). An essentially contestable concept was coined by Gallie (1956) and exists where individuals On a positive note there are encouraging signs that some of the positions advocated by accommodating environmentalism are gaining traction and this reflects a shift from the findings of Cook and Golton's study of the UK construction sector in the early 1990s (Cook and Golton 1994). Given that Brown (1995) has stated that weak sustainability will not, in itself, provide the solutions to the problem humankind is facing; there are significant issues that we need to address as an industry, as individuals and as a community. For all our green building rating tools and schemes we are, with our current level of understanding of sustainability, in imminent danger that we will hit the targets but miss the point.

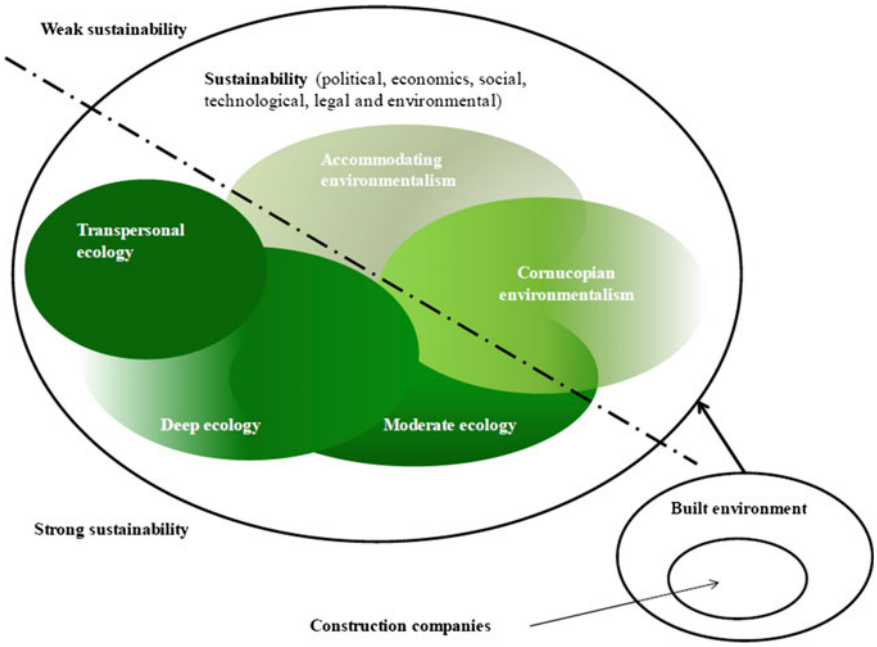

Fig. 1.3 The relationship of built environment and construction companies to the spectrum of sustainability concepts (Wilkinson 2012)

1.8 Sustainable Development and Urban Settlements

Urbanisation is a complex dynamic process playing out over multiple scales of space and time (Alberti et al. 2003). It is both a social phenomenon and physical transformation of landscapes that is now clearly at the forefront of defining humanity's relationship with the biosphere. Urban landscapes represent probably the most complex mosaic of land cover and multiple land uses of any landscape and as such provide important large-scale probing experiments of the effects of global change on ecosystems (e.g. global warming and increased nitrogen deposition). Urbanisation and urban landscapes have recently been identified by the Millennium Ecosystem Assessment as research areas where significant knowledge gaps exist (Millennium Ecosystem Assessment 2005).

The ideal of the good city is for all times. Planners and designers have always played a central role in the creation and development of vital and liveable cities. Depending on the spirit of the times, this sometimes meant the promotion of zoned, single-use urban forms; at other times, it meant the pursuit of a compact, spatially mixed and intensively used city (Williams et al. 2000).

Sustainable Urbanism, as a defined term, is the application of sustainability and resilient principles to the design, planning, and administration/operation of cities.

There are a range of organizations promoting and researching sustainable urbanism practices including governmental agencies, non-governmental organizations, professional associations, and professional enterprises around the world. Related to sustainable urbanism is the Ecocity movement (also known as Ecological Urbanism) which specifically is looking to make cities based on ecological principles, and the Resilient Cities movement addresses depleting resources by creating distributed local resources to replace global supply chain in case of major disruption. Green urbanism is another common term for sustainable urbanism. Sustainability can be defined as the practice of maintaining processes of productivity indefinitely—natural or human made—by replacing resources used with resources of equal or greater value without degrading or endangering natural biotic systems (Hendrix 2014; Lynn et al. 2014).

Now more than ever, cities are hot spots responsible for threatened global ecological boundaries. Climate change impacts and global environmental change are challenges for urban dwellers, planners, and managers. To develop opportunities for the sustainable development of cities, researchers from multiple disciplines are studying the feedback, dynamics, and behaviour of urban systems in the face of change (Chelleri and Olazabal 2012).

Although, highest per capita car ownership rates are still in the USA, Canada, Australia and Western Europe. Along with these trends are increases in fuel consumption and emissions. Given these indicators, the extent to which changes in urban form, facilitated through spatial planning, can have an impact on sustainable transport is rightly questioned (Williams et al. 2000).

There is a plethora of terms used to encompass the concept of sustainability;

1.8.1 New Urbanism

New Urbanism is an urban design movement, which arose in the USA in the early 1980s, promoting walkable, mixed-use neighbourhoods and transit-oriented development, seeking to end suburban sprawl and promote community. Characteristics include narrow streets, wide sidewalks and higher densities, qualities which we can all find in the European cities (Boeing et al. 2014).

1.8.2 Smart Growth

This is a transportation and urban planning theory that promotes growth in compact walkable city and town centres to avoid sprawl. Smart growth promotes compact, walkable, transit-oriented, bicycle-friendly environments, with local schools and mixed-use development with a range of housing choices (Boeing et al. 2014). Smart growth is used mostly in North America, whereas in the UK and Europe the term ‘compact city’ or ‘urban intensification’ are used to describe similar notions.

The concept of the compact city has influenced government planning policies in the UK and several European countries. The ecological city approach seems complementary to the other two approaches in terms of their respective areas of strengths and weakness (Jepson and Edwards 2010).

1.8.3 Green Urbanism

Green Urbanism is a conceptual model for zero-emission and zero-waste urban design, which arose in the 1990s, promoting compact energy-efficient urban development, seeking to transform and re-engineer existing city districts and regenerate the post-industrial city centre. It promotes the development of socially and environmentally sustainable city districts. It probably contains the most similar ideas with sustainable urbanism. They both put emphasis on urban design with nature, as well as shaping better communities and lifestyles. However, the principles of green urbanism are based on the triple-zero frameworks: zero fossil-fuel energy use, zero waste, and zero emissions. Sustainable Urbanism, on the other hand, is more focused on designing communities that are walkable and transit-served so that people will prefer to meet their daily needs on foot (Cerveroa and Sullivana 2011).

There are two contradictory, yet predominant, theories related to strategies for designing and planning of sustainable city form. They are the "compact city" idea from the European context and "urban sprawl" theory from Australia and North America. These two theories consider two main factors of land use and density patterns in cities' form. It has been concluded and then argued that the necessity of "mixed use" function which should be combined with "density" measures simultaneously to create a new balanced model which can be termed "compact mixed use city form" as the alternative for achieving urban sustainability (Masnavi 2011). Both these ideal-types of urban development have been encouraged because of their alleged social, cultural and economic advantages. Yet the compact city model is credited with being less detrimental to the environment (Williams et al. 2000).

1.9 Theory of the Compact City

Compact, liveable urban neighbourhoods attract more people and business. Compactness, or density, plays an important role in sustainable urban development because it supports reductions in per-capita resource use and benefits public transit developments. The density of new development across the U.S. averages roughly two dwelling unit per acre, which is too low to support efficient transit and walk-to destinations. Such low-density development is a characteristic of urban sprawl, which is the major cause of high dependence on private automobiles, inefficient infrastructure, increased obesity, loss of farmlands and natural habitats, pollution,

and so on (Frumkin 2002). For these reasons, sustainable urbanism requires minimum development densities roughly four times higher than two dwelling units per acre.

Overall, compact development generates fewer pollutants to the natural world. Research has shown that low-density development can exacerbate non-point source pollutant loadings by consuming absorbent open space and increasing impervious surface area relative to compact development. While increasing densities regionally can better protect water resources at a regional level, higher-density development can create more impervious cover, which increases water quality problems in nearby or adjacent water bodies (Richards et al. 2011).

Increasing neighbourhood population density also supports improved public transit service. Concentrating development density in and around transit stops and corridors maximizes people's willingness to walk and thus reduces car ownership and use. Sustainable urbanism seeks to integrate infrastructure design increase with density, because a concentrated mixed-use development required less per capita infrastructure usage compared to detached single-family housing (Farr 2008).

1.10 Theory of the Urban Dispersal

In Europe and North America there is a growing concern about the development of urban form, especially deconcentration of urban land use in the form of urban sprawl. This has unintentional consequences such as city centre decline, increased reliance on the use of the private car, and the loss of open space. While governments try to regulate the development of urban form, there are no easy solutions. However, policies such as 'new urbanism' and 'smart growth' in North America, and 'compact city' and 'multifunctional land use' policies in Europe, though difficult to implement, have the potential to curb urban sprawl and the further growth in car use (Dieleman and Wegener 2004).

Most of studies concluded that sprawl has both positive and negative effects. The most complete and rigorous North American studies concluded that overall, sprawl is more costly than compact development for both operating and capital costs (Burchell et al. 1992, 2000). The greatest savings gained from growth controls were in land consumed and infrastructure built especially water, sewer, and road facilities.

Urban sprawl or suburban sprawl describes the expansion of human populations away from central urban areas into low-density, mono-functional and usually car-dependent communities. In addition to describing a particular form of urbanisation, the term also relates to the social and environmental consequences associated with this development (Neuman 2005).

The term urban sprawl is highly politicised, and almost always has negative connotations. It is criticised for causing environmental degradation, and intensifying segregation and undermining the vitality of existing urban areas and attacked on aesthetic grounds. Due to the pejorative meaning of the term, few openly support

urban sprawl as such. The term has become a rallying cry for managing urban growth (James et al. 2013), have summarised the various definitions of urban sprawl in the planning literature to create a working definition of the concept as: '… unplanned, uncontrolled, and uncoordinated single use development that does not provide for a functional mix of uses and/or is not functionally related to surrounding land uses and which variously appears as low-density, ribbon or strip, scattered, leapfrog, or isolated development' (Daneshpour and Shakibamanesh 2011).

1.11 Urban Resilience

The continuous increase in the number and size of urban regions across the world, and the simultaneous shrinking of cities in some regions, pose great challenges for sustainable development. Urbanization patterns and the lifestyles of urban dwellers also affect the planet on wider scales in time and space. They contribute to shape bio-physical processes on planetary scales, and affect how humans around the world mentally connect with the Biosphere. However, through their local to global linkages, cities can play a key role in the quest to continuously and increasingly support sustainable development (Chelleri and Olazabal 2012).

Based on the definition of Holling (2001), Alberti et al. (2003) have defined urban resilience as the degree to which cities are able to tolerate alteration before reorganising around a new set of structures and processes. They assert that urban resilience can be measured by how well a city can simultaneously balance ecosystem and human functions. When most people think of urban resilience, it is generally in the context of response to impacts (e.g. hazard or disaster recovery), however what we learn from our understanding of resilience in regional social-ecological systems is a society that is flexible and able to adjust in the face of uncertainty and surprise is also able to capitalise on positive opportunities the future may bring (Barnett 2001).

Assuming that the process towards urban sustainability includes a combination of encompassing transitions (i.e. transformations) as a response to natural resource scarcity and climate change (adapted from Kemp and van Lente 2011), the theory of resilience is a promising framework (Chelleri and Olazabal 2012). Certainly, it supports the conceptualisation and development of tools to plan and manage urban sustainability transitions, providing a long-term perspective based on the three key concepts of learning, adaptation and transformation (Walker 2004; Folk et al. 2010). Resilience plays a crucial role in achieving sustainability (Brand and Jax 2007) and Promoting resilience means changing the nature of decision-making to recognize the benefits of self-sufficiency and new forms of governance which focus more on social equity, learning and the capacity to adapt (UN 2012).

In summary, the goal of urban sustainability poses great challenges to urban planners and policymakers; the cross-scale nature of urban interactions places these challenges at the centre of global scale solutions. As discussed here, urban

transformation can be positioned around three challenges: reducing resource consumption, integrating social and environmental criteria alongside economic interests in decision-making and mitigating the impacts of and adapting to climate change. To help cities in this process of transformation a significant aim of urban sustainability must be to reduce potential vulnerabilities, especially to climate change, and notably in low-income countries where rapid urbanisation brings significant threats. Moving from vulnerability to resilience is the key to this process.

1.12 High Tech Versus Low Tech Paradigms and the Conundrum of Measurement

The Brundtland Commission defined sustainable development as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED 1987). From this proposition sustainability goals have been defined and, to a limited extent achieved. This has lead to greenhouse gas emission restrictions and targets for the reduction of energy and material use. Worldwide, the building industry is responsible for 25 % of the road-traffic, 35 % of the waste produced and 40 % of the energy consumption and CO_2 emissions (UNEP 2009).

Where sustainable development is perceived as development without growth, this philosophy lead to ideas about extended lifespan (De Jonge 1990), cradle-to-cradle developments that consider recycling or upcycling of second hand building materials (McDonough and Braungart 2002) and the circular economy (MacArthur 2013) that reduces waste production and energy use in construction. Viewed on this basis, sustainable development of the built environment is understood as durable; focusing on a long life span, sustainable; focusing on energy use, and adaptable; focusing on loose fit and space use. Furthermore sustainable development demands balancing these three criterion.

1.12.1 High-Tech

Expanded functional lifespan or multiple functional lifespans contribute to sustainable development, although these contributions are not as easily recognised and accounted for as the more technical, energy saving solutions. In comparison buildings with climate facades, maximised thermal insulation and reduced CO_2 emissions are seen as sustainable, and these aspects are recognised in sustainability rating tools, such as LEED, Green Star and BREEAM (DGBC 2009; Eichholtz et al. 2008). However, the sustainability measures that are adopted, are not necessarily related to the structural parts of the building, and do not say much about the quality of the building. Moreover, sustainability-rating tools are based on different rating systems and the highest achievable levels of the rating tools differ (Reed et al. 2009).

The highest level of BREEAM is the rating 'Outstanding', which has a far higher level of sustainability compared to the highest rating in Green Star (6 Stars) or LEED (Platinum) (Reed et al. 2009). None of the existing rating tools have well incorporated criteria to measure refurbishment only BREEAM has a refurbishment tool, called BREEAM In Use. This is surprising, given that only 1–2 % is typically added to the total existing building stock each year (Reed et al. 2009). Furthermore, the required performance of buildings such as offices, for example, which includes increasing comfort and emission reducing building characteristics, changes over time. Measures reducing the energy use and emissions from office buildings should therefore be seen as part of an adaptable building concept (Kendall 1999). Several researchers propose the use of a life cycle costing approach (LCA) as these are more complete than the sustainability rating tools. As an example, the model of Eco-costs/Value Ratio (EVR) allows comparing new construction to renovation and maintenance (De Jonge 2005). This type of LCA model could be used in the initial phase of new developments, to calculate the possible benefits of buildings with future adaptation and transformation possibilities, compared to traditional standardised buildings.

1.12.2 Low-Tech

Low-tech sustainability is an umbrella concept covering a range of sustainability measures, all focusing on the quality of the building, for example use value, adaptability, extended building lifespan, material use and relationship with the surroundings. Examples of low-tech measures are buildings that work with the climate and site, specific (micro) climatic design solutions, natural materials rather than man made materials, solutions for passive houses, adobe walls to provide high thermal mass, and so on. However, in medium to high-rise buildings and high-density city centres these solutions are not always viable. A solution that is viable on all scale levels is extended building lifespan. The remainder of this section will focus on this solution. Extended building life span is a low-tech proposal to improve the sustainability of the built environment by increasing the durability of the buildings, considering the buildings technical, functional and economic lifespan (De Jonge 1990). Adaptation contributes to prolonging the building lifespan. In housing, if a building is adapted, an extended lifespan of 30 years following the adaptation is expected (Douglas 2006). In commercial property, offices respond much faster to both market and user preferences, and so the extended lifespan expectation of each adaptation will be lower.

Buildings with a long lifespan are sustainable as such; they contribute to lowering the construction industry's waste production, reducing construction related traffic, and reducing energy use for construction (Lichtenberg 2005). Depending on a buildings lifespan, the building materials are more or less important to the total environmental load of the building. Buildings constructed for a long lifespan should be built with focus on sustainable energy solutions, the type of building materials is