3. UNDERSTANDING SUSTAINABILITY

The problem we face is not so much a management problem as a design problem. In order to develop a sustainable society we need to describe a system of consumption and production in which each and every action is inherently sustainable and restorative.[71]

3.1. Sub Problem Two and Hypothesis Two

Sub problem: What are key concepts in sustainability that are useful in understanding how buildings and construction can support sustainable development?

Hypothesis: Concepts from sustainability can inform the development of a specification for an assessment tool that aims to integrate sustainable development into building briefing and design processes.

3.1.1. Introduction

There are numerous definitions of sustainability.[72] In this chapter a number of these definitions are reviewed in order to understand the concept of sustainability. It is suggested that these definitions can be grouped in to sets. These groupings are used to explore the idea of sustainability in some detail and enable the study to develop a description of the characteristics of sustainability.

A review of sustainability enables the study to be informed by theory in this field. It also helps locate buildings and construction within the sustainability discourse. An exploration of sustainability is valuable as it assists in the defining of the goal of sustainability that buildings and construction should aim for. It also offers models and approaches that can be drawn on to support the achievement of this goal.

A review of the definitions of sustainability reveals a number of patterns. The first pattern is that many definitions that attempt to describe *what* sustainability is, share a concern about ensuring that the *environment, development or systems need to be designed and maintained to provide for existing human populations as well as for future populations*. The second pattern, is that definitions that tackle *how* sustainability can be achieved, generally agree that this will have to be *pursued simultaneously, and in an integrated way across social, economic and environmental arenas.*

Studies in sustainability often investigate how different systems interact and interrelate. In order to understand this, systems are broken down, and studied, in their individual

[71] Elkington. 1997. p. 38
[72] Bell and Morse.1993. p.10

components. This can be called a ‘bottoms up’ approach. However when one looks at the overall characteristics of these interacting systems or components, properties appear that could not have been predicted from only a study of the isolated parts. These properties, defined as emergent properties, also need to be understood. This requires a ‘top-down’ approach. Therefore, the study of sustainability could be said to require both a top-down as well as a bottom-up approach.

To reflect these patterns the literature review on sustainability will have two main sections. The first will be concerned with developing a broad definition and understanding of sustainability. This will be done by reviewing a range of general definitions of sustainability, such as those developed by the United Nations. This establishes the top-down view of sustainability The second part of the review will develop a more detailed understanding by exploring definitions of sustainability within the social, environmental and economic arenas. This will develop a bottom-up view.

3.1.2. Sustainability: A General Definition

Sustainability

The Oxford English Dictionary defines ‘to sustain’ as ’to keep a (person or community, the mind, spirit etc) from failing or giving way ‘ or ‘ to keep in a state of being; to cause to continue in a certain state; to keep or maintain a proper level or standard’.[73]

Using this definition two questions can be explored. The first asks what is the entity that needs sustaining? The second asks what should its requisite state be? We can use these questions as a way of reviewing definitions of sustainability, so as to extract characteristics of sustainability from these definitions.

General definitions of sustainability appear to fall into two camps. One set has an emphasis on systems and how these can, and should be, maintained and developed. These can be referred to as Systems definitions. A second set has an emphasis on humans and their existing and future needs. These can be referred to as Human Development definitions.

Systems Definitions

Sustainability can be understood very simply, at a practical level, as ways and systems that are ongoing. For example, Pearce uses an example of fisher people or foresters who understand that yields are sustainable so long as they harvest fish and trees at a rate equal to the growth of biomass.[74] Using our general definition questions, the entity in this definition would be the environment and desired state would be one in which the consumption of fish or trees match the ability of the environment to provide these.

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[73] Little, Fowler and Coulson. 1998.
[74] Pearce.. 1993. p.3

Another systems definition is by Lynam and Herdt:

…The capacity of system to maintain output at a level approximately equal or greater than its historical average, with the approximation determined by the historical level of variability[75]

The entity in this case is the system and its required state is to maintain output at equal or greater than it has in the past. This definition brings in the concept of time and productivity. It suggests that it is important to have an output, and that this output must be fairly steady over time.

Pearce and Turner, in their definition place a strong emphasis on outputs. Here they state that productivity must be optimised within limits that relate to natural resources:

…maximising the net benefits of economic development, subject to maintaining the services and quality of natural resources over time.[76]

The entity in this case is a system, and the required state is one in which optimal economic benefits are provided. These benefits however, he maintains, must be achieved without affecting the quality and services of natural resources. This definition indicates that limits are important and that these must be defined, if a sustainable system is to be created.

Fresco and Kroonenberg suggest that sustainable systems are variable and can be affected by change such as climate change:

The sustainability of natural ecosystems can be defined as the dynamic equilibrium between natural inputs and outputs, modified by external events such as climatic change and natural disasters.[77]

In this description the entity is an ecosystem and its required state is that the ecosystem maintains a steady state. This definition shows that an important characteristic of a sustainable system is the ability to maintain a steady state. This state however, may be redefined by changes such a climate change or natural disaster.

It is clear that a review of these patterns reveal a number of characteristics of sustainability. These are summarised at the end of the chapter. It is also apparent that ecosystems, in their natural state are sustainable and that it is important to understand these better in order to

[75] Lynam and Herdt. 1989. p 381-398
[76] Pearce and Turner.1990
[77] Fresco. and Kroonenberg. 1992. p. 161-170

create sustainable systems. This will be done in the review of environmental sustainability later in this chapter.

Human Development

In the human development set of definitions, the concept of sustainable development is often referred to. For instance:

Sustainability reminds us that there are future generations, ..and that we can very easily shift unacceptable burdens on to them. Sustainable development, as opposed to sustainability, reminds us of other social objectives, most notably the plight of the poorest in the world.[78]

The entity in this case is development, and its required state should be one that ensures that the poorest people and future generations should be considered. Development is normally defined as a process of evolving, or the production of a new form. This definition therefore suggests that man, in evolving or designing all new forms and processes, must take into account certain considerations, which include the poor, and future generations. This definition is extremely broad and has significant implications. It suggests that there should be a fundamental change in the way in which development occurs.

This also reflected in other definitions. Probably the most well known definition comes from the World Commission on the Environment (WCED). Here sustainable development is described as:

…development that meets the needs of current generations without compromising the ability of future generations to meet their needs and aspirations.[79]

The entity in this case, is again, development. However the required state for development is that it meets the needs of current generations. The definition also suggests limits, in this case, that needs should be provided for in a way that also enables future generations to meet their own needs and aspirations. This definition raises the question as to what is defined as 'needs', and 'aspirations'. These clearly will be defined differently by different societies, and will differ widely between developing countries and developed countries. The concept of 'needs' and 'wants' will be explored further in the section of sustainable economics, later in this chapter.

The WCED definition is qualified by suggesting that needs should be *essential* and that our ability to meet these needs is limited by *technology* and *social organisation*:

[sustainable development] *contains within it two key concepts:*

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[78] Pearce. 1993

[79] World Commission on the Environment and Development. 1987. p. 43

The concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority must be given
And
The idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs.[80]

This definition dwells at some length on limits and seems to imply that if we can change our social structures and develop different technology we will be able to meet our own as well as the future needs of others. This idea is particularly relevant to this study as there is a close relationship between technology, social structure and building and construction. This aspect will be explored further later in the chapter.

The International Union for the Conservation of Nature (IUCN) provides a similar definition to that of the WCED:

…. development that improves the quality of human life while living within the carrying capacity of supporting ecosystems.[81]

However in this definition the required state for sustainability is to improve the quality of human life. This must happen within limits, in this case the carrying capacity of the supporting ecosystem. This definition raises the question of how quality of life is defined. This will be explored further in the sections on social and economic sustainability later in this chapter. This definition introduces the concept of carrying capacity. It suggests that in sustainable systems it is important to define the carrying capacity and ensure that this is not exceeded. Having reviewed these definitions it is useful to summarise the definitions in the form of a table (Table One).

Table Three: Sustainability Definitions

Source	Entity	Required State	Limits
Pearce	Fisherman and Foresters and their Environment	Provision of fish and trees for man	Ability of environment to provide biomass
Lynam & Herdt	System	To provide output	Output must be same or greater than in the past
Pearce & Turner	System	Maximise economic benefit	Maintain quality and services of natural

[80] World Commission on the Environment and Development. 1987. p43
[81] International Union for Conservation of Nature. 1991.

			resources
Fresco & Kroonenberg	Ecosystem	Dynamic equilibrium between inputs and outputs	Balance could be altered climate change / natural disasters
Pearce	Development	Avoid placing burdens of future generations, addressing the poor	
WCED	Development	Meets need of current generations and needs and aspirations of future generations	Environmental ability Technological state Social organisation
IUCN	Development	Improve quality of life	Carrying capacity of ecosystem

3.1.3. Environmental, Social and Economic Sustainability

A review of the main current definitions of sustainability indicates that there are a range of different emphases. In particular there seems to be split between an emphasis on human issues and development and system or ecosystem issues. As buildings have both human and environmental aspects it is important to develop an understanding and definition of sustainability that encapsulates both of these. This will be done through an investigation of environmental, social and economic aspects of sustainability.

3.1.4. Environmental Sustainability

In order to review environmental sustainability it is useful to describe this in terms of the original questions that were applied to definitions of sustainability. We therefore need to define the entity that is to be sustained and the required nature of this entity. In environmental sustainability two entities can be explored. At a very large scale the entity explored could be the planet. Here the state required is the healthy operation of the systems that maintain this. At a much smaller scale the entity explored could be an ecosystem. The state required in this case is the healthy and ongoing operation of all of the aspects that sustain this.

Exploring these entities in this study is appropriate for a number of reasons. The first is that by developing an understanding of planetary systems, the study can begin to understand the relationship between building and construction and planetary systems and begin to establish how the building and construction has an impact on these. This understanding will inform the

study, as it will help establish how buildings and construction can minimise or avoid negative impacts on planetary systems.

The second reason is that buildings are part of ecosystems and have an impact on them. Developing an understanding of ecosystems will begin to define the requirements that buildings and construction will have to meet, to limit or avoid negative impacts on ecosystems. It may even suggest ways that building and construction could enhance the healthy operation of ecosystems.

Thirdly, buildings and man together, can be described as a system. Clues for making this system more sustainable may be found from a study of natural sustainable systems, such as ecosystems.

Planetary Systems

The Earth has been described as a living organism.[82] Although this idea has been controversial it may provide useful insight for developing an understanding of the impact of human activities, and in particular, the built environment, on the Earth. In the Gaia hypothesis, Lovelock illustrates the validity of this view through listing a wide variety of similarities between planetary systems and living organisms. An example given is how the Earth is able to maintain temperature and chemical balances in the face of perturbations, in the same way as living organisms.[83]

Lovelock uses his definition of the Earth as a living organism not only to help understand this but also to suggest a role for man in ensuring its continuing health. He suggests that it is vital to understand more about the earth and to ensure that we begin to understand, and act on, any signs of ill health. This he describes in the following way:

I insist that Gaia theory itself is a proper science and no mere metaphor. My use of the term alive is that of an engineer who calls a mechanical system alive to distinguish its behaviour from when switched off, or dead. Engines on whose proper function many lives depend have health monitors; devices that ensure that signs of failure are detected early enough to avoid a tragedy.[84]

Lovelock is quick however to explain that, unlike man-made engines, man still has a very poor grasp of the mechanics of the Earth as a whole, a field that he refers to as planetary science. He attributes this to the way knowledge has developed in this area. This he calls the ‘bottoms-up’ approach, in which detailed knowledge in specific fields has been developed by specialised disciplines such as meteorology and geology. He suggests that there has been

[82] Lovelock. 1991. p.6
[83] Lovelock. 1991. p. 29
[84] Lovelock. 1991

very little interaction between these highly specialised disciplines preventing the development of a clear understanding of how the planet, as a whole, works. Lovelock indicates that alongside this bottoms-up approach, it is important to have a top-down approach:

This top-down view of the Earth as a single system, one that I call Gaia, is essentially physiological. It is concerned with the working of the whole system, not with the separate parts of a planet divided arbitrarily into the biosphere, the atmosphere, the lithosphere, and the hyposphere. These are not real divisions of the Earth; they are spheres of influence inhabited by academic scientists.[85]

Lovelock asserts that the planet is in a serious state of ill health and that there is insufficient time to develop a full understanding of planetary science before acting to address ill health. He proposes that, as with early medicine, we use empiricism as a method of progressing. The example Lovelock provides is that of the Romans who thought that marshes had 'bad odours' that caused disease, and so drained marshes. This actually got rid of the real problem as well: malaria.[86]

He states that is important to move away from our current way of thinking that tends to be self-centred and short term. This thinking has failed to enable man to see, as part of a much larger system, the real value of aspects of the environment such as the Amazon rainforest or marine algae. For instance, he describes how a popular reason given for not cutting down Amazon rainforest is a fear that a particular cancer curing species of plant will be lost.

Dwelling on these issues, although important, he maintains, often obscures far more important issues. A very important contribution that rain forests make is its global contribution as: "A self regulating system that keeps the climate in the region comfortable for life". A planetary physician, it is proposed, would regard the great forests of the earth as part of the skin of the earth, which like human skin sweats, to keep us cool. If a value was to be obtained for this natural air conditioning, using costs attributable to mechanical systems, Lovelock calculates that this would be within the region of $150 trillion.[87]

True sustainability, Lovelock states, can only occur when we realise our level of ignorance about the Earth and instead of seeing ourselves as masters, and in control of the Earth, we see ourselves as stewards. He describes this in the following way:

I would suggest that our real role as stewards of the Earth is more like that of proud trade union functionary, the shop steward. We are not managers or masters of the earth; we are just stewards, workers chosen, because of our intelligence as representatives for others, the

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[85] Lovelock. 1991. p.11
[86] Lovelock. 1991. p. 14
[87] Lovelock. 1991. p. 183

rest of life on our planet. …. Indeed all living things are members of our union and they are angry at the diabolical liberties taken with their planet and their lives by people. People should live in harmony with the other members, not exploiting them and their habitat.[88]

There are aspects of Lovelock's work that are relevant to the study. These include the following ideas. Man must become more attuned to the biophysical systems that support life and steward these to ensure they are healthy. A useful way of indicating the value of biophysical systems is to calculate the costs required for a mechanical system to do the same work. To achieve sustainability, action must be taken now, even if full knowledge and understanding within area has not been achieved.

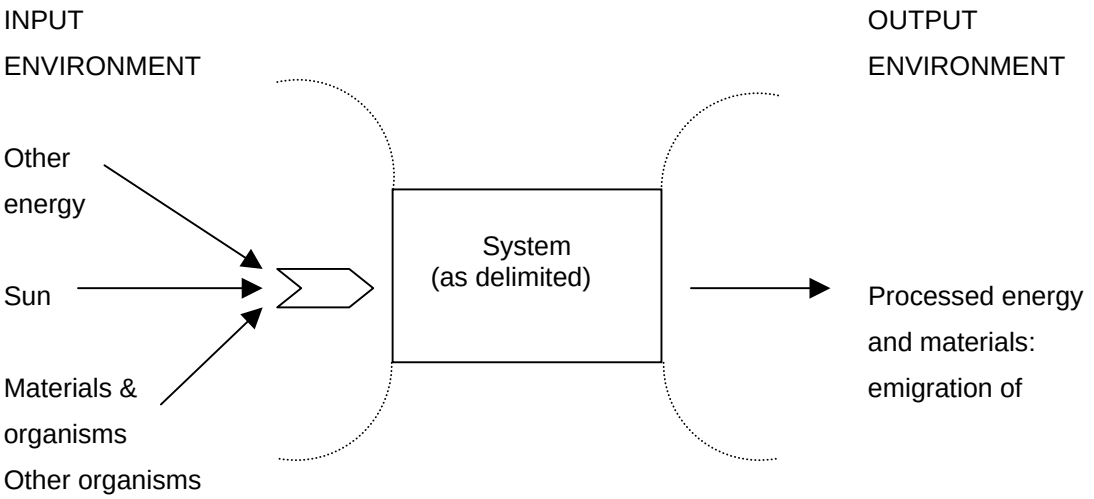
Ecosystems

A number of the definitions reviewed early in this chapter refer to ecosystems. The definition of ecosystems is attributed to Sir Arthur Tansley who described this an organised unit consisting of biotic (living) components and abiotic (non-living) components. This unit is organised in such a way, that although there may be change, and organisms and material may pass through it, it essentially remains constant.

Odum describes ecosystems as an open system in which there inputs (which come from an input environment) and outputs (which come into an output environment).[89] Examples of ecosystems that he provides include a section of beach and a block of forest. An essential component of the input environment is energy, which drives the system. This usually comes from the sun but can come from other sources such as wind, rain or water flow. The input environment may also include water and nutrients as well organisms that enter the system. Out of the system flow emigrating organisms and processed energy and organic matter such as food and waste products. Odum's model of an ecosystem is shown in Figure One.

[88] Lovelock. 1991. p. 186
[89] Odum. 1989. p. 39

Figure One: Ecosystem Components[90]



IE + S + OE = Ecosystem

Odum describes this model in the following way:

Model of an ecosystem as an open, thermodynamic non-equilibrium system, with emphasis on the external environment, which must be considered an integral component of the ecosystem concept.[91]

Odum describes a number of properties of ecosystems. These are reviewed in order to develop a better understanding of systems and extract characteristics of ecosystems that may be useful for guiding the development of more sustainable systems. Where appropriate this will be used to provide an input to the specification developed in Chapter five. Odum describes ecosystems as having the following characteristics:[92]

Ecosystems are emergent. Ecosystems have properties that result from the functional interaction of their components and therefore cannot be predicted from the study of these components separately or decoupled from the whole system. It is interesting to note that an understanding of this property requires the top-down approach suggested by Lovelock.

Ecosystems tend to be governed by homeostatic mechanisms. Odum describes these as 'checks and balances' and gives a number of examples. At a physiological level homeostasis ensures that our body temperature keeps constant despite fluctuations of the external environmental temperatures. At a larger scale, homeostatic integration of biotic and abiotic

[90] Odum. 1989. p. 39
Odum. 1989. p.
[91] Odum. 1989. p. 39

processes of the biosphere keep carbon dioxide and other gas concentrations relatively constant despite large volumes of gases leaving and entering the atmosphere.

Energy - the currency of ecosystems: An understanding of ecosystems, Odum indicates, is aided by models. A model he defines as a simplified formulation that mimics a real-world phenomenon so that complex situations can be comprehended and predictions made. He proposes that the easiest way to model an ecosystem is to chart the flows of a currency that is common to all of its components. He suggests that this currency should be energy. Using this currency he defines different aspects of an ecosystem. There are energy sources like the sun. There are producers that convert and concentrate solar energy, such as plants. There are also consumers (like herbivores) who them use this converted energy to produce higher quality energy.

Ecological niches: Ecosystems exist within a biosphere, which is differentiated, through gradients in its physical factors. For instance, there are temperature gradients from the Arctic to the Tropics. There are also moisture gradients from deserts to the tropical rainforests of the world. Species have developed to occupy specific habitats along these gradients. The particular way that the organism has developed (the way it lives and interacts with other organisms) is called the ecological niche. From this one can see that a range of organisms can occupy the same niche. For instance kangaroos, bison and cattle all occupy the same niche when found in grassland. Organisms with these same ecological niches are termed ‘ecological equivalents’.

Coevolution: A characteristic of communities of organisms that have existed together for a very long time is the way they tend to evolve together. This coevolution often enables them as .a whole, to adapt better to change and enable them to inhabit more extreme ecological niches.

The structure of natural communities in ecosystems: Natural communities also have particular community structures. They tend to have few species that are very common (have large numbers) and a large number of species that are relatively rare. These common species are called ecological dominants. Species that have strong controlling influence, whether dominant or not are called keystone species. The rarer species on the sidelines add greatly to the robustness of the system. This is because if the major species fails as a result of, for instance, physical changes, often a rarer species, more tolerant of change can take its place as the keystone species. This ability to ‘swop players’ is termed redundancy and contributes greatly to the resilience of an ecosystem.

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[92] Odum. 1989

Carrying capacity: The size of populations within an area will be limited by the ability of the environment to support it. This is termed the carrying capacity of the environment. In biology this is usually defined in terms of the number or biomass of organism that a given habitat can support. It also can be applied to humans. However there are difficulties with this as different populations consume vastly different quantities of resources and energy.

The initial review of planetary systems and ecosystems indicates that there are useful concepts that can be applied to develop a definition of environmental sustainability. This will be discussed and developed in further in Section 3.2, Addressing Hypothesis Two – Environmental, Economic and Social Sustainability

3.1.5. Economic Sustainability

A review of economic theory related to sustainability, sometimes referred to as 'green economics', indicates that there are numerous problems with the current economic system which make it incompatible with the development, and implementation, of more sustainable practices. This section reviews relevant literature in order to develop an understanding of green economics. The review has two sections. The first part reviews the arguments against the current economic systems. The second part attempts to extract a list of characteristics of the green economics in order to understand the implications of this for buildings and construction.

The role of economics can be described as the creation, distribution and consumption of wealth.[93] Conventional economic science asserts that this role is carried out in a neutral value-free way. Green economists suggest that this is not only untrue, but also wrong - if we are to develop more sustainable practices, economics must guide and expose underlying values and assumptions:

The role of economists is as *much to expose the values and assumptions underlying economic choices, as it is to give guidance about the choices themselves*[94]

Green economists argue that economics is a means and not an end and it should be developed to provide for needs of man. They point out that the current economic system only addresses a limited number of people's needs and has a wide range of problems associated with it. They argue that it is highly inefficient, produces large amounts of waste and causes avoidable social and environmental problems. Numerous examples of waste are provided. These include speculation:

Making money independently of productive activity or real wealth creation has become a debilitating virus in the economic system.[95]

[93] Ekins, Hillman and Hutchinson. 1992. p. 30

And the high levels of solid waste and pollution in America:

The solid waste produced by each American is nearly one million pounds of material per person per year.[96]

They argue that the system is not only wasteful of resources it is also wasteful of people. Figures quoted from the International Labour Organisation (ILO) suggest that there are nearly a billion people (about 40% of the world's population) who are unemployed or underemployed.

Many manufacturing systems are also highly inefficient. In the agro-forestry business, often only about 5% of a crop is actually used, with 95% being discarded.[97] In conventional cars, only about 5% of the energy produced by the engine actually is delivered to the wheels and used to propel the car.[98]

Green economists argue that it is increasingly important to move towards a system of economics that improves resource efficiency and values the environment and people. The key priorities for economics should be to ensure that the needs of every person are addressed. The elimination of poverty, it is argued, not only makes sense from a moral point of view, but also from an economic point of view:

Poverty destroys motivation and potential and fosters anger and alienation. Poverty tends to perpetuate itself. The elimination of poverty can be justified on the grounds of both economic efficiency and social justice.[99]

Conventional economics, it is argued, often does not value the most important things, such as people and the environment, probably because these are hard to quantify. Green economists point out that most indexes do not have environmental or social indicators and yet, the World Bank, in a study in 1995 calculated the value of human capital to be three times greater than all existing financial and manufactured capital. They also point to many aspects of life and work, which, by not being quantified and reflected in costs, have perpetuated the involuntary subsidization by everyone of highly inefficient and damaging practices. Hawkins et al provides an example of this from car usage in the United States of America:

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[94] Ekins, Hillman and Hutchinson. 1992. p. 31
[95] Ekins, Hillman and Hutchinson. 1992. p. 24
[96] Hawken, Lovins and Lovins. 1999. p. 52
[97] Pauli. 1998. p. 23
[98] Hawken, P., Lovins, A., Lovins, L.H. 1999. p. 24
[99] Hawken, Lovins and Lovins. 1999. p. 33

The social costs of driving – related both to the conversion of fuel into smog and congestion, lost time, accidents, roadway damage, land use and other side-effects of driving itself- are largely socialized. 'External' costs approaching 1 trillion dollars a year, perhaps a seventh of the American GDP, are borne by everyone, but not reflected in driver's direct costs.[100]

In conventional economics the environment is often taken for granted and is of little concern. Green economists argue that this will change, as the environment rapidly becomes the limiting factor for future development. Drawing on history, they illustrate how changes in limiting factors in economies cause fundamental paradigm shift because "behaviour that used to be economic becomes uneconomic".[101]

Many Green economists argue that this paradigm shift is beginning to happen. They suggest that increasingly, business and governments are becoming concerned about environmental and social issues, and that this being reflected in the evolution of a new economic system. Terms for this new form of economics differ with Hawkins et al calling this 'Natural Capitalism', Ekins et al, 'Green Economics' and Elkington, 'Triple Bottom Line Accounting'.

Ekins et al suggests that the fundamental priorities for this new system will be the alleviation of poverty and the matching and maintenance of economic systems with optimal ecological size and performance.[102] Key characteristics of a green or sustainable economy are summarised in Section 3.2 Addressing Hypothesis Two – Environmental, Economic and Social Sustainability

3.1.6. Social Sustainability

It is difficult, initially, to see the relationship between social systems and sustainability. However this relationship is vital. As already described, economics for sustainability has a strong emphasis on people. We need to understand which forms of society are more supportive of sustainability and understand what mechanism are required in these to encourage the development and implementation of more sustainable practices. This is important because, without a concerted effort that integrates social and economic systems, more sustainable practices are unlikely to be adopted.

This section reviews literature that describes the role of society in sustainable systems. It has three parts. The first part reviews definitions of human and social capital; concepts widely considered important in establishing how society can support sustainability. This leads to a review of examples, which help describe the role society has to play. Finally, the review extracts a number of characteristics of society that need to be cultivated in order for societies to become more sustainable.

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[100] Elkington. 1997. p. 349
[101] Hawken, Lovins and Lovins. 1999. p.156 -159
[102] Ekins, Hillman and Hutchinson. 1992. p. 33

Behind economic activity, Elkington argues, there is an invisible structure of beliefs.[103] These guide economics and are often responsible for the particular strengths or weaknesses of a system. Green economists argue that instead of this being invisible, this structure should become explicit and must have as objectives, the restoration and assignation of value to people and the environment. People and characteristics of society, they argue, play a key role in wealth creation. To describe these roles they use the terms 'Human Capital' and 'Social Capital'.

Human Capital

Human capital is a concept, which describes the contribution of health, knowledge, skill and motivation of people to wealth creation.[104] It describes the potential for efficient and directed productivity within people themselves. A person who is healthy, motivated and happy will be more productive than one who is not. In a similar way, a person who is provided with skills and knowledge is likely to be more productive than someone without these attributes.

Social Capital

Social capital describes the contribution of social relationships, trust and cooperation to wealth creation. While human capital emphasizes the productivity of the individual, social capital emphasizes the productivity of the group. Putnam defines social capital and describes its leveraging effect on other forms of capital in the following way:

Social capital refers to the features of social organization, such as networks, norms and trust that facilitate coordination and cooperation for mutual benefit. Social capital enhances the benefits in physical and human capital.[105]

Green economists suggest that investing in social capital has a wide range of benefits including increased capability, reduced friction, and an increased ability to innovate. All of these support the development of more sustainable systems as they enable increased resource productivity, reduced consumption, and more equitable distribution of resources. Fukuyama describes these benefits:

If people who have to work together in an enterprise trust one another because they are all operating according to a common set of ethical norms, doing business costs less. Such a society will be better able to innovate organizationally, since a high degree of trust will enable a wide range of social relationships to emerge.[106]

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[103] Elkington. 1997. p.139
[104] Ekins, Hillman and Hutchinson. 1992. p. 49
[105] Putnam. 1993. p. 2
[106] Fukuyama. 1995

It is argued that social and human capital are important initial ingredients required in order to begin to move towards sustainability. Societies where there are high levels of social capital and trust are be able to innovate and organize more rapidly in developing and implementing sustainability. Elkington describes this in the following way:

Sustainable development is most likely – and will be achieved at lowest cost to the economy – in those societies where there are the highest levels of trust and other forms of social capital.[107]

Areas where social capital is low however are likely to lag and to continue to suffer from low productivity and waste. Elkington points out that distrust can be equated with tax:

Widespread distrust in society imposes a kind of tax on all forms of economic activity.[108]

Hawkins et al provides a range of examples of how a lack of investment in social and human capital leads to high costs in unproductive areas. As examples, they refer to the security and private police, which is currently the fastest growing industry in the world, and the five million Americans currently in prison.[109]

It is argued, that social and human capital, instead of being ignored, should be central to economics. Elkington points out that if these aspects were quantified, in many instances these are actually likely to be more valuable than economic and manufactured capital. He gives the example of the company Skandia, where intellectual capital is regarded as at least as valuable as financial capital, in providing substantial earnings.[110] This point is argued strongly by Jolly who suggests:

Human capital is a more important factor for achieving economic growth than physical capital.[111]

Having established that human and social capital are important considerations in sustainability, it is useful to review how these concepts can be developed and supported. Green economists argue that there are a number of mutually reinforcing components that contribute to strengthening social and human capital. A number of these are outlined below.

Health and Education

It is argued that people are an important productive resource that should receive continuous investment and attention in order to ensure that they are maintained and enhanced. This

[107] Elkington. 1997. p. 85
[108] Elkington. 1997. page 85
[109] Hawken, Lovins and Lovins. 1999. p.8, 54
[110] Elkington. 1997. p. 88
[111] Ekins, Hillman and Hutchinson. 1992. p. 54

investment should be made into health and education. Ekins et al describe the value of this investment to a productive economy in the following way:

Enhancing human capital becomes an objective of, as well as a measure to, a productive economy through investment in education and training and stimulating work experience.[112]

Morley suggests that investment in social aspects is as important in development as investment in physical facilities:

Motivating, mobilizing, education and training is as important as the accompanying physical investments.[113]

To be fully productive people need to be healthy motivated and appropriately skilled; qualities that need to be constantly renewed. This renewal …should be an integrated part of working life.[114]

Capability and Opportunity

It is argued that everyone needs to be able participate fully in economic development and that this should be not be limited to a few people. As well as being able to have needs addressed it is important that people are empowered and fulfilled by being able to do this themselves:

Power…can yield power over oneself, the ability to fashion and achieve one's own fulfilment. This is the power expressed by the word capability. In Green economics the whole notion of economic "development" boils down to an increase in the capability of the least well off people in society, and thus their ability to satisfy an ever-increasing number of needs.[115]

Ekins et al suggest that there are three requirements for this increase in capability

First, political power must be isolated from economic power. Second, because this will not be entirely possible, the concentration of economic power must be avoided. Third, everybody must have effective access to each of the 4 capitals necessary for production: environmental resources including land: human capital through education and health rights: social and organizational capital, through freedom to organize and agitate, and to live in communities free from disruption: and tools and machines, through cooperative ownership structures and the creation of public infrastructure.[116]

Resource Productivity and Efficiency

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[112] Ekins, Hillman and Hutchinson. 1992. p. 55
[113] Ekins, Hillman and Hutchinson. 1992. p.125
[114] Ekins, Hillman and Hutchinson. 1992. p. 54
[115] Ekins, Hillman and Hutchinson. 1992. p. 74
[116] Ekins, Hillman and Hutchinson. 1992. p. 74

Many of current systems of production and consumption are highly inefficient. Often they have also been developed to minimize employment. These systems, it is argued, will have to change as natural resources become increasingly scarce and access to employment becomes more important. Hawkins et al and Pauli argue that radically increased resource productivity is possible and that implementing this will solve both environmental and social problems. Pauli suggests that companies, instead of 'downsizing' and looking at ways of minimizing employment should upsize and create additional employment by developing useful by-products and services from areas previously considered waste.[117] Hawkins et al suggest that there are a number of environmental benefits as well as social ones that could be achieved from this approach:

Radical resource productivity slows down resource depletion at one end of the value chain, lowers pollution at the other end and provides a basis to increase worldwide employment and meaningful jobs.[118]

Measurement and Taxation

If changes in society are an important part of moving towards sustainability, tools for measuring and implementing this need developing. A range of measurement systems have been developed which take into social aspects. These include the Human Development Indicator (HDI) and the Index of Sustainable Economic Welfare (ISEW). Useful tools for encouraging change are taxes and subsidies. Hawkins et al point out that many current taxes and subsidies are vestigial, and reduce sustainability, by promoting inequity, inefficient practices and high levels of unemployment. They suggest that it is important for governments to revisit these and change them in order to promote more sustainable practices. This is already happening in Europe where it is suggested:

tax reforms aimed at increasing employment by shifting taxes away from people to the use of resources have started to be instituted.[119]

Creativity

Achieving sustainability with the limited resource and time available will require a high degree of creativity and ingenuity. It will also require motivation and willingness to change. Sustainability will require a radical rethink and redesign of our current systems. Paul Hawkins describes the problem in the following way:

The problem we face is not so much a management problem as a design problem. In order to develop a sustainable society we need to describe a system of consumption and production in which each and every action is inherently sustainable and restorative.[120]

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[117] Pauli, G. 1998.
[118] Hawken, Lovins and Lovins. 1999. p. 10
[119] Hawken, Lovins and Lovins. 1999. p.14

The problem of sustainability, Hawkins et al suggests, is most acute in developing countries. They suggest however, that through careful design and 'whole-system thinking', it may be possible to develop solutions, which solve many of the existing problems and are sustainable.

In the developing countries of the South, such whole-system thinking is at a premium, because the new pattern of scarcity….abundant people but scarce nature – has arrived early and with a vengeance. For the developing world, most acutely, the relevant question will be: How many problems can be simultaneously solved or avoided, how many needs can be met, by making the right initial choices? And how can those choices be linked into a web of mutually supporting solutions, creating a healthy economic, social, and ecological system that develops both better people and thriving nature.[121]

3.2. Addressing Hypothesis Two

The initial review shows that the hypotheses that literature on sustainability can inform the development of a specification for an assessment tool to be correct as this enables a detailed understanding of sustainability to be developed. It also provides characteristics of sustainable systems. These are discussed below:

Environmental Sustainability

A healthy, diverse, productive environment is vital in sustaining human life. The environment carries out a wide range of functions that support and enable human life. Many of these we do not fully understand. These functions include the following:

- Production of oxygen and absorption of carbon dioxide
- Absorption of waste products and pollution
- Temperature regulation
- Humidity regulation
- Production of renewable natural resources such as food, fuel, building materials etc

For the environment to be effective at carrying out these functions it must to have a range of attributes. These include the following:

Size: Environments and ecosystems have a carrying capacity. This limits the size of the human population it can support on a sustainable basis. It is therefore important that the size and productivity of biophysical systems are matched to, or are preferably larger, than the sizes of the human population they are required to support. The human population has been growing rapidly and levels of consumption have been increasing. The size of the biophysical

[120] Elkington. 1997. p. 38
[121] Hawken, Lovins and Lovins. 1999. p. 288

environment, on the other hand, has been decreasing.[122] This has meant that we have moved from a point at which we were within the earth's carrying capacity to one in which we are now living beyond this. This point according to the World Wildlife Fund occurred in the 1970's.[123] It is therefore becoming increasingly urgent to balance this equation. This will require significant economic and social change in order to reduce the required carrying capacity. Increasing, or at least maintaining, the current size of biophysical environment on the environmental side of the equation is essential, if this balance is to be achieved.

Diversity and complexity: Healthy, highly productive, resilient ecosystems are usually complex and consist of a diverse range of species. There are also a wide range of ecosystems, which have evolved to occupy a wide range of different environments. This complexity and diversity has been vital to enabling ecosystems to accommodate change (such as climatic change). This characteristic is also described as resilience. This ability is extremely important to retain, and enhance, in order to cope with the current climatic changes. Retaining, or even improving, the levels of biodiversity will help increase the chances that ecosystems adapt to changing climate conditions and can continue to support life. This complexity and diversity of ecosystems have also enabled harsh environments (such as deserts) to support ecosystems. With increasing human populations it is likely that there will be increasing pressure on these marginal environments to support human life. It is therefore important to retain and develop ecosystems in these areas.

Productivity: Humans consume large quantities of resources and energy. This can be produced naturally and in a sustainable way by the biophysical environment. With an increasing population it is important to ensure that biophysical environments are as productive as possible. It is therefore important to understand how productivity in terms of the different requirements for human life support can be maintained, and enhanced, in the biophysical environment.

Location: As far as possible the location of life support ecosystems should be close to where they are needed. This is for a number of reasons. Locating natural resources consumed by man close to where these are used reduces the requirement for transportation and the associated negative impact of this on the environment such as the consumption of non-renewable resources and pollution. Ecosystems also absorb and recycle human waste such as carbon dioxide, sewage and organic waste. Locating ecosystems that absorbs this waste close to its production, avoids the need for transportation and reduces possible negative impacts on human health of these products, as they are not allowed to accumulate. Finally, it is useful to have the environmental control function that ecosystems provide interspersed with human habitation as this enables better regulation. This reduces for the likelihood of

[122] World Wild Life Fund. 2000. p. 2
[123] World Wild Life Fund. 2000. p. 1

uncomfortable or unhealthy conditions developing, for instance as a result of the urban heat island effect or high concentrations of pollution in large cities.

Economic Sustainability

Economic systems have implications for sustainability. In many ways economic systems structure the relationships between people, machinery, buildings and the environment. It also provides a value system that drives, and controls, productivity. Increasingly, it appears that existing economic systems are partly responsible for social problems and environmental damage. To become more sustainable it is therefore important that our economic system needs to change. These changes and the characteristics of more sustainable economic systems are discussed below:

Equitable: Economic systems will have to become more equitable. The current structure of the economy provides a number of societies, such as those in developed countries, with a surfeit of wealth while barely providing for the basic needs of other societies. Societies that have a surfeit often are very wasteful. Relative to the number of their members, they consume large amounts of resources and produce high levels of pollution. Societies who do not have enough for their basic needs often rapidly damage the fabric of their society (through, for instance, crime and ill health) and their environments (by, for instance, over grazing, soil erosion and pollution) in their attempts to sustain themselves. This reduces both the carrying capacity of the natural environment and social and human capital within that society. In the long term, this can lead to war and famine, which wealthy countries then have to address through peace-keeping forces and aid, both of which are highly inefficient as they require large quantities of resources and often only have a short term effect. A more equitable system would therefore help reduce the negative environmental impacts of both wealthy and poor societies by reducing waste and avoiding the need to damage the environment by ensuring that everyone was able to provide for their basic needs in a fulfilling and sustainable way.

Local economy: Emphasizing the local economy supports sustainability in a number of ways. It supports sustainability in a very simple way by reducing the need for transportation. This limits the consumption of non-renewable resources and pollution. A more subtle aspect of this is the way it draws on the connections between people and their environments. The local emphasis encourages people to adopt more sustainable practices by ensuring that people experience directly both the negative and positive consequences of their actions.[124]

Complexity and diversity: Economic systems that are sustainable are likely to be complex. This is because they are likely to evolve, like ecosystems, a range of characteristics that enable them to make highly efficient use of resources and to accommodate change. Examples of these characteristics can be seen in the growing field of industrial ecology.

[124] Ekins, Hillman and Hutchinson. 1992. p. 35

Industrial ecology is the science of linking different industries for mutual benefit. This leads to increased efficiencies and reduced waste. For instance a by-product of one industry, such as the ash from a power station can be the input into another industry and used in the manufacture of Gyproc building boards.[125] This increased efficiency has economic benefits as the cost of disposing of waste is reduced. It also has environmental benefits, as there is increased resource efficiency as well as reduced waste and pollution. There can also be social benefits such as increased levels of employment.

Value society: Economic systems can generate wealth in a wide variety of ways. To be sustainable it is important that wealth is generated in a way that values people and encourages and enables them to develop more sustainable practices and habits. This means a priority is ensuring that the basic needs of everyone are met. It also means considering the social impact of different practices as well as developing practices that support a more sustainable society.

Value the environment: The biophysical environment plays a crucial part of supporting human life. However this role is not recognized in our current system and the value of this is not accounted for. In order for the environment to be a part of an economic system its value must be quantified in economic terms. This value must be recognized formally, for instance, through accounting systems, legislation and taxation.

Productivity: Natural resources are limited and ecosystems and environments have a finite carrying capacity. With increasing populations it is therefore important to make the best use of these resources. This means that the economic system must encourage and maintain high levels of efficiency and are effective in providing for human needs while being resource efficient as well as minimizing waste and pollution

Social Sustainability

Human activity is beginning to have a significant impact on the environment. This is resulting in damage to the biophysical environment, which if allowed to continue, will reduce the earth's ability to support human life. It is therefore important that we not only try and preserve existing natural environments and their ability to support life but that we change how we behave. We need to ensure that society that develops activities and habits, which value and maintain the environment. An important first step in this process is ensuring that the essential needs of people are catered for. This helps ensure that there is a balance in society, which will enable and support the development of a balanced relationship between society and the environment. The attributes of this type of society can be described as follows:

[125] Carley and Spapens. 1998. p. 125

Access to capital: Sustainable societies will enable their members to have adequate access to different forms of capital in order to enable them to fulfil their own needs. For example this may mean enabling people to have sufficient access to land (natural capital), start-up capital (economic capital), equipment (manufactured capital), knowledge (human capital) and markets with agreed systems of trading (social capital).

Inclusiveness: Sustainable societies are likely to strive to be more inclusive. This means making sure that people such as disabled people, old people, people with different cultural and educational backgrounds are not marginalized but are included and encouraged to be productive members of society. This supports sustainability through increased social capital and reduced need for additional special facilities and services.

Health: Sustainable societies are likely to strive for high levels of health and wellbeing amongst their members. This supports sustainability by avoiding the negative effects of ill health. Ill health has a negative effect on the environment as treatment of illness can consume large quantities of resources and produce large amounts of waste. Another negative impact is the productivity of the person that is lost.

Education: Sustainable societies are likely to strive for high levels of education and awareness. This will support them in becoming more resourceful and innovative in developing more sustainable practices. It will also increase the awareness of sustainability and it's implications amongst all members and encourages them to adopt more sustainable practices and habits.

Social interaction: Sustainable societies are likely to value social interaction. This encourages increased levels of understanding between members, enabling them to organise themselves more easily. This ability to develop trust and to organize enables societies to become more sustainable as they can tackle problems in a coordinated and integrated manner and are more able to share.

3.3. Concluding Hypothesis Two

The hypothesis that concepts from sustainability can inform the development of a specification for an assessment tool that aims to integrate sustainable development into building briefing and design processes is shown to be true. The review of literature on sustainability has proved to be highly useful.

The review enables a clear understanding of sustainability to be developed. It also enabled detailed descriptions of environmental, economic and social sustainability to be developed. This is valuable for the development of the specification for an assessment tool as it provides a detailed description of sustainability, the goal that the tool aims to support.

The review also provides many concepts about the structure and characteristics of sustainable systems as found in environmental, economic and social systems. As aspect of buildings and construction are found in each of these areas, useful clues as to the nature of more sustainable building and construction systems are provided.

Having discussed the characteristics of sustainable environmental, social systems definitions of sustainability appropriate to the study can be described.

Defining Sustainability

Sustainability may be seen as the science and the art of understanding, developing and implementing systems that enable man and future generations to live within the earth's carrying capacity. Given, that man has already exceeded the earth's carrying capacity the task is an increasingly urgent one.[126] This is not only urgent but also large-scale and will require a concerted, integrated effort across social, economic and environmental systems to be tackled effectively.

Environmental Sustainability

Damage to existing ecosystems must be halted and where possible, damage should be repaired and new ecosystems developed to replace the ones that have been lost. By retaining and developing productive ecosystems it may be possible, over time, to be able increase the earth's carrying capacity and thus make it easier to balance this with human activities. Bio physical environments that support sustainability will include thriving, productive, resilient and adequately sized ecosystems that are well able to provide life support functions for man.

Economic Sustainability

Economic systems have to be developed which enable societies to live within the carrying capacity of the earth. This will mean *doing more with less*. Economic systems will need to be more equitable, more resource efficient and value people and the environment.

Social Sustainability

Societies will need to be more trusting, cooperative and share more. This will avoid wasting scarce resources on crime and defence. They will also need to become increasingly innovative and resourceful – in order to be able to maximise the benefit of limited resources for as many people as possible. Society will require organisation and capacity that enables, and ensures, that it's current and future members' needs are met and are able to live fulfilling lives within the carrying capacity of the environment.

[126] World Wild Life Fund. 2000. p. 1

For buildings and construction to support sustainability it is therefore important to understand the relationship between buildings and construction and Environmental, Economic and Social Sustainability. This understanding must be used to inform and implement changes in order to ensure that buildings and construction actively address and support the development of *Environmental, Economic and Social Sustainability.*