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THE APPLICATION OF SYSTEMS THINKING TO THE CONCEPT OF SUSTAINABILITY

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The study proposes a systems model for the concept of sustainability. Based on the premise that the spectrum of challenges of sustainable development are systemic problems that cannot be resolved with a reductionist approach, the paper explores the key conceptual successions to explain the root of sustainable development. It then clarifies a few misconceptions concerning the Brundtland Report and highlights the limitations of the current widely used model of sustainability. The study collates and synthesises recent definitions of the concept. It then applies systems thinking to develop a more comprehensive model to promote the understanding and form the basis for further research in the application of a systems approach to the concept of sustainability.

Keywords: historical, models, sustainability, systems, views.

INTRODUCTION

The concept of Sustainable Development has attracted major interest since the publication of Brundtland Report 'Our Common Future' in 1987 and has become a commonplace term since the Earth Summit Conference in 1992. Many academics and practitioners are actively seeking to better define the concept. Although the Brundtland definition has made a major contribution in promoting the concept throughout the world, the need for a more comprehensive model is apparent from:

- the growing attempt of stakeholders to further understand the concept as evidence from the existence of multiple definitions;
- the limitations and narrow scope of the current model (represented with three overlapping circles as depicted in Figure 1) which implies, among others, equal weightings of the three conceptual components and fails to show that the environmental dimension is pre-conditional for both the social and economic sustainability; and
- the fact that the spectrums of challenges of sustainable development are systemic problems that cannot be resolved with the traditional scientific method of the reductionist approach (explaining the properties of the whole system from the properties of the components).

Sustainability is the integration of the environmental, social and economic systems to improve the quality of life within earth's carrying, regenerating and assimilating capacity. Each of these systems has a numerous nested hierarchy of subsystems; each subsystem is a whole on its own and forms an integral part of a complex system. The properties of each of these subsystems greatly change when interact with other

subsystems. As a result, the properties of a single subsystem cannot be used to explain the properties of the whole system. Hence the concept of sustainability falls beyond the narrow scope of reductionism and compartmentalised specialization. The issues addressed by sustainability are complex with multidimensional variables and sub-variables. Their complexity cannot be fully understood nor managed, without a systems approach and strategy (Rose, 2001; Dovers and Handmer, 1992). With systems approach each system with their subsystems can be viewed and are always treated as an integral whole of their subsidiary parts, and under no circumstances “as the mechanistic aggregate of parts in isolable causal relations” (Laszlo, 1972 pp14). A mechanism to help define the systems to be integrated and view the systems hierarchy would aid understanding, practical application and clarify a few misconceptions surrounding the concept of sustainability. The paper proposes a systems model for the concept of sustainability. It sets the background by examining the conceptual succession of sustainability to: show that the historical environmental decline, the content and structure of many traditional views, religious beliefs and wealth of knowledge are the key foundations of the concept of sustainability; and emphasise the fact that the environmental system is pre-conditional to social and economic systems. The study establishes the central themes of the Brundtland Report and overviews the predominant model of the concept (see Figure 1) and its limitations. It then explores the recent evolution of the terminology to identify a common theme (see Figure 2). Finally, through the application of systems thinking, the paper proposes a systems model of sustainability in Figure 3 as an alternative to the current predominant model.

SUSTAINABILITY EMERGING: THE CONCEPTUAL SUCCESSIONS

The natural environment is a self-regulatory system with a complex network of positive and negative feedback systems that function within the context of carrying, regeneration and assimilation capacity of the respective system. The realization that natural resources are finite and humans need to live within a certain capacity has followed a steep learning curve. This section draws on the past environmental decline, traditions and religious beliefs, and key body of knowledge to show the conceptual root of sustainability and that the environmental system is pre-conditional to social and economic systems. Historically, environmental degradation, over exploitation of natural resources (Ponting, 1991), deforestation, hazards of pollution, land degradation and chemical food adulteration have dogged humanity, more or less, for most of its existence (Wall 1994). The Old Kingdom of Egypt around 1500 BC, the Sumerians in 1800 BC, the Maya at about 600 AD and the Polynesians of Easter Island at about 1600 AD are a few examples of societies which ceased to exist due to not living in harmony with nature (Pointing, 1991) while lead pollution is recorded as one of the main internal factors to the fall of Rome (Nriagu 1994). The review of various traditional views and religious beliefs; the main repositories of human knowledge, apart from modern science, indicates a causal relationship with the fundamental doctrine of the concept of sustainability – *‘living in harmony with nature and within society’*. The Africans (Mbiti, 1996), the Hawaiians’ traditional beliefs (Dudley, 1996) and many religious beliefs – Hinduism and Buddhism (Dwivedi, 1996), Islamic (Deen, 1996) and Christianity (Kinsley, 1996) view humanity as an integral part of nature, although these views and beliefs vary in context and structure. For brevity, indicative literatures of the key conceptual precursors are cited herein. Malthus in his *Essay on the Principle of Population* in 1798 addressed the concern of population growth and the limitation imposed by physical capacities. He argued that, since

population grows in a geometrical fashion as opposed to agricultural output in an arithmetical fashion, population would ultimately exceed food resources thereby leading to restrictions on population growth. The *Principles of Political Economy* by Mill in 1848 revealed the destructive impact of economic growth on nature. The *Mountains of California* in 1894 by John Muir gave account of the loss of biodiversity in California due to overexploitation. Towards the end of the twentieth century, the scale of environmental concern expounded. Other indicative landmark publications are *The Silent Spring* in 1962 by Rachel Carson, which challenged the environmental impact of our scientific and technological progress and the *Population Bomb* by Paul Erhlich in 1968. *The Limits to Growth* in 1972 by Donella Meadows, though much criticized for the assumption of the computer model, confirmed the long-term environmental impact of economic and population growth. *Small is Beautiful* by Schumacher (1973) was concerned about the exhaustion of the world's resources and advocated for the use of appropriate technology. Of equal importance are the direct signals, such as, the discovery of the ozone layer and the Chernobyl nuclear power station catastrophe in Russia. Sustainability demands a shift to a new perspective; the need to recognize our place in the ecosystem by living in harmony with nature. This perspective is realized through the bridging of many previously disparate ideas, (Hardi and Zdan, 1997) views and disciplines. The historical environmental decline, the content and structure of many traditional views and religious beliefs, and body of knowledge, particularly towards the end of the twentieth century, are the crucial tenet of the contemporary concept of sustainability. The Brundtland Report *Our Common Future* brought the concept of sustainability to the political arena.

THE CENTRAL THEMES OF THE BRUNDTLAND REPORT

The main political dilemma of the Brundtland Report (1987) is the integration of environmental and social decline with the desire for economic development in the South and economic growth in the North. The report brought the concept and phrase 'sustainable development' to prominence towards the end of the twentieth century. Therefore, Brundtland's definition '*development that meets the needs of the present without compromising the ability of the future generations to meet their own needs*' is the reference point of contemporary discussion: the two key concepts are: the needs, especially of the poor, deserve uppermost priority – implies **intragenerational equity**; and the idea of environmental limitations – leads to concern for **intergenerational equity**. However, since the publication of the Brundtland Report, the concept has attracted much criticism, such as, vague, incompatible, meaningless and lack of practical application. The major reason for this criticism stems from the historical difficulty of defining development. It means different things to different people. To some it implies human development through improving education, decent health care, infrastructure and the provision of basic needs while to others it is about material consumption through economic growth (Dresner *et al.*, 2002). The underlining message in *Our Common Future* is the reorientation of development and economic growth to meeting people's basic needs. The report acknowledges that the interpretation of economic and social development will vary from developed and developing countries, market oriented and centrally planned market but suggests that any interpretation must share certain features and consensus on the basic concept of sustainable development. Meaning is context-dependent (Wilber, 2000). Sustainable development is contestable and has many basic meanings like many other political objectives such as liberty, social justice and democracy, which attract multiple competing interpretations (Jacobs, 1991). The difficulty in reaching consensus on the

meaning of sustainable development is not necessarily about reaching consensus on a clear-cut definition, but rather on the values that would underlie any such definition (Dresner, 2002). As long as a general consensus exists amongst a language community, every word has a meaning.

THE PREDOMINANT MODEL OF SUSTAINABLE DEVELOPMENT

The predominant model used to describe the concept of sustainable development has been depicted in Figure 1 below. The model is predominantly used because of its conformity with conventional divisions of discipline, knowledge and the resultant division of empirical information (Walter and Wilkerson, 1998). The dotted circle represents the contemporary economic model, the major cause of the unsustainable pattern of production and consumption, based on the ground that the natural, economic and social systems are divorced and non-interrelated. Contrary to this belief, a detailed analysis of the situation accurately suggests that the three systems are interlinked thus:

- the linkage between the natural and social system forms socio-ecological interactions;
- the linkage between the social and economic system forms socio-economic interactions;
- the linkage between natural and economic system forms eco-developmental interactions; and
- the intersection zone of the three systems (SD) is the process of achieving the decisive goal of sustainability to ensure intergenerational and intragenerational equity.

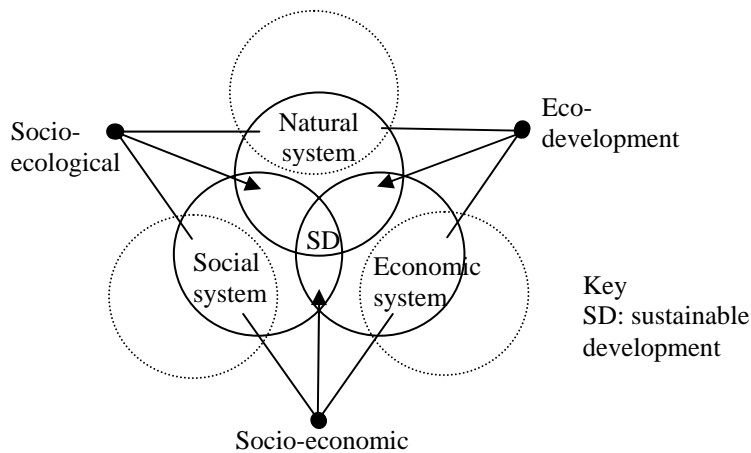


Figure 1: The predominant model of sustainable development

This model is a highly influential and helpful tool, but has limitations such as its graphical representation and narrow scope. Representation of the triple bottom lines with the three overlapping circles implies equal weighting, thus failing to underline the basic doctrine of sustainability that is the environmental system is preconditional for the other two systems. The model is a gross simplification, lacking sufficient information and the cause of the current is conception that economic sustainability (increasing profit and GDP) is prerequisite to environmental and social sustainability.

RECENT EVOLUTION OF THE TERMINOLOGY

There are multiple definitions for the concept of sustainability. Back in 1994, Holmberg (1994) recorded over 80 definitions of sustainability. Over the span of four years, this number has doubled itself to 160 (Hill, 1998) and currently rumoured over 200 (Parkin, 2000). It is not intended herein to validate the existence of over 200 definitions. Suffice it to say that a few definitions vie for supremacy. Sustainable development encompasses deeper and wider issues and there is no single and all-encompassing definition available. The review of the recent evolution of the terminology facilitates the development of a more comprehensive model (Figure 2). The model shows the deep-rooted interconnectivity of the three key systems. At the apex of the model is the environmental system indicating that environmental sustainability is pre-conditional to the social and economic systems.

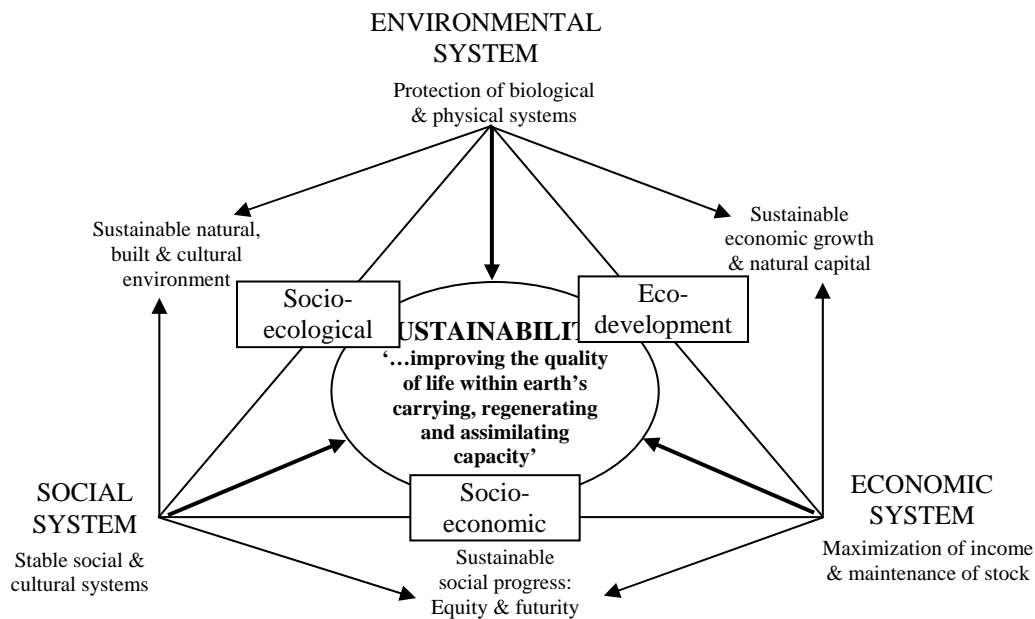


Figure 2: Model of sustainable development based on recent definitions

The principle of intergenerational and intragenerational equity are implicitly encapsulated in Brundtland's definition of sustainable development, and explicitly defined in the revised definition of the Rio Declaration on Environment and Development "to equitably meet developmental and environmental needs of present and future generations" (UNCED, 1992). Sustainable development is a quest for new ways of thinking (Groenewegen *et al.*, 1996). Pearce *et al.*, (1989) proposes three concepts of achieving sustainable development. These are environment, futurity and equity. The environmental value substantially increases the real value of the natural, built and cultural environments. The futurity involves concerns for short and medium as well as longer term that will ultimately impact on the inheritance of future generations and their quality of life. The equity places emphasis on two issues; firstly the intragenerational equity, that is, provision for the needs of the least advantaged within society (also between societies and countries) and secondly, the intergenerational equity advocates for fair treatment of future generations.

Sustainability embodies the promise of societal evolution towards a more equitable and wealthy world in which the natural environment and our cultural achievements are preserved for the generations to come" (Dyllick and Hockerts, 2002 pp130). Munasinghe (1993) suggested economic, ecological and socio-cultural as three

approaches to sustainable development. The economic approach to sustainable development is to maximize the flow of income while maintaining the stock of the assets (or capital). The ecological approach protects biological and physical systems. The socio-cultural concept stabilizes the social and cultural systems and reduces the destructive conflicts for both intra- and intergenerational equity.

A SYSTEMS MODEL OF SUSTAINABLE DEVELOPMENT

The concept of a system is “the idea of a whole entity which under a range of conditions maintains its identity, provides a way of viewing and interpreting the universe as a hierarchy of such interconnected and interrelated wholes” (Checkland, 1999 pp14). A system is composed of subsystems, and belongs to suprasystems, which can be referred to as nested or growth hierarchies (Wilber, 2001). In a whole system nothing is irrelevant. The parts are integrated into a different, more complex and generally more competent thing by virtue of their relationship to each other in pursuit of a common goal. A whole system view of the concept of sustainable development would include all the factors involved to examine their relationship and how they work as a whole. Sustainability is the suprasystem; composed of environmental, social and economic systems. The nested hierarchy of the subsystems of the environmental system are atoms to molecules, to cells, to organisms, to ecosystems, to biosphere, to universe. Each of these units, irrespective of the level in the hierarchy, is absolutely vital for the entire sequence - destroy all atoms and you simultaneously destroy all molecules, cells, ecosystems, and so on (Wilber, 2001). In sociological terms, “a social system is a system of individual human beings who are involved in social relations with each other” (Lopez and Scot, 2000 pp46). It is a network of interactive relationships. The nested hierarchy of the subsystems of the social system are individual to family units to local communities and so on. Similarly, the economic system has a nested hierarchy from firms to sectors, (for instance the construction industry), to local economy, etc.

Key Features and Benefits of a Systems Approach

The key features of a systems approach are: the emergence of unique properties which are critical for understanding the system as a whole but may have little or no meaning in terms of constituent parts; a hierarchical structure in which systems are nested within other systems; and processes of communication, feedback, and control that facilitate adjustment and adaptation in the face of stress (Hardi and Zdan *et al.*, 1997). The benefits of this approach are multifaceted. It makes certain unique properties visible that are invisible when looking at the constituent parts individually from a reductionist approach. It facilitates the testing of the overall welfare of the whole system, which is impossible by independent analysis of the parts. This is crucial as any action to adjust the system can only be effective if the integrated set of factors affecting the system, such as stress imposed on the ecosystem by human activity, is wholly considered. Also, the ability to sustain an overall perspective on the whole system assists development of a facility to “anticipate and prevent” as opposed to having to retrospectively “react and cure.”

As can be observed in Figure 3, the proposed system model shows that:

- Each system has a nested hierarchy as indicated with the dotted lines. Each part of the system is a whole on its own but becomes a part of a system when met with another part. The whole system is greater than the sum of its constituent parts and

each part is critical for the existence of the whole system. Each system is interconnected to form a complex suprasystem.

- The environmental system provides life-supporting services (climate regulation, geochemical cycling, ecosystem maintenance), exhaustible and renewable resources (fossil fuel, minerals, metals and other raw material). In the absence of these services and resources, social and economic systems can never be possible.
- The economic system depends on the human and physical resources from the social system while the social system relies on the economic system for the transformation of raw material for consumption. Both systems interact in the market facilitated by the socio-ecological conditions.
- According to the laws of thermodynamics, matter and energy can neither be destroyed nor created though may be transformed. The economic and the social systems transform resources into waste (residual, heat, end of life and so on). Resources and waste are in due course the same in total. They differ only in entropic value (resources have low entropy while waste has high entropy) (Jacobs *et al.*, 1991). Waste is stored and assimilated through the environment system.
- The environmental, social and economic systems are closely linked, interact and overlap. The depletion of forests affects climate regulation, biodiversity and raw material supplies. Pollution reduces available resources, disrupts ecosystems and impairs human health. Climate change can reduce soil productivity and impact on the built environment. These interconnections indicate the 'wholeness' of the systems and crucial feature of the relationships between the systems.
- Eco-development; the current economic model, describes the transition from traditional societies to the affluent life style of capitalist societies through resource-intensive consumption, within developed countries, which the Third World countries aspire to. This model is the cause of emission of ozone-depleting chemicals and the source of other major challenges, which threaten the global atmosphere and other life-support systems. The environmental system is approaching its limit. Sustainable development emerged as a possible solution.
- In this context, sustainable development can be defined as the process of achieving sustainability through integration of environmental, social and economic systems to improve the quality of life within earth's carrying, regenerating and assimilating capacity to ensure intra- and intergenerational equity. This involves maintaining socio-ecological balance between environmental (the pre-condition for the other two systems) and social systems, which provides the platform for socio-economic activities.

Sustainable Development Assessment: model in practice

There are number of models for assessing sustainability or the quality of community life (e.g. Murdie, 1992; LGMB, 1994; Hodge, 1996; Maclaren, 1992). However, most of these approaches have shortcomings in assessing community sustainability (Walter and Wilkerson *et al.*, 1998). According to Walter and Wilkerson (1998) the productive approach to assessing community sustainability must be:

- broadly applicable at all levels including municipal and region;
- comprehensive in identifying steps and sustainability issues relevant to the community and stakeholders' interests and values;
- adaptive to local situations;
- accessible to specialists, policy makers, as well as, the general public; and
- system oriented

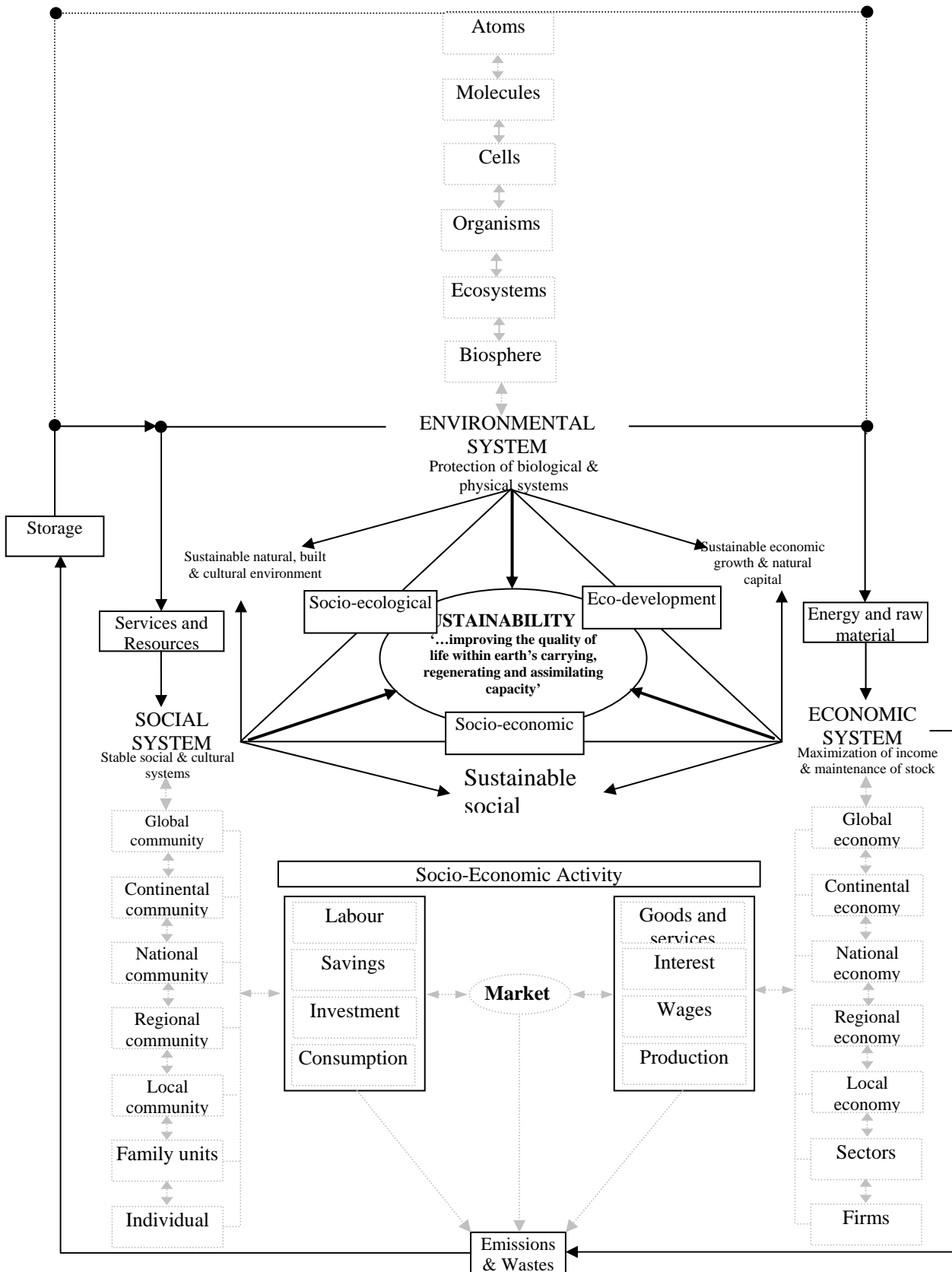


Figure 3: A systems model of sustainability

The assessment of sustainability requires a review of the whole system as well as its constituent parts. Information must be gathered on the three systems and their subsystems, that is, on human welfare, ecosystem and the economic systems - their state as well as the direction and rate of change of that state, of their constituent parts, and the interaction between parts. Consideration must be given to both positive and negative consequences of human and ecological systems, in monetary and non-monetary terms (Hardi and Zdan, 1997). The system model establishes interaction of the three system dynamics of sustainability.

CONCLUSION

Sustainability demands a shift to a new perspective; the need to: recognize our place in the ecosystem by living in harmony with nature; and integrate continuing socio-economic development with environmental protection. This perspective is realized through the bridging of many ideas, traditional beliefs and religious views and disciplines. The Brundtland Report promotes a debate on this new perspective. The critical review of Brundtland Report clarifies a few misconceptions. The underlining message in *Our Common Future* is the reorientation of development and economic growth to meeting people's basic needs. This paper has attempted to advance the understanding and practical application of the concept of sustainability by presenting a systemic model of the concept, which shows the interrelationship between the three systems and the importance of each subsystems to the complex suprasystem. In addition, it clearly emphasized the fundamental doctrine of sustainability that the environmental system is pre-conditional to social and economic systems. What the present economic model and the current predominant model fail to convey. The paper established the major limitations of the predominant model and highlighted the key features and benefits of the systems approach.

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