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Conceptualizing Sustainability Dynamics

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Principal Advisor: Professor Mino Takashi

Co-Advisor: Professor Iwata Shuichi

(76962 Niranji Satanarachchi)

Abstract

Based on the proposition that sustainability, instead of a past, present or future state is a continuous process which evolves over time, the thesis aims to understand what the perception of dynamics would specifically mean in relation to sustainability, hence the dissertation illustrates a logical process of conceptualizing what we call as *sustainability dynamics,* to reach a conceptual model which has the potential to frame the concept within firm scientific grounds. Through evaluating various complex socio-environmental systems on one hand from the viewpoint of their natural evolutionary patterns, and on the other hand, through the lens sustainability/unsustainbility principles, concepts of sustainability sphere, sustainability path, patterns of movements along the path and finally dimensions which form the sustainability sphere and determine the path movements within, are developed in various stages. The basic model of sustainability sphere and sustainability path is defined reaching from the internal dynamical forces and external dynamical forces. Internal forces are identified as the ones which govern the functional movements or dynamics within the system despite whether they generate sustainable conditions or not. The external forces are identified to be straight away linked with sustainability characteristics or principles inherent or concerned with a certain system. In addition, with the support of few contextually different cases the movement patterns which are created by these forces, path dynamics are characterized in to two main forms, namely Horizontal Process Dynamics (HPD) and Vertical Process Dynamics (VPD). Finally integrating the two approaches together a model is introduced which explains Sustainability Dynamics in relation to movements and forces, while in the latter part of the thesis ways to further improve and strengthen the proposed conceptual model to be successfully utilized in research are discussed in detail.

Preface

The thesis represents the finishing work for my Master Degree of Sustainability Science, at the University of Tokyo. In Principle it is written to illustrate a logical process of conceptualizing adapted to reach the conceptual model for *sustainability dynamics*. So in a way rather than just a finishing step, the thesis reflects a challenging effort to do the maximum justice for, as my supervisor would say, not so usual approach of doing research, and, for the reader who I know might be suddenly introduced for what I had the luxury of slowly becoming familiar for two whole years. Apart from that, it carries a reflection of sometimes frustrating yet often enjoyable and most of all incredibly valuable experience of finding one's way within novel territories.

Therefore at this happy moment of completing my thesis work I want to convey my deepest gratitude to Mino sensei (Professor Mino Takashi) for being such a wonderful advisor, always somehow finding time to give me now I feel, the right advice at right time, often leaving me enough room, yet whenever needed being ready to help me to focus and move ahead, and those are just a few out of many reasons why I sincerely respect you. I also am very grateful for many professors from GPSS for their continuous encouragements, valuable advices and suggestions, and also from outside, from whom time to time I received many insightful ideas to mould the final thesis outcome. And my gratitude extends to the University of Tokyo for giving me numerous opportunities in many instances to broaden my horizons both in my research field and outside, to Asian Development Bank for financially supporting my stay in Japan, so that it enabled me to give whole of my energy to research.

At the end it is with love that I remember my family and close friends for always being there with love, encouragement and great friendship, and Chandana for his invaluable companionship sharing both easy and tough times together. Without them I know I wouldn't have made it a half way through.

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Chapter 1: Introduction

1.1 Sustainability; the concept seen in different light

The universe we know today is a highly complex system with many different subsystems interacting with one another to form incredibly diverse patterns and relationships[1]. Anyone who would be interested to see beyond the boundaries of a village, country, the earth, or the whole solar system may start to identify these numerous viable interactions. Over the years the man, one of the most intelligent creatures on earth has understood this reality and tried to give interpretations for what he has seen around him, to answer many puzzles, and more importantly to face the challenges he continuously faced by the hardships his surrounding induced upon him. Sustainability is a concept which has surfaced and stands upon many of such realities. Even though it's well recognized milestone in 20th century, with the related concept of sustainable development, is much known and cited in sustainability literature, the essence of facing the challenge of survival, the suitable way of existence, the sense of noble path has been a question always hovered in the background and surfaced from time to time in many eras of human history at many different parts of the world. These have taken the form of beliefs or perceptions which sometimes evolved in to ideologies, philosophies or even religions. Stressing on such hard conceptual side in modern discussions on sustainability is now often regarded as perceptions of strong sustainability. Such terminologies have emerged with the complexity today we face with the highly interrelate but contextually diverse dimensions of what we understand as sustainability. These dimensions would vary from, economical, technological, ecological, social aspects, even to integrate ethics or what one perceive as values. In addition any form of sustainability that is

[1] We use the term system to mean an interdependent group of items forming a unified pattern

talked of today, often carries the desperation of reaching tangible or physical grounds, so that goals can be set easily within existing structures of research, policies, engineering etc. This strong inclination to frame the concept has lead to interpret sustainability from many view points, in the way to suit a particular application, goal or a target. Such efforts have been challenged but not completely stopped by the existing vagueness and ambiguity in the definitions. However linked with the unavoidable confusion made by highly spectral approach to integrate this conceptual value in to policies, research, actions etc., instead of basing a foundation in holistic viewpoints, very often sustainability is implied as a future state or a target, which is not quite clearly defied, yet since known as good, to be followed or even raced to reached through different means. For instance, nowadays, terminologies such as reaching, achieving, future state, are quite abandon in the scattered literature. This in a way has come through the reality that lots of existing dialogues have reached more from policy related perspective than being supported philosophically or even scientifically. Or on the other hand one could argue that the transition from Sustainable Development to Sustainability has created a situation where the sense of continuation and movement is lost to a certain extent. Whatever the exact reason, the end result is that sustainability tends to carry much implication on maintenance, sustenance of either conditions, resources, systems or even relationships, in other words perceiving the concept as an end state or a goal.

Hence the focus of this thesis has been drawn from the observation that the recent discussion on sustainability often tends to carry an underlying implication of a static past, present or future state. Whether it is holistic interpretations or the often found problem driven approaches it is observed that a strong need exists for effectively integrate the inherent properties of change and continuation in any relevant system. On the other hand in viewpoint of sustainability as a science, the importance of perceiving or framing dynamics within sustainability research can be seen according to few different justifications or reasoning,

(i) Sustainability Research is a field in its early evolution, and the perception of continuity and what courses continuity, that is the time dimension of dynamics, has not yet drawn enough attention in the research.

(ii) Since sustainability dynamics is closely linked with how different stakeholders perceive the concept , hence how a specific society or a system would choose to follow action toward sustainability, embedding sustainability dynamic in research may provide a strong trigger in pulling certain society or a system in a sustainable direction.

All of these converged for forming the objective of the thesis as to understand and frame the dynamics in sustainability or, conceptualize Sustainability Dynamics.

The conceptualization is done in two stages, one a relatively bottom up approach, that is to visualizing sustainability within identified dynamics of an existing relevant system, and the second is to regard a cluster of systems in a more holistic view point and then generalize part of such dynamics which are believed to be necessarily relevant for any discussion.

The conceptual model developed in the first half is used to introduce two important concepts *sustainability sphere* and *sustainability path*. The second half is explicitly aimed to conceptualize what created path dynamics. This particular process, at this moment, we would call more of a characterization process than a complete categorization and according to such characterization, path dynamics, which later explained as forming a part of sustainability dynamics are perceived and explained in two different subunits, namely,

(i) Horizontal Process Dynamics (HPD)

(ii) Vertical Process Dynamics (VPD)

along with a somewhat related sub category of intrinsic dynamics.

By introducing them, it is expected to build the foundation to visualize or conceptualize what sustainability dynamics is in a broader sense, and then to look for avenues how such conceptual basis could be utilized in sustainability research.

1.2 Methodology

Though as mentioned, in our understanding the dynamics is one of the key elements needed to be reflected within any conceptualization of sustainability, at the same time explaining the characteristics of such dynamics explicitly within our scope with a clear and concise problem/solution perception was indeed hard and challenging, leaving us in a situation where the research's both starting point and the end point were not very clear (Box 3.1).

Box 3.1 Interpretation of problem and solution space: adapted from Scholz and Tietje, 2001

(i) Task

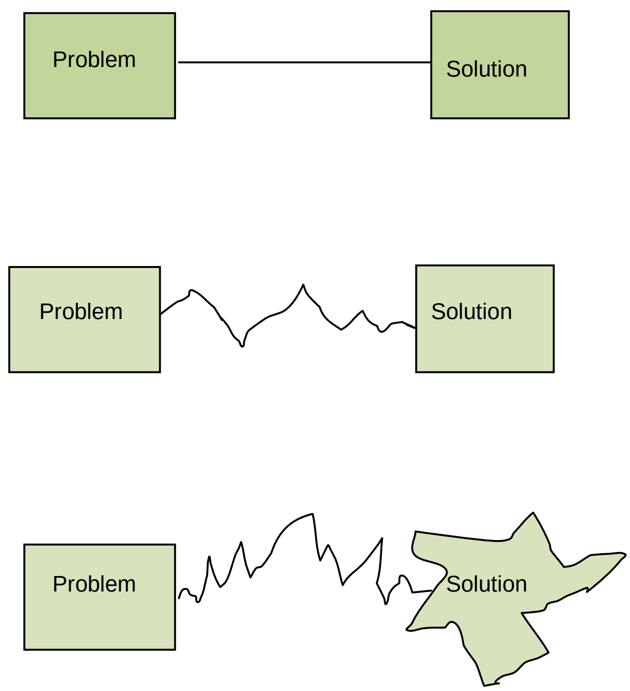
Initial and target states are known, hence reproductive thinking using existing methods.

(ii) Problem

Defined initial and target state, solution by passing barriers with old and new methods

(iii) Ill-defined problem

Initial state cannot be precisely described, target is not sufficiently known, types of barriers to be passed are not known



Therefore the methodology adapted in this thesis may appear somewhat different from usual and popular approaches in not only the limited literature of sustainability science, but also within traditional natural and social science research. Having extra emphasis on conceptualization or building conceptual models, it was a slow process generated with knowledge acquisition with numerous related readings and reviews. However it was strongly recognized that such conceptual processes needs to be backed by physical and tangible data to complete the theorizing process effectively, therefore wherever possible a case supported approach was adapted to make the model components clearer and understandable. So it in a way is an effort to integrate several scattered techniques to reach an ultimate logical output, hence the method of research itself can be regarded as an outcome of the effort to yield maximum tangible result retaining utmost significance and broadness of the subject at hand.

1.3 Thesis Overview

In order to give the best insight for the process adapted in developing the final explanatory model for Sustainability Dynamics, dissertation is arranged in following order.

Chapter 1 gives a general introduction on the background of the study and its path to the problem identification process along with a brief summery on methodology and thesis arrangement.

Chapter 2 gives a detailed literature review, which includes both the literature which led for the problem identification and then the ones which in various stages supplemented and enriched the research.

Chapter 3 reflects the core part of the thesis. Starting with a rough model derived from existing knowledge and implications from literature (section 3.1), the chapter is divided to reflect step by step process adapted in building the model.

Inside chapter 3 the discussion diverges in to two different approaches to reach the same model the first part (section 3.2) to observe the concept relative to a system's internal dynamics. Here with a detailed study taking market based capitalistic system as an example part of the conceptual model (sustainability sphere and sustainability path) is illustrated in detail. The possible link between sustainability dimensions to sustainability sphere and sustainability path is introduced.

In section 3.3, taking three cases for ease of interpretation, possible patterns of path dynamics (dynamics which reflects the path movements) are introduced, namely Intrinsic Dynamics, Horizontal Process Dynamics (HPD), Vertical Process Dynamics (VPD).

Section 3.4 summarizes the process of fusing the two approaches together by linking different components to reach the detailed conceptual model and based on that provides a concrete as possible definition to what we wanted to visualize as Sustainability Dynamics.

Chapter 4 concludes the conceptualization process stating and discussing the existing limitations provisions to validate, strengthen the model and finally to be embedded in to research and assessment process.

Chapter 2: Literature Review

2.1 Background

The process of literature review has become a main part of my thesis, since the conceptualization or the justifications I have repeatedly done is strongly linked with the spectrum of ideas I gathered throughout the reviewing process. Initially my focus has been on sustainability indicators and indexes, where different levels of indicators which specifically fall under sustainability metrics were referred in direction of their capacity for system integration. What I came across were quite rigorous attempts to reach from environmental discourse to sustainability, including many constructive criticisms for the viability of the processes being adapted so far (Mayer, 2007; Bell and Morse, 2001, 1999; Bossel, 1997). Bell and Morse (2003) have highlighted the cyclic nature needed yet non fully functioning, with the process of developing indicators, supporting their arguments by Pressure-State–Impact-Response (PSIR) classification which is originally developed by Jesinghuas (1999). In addition it was observed that there is a gap on these numerous indicators' ability to reflect both time and space significance of sustainability, or in other words the changing nature or the dynamics which are essentially important in any system's evolution. Of course the function of any indicator would be in a way a clear snapshot view of certain past, present or future state, relative to a specific concerned entity (Bossel, 1997), yet the question came, when speaking of sustainability, whether it is justifying to keep a same level or threshold as the desired level for, let's say a certain characteristic of the system, and it was obvious what is wrong is not entirely with indicators themselves but how they are being used at the application end. This realization urged me look for avenues where an entity or a system's dynamic nature can be integrated in how we perceive, address, evaluate, solve, place initiatives etc, not from reductionist direction which now I feel initially I was heading from, but from more of a holistic direction (Gasparatos et al, 2007 provides a critical review on reductionist approach compared to holistic approach).

Therefore the literature being summarized here will be straight away linked to understanding how far the perception of dynamics is developed in sustainability literature, both concept and research viewpoint, and for possible avenues to frame the basic understanding in to a conceptual model. For the ease of presentation only the main implications which paved path for deriving the final concept would be explained in detail, the rest of the references would be just stated at the end.

2.2 Sustainability and the perception of Dynamics

Sustainability is a concept whose roots run back to the history of human evolution (Mebratu, 1998; Kidd, 2005). Why specifically human evolution, is merely the fact that what today we call as sustainability does not make much sense if we take the entity of humans out from rest of the system. However the term has become popular with widely cited definition from *'Sustainable Development'* by Bruntland Commission (WCED, 1987). Over the years, the Concept Sustainable Development which had a clear objective significance has been interpreted and enriched with many different opinions, and through an ocean of literature, it is interesting to observe how this initial concept has evolved in to a broader and somewhat more subjective concept, sustainability. Examples on numerous assessments on how this process accord, could be found in Kidd (1992) and Mebratu (1998) in their historical and conceptual review. In addition though specifically did not look at this transition, the article *"Sustainable Development: Mapping Different Approaches"* by Hopwood, et al. (2005) gives comprehensive illustration on many different dimensions advanced in this concept from its pragmatic to normative and from its strong to weak ends (Niemeyer, 2003; Bell and Morse, 2003; Espinosa, et al., 2007) (For more details on weak and strong sustainability please refer to Ayres, 2006). There have been numerous attempts to frame or categorize such complexity and diversity, the most famous example is the three pillar view of sustainability with ecology, economy and society, which later argued to be needed for integrating some external dimensions of institutions, ethics, culture etc. (Hawkes, 2001; Gibson, 2006 and many others). In addition to that, the journal Sustainability Science states that its focus is on understanding the interactions within and between global, social and human systems, the complex mechanisms that lead to degradation of these systems, and concomitant risks for human wellbeing and security. These two approached along with some others are based on how the boundaries between different systems are identified and how the relationships between those identified systems are perceived in different angles. Coming back to the three pillar approach which describes sustainability as an entity to be perceived in relation to an integrated system having ecological, economical and societal significance, the overlapping regions represent graphical enclosing bodies for the transactions, feeds, movements taking place between theses three perceived systems. However, often this particular graphical interpretation helps to visualize more of flat surfaced interactions, than giving any inference on the system's progression from one state to another, a different form of dynamics (Hacking and Guthrie, 2008). In the article by Komiyama and Takeuchi (2006) the importance of dynamic interactions of the three systems appearing in the latter model are highlighted along with a visual interpretation to guide how the integrated system should be professed. The human system is stated as the sum total of factors effecting the survival of individual beings while the social system has identified to be comprised of political, economical, industrial and other structures created by human being that provide the societal base for fulfilling human existence. They identify global system to be comprised of the entire planetary base for human survival; the geosphere, atmosphere, the hydrosphere and biosphere. One basic difference in terms of dynamics in this interpretation is the recognition of the viability in addition to space wise interconnectedness of considered systems. These types of interpretations are closely linked with the perception of holism which is recognized as important in visualizing sustainability (Bell and Morse, 2003, Warburton, 2003, Kalland, 2002).

In addition depending on which disciplinary stream one would approach the concept from, there is a spectrum of interpretations for dynamics related to numerous systems or entities. For instance, in a strictly economic point of view Norton (1992) argues that "sustainability is a relationship between dynamic human economic systems and larger, dynamic, but normally slower hanging ecological systems, such that human life can continue indefinitely, human individuals can flourish, and human cultures can develop-but also a relationship in which the effects of human activities remain within bounds so as not to destroy the health and integrity of self-organized systems that provide environmental context for these activities." The statement itself reflects the strong anthropocentric view the concept may have emerged from (Baker et al., 1997 gives an interesting overview the anthropocentric and eco-centric paradigm behind the concept). However over the time quite contrasting views as well have emerged giving the concept an overall balance (Robinson, 1998). For instance, with a system perspective Costanza (1992) stresses that sustainability implies the system's ability to maintain its structure or the organization and functions (vigor) over time in the face of external stresses. Many natural or manmade socio-economical systems, in addition to not always maintaining a certain state or a condition, would often voyage through what we often call as a life cycle. Holling (1986, 1992) with the conceptual model of Panarchy, has interestingly explained this cyclic behavior in relation to ecological and socio-economical systems. Gumilev (1990) has identified such cyclic behavior in relation to ethnic systems, while Zotin and Zotina's (1993) interpretation on thermodynamics of cellular level again emphasize on this cyclic process (adapted from Voinov, 2006). It is interesting to note that sometimes, in systems where this type of cyclic processes happening, sustainability could be mistakenly identified to be an attempt to break the cycles and maintain a recognized positive entity in to the future or to maintain a 'sustainability system' indefinitely. Overall it is noted that terms such as achieving or reaching sustainability is quite common, and there are instances that visions of sustainability villages, states, countries or even companies were widely talked about. For instance when addressing sustainability within economic frames, it is noticed to be natural to look for tangible states where indicators, incentives etc can be concisely recognizable. However it is easy to forget that no end point is achievable and progress can only be measured in retrospect due to the uncertainty of current actions on future outcomes (Mappem and Gill, 1997). However many stay in the position that sustainable development or sustainability is simply a complex issue which involves number of interconnected systems, hence balance between reductionist and holistic view is necessary in all levels of understanding (Espinosa et al, 2007; Kates et al, 2001; Clerk and Dickson, 2003; Meppem and Gill, 1997; Berg, 1996; Stacy, 1993, Mihelcic et al, 2003, Robinson, 2003, Espinosa and Walker, 2007, Swart et al, 2004),where in some, beyond the conceptual importance of sustainability, the concern has reached to frame the inherent complexities within a scientific setting. For instance, in Kates et al, 2001, out of many fundamental insights one of the key concerns (Box 2.1) has been on how can today's relatively independent activities of research planning, observation, assessment, and decision support be better integrated in to systems for adaptive management and social learning. Another is how dynamic interactions between nature and society –including lags and inertia- be better incorporated in emerging models and conceptualization that integrate the earth system, human development, and sustainability?

Box 2.1. Core questions for sustainability science

1. How can the dynamic Interactions between nature and society-including lags and inertia-be better incorporated in emerging models and conceptualizations that integrate the Earth system, human development, and sustainability?
2. How are long-term trends in environment and development, including consumption, and population, reshaping nature-society interactions in ways relevant to sustainability?
3. What determines the vulnerability or resilience of nature-society system in particular kinds of places and for particular kinds of eco system and human livelihood?
4. Can scientifically meaningful "limits" or "boundaries" be defined that would provide effective warnings for conditions beyond which the nature-society systems incur a significantly increased risk of serious degradation?
5. What systems of incentive structures- including markets, rules, norms, and scientific information-can most effectively improve social capacity to guide interactions between nature and society towards more sustainable trajectories?
6. How can today's operational systems for monitoring and reporting on environmental and social conditions be integrated or extended to provide more useful guidance for efforts to navigate a transition towards sustainability?
7. How can today's relatively independent activities of research planning, observation, assessment, and decision support be better integrated in to systems for adaptive management and social learning?

Kates et al. (2001)

While as overall Kates, et al. (2001) has identified a framework for and emerging "sustainability science" for generating useful knowledge to support transition to sustainable development, the emphasis on lags and inertia for instance reflects the dynamic complexity of interactions between different systems. Swart et al (2004) highlight another concern in their approach to integrate sustainability science and scenario analysis by suggesting an eighth question to them, “How can the future be scanned in a creative, rigorous and policy relevant manner that reflects the normative character of sustainability and incorporate different perspectives?” While agreeing on all these questions and several other interrelated concerns raised by many authors later on, it is somehow still noticed that there is a gap between the frameworks identified so far to bring the concept in to scientific domain and what we would like to perceive as sustainability dynamics. Still the literature suggest that it may not be because of lack of awareness, but simply for the fact that the way of interpretation of sustainability may not yet have explicitly dealt with the subject matter of dynamics.

Two of key research areas where high emphasis is given for dynamics would be transdisciplinary or interdisciplinary research (Max-Neef, 2005) and they have a strong link with sustainability discussion both in general and research point of view. Interdisciplinary research, while still based on disciplinary vision of knowledge, seeks to coordinate the objectives and methodologies in order to achieve less fragmented views on sustainability issues, for instance the issue of climate change (Norgaard, 2004). On the other hand transdisciplinary research has provided a transition phase from a highly divided disciplinary approach to a platform which enables interactions between different parties from different levels to interact, often forming the needed link between the scientific methodologies with policy decisions for socio-natural-economic systems. One significant reason why transdisciplinary research is recognized in the sustainability paradigm was the implicit necessity to reach the same problem or the scenario in the different angles (Mappem and Bourke, 1999). On the other hand, proceeding interdisciplinary research it is in a way has identified the next reaction to societal demand for knowledge production and utilization in complex issues which are often related to sustainability (Rist and Guebas, 2006; Sholtz and Tietje, 2002). It takes in to account that science is part of the process it describes and is therefore focuses on systemic view of social and natural dynamics that are shaping the world. It also recognizes the plurality of forms of knowledge, world views and the ethical values connected to them within different social and cultural groups (Scheringer, et al, 2000, Wiek et al, 2007).

However the question comes whether transdisciplinary research alone in most existing forms, can incorporate the complexities of time-bound dynamics of a specific system in the same capacity as it does the flat planed dynamics. The reason on one hand strongly linked with the limitations of incentive structure in handling real time problems (Wiek et al, 2006). As a solution some authors have identified the need of science to go one step forward this *science driven* view to a more *tradition and local* approach. For instance Rist and Guebas, (2006) gives an interesting suggestion on how ethnosciences (a scientific realm on how humans are developing different forms of knowledge and beliefs) could play a significant role in linking transdisciplinarity and sustainability. In their narration they emphasize the importance in coupling the indigenous and ethnoscientific approaches in to contemporary frameworks for conservation and sustainable management of natural resources, and defend its pragmatic importance while exploring the key conditions and dimensions of a dialogue between ontologies and how ethnosciences could be integrated in the process.

Since the time of Russell, Whitehead and Einstein, thinkers have pointed out that problems created at one level of thinking can only be solved at a higher or meta-level of thinking (Espinosa et al, 2008). In order to make this view more complete, one can take many of the eastern cultural insights, accumulated over centuries where problem solving has given a somewhat different perspective and approach than western way of thinking (Agrawal, 2005). While many authors including Gadotti, (2003) give insightful account on eastern knowledge ways, they accept the fact that much of these knowledge are locked either not being translated properly or sometimes even lost scattered with the narrower knowledge transmitting ways these cultures often adapted in the past. However there are numerous studies done on traditional and indigenous knowledge systems in many parts of the world including studies on Traditional Ecological Knowledge (TEK) (Berkes et al, 1995; Olsson and Folke, 2001, Pierotti and Wildcat, 2000). Even though Traditional ecological knowledge and indigenous knowledge are two closely related concepts while indigenous knowledge may be used as generic term to refer to knowledge systems of indigenous people (Stevenson, 1996), traditional ecological knowledge may be defined as "a cumulative body of knowledge, practice and belief, evolved by adaptive processes handed down through generations trough cumulative transmission" (Berks et al., 1994). While many of the interesting studies of TEK more often are based in North American continent, there are similar efforts emerged from other parts of the world whose unique and diverse observations have started to created rich and diverse knowledge systems. Even some of these efforts have generated with a strong inclination towards the evolutionary significance sustainability giving excessive focus on areas as resource management and adaptation etc.

Likewise many scattered literature gives insightful references for how to integrate the dynamical nature of sustainability and its core research necessity. The overall observation suggests that there is a strong necessity for;

i. Bringing the perception of dynamics in to sustainability discussion in more direct, framed and understandable manner.
ii. Narrowing down and frame such dynamics relative to certain recognizable characteristics so that interesting knowledge bases and inputs from different older fields can interact efficiently in such a framed setting.

Therefore finally the attempt was to search for avenues which have already addressed such possible characteristics and methods of framing in different context and scale. In terms of characteristics which governs dynamics, one way of visualizing is through internal functions of a particular system, that is the functions, forces and movements any system will naturally follow in its path of evolution despite whether they support sustainability conditions or not. Different forms of such internal dynamics were found in many related fields. For instance the framing adapted by Bowel, et al. (2003) to interpret which aspects may create the main forces of dynamics in a market based capitalistic economic system, takes such an internal looking as well as a dimensional approach. On the other hand some characteristics which are induced externally too may have an effect on such dynamic patterns. And it was observed that some of these external dynamics can link to what some recognize as the principles of sustainability. Nonetheless these principles are highly subjective and would often come with diverse spectrum of opinions on what they should be (Robert, et al., 2001; Martens, 2006; Gibson, 2001). While there are well recognized principles as intergenerational justice (Thompson, 2003; Barry, 1999), ecological integrity (Pimentel, 2001) etc, coming to an agreement on which principle to be prioritized in each context can be highly influenced by their implicit assumptions, where they are being applied etc. However despite these complexities it was observed that in order to frame sustainability dynamics, dynamics may have to be addressed both from the concerned systems' natural evolution point of view and sustainability point of view alike, that is to embed dynamics on top of sustainability principles as well as within system's natural evolutionary pattern is equally important.

Coming to the point of methodologies or ways of framing or modelling such dynamic behaviour patterns of numerous systems, one of well recognized research domain is systems dynamics whose basic approach is to understand complex systems behaviour over time, dealing specifically with internal feedback loops and time delays (Hjorth and Bagheri, 2005). System dynamics is considered as a powerful methodology strongly based upon computer simulation modeling technique for framing, understanding, and discussing complex issues and problems (Hjorth and Bagheri, 2005). The roots of its development have ties with social dynamics, which in turn has strong basis coming from fields as system thinking, sociology and psychology. Out of them systems thinking which is being enriched from transition theory and complexity theory too is a framework that is based on the belief that the component parts of a system can best be understood in the context of relationships with each other and with other systems, rather than in isolation (O'cornner and McDermott, 1997; Clayton and Redcliffe, 1996; Meyppem, 1998). Depending on approaches taken to visualize/analyze a system, systems in this field have been broadly categorized in to three domains, namely;

i. Hard systems - In the problems perspective these are the systems which can justifiably be quantified.

ii. Soft systems – These are the systems that cannot easily be quantified, especially those involving people holding multiple and conflicting frames of reference. Useful for understanding motivations, viewpoints, and interactions and addressing qualitative as well as quantitative dimensions of problem situations.

iii. Evolutionary systems – These are applicable to complex social systems. They are linked with techniques which integrate critical systems inquiry with soft systems methodologies. Evolutionary systems, similar to dynamic systems are understood as open, complex systems, but with the capacity to evolve over time. Here attempts have been made to integrate the interdisciplinary perspectives of systems research, cultural anthropology, evolutionary theory, and others.

Out of them it is identified that what we trying to perceive as sustainability dynamics has strong links with both soft systems and evolutionary systems. Nevertheless the inherent complexities related to many integrated systems where sustainability is concerned, brought us back for the urge to find common patterns and grounds to interpret numerous dynamics within and among these systems taking back a holistic viewpoint. In this respect, similar attempts to frame certain realities important for various fields were encountered; the most significant approach has been the conceptual model of ‘Panarchy’ (Gunderson and Holling, 2002). The term Panarchy has many contextually related meanings, in systems theory it describes evolving hierarchical systems with multiple interrelated elements. In this particular context, Panarchy is the structure in which systems, including those of nature (e.g., forests) and of humans (e.g., capitalism), as well as combined human-natural systems (e.g., institutions that govern or effect natural resource), are interlinked in continual adaptive cycles of growth, accumulation, restructuring, and renewal etc. Regarding the formation of the model a strong qualitative justification has been soundly backed by numerous case studies. Further there are similar conceptual models which have been supported by both qualitative and quantitative mathematics in different stages. Finally it is mentioned that all these different viewpoints and approaches have paved the basis for moulding, developing the conceptual processes for interpreting sustainability dynamics illustrated in the subsequent parts of this thesis.

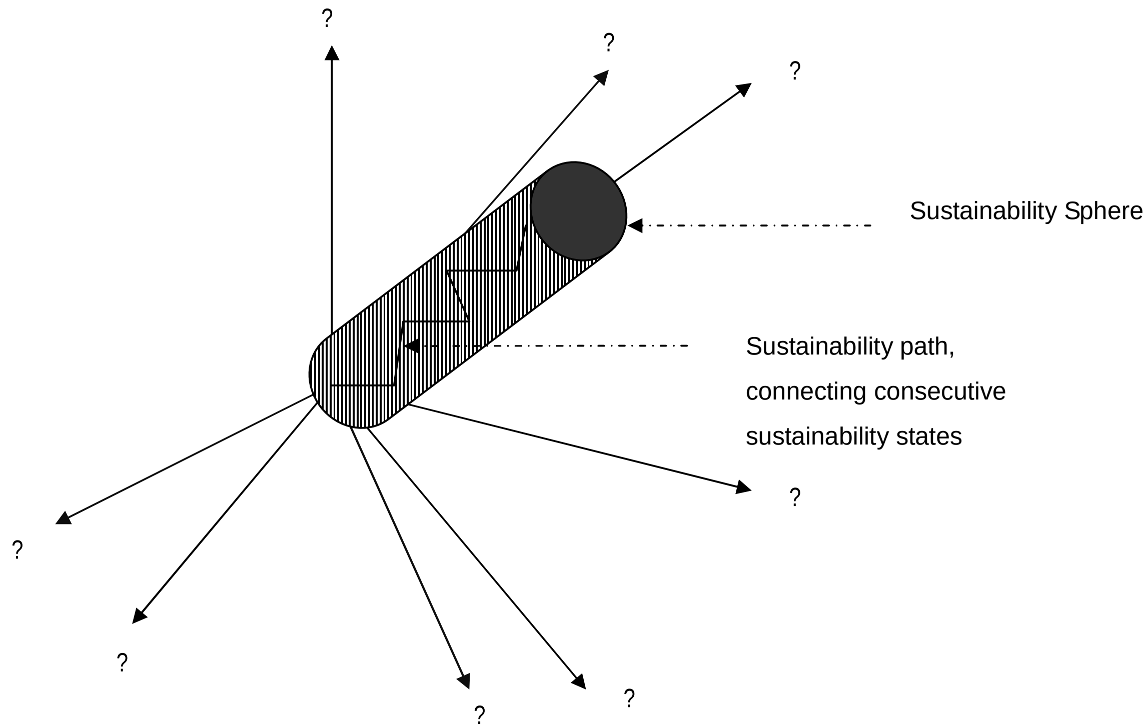
Chapter 3: Sustainability Dynamics

3.1 Sustainability Sphere and Sustainability Path

The word *dynamics* carries many different contextual meanings. In sustainability literature related to various contexts the word dynamics has appeared. One of the key documents in sustainability science, 'Sustainability Science: The emerging research program', emphasizes the importance of harnessing the dynamic interactions in science and technology with attention of how social changes shapes environment and how environmental change shapes society (Clark and Dickson, 2003). Constanta and Patten (1995) suggest that much of the sustainability discussion misdirected because it fails to account for the range of interrelated time and space scales over which the concept must apply. They state that, 'sustainable system is one which survives or persists and then ask the questions; What systems or sub systems or characteristics that persists?; For how long a system must persist to be considered sustainable?; They base this type of arguments to reach a further insight that immortality of any subsystem is not sustainable because it cuts off evolutional adaptation (Howe, 1997). In addition, according to system's theory (Clayton and Redcliffe, 1996), problem can be defined in many different ways, and one way of identifying problem is through diverse effects it creates. Whether directly referred to or not, in many of the found literature exclusively of sustainability science or of which have led to concept of sustainable development or sustainability over the years, the significance of the continuation, movement, progress has won attention from time to time.

Our interpretation on dynamics in sustainability is strongly linked to a preposition that sustainability of a specific entity could be perceived as a path, instead of a past or future state to achieve or a present state to maintain.

Just as change and evolution is important for any existing socio-cultural or ecological system, there need to be well adjusted balance between change and stability. This fact may lead to the preposition that any system we encounter will have its distinct path in terms of its behavior and existence. This path may closely be related to its evolution. Today we talk about the sustainability of many different systems. One significant fact is that when perceiving a system's sustainable path its internal movements will take place due to both natural and manmade or man influenced causes. In other words many systems which may viewed as linked to sustainability may have both natural and human induced or influenced factors which over the time would have influenced their evolutionary path. In a more anthropocentric viewpoint what ought to be meant by sustainability in relation to those specific systems, in our perception, is linked with either maintaining a certain existing characteristic or navigating the systems behaviors and functions till a certain characteristic or set of characteristics reach a desired level. Due to many reasons desired level may change over the time. What would connect these desired levels or states over the time will form a path relative to the set of characteristics of the system. Both the movements themselves and what would decide or trigger the movement from one state to another may be called the dynamics related to this system. They could be either the dynamics which are explicitly characterizing the basic functions of the system, or else they could be linked to external, peripheral influences. However in the point of view of sustainability the above path could be either sustainable or unsustainable, yet in theoretical sense depending on the concerned system, the triggering characteristics, and external limits etc there might be an area or space within which the movement of the system may be identified as sustainable.



Note: Dark arrows are the possible dimensions reflecting criteria which will induce forces that bring the movement of the system relative to time. There could be a space or a sphere within which such movements are regarded to as sustainable, and that particular space or sphere is referred as sustainability sphere, and the path within as sustainability path.

Fig 3.1 Concept of sustainability path and sustainability sphere in generalized visual form

Fig 3.1 gives a graphical interpretation of sustainability sphere and the sustainability path within. The characteristics shown by different axis are the ones which would govern the path within the system and they can be either the dynamics which describes the basic functionality of the system or else, some external characteristics. In the next few sections, this model will be explained in detail, giving equal significance for both the *internal dynamics* of the system, and the dynamics which are induced upon the system from outside, or *external dynamics*. Here an assumption is made that any form of sustainability could not be addressed in isolation of the internal dynamics of the concerned system, and recognizes the fact that any system which may be quite efficient in terms of utilizing the positive traits of its internal dynamics may easily find itself in unsustainable situation.

Based on such grounds, the section 3.1.1 gives a detailed description on how sustainability sphere and sustainability path is conceptualized relative to a market based capitalistic economic system, to a certain extent giving high priority to internal dynamics of the system. However due attention was given to set of sustainability principles relevant to this particular scenario were taken as base line, in order to identify points or extremes of unsustainability to reach the justification for sustainability sphere.

3.1.1 Metaphorical interpretation via Market Economy and Sustainability Mapping

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SATANARACHCHI, N.N., Graduate Program in Sustainability Science, The University of Tokyo, e-mail: niranji.satanarachchi@gmail.com

MINO, T., Graduate School of Frontier Science, The University of Tokyo, e-mail: mino@k.u-tokyo.ac.jp

MARKET ECONOMY AND SUSTAINABILITY MAPPING: ROOM FOR MUTUAL LEARNING[2]

Abstract

Often sustainability is considered to be most challenging in the face of market realities. All countries in the world either directly or indirectly linked with global market. Within the field of sustainability there is a debate on whether market is the correct instrument to be highly relied upon, mainly due to disparities it creates in terms of wealth division and the challenge it induces upon global ecological sustainability. Among these discussions there are two distinct views, namely; (i) Market based capitalistic economic system has to be replaced in order to live within the capacity of ecosystem; (ii) Sustainability could be achieved still with capitalism and market, focusing on new directions such as ecological modernization. Considering these two views along with the hypothesis that sustainability rather than a static end state carries a strong implication of dynamics, the existing correlation between dimensions of market dynamics, and sustainability is explored with the aid of qualitative scenario analysis. Extending those observations to a further

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stage of metaphorical conceptual model building, how market triggered positive dynamics can intrinsically steer a society within an identified sustainability sphere is argued and illustrated in detail. Finally, additional implications for the process of characterizing Sustainability Dynamics (SD) are discussed at length.

Key words

sustainability mapping, sustainability sphere, market economy, dynamics, metaphors

1. 1 Background

Within the emerging field of sustainability, there is ongoing debate on whether market is an instrument to be highly relied upon leaving it to form intrinsic societal movements. The resistance emerges not only due to market's widely talked disparities creating in terms of wealth division, but also for the challenges it induces to achieve long term global ecological sustainability. (Costanza and Daly, 1992; O' Connor, 1993; Hawkins, et al., 1993, 1999; Pepper, 1998; Balakrishnan, et al., 2003)

A market is a social system based on division of labor, where the prices of goods and services are determined in a free price system set by supply and demand. This is often contrasted with a planned economy, in which a central government determines price of goods and services using a fixed price system. In the real world, market economies are regulated by society (Alvater, 1993). While no country has ever had within its border an economy in which all markets were absolutely free, many states which said to have a market economy have a high level of market freedom. Thus, almost all economies in the world today are either mixed economies with varying degrees of free market or planned economy traits. (Alvater, 1993)

Even though the term free-market is sometimes used synonymously with market economy, in literature there are mainly four systems explicated; namely, capitalism, laissez -faire, anarcho-capitalism, and market socialism. Both laissez-faire and anarcho-capitalism are being referred to strictly free markets which are free of government interventions and regulations besides the minimal function of maintaining the legal system and protecting property rights. (Clerk and Cynithia, 2003) The book that is considered as the most influential in economic history, ‘The Wealth of Nations’ by Adam Smith which expounded the idea of government leaving market to itself, has popularize the concept of laissez-faire (Smith, 1776). Market socialism refers to various economic systems in which the government owns the economic institutions or major industries but operates them according to the rules of supply and demand. Finally capitalism generally refers to an economic system in which the means of production are all or mostly privately owned and operated for profit, and in which investments, distribution, income, production and pricing of goods and services are determined through the system itself.

Within this paper, more emphasis was given for those economies in which the concept of capitalism is functioning to the highest extent.

1.2. Introduction: ***Sustainability and Market;*** the famous paradox

“Although overall sustainability requires a long term view, our particular money creation system is like a pair of spectacles which give short term economic issues such prominence that they obscure our vision of the future.”

(Douthwaite and Siochrú, 2006)

Historically, man has continuously been in war with nature considering it as a basic resource pool and a waste sink; although there are records of some indigenous cultures who had kept on nurturing more harmonious relationships (Diamond 1997, 2005). Three major distinct stages of human history have paved the road for the current capitalistic market economy. First the agricultural revolution which took place about 10,000 years ago, then the industrial revolution, triggered by trade between different parts of the world which ultimately led to sharing and advancement of new ideas and technologies. Starting from some parts of England in around 1500 AD, the development of market based capitalistic epoch unfolds a long story of, permanent technological revolution, sudden enrichment in material life, population explosions and growth of cities, change in nature of family units, threats to ecosystem, changed role of governments, etc, which expands in to present day complex globalization. (Bowels, et al., 2005) In the face of this rapid change, neither market nor capitalism has been free from continuous debate, dialogue and criticisms. Initially the biggest concern has been to identify the coupled system's functionality and to justify or challenge its suitability to serve the basic purposes of what it stands for. Many different views from Adam Smith, Karl Marx, Joseph Schumpeter, Thomas Malthus, John Keynes, Amartya Sen and many other economists and social scientists to answer this fundamental basis, have formed most of the theoretical concepts we know today about this complex system.

On the other hand starting from the 'Sustainable Development', which first introduced in famous Limits to Growth (Meadows, et al., 1972), and then often quoted from Our Common Future (WCED, 1987), today the concept 'Sustainability' has become a key global concern which spreads right across many scattered disciplines. However, when it comes to addressing the economic circle of the famous three pillars which most would in a glance identify as the visual description of sustainability (yet in our view would not necessarily be an adequate interpretation), there are two fundamentally dissimilar opinions yet being expressed in similar terminology. For instance, when a particular firm, corporation or an economy talks of sustainability, often it is about the entity's own long term survival, in other words, more or less about sustaining itself. Some others, though not many, would pay more attention on ways to maneuver their system's functions to ensure an improved state for the surrounding as well. These efforts have come in forms of many criticisms as Limits to Growth (Meadows, et al., 1972), Tragedy of Commons, ethical de-coupling (Vranceanu, 2003) as well as radical viewpoints such as ecological economics (Daly and Farley 2004) and ecological modernization (Hajer, 1995; Huber, 2000) etc. With ecological economics, Herman Daly has asserted that continuous growth in economy in its physical dimensions is limited by the fact that the economy is a subsystem of a finite, non-growing, materially closed ecological system (Daly, 1990; Daly and Farley, 2004). On the other hand, rejecting the fundamental opposition between economy and ecology, ecological modernization theory stresses the increasing importance of economic and market dynamics in ecological reform and the role of innovation, entrepreneurs and other economic agents and social carriers of ecological restructuring (Mol, 1997). In addition, there are some other views which support market's capacity to level down terrains of human interactions to overcome wealth disparities (Friedman, 2005), although such standpoints are strongly challenged in the face of one of the fundamental basis of unsustainability, the natural limitations induced by earth's physical carrying capacity (cf. Wackernagel and Rees, 1996). Likewise in the face of negative factors such as uncontrollable competition, excess consumption patterns, undesirable negative externalities on environment, difficulty in taking timely corrective actions so on and so forth, numerous opinions are being raised either to introduce improvements or to suggest for a paradigm shift from capitalistic economy based market model. (Common and Pierce, 1973; Daly, 1990; Jacobs, 1994; Petrella, 1994; Jacobs, 1996; Foster, 2002; Daly and Farley, 2004) However it is important to note that, all these views equally identify not only the dependency many human transactions and relationships have grown upon the market model, but also the fact that, the vigor and resilience the whole system has shown in its long term evolution is incomparable to any other known economic movement.

On the other hand, the concept sustainability too is still on its evolution. Different disciplines may constantly use the same term sustainability, where, while their implications often manage to fall in to a common domain, do not necessarily converge to a common focal point. For example, when a natural scientist may think of ecological replenishment or carrying capacity, an engineer may think of a particular clean technology, and an economist probably of corporate social responsibilities or green investments. One of the positive aspects of this lack of commonality would be that, instead of producing hasty, incomplete and biased sketches, the uncertainty and complexity entwined with a dynamic learning process would enable to create a more colorful and profound masterpiece. Clerk and Dickson (2003) has addressed sustainability challenge as the multiple movements to harness science and technology focusing on the dynamic interactions between nature and society, while giving equal attention to how social change shapes the environment and how environmental change shapes society. Yet nowadays the multiplying views about sustainability tend to bring forward a common underlying assumption of a rather static ultimate state, than treating it as a path or navigation route itself (that is closer to the process of selecting colors and patterns to draw a picture), which as a result leads to interpreting sustainability of not only an economic system but of any other relevant system as an incomplete, fuzzy state. Therefore we reemphasize that, more than an isolated static state, or as fuzzy concept lying above or ahead of us, sustainability can be identified as a sub system of rest of our surrounding systems, and it necessarily involves continuous changes, deviations and dynamic behaviors of those system's intrinsic components, characters as well as the peripheral environmental forces and triggers they subjected to. In this article taking the capitalistic economy based market model as an example, the above hypothesis is observed and qualitatively analyzed. In addition, a metaphorical approach of mapping a sustainability path within a defined sustainability sphere is illustrated and discussed in detail.

2.1 From Dynamics to Sustainability Sphere: A Metaphorical approach

Approximately fifty years ago, economist Joseph Alios Schumpeter introduced the term creative destruction in economies where he has insisted that disequilibrium was the driving force behind capitalism. Following him some other scholars have described the underlying force of a capitalistic structure identifying their interactions and interrelationships (Petrella, 1996; Fligstein, 2001). Fligstein (2001) has summarized most of his observations on how the dynamical forces govern the market taking the viewpoint of sociology. Another remarkable recent attempt has been by Bowel, et al. (2005) where he has taken a dimensional approach to interpret capitalism. In order to base the foundation for our conceptual model, we have selected the same dimensions he has used in order to describe dynamical behavior of any economic system. The dimensions are command, competition and change. Command stands for those aspects of economic relationships which involve power, coercion, hierarchy, subordination, or authority and it has a strong link with choice. Competition refers to the aspect of the system in which exchanges plays the most important role, and an analysis on how competition work is essential to any attempt in understanding an economy. The third dimension, change, is concerned with the passage of time and the way in which, over time, the operations of an economic system will change the system itself. (Bowels, et al., 2005) The most significant fact is that the interactions of these three dimensions lay the basis to observe the behavior of an economy through modern complexities in different viewpoints of politics, economics, psychology and other social sciences.

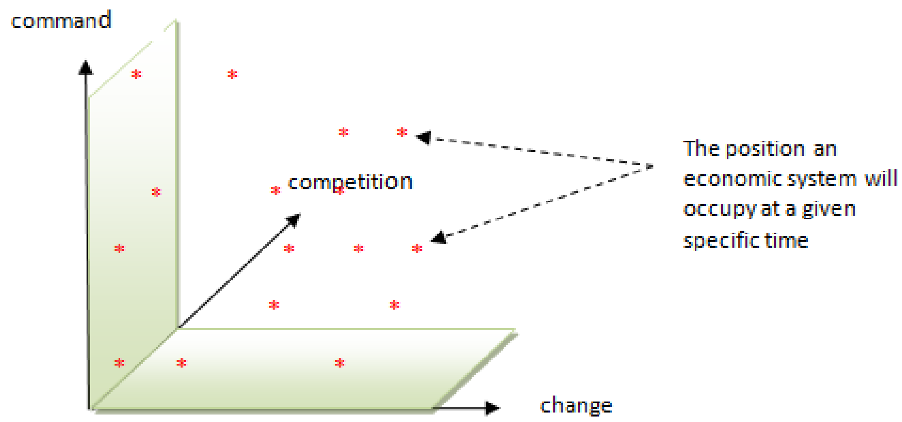


Fig 1 The dimensions of economic system in terms of dynamic behaviour

(Fig 3.2)

Fig 1 could be regarded as a snap shot of a cluster of economic systems. That is, a random point marked relative to shown three axes may represent a position a particular economic system will occupy at a given specific time. It could be a company, a firm, a strictly locally bound economy or even a complex global market. Each of these systems would vary depending on its physical properties as, size, boundaries, etc or external factors such as interactions with other economies and places they secure within some other broader domains etc. However relative to time, they all would be moving within a larger three dimensional system space. This random movement, we would interpret as dynamics of an economic system towards the end of this paper.

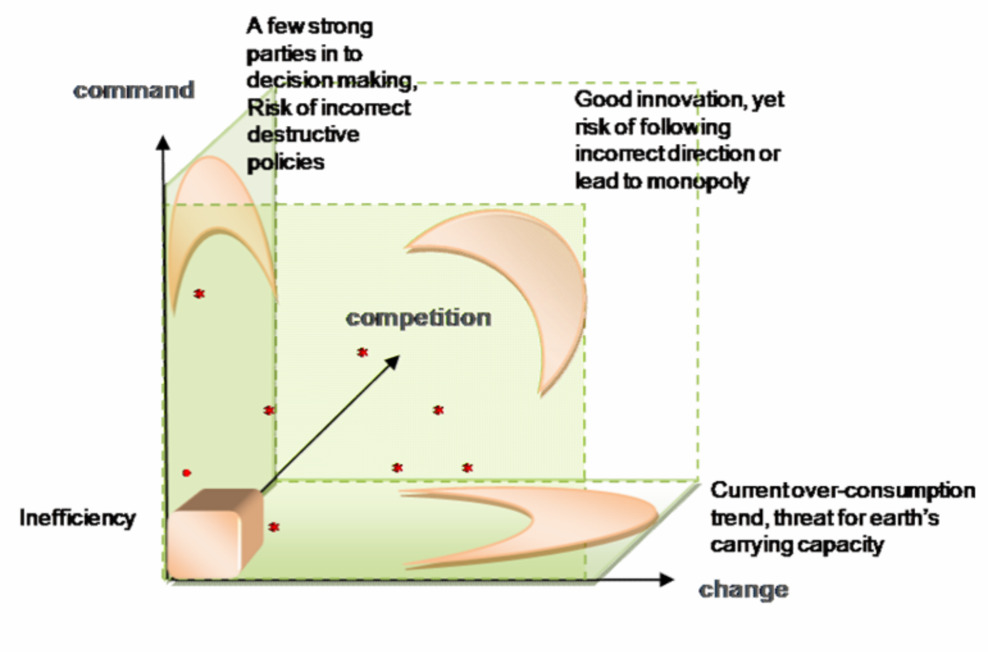


Fig 2 Sustainability Problem Sphere

(Fig 3.3)

Assume one of the moving points represents a particular country's market economy, whose boundaries, intrinsic behaviors, external relationships are well understood. One might prefer to keep this market closer to command axis to make sure his control over the system is high. Such behavior could be state interventions or even the power one would gain through being a lone successful player. Another might like to 'let loose' and let the intrinsic forces to compete within. Such would be a highly volatile environment which theoretically would let only the best or the fittest win. The final one who would rather stay closer to change axis may keep on innovating so his market would never age. These are three extreme choices. In reality, at a given time any market will have a specific point within this space, and relative to time, the point will move both due to external or internal drives.

Now the question comes can we identify sustainable or unsustainable domains/sub-spaces within this defined space, if so where? Assuming the market's behavior will reflect at least two of these dimensional attributes, while sticking to our earlier position on what sustainability is, we identify three possible long term unsustainable extremes, which are illustrated in Figure 2. Those extremes reflect direct consequences of biased behaviors relative to only two of the dimensions, neglecting the other. For example, when in the system, there are highly competing strong entrepreneurs and their capacity to innovate is very high, the two factors coupled together can lead to increase material production, hence in long run, extreme consumption habits within societal boundaries it operates. Many different arguments have risen in literature on market's position in sustainability, where these three unsustainbility extremes are extensively talked about. For instance, Petrella (1996) describes globalization and internationalization of resent times as a new 'competitive era' emerged in the last twenty years, especially in connection with the globalization of economic process. He emphasize that competition no longer describes a model of functioning of a particular market configuration such as a competitive market as distinct from oligopolistic and monopolistic markets. To be competitive has ceased to be a means. Competition has acquired the status of a universal credo, an ideology. For industries and bankers, competitiveness has become the short- and middle-term primary goal, whilst profitability remains the long-term goal and the *raison d'être* of the firm. For government, the competitiveness of the nation is now the primary concern, with a view to attract and retaining capital within its territory, in order to secure a maximum level of employment, access for local capital to global technology, and revenue needed to maintain a minimum social peace (Ricardo, 1996). His interpretation is embedded with two interesting observations. First it clearly reflects the obsession and biasness the behavior of market have started to show upon the competition axis. Secondly, it reflects the fact, even though a market or a capitalistic economic system may regard as a separate entity, it is inseparably linked with many other important geopolitical and ecological systems.

Thomas Friedman in his two books World is Flat (Friedman, 2005) and The Lexus and the Olive Tree (Friedman, 1999), repeatedly mentions that today, the virtual distance between different regions has shrunken making the new globalized world to operate in a flatter platform than ever before. He bases most his arguments on his observation that, world is losing many of its internally set traditional boundaries. He pictures how the command of globalized market being taken over by players themselves and how their open competition results in leveling the terrain of world. However, with his counterargument to this in "Bad Samaritans: The myth of free trade and the secret history of capitalism" (Chang, 2007) Ha-joon Chang is totally against the view that free trade is usually beneficial to the development of poor countries. In the process he brings forward very interesting two points, one, that almost all capitalist economies including countries as United States, Japan, South Korea, England have relied on protectionist policies and government "intervention" to achieve development, while engaging themselves in "free trade" which is in line with many other similar view points. In Friedman's perception, though it is not directly stated in terms of dynamics or sustainability, strong emphasis given for the intrinsic command which is created among the players themselves, one question could be how far this intrinsically formed command is willing to think of sustainability. One of critical drivers to form intrinsic commands which are sustainable as well would be the incentive structure within the system. In the counter argument on the other hand, much less trust is given for intrinsic commands, but more on governmental interventions, protectionism, and strategic investments.

2.2 Sustainability Sphere

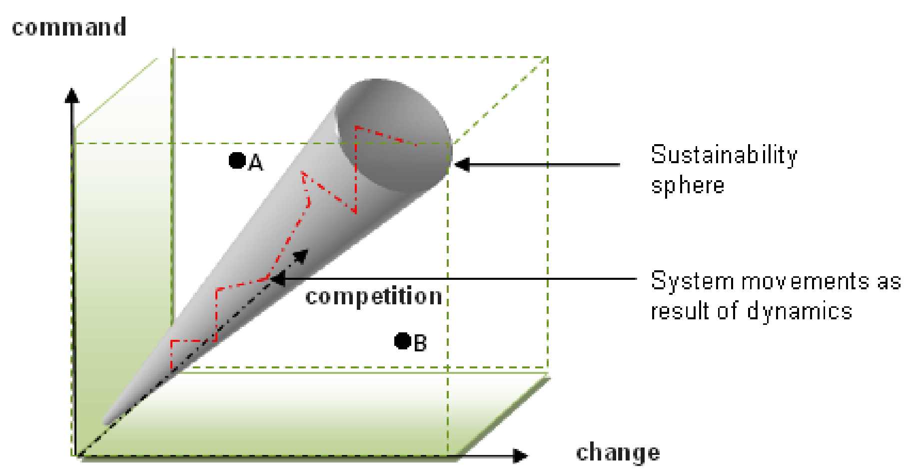
Once the key dynamic triggering forces and their positive and negative effects are identified as above, most fractions of the problems encountered with existing systems are coupled with what creates the dynamics within the system. Fig 3 shows a possible movement of one of the points in a way that the economic entity represented stays within sustainability boundaries. The path is selected in such a way that attractions from each of peripheral dimension are balanced. The metaphorical sphere which encloses the space where this random movement occurs, we may call, sustainability sphere. However this interpretation is strictly relevant to a system's intrinsic dynamics, in other words, most of the other relevant parameters of sustainability, (for example the amount of environmental degradation a country where the economic system is based on has already undergone), are kept external. Even though explaining their role is outside the scope, these external factors indispensably play a significant role in defining the size and shape of the sustainability sphere. However these factors have to be dealt in each and every case separately. For instance two sustainability spheres for equal economic systems in two different geographical locations may look very different from each other. What shown in Fig 3(a),(b) are conceptual approximations of boundaries which enclose a controlled path. In addition, it is important to take in to account that suggesting this type of a boundary is influenced by several key underlying assumptions;

(i) Relative to time, all the dimensions describing dynamics of the observed system are equally important and have equally strong influence over the system's path.

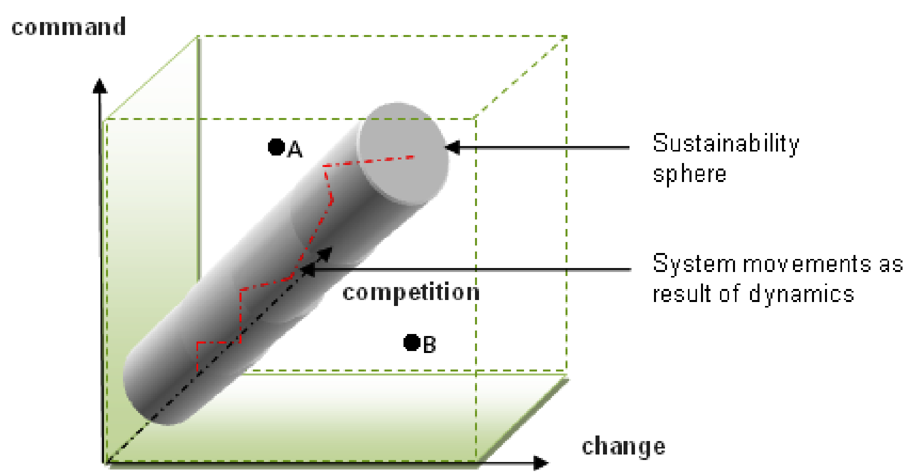
(ii) The dimensions taken as together have the capacity to induce a balancing but not neutralizing effect on its path relative to time, rather all three dimensions have a common positive vector component which will ensure the system's future advancements.

(iii) The imbalanced forces induced by the dimensions over the system make it move within this dynamical space.

(iv) The time taken to for the dimensional force to have the impact on the system is roughly similar for all three dimensions.



(a)



(b)

Fig 3 Sustainability Solution Sphere

(Fig 3.4)

A sustainability sphere for a market based economic system could take different forms. Figure 3(a) would suggest when dynamic forces are high; the movable area of the system is high, still being within sustainability constraints. One reason could be a situation closer to when high competition for more sustainable focused innovative products supported by correct strong policies taken by entrepreneurs and other influencing commanding bodies. However it has an underlying assumption that the geographical base within whose boundaries the concerned system operates is infinitely away from reaching its carrying capacity limits, there can be scenarios where such limits has already reached, that increased system's dynamical triggers could no longer provide a basis to extend the limit, rather might lead to reach sooner, hence the sphere could be of an inverted shape. Fig 3(b) would suggest an ideal situation where the three dimensions alone can continuously keep the system balanced; in other words, the dynamics within the system themselves are arranged in such a way not to have any negative effect on recognized sustainability thresholds. Likewise the position of a time span the system secure and the influencing external sustainability parameters relevant for that specific time will determine the shape, size and position of the sustainability sphere. However the forces which manure the system within, to determine its path needs to be the internal dynamics (competition, command and change in example here) and intrinsic forces, triggers they help to generate. Such forces can both be negative and positive in the face of sustainability and they course path deviations to ensure any component of the system to stay within those identified boundaries at any given specific time, for instance. To prevent diverting to point A or B, would need thorough understanding of not only of boundaries it would be constrained to (sustainability sphere) but also the system's capacity to induce and balance these forces.

3. Discussion and Conclusion

While this type of macro level conceptualization would be helpful to stop catastrophically failures (by roughly identifying the boundaries of sustainability sphere), it is equally important to zoom in this holistic macro picture to reach down for more micro details, for instance such as the path within. Only such a process would allow to identify where changes in directions need to be made, and more importantly within which time scale. In the transition theory it is emphasized that fundamental changes of assumptions to introduce new rules and practices are necessary to reach from one equilibrium to next, through stability and inertia. (Rotman, et al., 2001). To make such changes, one needs to be able to identify where the error is. In order to utilize such inertial forces to transit through temporal stabilities, the knowledge on what courses these forces and where these forces are needed etc are equally essential.

In response to above conceptual illustration, one important counter argument would be, why trying to super impose a sustainability scenario on few random dimensions. The three dimensions taken for this example, command, competition and change, may well interpret dynamic behavior of an economic system, but often sustainability will be recognized with many other different dimensions. The basis of selecting these three dimensions instead of expanding them to include some others to increase the comprehensiveness of the model in sustainability perspective is partly with the objective of achieving the optimal point between interpretative capacity and complexity, as a mapping process which includes all such possible dimensions would need numerous other parameters such as, environmental limitations and priorities, social factors, ethical factors, technological limitations etc to be taken in to account. However there won't be universal parameters representing sustainability which can adjust to any given situation, hence no handy kit of dimensions to fix in to a random dynamic model. Here we come back to our earlier argument that, sustainability rather than an end point or a system itself could be regarded as cumulative set of paths of some other existing systems. Therefore instead of measuring a system's behavior in the point of view of a common sustainability view alone, we suggest a process of identifying sustainability or unsustainability within the dynamical process of a concerned external system. This in a way is place a foundation to expand the current discussion on sustainability to a further level to include dynamic component which we would call as Sustainability Dynamics (SD). One strong point to conclude from this conceptualization could be that, just as making a system more sustainable needs expanded knowledge on the system's dynamics, to understand sustainability dynamics, the same relationship might be able to provide a sound basis.

In addition, this form of metaphorical conceptualizing could be a first step to allow fractured and highly specified different knowledge domains to come in terms with sustainability much easier than imagining the whole concept as a partly relevant yet mostly irreverent, complex but attractive piece of art. Especially at points where systems are expected to take rapid actions, such an approach becomes highly advantageous. Even though what's being described may sound highly conceptual and overly simplified, they can be strengthened with case studies and empirical justifications. The methodologies such as Environmental Impact Assessment (EIA), Integrated Sustainability Assessment (ISA), to a certain extent have succeeded in coupling environmental and social aspects in to development project decisions. One interesting and novel fact in the approach suggested here might be that, instead of static reference base-line data, the concept emphasizes the strong need to map those external interactions within dynamics of the concerned system. That way in addition to prevention and control, throughout the ongoing process, one might be able to even trigger catalysts for constant positive outcomes. This is in a way helps to detach certain negative aspects from your system while making room for novel insights gained through an eye of holism to facilitate a mutual learning process. It brings us to

Sterman (2002) interestingly states, "*all decisions are based on models, and all models are wrong*", which indirectly carries the message that at no matter how far we think we understand, at any given instance we should be prepared to question our assumptions.

While watching Flatland (Flatland, 2007), we feel A^2's frustration when he tried to make his fellow landers see that the third dimension is nowhere to left or right but to up and down, something which had not crossed their plane of perception ever before. What finally made A^2 himself to accept that there are higher dimensions than just the two he knew was to detach himself out of his own world to a higher dimensional space, and then look back down, with a completely new and different insight.

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3.2 Characterization of Path Dynamics

3.2.1 General Overview

In the previous section the concept of sustainability sphere and the sustainability path was illustrated with a detailed example on how those concepts can be visualized in a seemingly external system, the market based capitalistic economic system. At the end of it, the importance of reaching the micro or detailed level in the sustainability path is emphasized. This emphasis led us to look beyond to understand how the path dynamics are formed, how different systems reach or navigate from one stable state to another, in which form these movements could be judged as sustainable or not. Of course coming to a generalized conclusion is extremely challenging, as one system is necessarily differing from another, and the complexities each system may have would create individual behaviour patterns which are hard to be brought in to common grounds. However careful and critical observations of many different systems may allow identifying certain patterns of such path dynamics which can play as main or peripheral forces in sustainability. On the other hand, they may be interpreted in many different perspectives. For instance it is possible to perceive path dynamics in terms of the movements, patterns, who or what is involved of those interactions, or else, observations made related to outcomes these interactions may generate. Often such outcomes are related to how sustainability is perceived through real world problem perspective. However, if taken the stand that sustainability could be visualized beyond such problems perspective, then the need arises for understanding and framing these numerous dynamic interactions of the world in a rather holistic manner. Though probably the same terminology hasn't been used in available literature of sustainability science, sustainable development, and many related fields such as transdisciplinarity, complex systems, ecology, adaptive management, etc, similar attempts can be found, what probably missing is an effort to frame such interesting observations in a way that it could provide guidance or even an evaluating criteria to further observe, measure or judge whether system's path or the quest is kept within a sustainability sphere, space or not.

Therefore taking the systems perspectives along with the strong sense of time and space which can describe the relative position or the behaviours of a particular system, three distinctive categories of dynamic interactions which are common for many of the systems concerned in sustainability discussion are suggested and described in detail. They are namely Intrinsic Dynamics, Horizontal Process Dynamics, and Vertical Process Dynamics.

3.2.2 Intrinsic Dynamics

In general, the term intrinsic has been associated with internal movements and changes in different contexts. So what do we mean by intrinsic dynamics?

Any of the systems that we could think in our surrounding or even within ourselves, function wise, they often are linked with many different other systems in a lower or higher level. For instance human body functions depend on number of other internal systems as the system of blood circulation, nerves etc which again are arrays and patterns created by cells whose function again depend upon integrity of several other entities. In other words, the functionality of the body will depend on the functionality of those of its sub systems. Similar relationships can be identified from aquatic ecosystems, terrestrial ecosystems, or taking earth as a whole. One little entity is inevitably linked to other entities and systems they form together will equally be linked to parallel, higher or lower ones. Similarly, concerned with sustainability too it is possible to find where attention given for such relations, for instance, the three systems of human social and global, which at times identified as one system enclosing the other. Such enclosing systems are referred as viable systems. A viable system is a system of complex entity capable of maintaining an independent existence- not an existence totally separate from an environment, but one where structural changes take place without loss of identity and without severance from a niche. (Espinosa et al, 2008)

Another simple example for the concept of intrinsically interrelatedness of different systems is found in sustainability metrics. Sustainable Indicators are diverse in their scope, target etc, yet when mapping process of any existing environmental indicator in to sustainability indicator needs the understanding of not only how each environmental systems is closely linked with any other peripheral system, for instance an economic or a legal system, but also of the drivers, dependencies the total environmental system itself would have upon some higher system it is included in or a lower system it may enclose. In the repot of “Indicators for Sustainable Development; theory, method and applications” Bossel (1997) distinguishes between two types of indicators; (i) For the viability of a system

(ii) For its contribution to performance of another system

He illustrates his concept as follows;

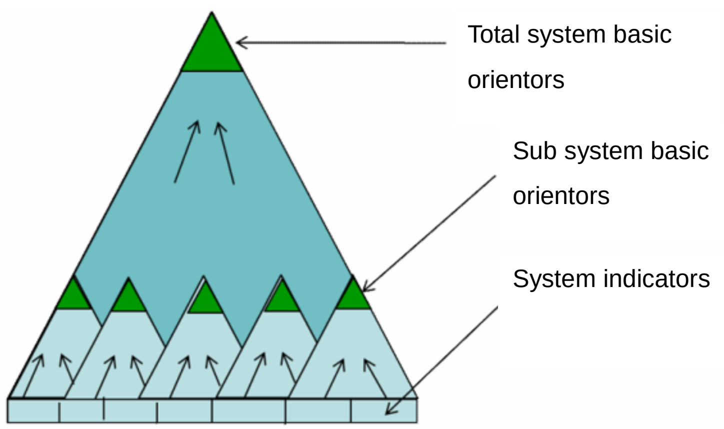


Fig 3.5 The phenomenon of “Russian doll”; Illustration of viability in relation to enclosed systems

This is a recursive relationship; sub-systems may depend on sub- subsystems, and so on.

The dynamics which links with the viability of a specific system, can be regarded as a main building block of **“intrinsic dynamics”**

Intrinsic Dynamics occur when a system is extensively influenced by sub systems. The sub system or sub-sub system’s basic orientors cause intrinsic dynamics in a particular concerned system. The independencies which create intrinsic dynamics may have both time and space significance.

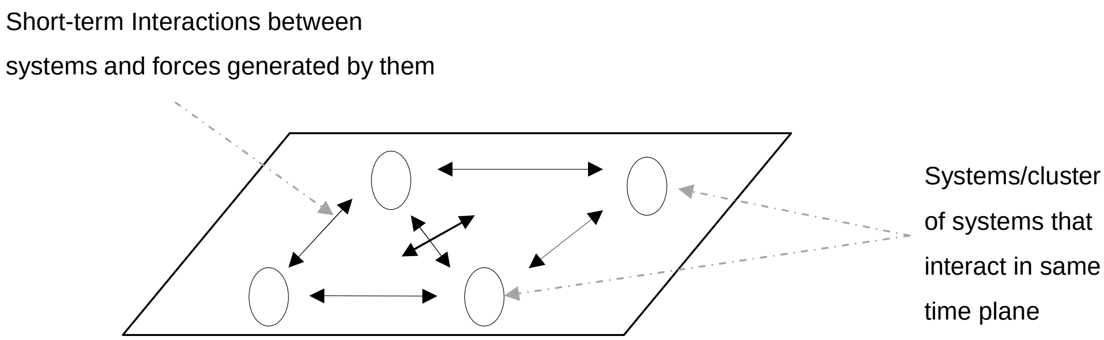
While intrinsic dynamics are essential component in evolution of any system either related to sustainability or not, at the same time depending on the situation they may take different forms. Specifically related to sustainability, their effects may well spread in both time and space. Further illustration on Intrinsic Dynamics with contextual examples will appear in section 3.3.

3.2.3 Horizontal Process Dynamics

Just like there are links of a particular system with its sub systems, the same system could essentially have numerous links with other similar ones in its outer environment, which are not necessarily considered as viable systems. The path which any of them will take relative to its surrounding or relative to its own dynamical axis as explained in section 3.1, within higher dimensions of time and space, can be argued as determined by several stable states joining one another in the scale of time. These sates which will be seen as stable relative to longer time scale will have complex interactions within themselves. These interactions will be linked with behavioural changes induced by short term feedbacks, incentives etc. The significance of these interactions is that one could observe them if he detach or distant himself from both the system and its environment and then take a snapshot view of what he observes. In other words the span of time when the interactions are observed is comparatively very small from the perception of time especially in terms of sustainability of the considered system. In addition this type of dynamics can be better visualized once the time lags between feedbacks are not fully considered.

In summery Horizontal Process Dynamics (HPD) of a considered system, or cluster of systems are the flat surfaced or two dimensional interactions, triggers and forces generated by these interactions. Such dynamics has an effect on the movement system’s path.

One can visualize HPD in many different contexts, in fact when most of us think of dynamics in relation to sustainability or merely in relation to any random system, what often comes to our minds would fall under HPD. However they do not necessarily help to create sustainable conditions, as their effect may well support unsustainable conditions, or the conditions which can deviate a system’s path away from the sustainability sphere as well (illustrated in Figure 3.1 in section 3.1). With the complexity of globalization, the information revolution, market transactions, in fact what is seen and experienced everyday can be identified as short term interactions, spreading across a flat plane. This flat plane could be the World Wide Web, stock exchange, or even a simple discussion in a class room where a group of students trying to learn sustainability. Or it could be basic livelihood taking place over day, month, year in a rural village.



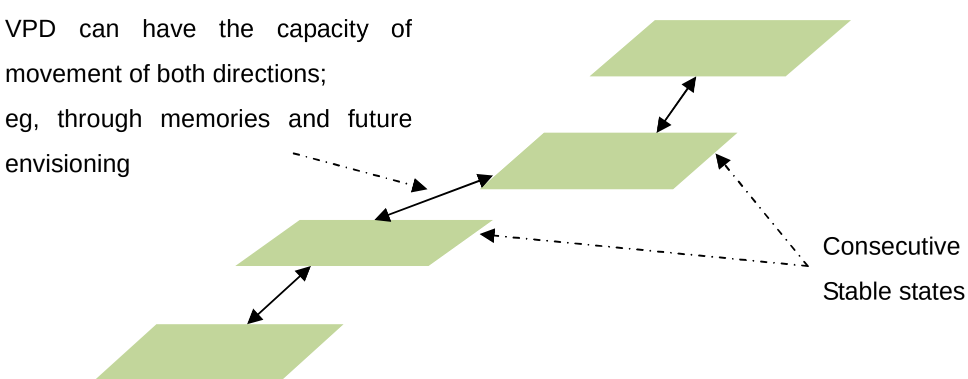
Note: the plane represents a random system's particular state relative to time, and circles represent subsystems, or entities within the system. The interactions and triggers generated by interactions are identified as Horizontal Process Dynamics

Fig 3.6 Visualizing Horizontal Process Dynamics

In the discussion of dynamics explicitly related to sustainability, what will decide the time frame is the path of the system and the time duration for sustainability assessment, evaluation or simply to understand the meaning of sustainability related to the system of concern, which will characterize or distinguish this type of dynamics from the rest. It simply means that to perceive or visualize HPD the axis of time needs to be fixed while axis or plane of space alone would be scrutinized.

3.2.4 Vertical Process Dynamics

Vertical Process Dynamics (VPD) are on the other hand, the movements or interactions which may attribute for evolution, progress and adaptation over the time, of a particular system or a cluster of interlinked systems. These in fact are the ones which bring a system from its one stable state to another along its path over time. What make the vertical process dynamics significantly different from horizontal process dynamics is that their strong link with the time axis. The perception of time should be a strong consideration, to perceive evolution of any human, social or natural system, whether they are considered distinctively separate from each other or regarded as intervened. VPD could be influenced by memory, learning or knowledge progression. Or else some time they could be related to what we call as envisioning future, targeting etc where the feedback, signal, learning is received from a future state to a past or present state. In other words VPD may consist of what is carried forward or even backward from each horizontal or space wise interactions and triggers they generate.



Note: Each plane represents a random system's particular state relative to time, and what link two such states represents vertical process dynamics or the dynamics which moves a system's state over time.

Fig 3.7 Visualizing Vertical Process Dynamics

Vertical Process Dynamics (VPD) of a considered system, or cluster of systems are the movements or interactions which may attribute for system's evolution, progress and adaptation over the time.

Probably many of most well read and understood example on how vertical process dynamics work in relation to normal evolution patter of human history can be extracted from the famous geographer in recent times, Jared Diamond's detailed narrations. For instance in Guns Germs ad Steel (Diamond, 1997) he gives high emphasis on how different indigenous societies in different parts of the world faced the challenge of survival, and then how some of the societies gradually evolved in acquiring different technologies according to what they needed and what they were offered by the surrounding, then how theses clusters evolved for centuries isolated from each other which subsequently led them to deviate in terms of knowledge, cultures, norms etc. Going somewhat beyond the basic causes mentioned for the difference of evolution patterns of each of these societies, within his narration itself one could observe how the differences as of knowledge accumulations, transmissions adapted in each of these societies may have affected their needs, behavior patterns, choices and at the end, the simple diversified evolution of these human societies.

Now that we have come to the most interesting known stage of human history after probably the plant and animal domestication in the crescent valley centuries ago, where the world appears to be interconnected in a strange sense, reaching somewhat beyond the geographical, political, cultural etc differences, finally it has given man the possibility to visualize the earth, or the world as one unit itself, it has made the task of visualizing the stable states of earth or global system far more easier than before. Further it has given the science courage to envision future and to adapt processes as back-casting (Robinson, 1998) to set and reach goals having global significance.

However the reality which existed for an isolated continent or an island many centuries ago still lies for the island of globe we speak of today. That is the experience and knowledge gathered from one stable state, will inevitably determine the world's future path deviations and continuations.

3.3 Further Explanation with Cases

In order to make the so far explained path dynamics clearer, few cases have been selected and illustrated as bellow. Especially the first hypothetical case was selected to place the foundation to visualize the explained three forms of dynamics (Horizontal Process, Vertical Process, and Intrinsic) in a relatively simple setting. This hypothetical case could be also regarded as a transition phase to bring the basic discussion on path dynamics to a more complex sustainability/unsustainbility conscious discussion, as the next two cases were purposefully chosen in a way that interactions of two different socio-environmental systems are reflected in broader sense. Each of these latter two cases may mirror both sustainability and unsustainability scenarios, yet at this initial point we purposefully did not explicitly judge whether these behaviours and triggers have led these societies in sustainability path or sustainability sphere repetitively to which we have been referring in the early stage. However since the structure of the cumulative socio-environmental system gives quite effective examples on what is explained in the three types of path dynamics so far, and the discussion itself may have the essence of sustainability integrated in it, the reader can look beyond mere behavioural or societal dynamics in to what is tried in this thesis to be perceived as sustainability dynamics.

The three cases selected are namely;

i. A hypothetical case of integrated system of aquatic, terrestrial and human systems

ii. The unit of Weva (tank) and Gama (village) of ancient Thambapanni

iii. The Lake Victoria, the story known as Darwin’s Nightmare

3.3.1 Three dynamics in common grounds: a hypothetical case of integrated system of aquatic, terrestrial and human systems to illustrate the dynamic patterns of sustainability

Imagine a random ecosystem which has terrestrial and aquatic importance linked closely, where the human operation has taken place just as anywhere else in the world. Some of them as fishing in the lake or cultivating crops are closely related to the surrounding environment, and some of modern institutions would have created different levels or platforms in human interactions with the ecosystem, either in terms of economic activities, resource management etc. This type of a complex ecosystem may found in any urban complexity, or a rural setting in Japan or even with the indigenous New Geneon habitats well described in Jared Diamond's famous narration 'Guns Germs and Steel' (Diamond, 1997).

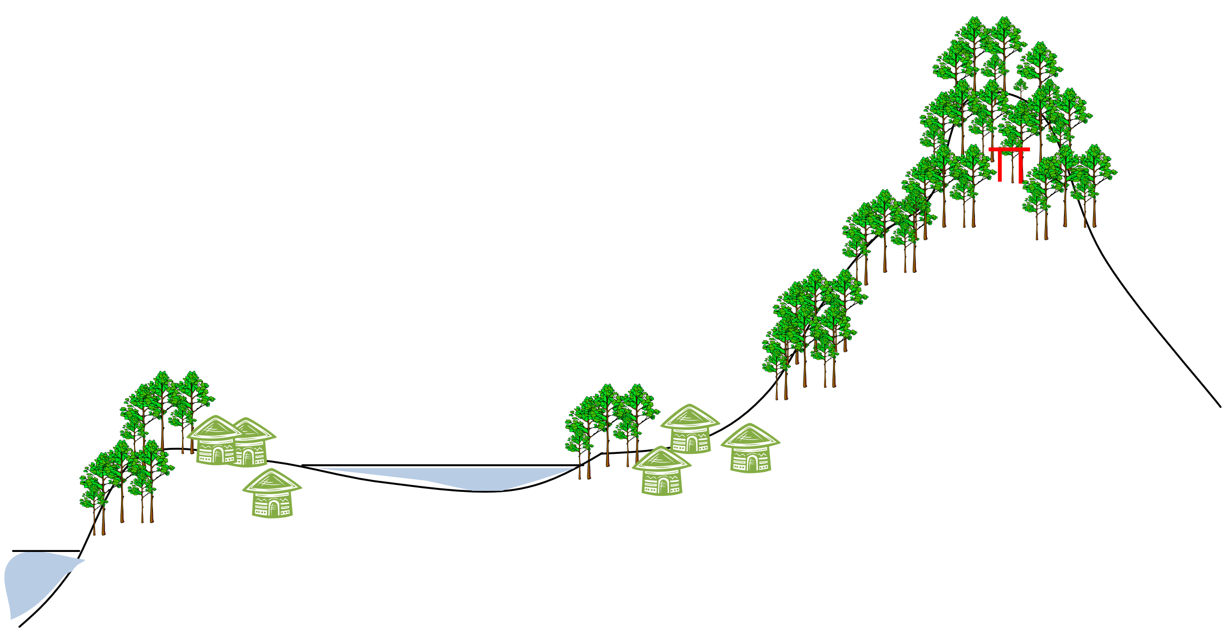


Fig 3.8 Graphical illustration on a random indigenous village ecosystem

Or else it could be a watershed described by Olsson and Folke, (2001) to illustrate the importance of local knowledge in ecosystem management or some other case of shallow lakes which has extensively been studied in past in relation to their relationship with the surrounding human settlements.

If we concentrate specifically on various interactions between lake ecosystem (natural system), the surrounding human settlement (human system and the social system), this cumulative system gives a sound model where these three systems undergo live interactions with each other. Depending on the perception of time and space these interactions may be categorized in different domains.

If a specific duration of one day, a month or year is taken most of the interactions between different systems in this setting will demonstrate a rather flat terrain net of links. For instance if the natural system taken isolated would undergo different movements where the balance of a system could be slightly disrupted, this could be naturally induced sudden erosion causing sediment accumulation in the lake bottom unexpectedly, which disrupt the lake bottom habitat, or the sediments may contain toxic impurities as a result of agricultural activities of settlers. Or else there could be direct intervention from the settlers through fishing. The settlers may have used the lake as their resource pool. And indirectly the lake may have acted as a biological waste sink for the small number of settlers (who were not exposed for advanced technologies for them to worry about disposal of industrial waste). A sudden change in the lake bottom sediment accumulating rate may have rapid consequences on the breeding pattern of a specific fish species, which may result in depletion of the fish species altogether. In addition to the direct loss of biodiversity, this particular fish species could be an important pray for a different species common to the ecosystem, or else the particular species may be harmful for the viability of a higher system in the first place so their extinction might after all looked upon as viable to maintain the diversity of the system. Again whichever the case, the above explained scenarios highlights an important aspect, that is, different systems within these eco system are linked intrinsically with one another that they become subsystems of a higher system and they on the other hand may comprised of many inclusive sub systems of whose sustainability has a direct impact on the higher system. Interactions or movements which may occur between systems in such an internal manner come in our definition under the categorization of *intrinsic dynamics*.

On the other hand with regards of fishing, in terms of sustainability such an extraction may reach to disruption of stability once the fishing has increased rapidly, let's say with a new change in the institutions the settlers have created for themselves. Such an institutional change could be the settlers finding a new market to sell their fish which would lead a sudden increase in fishing activities in the lake. In these situations the systems which interact with each other are not necessarily linked intrinsically as explained in the previous section. Rather these systems while having their own evolutionary relationships, in addition takes part in some external relations. The results of such movements either would have instantaneous effects on the parent systems (In this context the lake-village ecosystem), or else may take long time in the scale of few decades or even longer. Whichever the situation if the short term triggers and forces generated by basic movements happening between different subsystems in lake ecosystem can easily be mapped in a horizontal plane, once considered a relatively small time scale within which the interactions taking place, such a map is almost like a snapshot image that we would often use to describe any particular ecosystem. As in the context of assessing sustainability of a specific ecosystem, the base line data will often illustrate such flat planed interactions. The movements and immediate forces linked with such movements shown in that snapshot image we would call as the *Horizontal Process Dynamics* concerned with the Lake-village ecosystem.

Finally let's imagine the settlers in the vicinity of this lake have been in the surrounding for generations. Then they may have a strong base of traditional ecological knowledge (Please refer to section of literature review) with them accumulated over the years with the process of firsthand experience drawn conclusions, the corrections of assumptions, linking the observation with folk tales etc. In this context what is perceived as the time scale within which an upward direction process happening would be much longer than in the case of HPD, rather would be better explained with *Vertical Process Dynamics*. VPD would take in to accounts factors such as long term knowledge accumulations, experience, feedback, corrections, progress, etc hence may embedded within a long term time scale. In other words vertical process dynamics would help to see the direct coupling links from one after another of the evolution of the concerned aspect or the system of this village ecosystem. For instances, the villagers may have a superstitious belief that the hill adjoining their settlement to be inhibited by a mighty power, so that whichever the property in the hill may have to treat with utmost care and respect to avoid troubles. Such a belief might be linked with previous experience on extensive removal of hill's forest cover, and a simultaneous observation of draught, diseases etc. Such observations may have led to set implicit rules for the management of ecosystem resources by human community in the region via, embedding the superstitious beliefs, which could be the strongest controlling agent for the community's actions. The path from either one or several such observations to the management action the community implicitly agrees upon may take a long process of feedback, corrections, re-interpretations, challenge, acceptance etc. Yet ultimately the accumulation of past traditional knowledge have lead the human system to limit its interventions to the surrounding ecological system, so that the stability of the cumulative system is not subjected for sudden disruptions.

3.3.2 The unit of Gama (village) and Weva (tank) of Thambapanni

In the past irrigation culture in Sri Lanka (known to be called as Thambapanni at the time) there has been an interesting cluster of socio-environmental systems found which were closely connected with each other, and whose interactions have created most of the behavioural patterns, how people perceived the nature and how their relationship with nature was formed and evolved. It is worth to mention at the beginning that, similar to some other past societies been scattered throughout the world, in these village systems too when the term environment is used, it is hard to find distinct differentiation for which exactly belonged to environment. Generally for human in this setting, environment often included not only nature, but their other neighbours, kith and kin as well, in other words strict differentiation as human and ecology may not make much sense in trying to understand the intrinsic relationships within these particular systems. At the same time such close relations with what we often call as nature today, did not prevent this society from trying to face the basic challenges they faced for simple existence, by changing their natural environment which is reflected by a famous quote made by a native king; ""not even a drop of rain water must flow into the ocean without being made useful to man" (Geiger – Chulavamsa, 1929, adapted from; Jayasena and Selker,n.d). Such facts suggest that the perceptions and relationships between such different socio-ecological or socio-environmental systems may have had their own uniqueness and complexities.

While the particular integrated system described bellow may closely resemble many clusters of early civilisations in rest of the South and South East Asia, (Grove, et al., 1998) and some other parts of the world, here there are some remarkable features which would support us to identify common dynamical evolutionary patterns of a particular socio-environmental system where a special water management structure too is firmly embedded.

Box 3.1. Overview of village-tank system of Thambapanni

The following narration is about a hydraulic-cultured system in past Sri Lanka, which is believed to have efficiently executed in a period from 200 BC – 1200 AD, where out of country's closer to hundred drainage basins, the basins underneath the dry zone were successfully irrigated through system of tanks and diversion canals. Apart from basic factorial history, Mahavamsa (Geiger, 1958) has revealed various religious, ethical and moral aspects interwoven with this irrigation culture.

The North Central Dry Zone of the island became the cradle of Island's civilization with a capital or main city of Anuradhapura, established there from the 3rd Century BC, and the society whose agriculture and culture were highly influenced by minor as well as large-scale waterworks for irrigation, flood control and water supply is referred to as "hydraulic civilizations" by many writers (Leach 1959, 1976). Also this unit has been referred as 'Village Tank (reservoir) Cascade Systems' – a 'cascade' is defined as 'a connected series of village irrigation tanks organized within a micro-(or meso-) catchment of the dry zone landscape, storing, conveying and utilizing water (Maddumabandara, 1985). In addition to its large-scale irrigation works, the drier areas of Sri Lanka are also covered with number of man-made lakes and ponds, known locally as 'tanks'(Tennent, 1860). Traditionally, several different types of tanks were built - some of which had nothing to do with irrigation per se but all of which had a critical role to play in the practice of irrigation agriculture.

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It has been recorded that there was a tradition to build a forest tank in the jungle above the village, which was not used to irrigate land, on the contrary, whose express purpose was to provide water to wild animals and, hence, to reduce the likelihood that they would descend into the cultivation areas and destroy the crops in the search for water. Other types of tanks included the mountain tanks, which were built to provide water for 'chena' or slash-and burn agriculture in the more hilly areas. The erosion control tank, or 'pota wetiye', was designed to get silt from the upper slopes deposited in it, before entering the main water storage tanks (Maddumabandara,1985), built in such a way that they could easily be de-silted. The storage tank, often came with duel structures, - one being used whilst the other was being repaired. For that reason, such tanks were known as 'twin tanks'. These small tanks find their best expression across the various landscapes of the North Central, North Western and Southern regions, reflecting some essence of traditional irrigation technology. More importantly the village tank system has always been the back-bone for the complex society formed within and around. At the same time, it has always occupied a special place in the consciousness and heritage of modern Sri Lankans, with certain amount of pride for its earliest sedentary human settlements woven around the cultural trinity - the Wewa (tank), Wela (Rice Field) and the Dagaba (religious monument).

(Adapted from Maddumabandara, n.d)

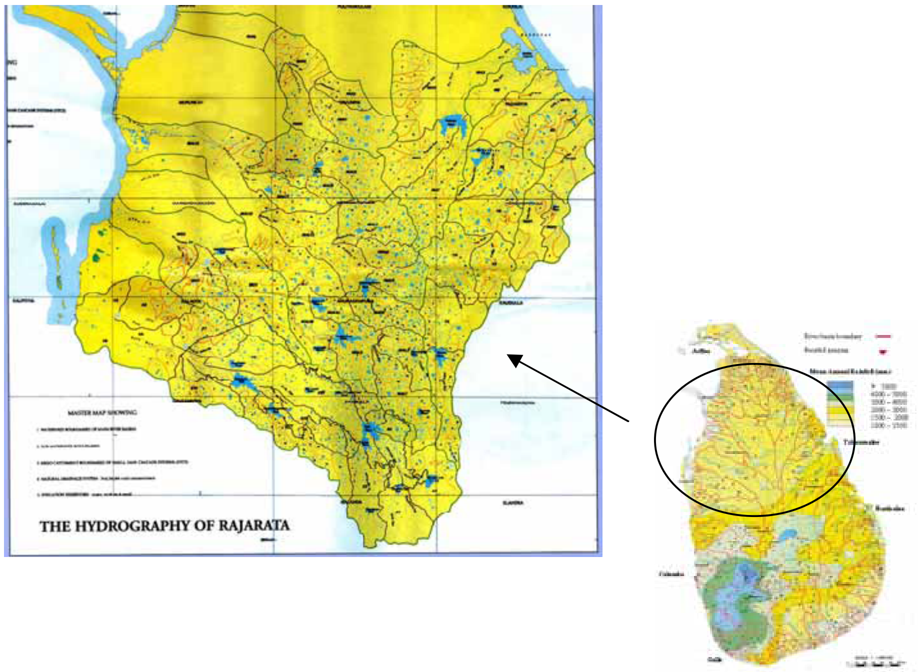

Fig 3.9 The network of small tanks and reservoirs in old days

in the north central part of Sri Lanka

Isolating one reservoir (the storage tank which was the biggest) –village unit from the rest of the cascade it enables to observe that the reservoir was one entity in the system which carried the importance of being the heart or the centre (Box 3.1). However there are evidences that reservoir though it's a manmade structure had closely woven relationships with the rest of the natural and human (environmental) systems around.

The communities that inhabited the tank villages were largely homogenous often confining to a single *caste or clan*. Therefore, one could suggest that, there the community spirit had been high, fostering the practices of sharing as reflected in the *bethma* (share) system. In the village rice field, tail-end of the irrigation ditches was related to those of the top-end either by descent or by marriage, which resulted in scattering of land parcels insuring them against severe droughts or damage from wild life. The rice fields were laid out as elongated strips parallel to the tank bund so that water management would be more rational (Figure 3.10). Whatever produced from the local resource base was sufficient for an egalitarian life style, with rice for all meals supplemented with finger millets and vegetables from *chena* farming and freshwater fish from the tanks (Maddumabandara, 1985). Obviously further from the complexities a today's similar system would have subjected to, a village in this system can be regarded as been closely knitted yet virtually self-sufficient except for very few goods and services.

In addition the environment around the reservoir always takes a similar shape, where trees grown in the close vicinity and upstream of it are always preserved, hence unlikely for any settlement. Often some superstitious beliefs were been integrated which subsequently led in achieving command and respect from the villagers for such resource management strategies. For instance in the *gama* there were clans who have been generationally given the task of protecting the reservoir, sometimes having considered as possessing spiritual powers, who may have generationally known the importance of the forest cover and taken the responsibility in the upstream areas and the immediate vicinity to sustain the water level in reservoir. Likewise in order to protect one entity of their system, they naturally could have respected and protected some other entities. The reservoir of course is needed for drinking water as well as the food production, so in other words if you take the village as one unit and reservoir, villages, forest as three other units for the viability of the system as a whole, the mutual behaviour and interactions with aspect to each of them highly mattered. The whole human and natural system always seen as the village itself is extensively influenced by its sub systems quite strongly that, the boundary between these sub units must have become vaguer and illusive.

On the other hand the water management system itself has some intrinsic unique features. More often than not they were linked with logical thinking, experiences, the existing management and command structure in the society etc. One significant fact about such management strategy, is that, though the whole relationship might have been woven around human interest in the first place, eventually it becomes less personal and more task oriented, to preserve a system which by experience known to be a vital part of whole system's (often the village system's) integrity. Such management often were not restricted to the reservoir, smaller tanks or the connecting canals, but for the feeding river and surrounding forest cover etc as well.

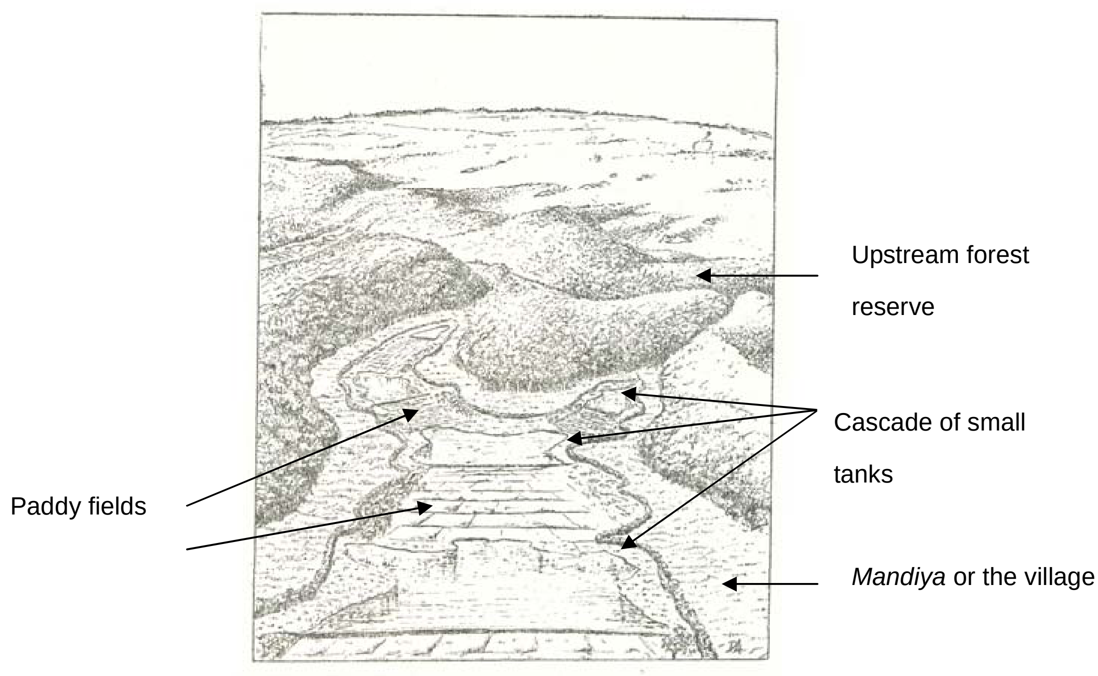

Fig 3.10 An artist's impression on village tank cascade system

Source: Maddumabandara, n.d

Though the village-tank system could be easily seen as one entity, as described earlier it is automatically linked with a cascade of many similar ones fed by the same source of water (Fig 3.10). Such interdependency on the other hand had created the sense of responsibility among the users of the water upon a similar system's which they are naturally linked to, for instance some of these systems (let's call them other villages) obviously depended upon the release of water from the reservoir to downstream, and the same relationship reversed may have existed with some other entity. As overall, several of these villages belonged to the same watershed. The significance of a certain watershed in terms of their capacity on food production may have affected the wellbeing of the area naturally, hence the security and integrity of a whole geographical boundary itself. More than mere interactions, the interdependencies naturally created triggers in behavior patterns in this society. In one sense these triggers can be called as another form of intrinsic dynamics, yet these intrinsic dynamics, obviously can be again explained in terms of both flat planed or short term social interactions (horizontal process dynamics) and, the ones which propagate over the time (vertical process dynamics). For instance the decisions on how much water used for one set of fields, and how much is released to other fields, downstream tanks of the cascade would have depended highly on water availability and the efficiency of the integrated management system. In other words behavior patterns, rules and regulations based on fundamental cause-and-effect relationships, short term feed backs, etc or forces and movements closer to specifically horizontal process dynamics can be easily differentiated (Fig 3.11).

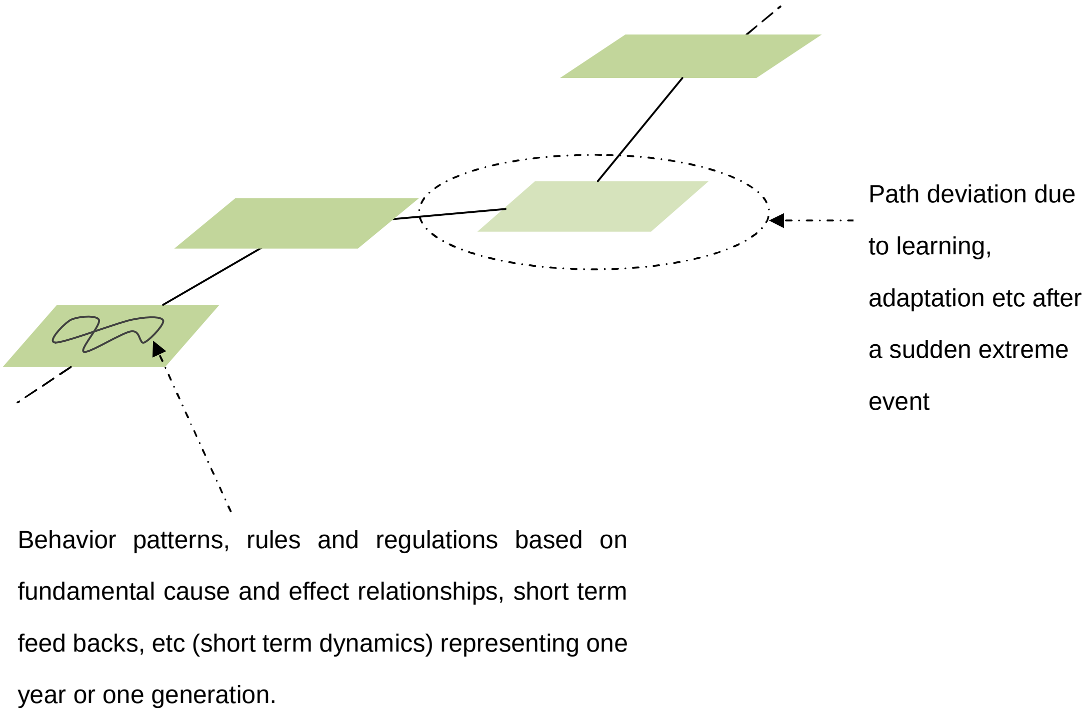

Fig 3.11 Visualizing Horizontal and Vertical Process Dynamics in relation to village-tank system

However, there are evidences that most of rules and regulations for the functioning of this management system have been embedded with the ethical values, norms, and soft cultural rules, prevailed for centuries in each village. In other words it is apparent that what may have looked as a successful integration of different systems to form an efficient management system may have intensively influenced by the experiences, teachings, accumulated over a long period of time within these cluster of reservoir-village systems. In some instances the process of accumulation of such normative knowledge and experience to create the tangible visible path of the management system, may have been disrupted or rapidly influenced by certain natural courses, for instance, extreme weather conditions, failures of dams, wars, etc, whose outcomes may have created new knowledge or experience which could have the direct effect of shifting the management system's usual path (Fig 3.11). Both such movements and forces, according to our definition can be regarded as vertical process dynamics. However it is important to note that what we see as the change of path or pattern of the integrated system after centuries now would have taken place by changes happened in set of flat planes which could involve one specific generation of villages, or even a few decades in time scale .

Likewise the water management system along with the societal life gives visible examples to differentiate the dynamics (both forces and movements) which cause that evolution in to the two mentioned main sub categories of horizontal and vertical process. This particular example leads to observation that outcomes generated by viabilities of sub-systems (intrinsic dynamics) can lead to form such space and time dynamics. However here we did not address sustainability in explicit terms that is nowhere it was mentioned whether the tank-village system, at particular stage or time period, was sustainable or not, rather the discussion included more of complex characteristics embedded to the system itself which creates evolutionary dynamics within the system. Starting from this broader perspective the next example described will address the path dynamics and sustainability in a much interwoven setting.

3.3.3 The Lake Victoria, the story known as Darwin’s Nightmare

Box 3.2. The lake Victoria, the story known as Darwin’s Nightmare

"Darwin’s Nightmare," Hubert Sauper’s harrowing, indispensable documentary, presents an agonized human face of globalization. While the flesh of millions of Nile perch is stripped, cleaned and flash-frozen for export to wealthy countries, millions of people in the Tanzanian interior live on the brink of famine. Some of them will eat fried fish heads, which are processed in vast open-air pits infested with maggots and scavenging birds. Along the shores of the lake, homeless children fight over scraps of food. In the encampments where the fishermen live, AIDS is rampant and the afflicted walk back to their villages to die. The Nile perch itself haunts the film’s infernal landscape like a monstrous metaphor. An alien species introduced into Lake Victoria sometime in the 1960’s, it has devoured every other kind of fish in the lake, even feeding on its own young as it grows to almost grotesque dimensions, and destroying an ancient and diverse ecosystem. To some, its prevalence is a boon, since the perch provides an exportable resource that has brought development money from the World Bank and the European Union. The survival of nearly everyone in the film is connected to the fish: the prostitutes who keep company with the pilots in the hotel bars; the displaced farmers who handle the rotting carcasses; the night watchman, armed with a bow and a few poison-tipped arrows, who guards a fish-related research institute. He is paid $1 a day and found the job after his predecessor was murdered.

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Filming with a skeleton crew - basically himself and another camera operator - Mr. Sauper has produced an extraordinary work of visual journalism, a richly illustrated report on a distant catastrophe that is also one of the central stories of our time. Rather than use voice-over or talking-head expert interviews, he allows the dimensions of the story to emerge through one-on-one conversation and acutely observed visual detail. But "Darwin's Nightmare" is also a work of art. Given the gravity of Mr. Sauper's subject, and the rigorous pessimism of his inquiry, it may seem a bit silly to compliment him for his eye. There are images here that have the terrifying sublimity of a painting by El Greco or Hieronymus Bosch: rows of huge, rotting fish heads sticking out of the ground; children turning garbage into makeshift toys. At other moments, you are struck by the natural loveliness of the lake and its surrounding hills, or by the handsome, high-cheek boned faces of many of the Tanzanians.

The beauty, though, is not really beside the point; it is an integral part of the movie's ethical vision, which in its tenderness and its angry sense of apocalypse seems to owe less to modern ideologies than to the prophetic rage of William Blake, who glimpsed heaven and hell at an earlier phase of capitalist development. Mr. Sauper's movie is clearly aimed at the political conscience of Western audiences, and its implicit critique of some of our assumptions about the shape and direction of the global economy deserves to be taken seriously. But its reach extends far beyond questions of policy and political economy, and it turns the fugitive, mundane facts that are any documentary's raw materials into the stuff of tragedy and prophecy.

The New York Times

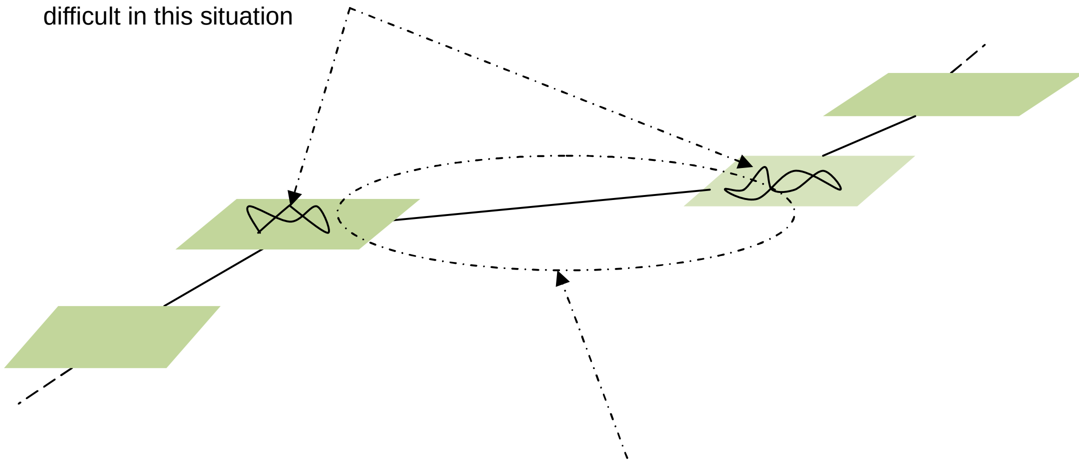
This final example taken is based on a true story which is successfully depicted in the movie Darwin's Nightmare (Box 3.2). To one, the story caries the weight of unsustainability, while to another it may reflect just an unavoidable reality, a transition stage of a societal evolution. Whichever the interpretation it is a complex situation, where the geographically bounded lake centered socio-economical system's own internal dynamics are shaped by inflows and out flows linking the external world. In other words it reflects how the complexities of globalization can affect one particular seemingly closed system, and how the forces of certain actions, behaviors of many involved within this system may generate complex dynamics, which on their own are closely than ever linked with the system's current position in terms of sustainability. In addition the scenario is a good example to understand both the concept of sustainability sphere with its closely related entity, sustainability path (please refer back to section 3.1 for basic illustration), and the three identified components of dynamics which are observed to create that path.

The interactions and forces in this setting is closely linked with three factors, the lake ecosystem, the local community, and institutions which links the local socio-ecological system with the rest of the world, mainly the market based capitalistic economic system and the network created by its core and peripheral functions. Victoria Lake gives a metaphorical appeal to the story, with its previous importance as a key entity in evolution, where with a single scientific experiment, by introducing a predatory species, has led to create an imbalance which reaches beyond the boundaries of lake eco-system. For instance this imbalance has effected traditional fishing community in the vicinity of the lake, making them abandon their familiar livelihoods to "frame and head left over when the fillets are taken for export" as Kaufman, 2006 puts. On one hand this gives a good example on intrinsic dynamics, how one system's disrupt of balance will effect or create negative triggers for another system (the traditional fishing community) that enclose and rely upon it. And as explained, the movie depicts numerous side effects of this social disruption has created, which have already gone beyond one generation (for instances the cycle of unemployment and uneducated working force, street children, prostitution, drug addiction etc). The evolution of the interdependency problems created in this society can be identified relative to both short-term and long-term time axis. In other words the intrinsic dynamics identified here can have their close links to both of horizontal and vertical dynamics. On the other hand one could in his or her interpretation can look at the three systems explained (the lake ecosystem, local community and institutions) mutually excluded or distinctive from one another. In such a setting, one will identify that how the change in lake ecosystem has forced the human system to adapt to new changes, or how the institution setting, or the market in this instance, has created triggers for the local community to adapt to these change. Such triggers and changes are closely linked with current knowledge, beliefs, feedbacks, incentives etc. For instance what force the fishing community to adapt in to new supply chain of fish export industry is strongly linked with the incentive scheme or short term feedbacks created by the external changes they experience in their societal movements. Such drives may take both long term and short term face considering the changes they may generate in the society.

In one sense, it is easy to see that the vicious cyclic effect seen in this socio-ecological-economical system has strong ties with the institutional frame the human entity is consciously or unconsciously subjected to. Historically a village or clan which had a traditional social system (in terms of governance, economy, norms etc) must have provided a certain institutional frame to bind human with surrounding, most probably away from current world's complexities, but with entirely different sorts created over centuries of evolution. As mentioned earlier this particular society has had a metaphorically significant entity as its centre of evolution, then the introduction of the new fish species marks a change which literary took place overnight, and let its presence felt, within few decades. If let all the other peripheral effects which would have slightly supported the change in the whole system taken out, the incident marks a shift in the path the society has taken for generations, by first disrupting the ecological balance within the lake boundary, then interestingly effecting the human cluster which has depended upon this ecological balance of the lake, that is by depleting the usual fish stock they relied upon as their major economic resource, yet replacing it with a new stock. The new entity which is in fact an invading species, not suitable for the old retinal livelihood, but may have looked attractive for an entirely new institutional setting, also one could say that the species metaphorically represents the same institutional change, the adaptation of market based economic system, and rapid cultural and normative changes came along. The simple incident of abandoning traditional fishing methods to engage in a global export network represents behavioral patterns created in two different planes. What links these planes are the triggers generated in the form of, incentives, experiences, commands (please refer to section 3.2 for some views on what characterise command) etc.

The interesting factor here is the time lapse between the two planes in this case may have been relatively small while the space wise distance between them may have been relatively large (Fig 3.12). Conceptually it would be interesting to know if the transition from state A to state B in Fig 3.12 would have moved the integrated system's path away from a recognized sustainability sphere boundaries. However in reality it is hard to decide which sustainability is and which is not. In one sense imbalanced changes as above relative to time and space as illustrated in Fig 3.9 would suggest unsustainable conditions in the point of view of adaptability.

Different forms of Horizontal process dynamics triggered by institutional changes, incentive structures etc. Often the adaptation from one form to next can be expected to be difficult in this situation



The time lapse between the two planes in this case may have been relatively small while the space wise distance between these two planes may have been relatively large.

Fig 3.12 Visualizing Horizontal and Vertical Process Dynamics in relation to Victoria lake- village system

The case illustrated here could be a good example to justify the link between adaptability and sustainability. However it is important to note that most past advances in human history are followed by such leaps over the space (rapid changes which demanded heavy adaptations). For instance the path of human system, relative to its natural environment generated by rapid changes proceeded (or proceeding), learn of controlling adapt of fire, plant and animal domestication, invention of wheel, industrial revolution, or even the revolution of web 2.0, and many other past, present or future milestones, which could change the path of a system drastically from its initial direction, could not always referred as unsustainable.

3.4 Linking Dynamics and Sustainability

Once reached the stage of categorization or break down adapted in the process of interpreting path dynamics the natural question is raised, why such a categorization or interpretation of dynamics needed? What advantage we will have by knowing a reality, in a simplified light? Now that we have distinguished three kinds of dynamics which could navigate a society through its path, how would that knowledge supplements the sustainability paradigm we all are impatiently talking about? In other words what is the link between the form of dynamics explained in the latter section with the initial model?

Therefore, with the theoretical base of sustainability sphere, sustainability path and then the path dynamics (patterns of movements along the path), the next step was to link all these concepts together so that the meaning of Sustainability Dynamics is made much clearer.

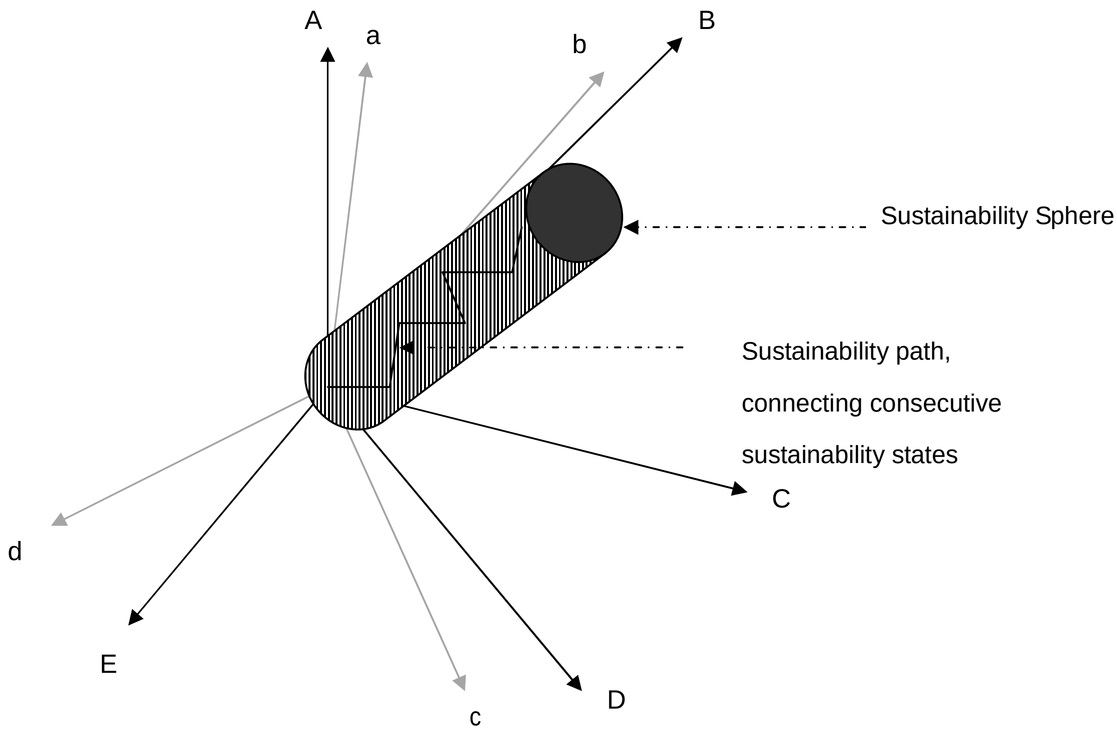
The three cases described in the previous section in order to further illustrate path dynamics carried an extended discussion on the possible causes led to such dynamics. Starting from light cause and effect relationships in first case (section 3.3.1), tank-village system in the second example reflected a more complex setting yet confined to a few identifiable socio-environmental relationships in a relatively closed system. The main significance of this case was while interpreting three types of path dynamics, no specific reference was done to any sustainability /unsustainability concern. However the description may have given the reader an insight that most of the forces which generate path dynamics are on one hand highly interwoven with normative factors to distinguish simple cause and effect relationships, on the other hand are generally quite intrinsic to the system. However the third example, that is on Lake Victoria was much integrated with the sustainability discussion, raising few unsustainability conditions on the process, which implies that already the senario had been analyzed according to some sustainability principles.

Now going back to our first most attempt to visualize what is referred to as the sustainability sphere or the sustainability space, two fundamental prepositions were taken;

i. Any form of interpretation of sustainability would not be complete if not its assumptions, interpretations, rationalizations etc are based intrinsically strongly on the concerned system or cluster of systems.

ii. In this intrinsic placement, both internal and induced (external) dynamics of the system are essential concerns. Internal dynamics are the ones that generated by system's original functionality, the induced dynamics are the ones the system is subjected to by external strengths, limitations, forces etc, in the current context could be a set of principles which characterize or define sustainability.

In the example of market based capitalistic system, based on these two prepositions a metaphorical interpretation of sustainability was introduced (Satanarachchi and Mino, 2009) It is important to note that this particular interpretation was done much in viewpoint of the concerned system's internal dynamics, the dynamics of market based capitalistic economic system. However as explained in order to visualize what is sustainability or unsustainability conditions within this external system, certain fundamental principles such as resource limitations, ethics (in the form of societal equality/inequality), environmental degradation (in the form of externalities) were taken in to account. In other words it is more like super imposing forces which generate sustainability/unsustainability on top of the movement or evolution of the system's natural dynamics. Therefore for a random system, the process could be generalized as illustrated in Fig 3.13.



Note: A, B, C,D, E are the dimensions reflecting the forces which generate concerned system's internal dynamics; while a, b, c, d are the ones reflecting the forces which generate dynamics linked to induced dynamics which includes sustainability principles(ethics, intergenerational equity, carrying capacity etc); such governing principles would change depending on the situational conditions.

Fig 3.13 Concept of sustainability path and sustainability sphere- linked to form sustainability dynamics

A, B, C,D, E are the dimensions reflecting the forces which generate concerned system's internal dynamics; while a, b, c, d are the ones reflecting the forces which generate dynamics linked to other external factors which may come under sustainability principles. These principles could be ethics, intergenerational equity, carrying capacity etc. And they would change depending on the situational conditions. The forces and triggers generated by both such internal dimensions and sustainability/unsustainability (external) dimensions along with the movements themselves create the path of the system within, towards or away from the conceptualized sustainability sphere. Therefore such movements along with forces which cause those movements within the sphere can be called as **sustainability dynamics**. It is important to note once again that sustainability dynamics are created by both internal and external functions of the system. And they are the ones which will determine whether a system's path is sustainable or not, and they are the ones which might even support to purposefully navigate a system away from its current state.

It is noteworthy to mention that the shape of the sphere is simplified for the sake of interpretational ease, yet depending on the balancing forces generated by internal and external dynamic dimensions the sphere can take any form of complex shape. At the same time theoretically it is possible that there might be systems which may not have such sustainable regions within their current forms. In addition in order to identify or visualize the path within sphere, one has to get away or detach himself from the system or the cluster of systems concerned to a higher or outer level. This is much like a person is taken out of the three dimensional space he has always lived to a higher dimensional space. Such a step will allow one to see the movements which create the path any system takes in space and time enabling to identify the direction the concerned system's path should take in order to maintain its sustainability. Again when one talks of sustainability of a specific system it is mandatory fact to realize that sustainability could not be perceived highlighting one system alone, making it separate from many other internal or external systems it would be directly or indirectly linked to. However such a detaching process from the system will allow seeing at least to a certain extent the relationships a system will have with its environment or the outside.

In order to understand sustainability dynamics further the zooming in or observing such movements and forces in micro level, has led us to interpret such movements in a different light. Two strong patterns linked to space and time was differentiated naming them Horizontal Process Dynamics and Vertical Process Dynamics (the Intrinsic Dynamics were subsequently explained as forming subsectors of HPD and VPD). As described how one perceive these path dynamics of a system, in relation to time and space-bound significance is the basis for suggesting for horizontal and vertical process dynamics.

Summarizing the whole process the definition derived for sustainability dynamics could be framed as follows.

Sustainability Dynamics

Any system or cluster of system's sustainability will be decided by how various characteristics which interact and evolve over time. Relative to these characteristics within the system there could be spaces within which the system's path would be regarded as sustainable, while a path outside could be seen as unsustainable. If such a space is called as sustainability sphere and the path within as sustainability path, both the movements and what course those movements along the path (path dynamics) could be called as sustainability dynamics. The dimensions or characteristics which govern sustainability dynamics may be internal or external from the system's basic functionality, some of the external ones may be sub categorized according to a set of sustainability principles.

As you may have already noticed, the method adapted to reach the thesis is converging from different directions or planes of perceptions to improve the holistic view needed for the cumulative concept. However it is identified that it has the potential to be further strengthened by approaching it with a comprehensive case study and try to identify;

i. The dimensions of internal dynamics of the system (shown by axis A,B,C,D.. in Fig 3.13)

ii. The dimensions of induced or external dynamics, which are related to contextually relevant sustainability principles (shown by axis a,b,c,d..in Fig 3.13)

iii. The ranges along these dimensions which in theoretical sense would generate the sustainability sphere

iv. How system's changes which effect its positioning relative to those recognized axis will change the path of the system relative to time (in the form of HPD and VPD explained in section 3.2)

Such a process on one hand would enable to provide a structured basis to evaluate whether a particular system or a cluster of systems is within sustainability sphere, in other words along the sustainability path or not. This could be regarded as a form of holistic sustainability assessment.

On the other hand thorough understanding on the interrelationship between the forms of dynamics (mainly the VPD and HPD) and the characteristics which generate the triggers and forces for these forms (internal and external dimensions of dynamics) would enable to identify significant unsustainability forces within the system, and in addition may enable to guide the system to reach back to its sustainability path.

However in reality in order to do this cumulative analysis, a deep understanding about the system is necessary to come up with minimum number of dimensions which could describe the general dynamics, and then would need to identify the ranges of each of those dimensions which will decide the boundaries of sustainability sphere. And eventhough theoretically the process looks logical enough in reality the interdependencies of these dimensions will be complex (as possibly with the case of tank-village system explained in section 3.3.2), hence may need both time and effort to generate a comprehensive individual sustainability dynamic model for the system.

As mentioned above the discussion in the case of Lake Victoria (section 3.3.3) already to a certain extent may have formed the basis to such a cumulative analysis, by addressing the village system's internal dynamics along with some of the sustainability principles which are concerned with the system. Here in addition to explaining just what VPD and HPD are, the discussion included a basic analysis on what may have caused each of these forms of dynamics, in other words, in our view it has already taken a step towards identifying the dimension which govern those forms of dynamics.

So, even though within this thesis itself, we could not go further as validating and using the cumulative model of sustainability dynamics (Fig 3.13) for one comprehensive study, with the insight gained so far we would suggest that the conceptual model has a strong potential to be further strengthened and solidly applied in an area such as sustainability assessment.

Chapter 4: Discussion and Conclusion

Starting with a fundamental preposition that sustainability, instead of a past, present or future state is a continuous process which evolves over time, the thesis had been to understand what would dynamics specifically mean in relation to a discussion of sustainability, hence the dissertation has illustrated a logical process of conceptualizing *sustainability dynamics* which finally converged in to a conceptual model that is believed to have the potential to frame sustainability dynamics within firm scientific grounds.

Through evaluating various complex socio-environmental systems, on one hand from the viewpoint of their natural evolutionary patterns and on the other hand, through the lens of sustainability/unsustainbility, along the process, concepts of sustainability sphere, sustainability path, patterns of movements along the path (manly in the form of Horizontal Process Dynamics and Vertical Process Dynamics) and finally dimensions which form the sustainability sphere and determine the path movements, were developed in various stages. Finally adding them together the following conclusions were drawn.

-Any system or cluster of system's sustainability will be decided by how various characteristics which interact and evolve over time. Relative to these characteristics within the system there could be spaces within which the system's path would be regarded as sustainable, while a path outside could be seen as unsustainable. If such a space is called as sustainability sphere and the path within as sustainability path, both the movements and what course those movements along the path (path dynamics) could be called as sustainability dynamics. The dimensions or characteristics which govern sustainability dynamics may be internal or external from the system's basic functionality, some of the external ones may be sub categorized according to a set of sustainability principles- (The concept is visually illustrated in Fig 3.13).

Such interpretation highlights the fact that while sustainability could not be addressed decoupled from the complexities of numerous interlinked socio-environmental systems, in order to ensure a system's path continued to be kept within sustainable boundaries, we may have to disintegrate those complexities in to interpretable components, (to a certain extent a reductionist approach) and then link them back to see provisions to assess, change, maintain or trigger dynamics within the system.

Finally it was identified that the developed conceptual model for sustainability dynamics could be further strengthened and brought in to next stage by one or few solid and comprehensive empirical justifications which could explain the whole concept as one integrated entity. Such a strong basis is believed to enable the model to be successfully utilized in future sustainability initiatives, especially in form of assessment or even what we may call as sustainability movement.

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