

SUSTAINABLE DEVELOPMENT AND COMPLEX ADAPTIVE SYSTEMS

Marita Naudé*

Abstract

The aim and contribution of this paper at a theoretical level is to discuss CAS and the principles thereof as an alternative to traditional management models as an option to enhance SD in an integrated and holistic manner. At a practical level, the author discusses management and leadership suggestions to implement the principles of CAS to enhance SD. A CAS approach is not static and allows for and encourages emergence as a result to the changing internal and external environments. As CAS is a process that allows for constant change and adaptation it could be compatible in the organization's SD challenge that is also constantly changing and adapting in response to the internal and external environments. Translating an integrated, holistic and CAS approach might require some cognitive, structural and political changes in the thinking about and understanding of how to deal with SD.

Keywords: Sustainable Development, Complex Adaptive Systems

* Associate Professor, Curtin Graduate School of Business, Curtin University, 78 Murray street, Perth, 6000, Western Australia
Tel.: +61892667615

E-mail: marita.naude@gsb.curtin.edu.au

1. Introduction

There is evidence that sustainable companies create economic value, healthy ecosystems and stronger communities; they are resilient and better able to survive both external and internal changes and shocks; they are over the longer term better able to effectively balance the economic, environmental and social and dimensions (Laughland and Bansal, 2011; Wals and Schwarzin, 2012; Baumgartner and Korhonen, 2010; Velazquez, *et al.*, 2011; Jamali, 2006; Epstein and Buhovac, 2010; Epstein, *et al.*, 2010). In most companies Sustainable Development (SD) is regarded as an important part of the company. In a 2010 survey by the Accenture and UN Global Compact which included 766 CEO's worldwide, 93% of the CEO's stated that sustainability is crucial to the long-term success of the company. In addition, 75% of participants stated that they select sustainability strategies to grow revenue, protect and build product, enhance corporate reputation and potentially decrease cost (Boerner, 2010). Nevertheless, the statement "Sustainable development is one of those ideas that everybody supports but nobody knows what it means" (Sir Jonathon Porritt quoted in the Financial Times, 1998) still rings true. At both theoretical and practical levels there seems to be a great deal of confusion as to what SD actually means as there are numerous definitions and interpretations (Becker, 2010; Jabbour and Santos 2008; Wallis *et al.*, 2010). The author of this paper accepts a tridimensional (including economic, social and environmental dimensions on equal levels) approach to SD as the theoretical

background which provides a basis for the arguments in the paper. This approach is consistent with the views of many authors and organizations (Stead *et al.*, 2004; Byrch *et al.*, 2007; Valezquez, 2011; Elkington, 2006; Hart and Milstein, 2003; Linnenluecke and Griffiths, 2010; UN, 1992; UN, 1997; WCED, 1987). In addition, the author accepts the approach that any SD implementation needs to include relevant aspects related to justice, inter-generational and intra-generational equity and that corporations need to work with and fulfill the needs, demands and aspirations of current generations without compromising the needs, demands and aspirations of future generations consistent with views by Becker (2010), Jabbour and Santos (2008), and Steurer *et al.*, (2005). There will be a variety of different interpretations as these will reflect the different individual and company "worldviews" (Byrch *et al.*, 2007; Esquer *et al.*, 2008).

Although many companies globally have accepted SD approaches and agendas, the practical results are still not good if compared to the overall need for change at individual, company and society levels. It is becoming progressively more obvious that the older management models are not very effective in delivering the desired outcomes (Espinosa and Porter, 2011). In order to improve outcomes at all levels, many companies, communities and governments are implementing a range of innovative strategies related to SD. Furthermore, there is a growing interest to develop innovative, creative and new ways to understand and approach SD in a holistic and integrated manner (Ison, 2009; White and Lee, 2009).

Nevertheless, it seems that many organizations are still using management systems similar to the Taylor's scientific management theory and the assumption that a successful organization resembles a well-oiled machine. This machine has a designer, usually the Director or Chief Executive, who specifies the different parts, what these different parts will do and how they interact. This machine-like approach appears inappropriate within the 21st century business context where changes in populations, service requirements and technologies necessitate constant change and adaptation to ensure delivery of new, innovative, creative and evolving services (Rowe and Hogarth, 2005; Kernick 2002; Espinosa and Porter, 2011). As organizations are defined as complex adaptive social systems which evolve, change and produce emergent behavior in unpredictable ways an alternative to the traditional machine like approach is to use a Complex Adaptive Systems (CAS) approach (Alaa, 2009; Mitleton-Kelly, 2003). Within a CAS approach, organizations are regarded as living entities existing within a complex ecosystem (the business context). In any ecosystem, all the different individual entities are independent, have their own identity, co-exist and are dependent on one another for the maintenance of the whole system and thus survival. These entities interact with the environment and are in turn affected by it which creates a balance of interdependent elements. Living systems are not fixed and stable but change, grow, repair, adapt and evolve (Rowe and Hogarth, 2005; Kernick 2002; Espinosa and Porter, 2011). The CAS approach emphasizes the permeability, interaction and exchange of information and feedback across all boundaries particularly those between the organization, its subsystems and external environment (Scott, 1987). Similar to an ecosystem, survival and success are related to timely perception of key external changes and making the relevant adaptation of internal systems, elements and processes to effectively respond to these changes. It aims to improve the organization's adaptability and sustainability within the changed and/or changing context. CAS is a framework which is characterized by ongoing change and development, feedback across all boundaries and levels, co-evolving bottom-up and top-down development. It is a dynamic model and could address the key issues and solutions to enhance SD (Espinosa and Porter, 2011).

As a dynamic and adoptive framework CAS seems to be relevant to companies that are currently operating in global, very competitive, and turbulent environments that demand companies which are able to adapt, change, and improve in order to develop and maintain competitive advantage, increase organizational success or even survival (Kriegesmann *et al.*, 2005; Weldy and Gilles, 2010). This notion leads the authors to ask the following questions:

- As it seems that traditional management models are not very effective and successful to enhance a tridimensional approach to SD in an integrated

and holistic manner, what is an alternative option?

- What are the principles to implement CAS holistically at a practical level within a SD context?
- How do companies implement the principles of CAS to enhance a SD context?

The aim and contribution of this paper at a theoretical level is to discuss CAS and the principles thereof as an alternative to traditional management models as an option to enhance SD in an integrated and holistic manner. At a practical level, the author discusses management and leadership suggestions to implement the principles of CAS to enhance SD.

This paper is presented in three parts. The first part discusses the relevant literature which forms the basis for the arguments in this paper. The second part focuses on practical management and leadership suggestions related to the implementation of CAS and the key principles to enhance SD. The last part discusses research implications and suggestions for further research.

2. Literature overview

The literature overview focuses on SD and CAS.

2.1 Sustainable Development (SD)

Society increasingly demands more social and environmental responsibility from companies which in effect increase support for SD (Daub and Scherrer, 2009; Steurer *et al.*, 2005). SD needs to be part of the core business and management decisions as well as daily activities of the organization to be most effective (Hazlett *et al.*, 2010; Samy *et al.*, 2010; Epstein *et al.*, 2010; Chuang and Liao, 2010). There are multiple and/or unclear definitions for SD which create some confusion in both theoretical discussions and practical implementations. SD is a value judgment which means different things to different people and companies but at a practical level SD is sometimes not clearly defined in the company. In addition, some areas of SD can only be assessed by inference from what is observed and there are not always tested frameworks and models available which are suitable to a particular company within its context (Becker, 2010; Jabbour and Santos 2008; Wallis *et al.*, 2010). Furthermore, it seems that little practical and implementable progress has been made regarding SD issues in the day-to-day functioning of companies and communities where these companies are operating (Baumgartner and Korhonen, 2010; Becker, 2010; Jabbour and Santos, 2008). In spite of the different definitions and interpretations, SD poses both a global and long-term challenge. Although there are different definitions and/or interpretations (Esquer *et al.*, 2008) there seems to be consensus that SD should have a tridimensional approach including economic, social and environmental dimensions at

equal levels (Byrch *et al.*, 2007; Valezquez, 2011; Naude, 2011). There is agreement that key issues in SD include that corporations need to work with and fulfill the needs, demands and aspirations of current generations without compromising the needs, demands and aspirations of future generations (Becker, 2010; Jabbour and Santos, 2008; Steurer *et al.*, 2005).

The author uses a tridimensional approach to SD. The economic dimension includes aspects such as financial performance, longer term competitiveness and economic impact. The focus of SD is on longer term approaches which mean that a company which claims that it is sustainable needs to take the necessary steps and set relevant strategic direction, goals and objectives. The company then needs to plan and implement effective strategies, programs and activities and monitor and evaluate outcomes to secure and improve competitiveness. The social dimension includes both internal and external social improvements where internal social improvements address the needs of employees and external social improvements address the needs of the community members in which the company operates. The environmental dimension includes environmental damage and risks management, responsible use of non-renewable resources and responsible management of emissions (Steurer *et al.*, 2005). In the process to create, develop and accomplish a balance, the company sometimes need to make a clear shift from merely maximizing profitability and 'doing things better' to maximizing meaning and value, and 'doing better things' (Wals and Schwarzin, 2012; McKibben, 2007).

There is clear evidence that companies which implement SD approaches and practices seem to be resilient; create economic value, healthier ecosystems and stronger communities; are able to survive both internal and external shocks, changes and shifts. When companies implement a SD approach it needs to integrate economic, social and environmental goals and strategies while drawing on the economic, social and environmental information to lead to more sustainable and relevant choices. This integrated approach demands a diverse range of relevant managerial, technological and company innovations (Laughland and Bansal, 2011; D'Amato and Roome, 2009; Baumgartner and Korhonen, 2010; Velazquez, *et al.*, 2011; Epstein and Buhovac, 2010; Epstein, *et al.*, 2010). SD is seen as an approach to guide companies to focus on the longer term and a time span of several generations (Becker, 2010; Jabbour and Santos, 2008; Steurer *et al.*, 2005).

In the process of implementing a tridimensional approach to SD goals strategies, processes and procedures, companies face a range of challenges (Epstein *et al.*, 2010; Hart and Milstein, 2003; Wirttenberg *et al.*, 2007) which include:

- There are multiple definitions for SD at individual, company and community levels.

- There needs to be a balance among and excellence in the economic, social and environmental dimensions which is sometimes very difficult to achieve.
- Economic performance is usually more easily measurable and possible over a short term period but both social and environmental impacts are not always easily measurable and mostly longer term. Sometimes, companies have relevant measures for implementations related to the environmental and social dimensions, but these measures are not always linked to the economic dimension.
- Integrating social, environmental, and economic impacts into operational and capital investment decisions and strategies has the potential to create difficulty and tension.
- Although social and financial initiatives might benefit each other in the longer term, there could be a conflicting need for resources in the short term.

Regardless of the diverse range of challenges, many individuals, organizations, communities and governments are increasingly engaging in SD strategies and incorporating their own understanding of SD into various aspects of their goals, strategies, systems, processes and procedures. Within their respective interpretations there seems to be emphasis on economic, environmental and social dimensions and inclusion of key concepts such as equity, fairness and futurity. The different interpretations capture the differing emphases (Byrch *et al.*, 2007). The concept SD seems to be part of the terminology within the current business context with 93% of the CEO's in a global survey stating that sustainability is crucial to the longer term success of the company (Boerner, 2010; Baumgartner and Korhonen, 2010; Becker, 2010; Patra, 2009).

Although companies are implementing SD goals and strategies it is becoming clear that the older and traditional management models are not very effective in delivering the desired outcomes and impacts (Espinosa and Porter, 2011). Furthermore, there is a growing interest to develop innovative, creative and new ways to understand and approach SD in an integrated and holistic manner (Ison, 2009; White and Lee, 2009). SD should be a co-evolutionary process of improving management systems through improved understanding and knowledge in an effort to enhance longer term SD (Rammel, *et al.*, 2007) and CAS offers such a holistic and co-evolutionary process.

2.2 Complex adaptive Systems (CAS)

Traditional Newtonian theory defines systems as collections of distinct parts which could be broken down and analyzed in parts, thereafter re-aggregated into a functioning whole. However, this approach is ineffective when the systems in question are turbulent, constantly changing, very interactive in

multiple directions simultaneously, and self-organizing. Traditional linear frameworks, models and methodologies cannot capture the multiple variabilities commonly found in complexity (such as a company) dilemmas today (Regner, 2001). Turbulent and constantly changing environments challenge organizations to be able to detect and create new and different opportunities and then select those opportunities that are worthwhile to engage in and allocate resources to in order to be effective and competitive (Cunha, 2004). When organizations find themselves in environments and marketplaces such as the current business context which is characterized as complex (rather than merely complicated), directors, leaders and managers need to mimic complexity

principles in their own structure, systems, policies and operations (Espinosa and Porter, 2011). Organizational sustainability and SD is not a continuation of the status quo. When viewed from a complexity theory perspective, it is a continuous and dynamic process of co-evolution within a constantly changing environment (Mitleton-Kelly, 2011). Along this line of thinking it is clear that a complex business context needs a complex approach and CAS is one such example. In addition, not all complex systems are adaptive and not every adaptation increases the company's chances of survival or success (Espinosa and Porter 2011). Table 1 summarises the differences between complicated, complex and complex adaptive systems.

Table 1. Differences between complicated, complex and complex adaptive systems (Goldstein *et al.*, 2008; Richardson, 2008; Espinosa and Porter 2011; (Richardson, 2008; Cross *et al.*, 2003; Rammel *et al.*, 2007).

System	Description
Complicated	System can be described in terms of its individual constituents (even if there are a huge number of constituents).
Complex	Interactions among the constituents of the system are of such a nature that the system as a whole cannot be fully understood simply by analyzing its components. In a complex system there is interaction and networks (and not only a reductive simple system); it allows a holistic approach; collective action and decision-making is of greater interest than individual charisma and agency. Causality is networked rather than singular and is a shift that questions conventional models and methods of linear causality.
Complex Adaptive Systems	A range of complex behaviours that emerge as a result of interactions among system components and/or among system components and the environment. In the process of interacting with and learning from its environment, a complex adaptive system modifies its behaviour to adapt to changes in its environment. CAS have a range of key characteristics which include self-organization, co-evolution, edge of chaos, emergence, path dependence, attractors, feedback loops and fitness landscape.

Companies never operate in a vacuum as almost every activity implemented by a company, impacts either positively or negatively on the community in which it functions (Porter and Kramer, 2006). Similarly, organizations are complex adaptive systems and they are in constant symbiosis with their environment. In the current business environment, organizations are operating in increasingly changing, demanding environments and they face challenges and developments related to technology, changing demographics and demands from employees, communities and societies. In addition, organizations face many other internal and external challenges including increasingly information-based, knowledge-driven and service intensive economies. Based on this notion, survival and success in this climate requires speed, flexibility, organizational changes such as mergers, joint ventures acquisitions, restructuring and retrenchment of employees (Brooks, 2005; Khandekar and Sharma, 2005; Pepur *et al.*, 2010; Price and Chahal, 2006). Jack Welch echoed this notion and stated: 'When the rate of change outside an organization exceeds the rate of change inside, the end is in sight.' (Batterley, 2004: 30). Darwin's Adaptability theory stated that all species must adapt

to their environment to survive. This argument holds true and is widely accepted in organizations (Denton, 2006).

CAS in general

The CAS approach is an open systems framework which reflects the ecological model idea where organisms and their environments co-evolve. The basic assumption is that the organization has a symbiotic, co-evolving relationship with the greater society and environment. CAS offer a planning and analytical tool to observe and understand the dynamics and co-evolution of organizational networks (Espinosa and Porter, 2011) and organizations are complex adaptive systems filled with uncertainty (McDaniel, 2007). When implementing CAS it allows organizations to incorporate variability, adaptations, uncertainty and non-linearity while at the same time improve understanding of co-evolutionary processes and dynamic patterns emerge, develop and interact across hierarchical levels (Cross *et al.*, 2003; Rammel *et al.*, 2007). Similar to ecosystems, sensitivity to external events and the flexibility to adapt in a timely manner are key success factors for organizations

seeking to improve SD. Survival and success are related to the timely perception of both key external and internal changes and adaptation of internal strategies, systems, processes and procedures to respond to the relevant changes. The purpose is to improve the organization's adaptability and sustainability within its internal and external environment. CAS are frameworks characterized by ongoing change and development; feedback across all levels and boundaries; co-evolving bottom-up and top-down development; a growing focus on processes instead of only performance (Espinosa and Porter, 2011; Hawkin, 2007). Most organizations are complex in nature as the interactions between different individuals and between groups are non-linear. In addition, CAS are multi-dimensional and include political, economic, social, technological, cultural and physical dimensions. These different dimensions influence each other and as a result change the organization's environment through a continuous and co-evolutionary process (Mitleton-Kelly, 2011). CAS interrelations and interdependencies are characterized by ongoing change and development, feedback across both micro and macro levels, and by co-evolving bottom-up and top-down development. CAS are dynamic frameworks that could highlight solutions to enhance SD (Espinosa and Porter, 2011; Hawkin, 2007). CAS are interactively complex and displays quick and unpredictable change without any apparent patterns (Tan *et al.*, 2005).

CAS are made up of a diverse range of agents, elements, systems and subsystems which interact in densely connected networks. Agents process information and have the capacity to modify their behavior based on the information which they have received (McDaniel, 2007). A large number of elements interact in a dynamic way and much information is exchanged. Complexity results from the patterns of interaction between the elements and/or the individual agents: for example, the people in an organization. The different agents will interact in unpredictable and interconnected ways which cannot be controlled in a centrally managed way. New generative relationships can stimulate change and generate solutions to complex problems (Rowe and Hogarth, 2005; Espinosa and Porter, 2011; Nishiguchi, 2001; Goldstein *et al.*, 2008; Sawyer, 2005; Holden, 2005). As the agents are allowed and encouraged to respond to inputs and stimuli in a range of different and fundamentally unpredictable ways, surprising behaviour (both good and bad) may emerge (Tan *et al.*, 2005).

The agents are diverse from one another and this diversity is beneficial as a source of creativity which is needed for survival (McDaniel, 2007). Agents within an organization act according to their own internal rules or mental models and these mental models could have either a positive or a negative influence on adaptability (Rowe and Hogarth, 2005;

Espinosa and Porter, 2011; Nishiguchi, 2001; Goldstein *et al.*, 2008; Sawyer, 2005; Holden, 2005). During implementation of CAS, organizations learn from previous experience with new behaviours emerging and allowing organizations to adapt accordingly. CAS encourages patterns of behaviour from which self-organization happens spontaneously, behaviour is non-linear and small changes can lead to large effects. Within CAS all behaviors (even complex behaviours) evolve from simple and basic rules which then lead to a diverse range of possible outcomes which are unpredictable (Penprase and Norris, 2005).

CAS recognises that an organization exists within the context of a larger environment, emphasizes the permeability, interaction and exchange of information and feedback across all boundaries and levels particularly those between the organization, its subsystems, and its external environment. This approach suggests that organizations take inputs from the internal and external environments that can directly or indirectly affect performance and outcomes. CAS are embedded in the context and no single element or agent (individuals in the organization) can know, comprehend, or predict the different range of actions and effects which are operating or will be operating within the system as a whole (Holden, 2005). No single agent knows and understands exactly what is happening in the overall system but each agent gains information from and pays attention to the local environment and responds primarily to other agents in that same local environment. As no chief agent has the capacity to oversee the complexity in the whole system there is no chief agent which directs the behavior of all other agents. Not even an extensive network of computers really fully capture, interpret and understand an organization's dynamic complexity as it is beyond a computer's capacity to recognize, interpret and/or understand the multiple informal relationships that emerge from both social and task relatedness and also how these relationships affect internal and external agents. Furthermore, a computer system is incapable of capturing the tacit knowledge which enables an organization to function (McDaniel, 2007).

When a social dimension and human aspect (as part of a tridimensional approach to SD) is embedded as part of the CAS approach it has the added benefit that it is different from CAS observed in the nature. In a model with the social dimension embedded, it co-creates emergent creativity and learning within the boundaries of administrative control and coordination; it addresses and highlights the role of organizations and the interactive technologies in the co-creation of learning, creativity and adaptability. In an organization this leads to the acquisition and transfer of knowledge, modifying behavior to reflect the new knowledge and insights (Desai, 2010). In a CAS approach the development of political, social and/or

cultural order is the combination of individual intentions and the collective result of non-linear interrelationships and interactions (McDaniel, 2007).

CAS key behaviours

CAS have specific key behaviours and these are discussed in detail below.

Self-organization: Within CAS frameworks self-organization refers to the spontaneous emergence of both new structures and forms and new elements emerging at various points and times. These changes may be incremental or dramatic in nature as they adapt to and change according to reactions between subsystems and with other systems. It usually is a spontaneous and bottom up process through interactions and interrelationships whereby a system's elements and agents interact and recombine with not much top down design or control (Rowe and Hogarth, 2005; Espinosa and Porter, 2011; Nishiguchi, 2001; Goldstein *et al.*, 2008; Sawyer, 2005; Holden 2005; McDaniel, 2007). Self-organization relates to processes that occur and happen that are not imposed from hierarchical control (Penprase and Norris, 2005; McDaniel, 2007).

The capacity for self-organization is a function of (among other things) the number and intensity of interrelationships and interactions. Too many interactions could result in behavior that never stabilises into a recognizable pattern. Conversely, too few interrelationships and interactions could result in frozen behavior rather than dynamical self-organization (McDaniel, 2007).

Emergence: Emergence is the development of creative, innovative, novel and coherent patterns and properties during the process of self-organization and is a consequence of CAS (Rowe and Hogarth, 2005; Espinosa and Porter, 2011; Nishiguchi, 2001; Goldstein *et al.*, 2008; Sawyer, 2005; Holden 2005). Emergence is unpredictable and this is fundamental to and one source of surprise in CAS (Goldstein, 1999). Emergence is not the same as serendipitous novelty (eg. patterns of raindrops on a window) but rather the result of non-linear dynamics generating new properties at the macro level of analysis (McDaniel, 2007).

Emergence is regarded as a holistic phenomenon because the whole is more than the sum of the parts and is the results of agents interacting and mutually affecting each other. Diversity enhances emergence due to the greater interaction and richer patterns. Emergence is often seen in crises when individuals and/or groups organize and adapt based on the urgent demands. Emergence is when novel patterns, structures, and ideas develop from the different interaction, interconnection and interdependencies between the different people and between different people and systems (Rowe and Hogarth, 2005; Espinosa and Porter, 2011; Nishiguchi, 2001; Goldstein *et al.*, 2008; Sawyer, 2005; Holden 2005).

Change is a result of multiple relationships, interrelationships, interdependencies and interactions between different people or systems and it is from these that new behaviours emerge (Penprase and Norris, 2005).

Edge of chaos: Interactions result in creative adaptations and change that emerge, often during times of crisis and this is referred to as the 'edge of chaos'. There will be simultaneous stability and instability at the edge of chaos. Edge of chaos is between stability and chaos and is where creativity and innovation develops (Rowe and Hogarth, 2005; Espinosa and Porter, 2011; Nishiguchi, 2001; Goldstein *et al.*, 2008; Sawyer, 2005; Holden 2005). During the edge of chaos groups self-organize and this might lead to innovative and creative ideas. The edge of chaos (which occurs between stability and chaos) is where creativity, innovations and new ideas occur (Penprase and Norris, 2005). The edge of chaos is the area where change occurs. Although the context is usually unpredictable, there is a feeling of excitement and a diverse range of creative and innovative ideas developed and discussed. The edge of chaos is unstable enough to stimulate new ideas to spontaneously emerge and is unstructured which means that most behaviours and/or outcomes cannot be accurately predicted. In addition, new behaviours emerge based on previous learned behaviours. Within CAS attractors, fitness of landscapes and feedback loops are some of the key components to understand and be able to operate at the edge of chaos (Penprase and Norris, 2005).

Attractors: Attractors emerge from organizations in an attempt to adapt to their respective environments and are those aspects that organizations, groups and/or individuals are naturally drawn to. Attractors:

- are prerequisites for order,
- govern behavior over time,
- serve as memory banks,
- have the ability to retain information over long periods,
- are vibrant enough to process information,
- serve as road maps for future behaviors build on previous experiences,
- assist to determine how change will occur,
- often function as feedback loops to behaviors.

Stable attractors keeps behaviors mostly in predictable patterns where the meaning is defined and understood by the organization, groups and individuals within that organization which then leads to more predictable behaviors and outcomes. These stable attractors encourage the status quo, a stable environment, leading to more predictable behaviors which are less creative and innovative. Conversely, unstable attractors could cause more creative and/or less desirable behaviors, could be positive if people are more readily adapted because the environment is thriving at the edge of chaos (Penprase and Norris, 2005).

Fitness landscape: All the interactions, interrelationship and interdependencies between different people and between different groups of people, different units, or different organizations form webs of feedback loops. These feedback loops moves organization into its fitness landscape (Rowe and Hogarth, 2005; Espinosa and Porter, 2011; Nishiguchi, 2001; Goldstein *et al.*, 2008; Sawyer, 2005; Holden 2005; Penprase and Norris, 2005).

The ability of an organization to adapt depends on the fitness landscape of that particular organization and in turn this is dependent on the organization's interactions with other organizations as organizations share environments. In any business context, all organizations are always competing as well as co-evolving. Organizations might compete for customers and staff. In addition, change in one organization will have an influence on and effect change in other organizations which share the same environment. Some change will include some response or reaction and doing nothing is also regarded as a response. When one organization makes any changes it has a ripple effect and will impact either positively or negatively on other organizations. Change cannot occur without this overall rippling effect which means that both competition and coevolution work together and result in continuous changes. Similarly, if change happens in one department of an organization it will impact on other departments and they need to adapt to occurring change in an effort to survive (Penprase and Norris, 2005).

Feedback loops: As there is no over-arching framework that controls the flow of information, interactions are rich, non-linear and there is the ability to exchange behaviour. Non-linear feedback is agents' ability to both give and receive responses to their own and other agents' behaviour (Rowe and Hogarth, 2005; Espinosa and Porter, 2011; Nishiguchi, 2001; Goldstein *et al.*, 2008; Sawyer, 2005; Holden 2005; Penprase and Norris, 2005).

There do not need to be a large number of interactions and interrelationships among agents to lead to orderly and meaningful functions. Understanding CAS necessitates the search for and understanding of patterns of non-linear relationships where the different inputs are not proportional to outputs and where small efforts to change systems could lead to big effects. Conversely, large efforts might result in little or no change. This non-linearity is very often the result of both positive and negative feedback systems which operate in CAS where one agent's activity can influence that agent as well as other agents. In non-linear relationships simple deterministic equations might produce an unexpected richness and variety of behavior. On the other hand, complex and seemingly chaotic behavior could lead to ordered structures and/or patterns. In non-linear equations prediction is very often impossible, even though the equations might be strictly deterministic (McDaniel, 2007).

Individual behaviors usually generate a range of broad changes and these form webs of feedback loops. These negative and positive feedback loops affect how an organization behaves in the future and could reshape the processes and/or structure of the organization. In addition, the relationship or feedback loops formed between individuals and between different groups or departments more important than the individuals themselves. CAS emphasizes that feedback loops are critical for formal and informal communication networks within an organization as they release and disseminate new and creative information to all levels in the organization (Penprase and Norris, 2005).

Co-evolution: CAS operate within disequilibrium conditions resulting in continual adaptation and response to the constant flow of energy into the system. Uncertainty is inevitable in and an integral part of an evolving system. Consequently, top-down control is impossible. Spontaneous change occurs more readily where there is a range of different behaviour patterns. During change it is crucial that the organization adapts to the change in a relevant and responsible manner and continues to thrive. If it fails to adapt it might slowly become extinct (Rowe and Hogarth, 2005; Espinosa and Porter, 2011; Nishiguchi, 2001; Goldstein *et al.*, 2008; Sawyer, 2005; Holden 2005; Penprase and Norris, 2005).

CAS do not simply change but they also change the environment in which they operate as CAS and their environments co-evolve. CAS adaptation to their environment is a moving target and cannot achieve a 'correct' position as it is a dynamic and continuously changing situation. Agents have constraints within themselves and among neighbouring agents which means that they need to compromise and co-operate to reach workable solutions rather than a 'correct' and superb solution. Organizations continuously monitor and evaluate each other in an infinitely complex process of co-evolution (McDaniel, 2007).

Path dependence: Path dependence indicates that emergent changes are directly tied to the particular system and history in which they have developed. Consequently, they do not represent universal causes or truth (Rowe and Hogarth, 2005; Espinosa and Porter, 2011; Nishiguchi, 2001; Goldstein *et al.*, 2008; Sawyer, 2005; Holden 2005; Penprase and Norris, 2005).

CAS limitations

It is crucial to understand that the adaptive capability of CAS do not necessarily equate to competitive success. CAS produce variations in the existing order which may or may not equate to success and survival for the organization within its environment (Espinosa and Porter, 2011). In short, any adaptation which enhances a specific optimisation process of an individual subsystem could fail to enhance the

resilience of the whole system (Rammel *et al.*, 2007). CAS does not mean that organizations need to abandon good 'traditional' management strategies such as decision making, problem solving, data analysis, goal setting, or evaluation and other relevant management strategies in their day-to-day operations. However, these need to be regarded within the overall CAS approach (Penprase and Norris, 2005).

3. Management and leadership suggestions

Within a management context CAS necessitate a fundamental paradigm shift from a mechanistic perception of an organization towards a self-organizing, autonomous understanding (Alaa, 2009). Intelligent and effective leadership is essential throughout and during all management implementations (Tan *et al.*, 2005).

For the purpose of this paper and within the constraints of the structure of a paper the author presents management and leadership suggestions as separate entities and in a linear format. However, the author recognises that the macro and micro levels of SD in complex human systems cannot be separated and advocates that an integrative and holistic approach is applied. Management and leadership implementations are described for each of the key behaviours of CAS namely, self-organization, co-evolution, edge of chaos, emergence, path dependence, attractors, feedback loops and fitness landscape.

Self-organization

The principle of self-organization necessitates capabilities and possibilities for bottom-up, top down, inside-outside communication and the role of management is to officially enable and encourage these channels. Furthermore, management needs to generate conditions where cross-channel communication is unhindered (Espinosa and Porter, 2011; Rihani, 2002). Moving away from a machine metaphor (many of the traditional management models) where senior managers determine actions of other levels of management and employees in the company to a model of collaboration and emergence (such as CAS) it means that large numbers of staff need to be involved in the decision-making and processes regarding the extent and nature of change. An example of self-organization is where employees develop proposals and responses relevant to the changing local circumstances and needs. In this process efforts are needed to keep the process as inclusive and participative as possible and enable and encourage field staff to direct the change. Consequently, there should be consultation with community members who might be impacted by the change, if only to a limited extent. Strategies could include structured large formal workshops and small

informal discussion groups (Rowe and Hogarth, 2005).

Employees need to feel that they were allowed to and had been given the go ahead from senior management to self-organize, try out a range of different new ideas, experiment with alternative procedures and processes to improve the current situation. They need to be able to discuss the outcomes openly and honestly within their group and even share it more widely and openly with others which might initiate cross-departmental projects and assist to bridge the sometimes tight boundaries between different specialities (Mitleton-Kelly 2011). Allowing and encouraging staff to self-organize and by developing a culture of trust staff are encouraged to learn from previous behaviours and then new ideas should emerge. Through a clear vision, simple building blocks, encouraging the freedom and flexibility to spontaneously self-organize (and regroup if needed) into groups with similar interests, results could be accomplished in a short time (Penprase and Norris, 2005).

Edge of chaos

The edge of chaos is where new ideas emerge and this might include conflict but with a good opportunity where people can actively work on relevant responses which might cause productive energy to shift to key problems (Espinosa and Porter, 2011; Rihani, 2002). At the edge of chaos, self-organization occurs as a result from the interrelationships, interactions and interdependencies between people and between people and systems. Consequently, leaders and managers need to create a culture of trust, comfort, acceptance combined with risk management assessment. The development of new ideas followed by support for viable ideas must be encourages and supported. However, this needs to be accompanied by careful risk management strategies suitable to the particular company (Penprase and Norris, 2005).

Attractors

Attractors include the values and behaviours which people or organizations are drawn towards and attractors are bound up with the professional and organizational identity of the different individuals. Some of the key attractors in an organization might consist of the practitioners' mental models, certain organizational rules, policies, structures and procedures which encourage certain ways of working and discourage others. Therefore, a combination of changing the external organizational attractors and facilitating exposure and debate of existing mental models should enable practitioners and managers to work towards future models based on their own fundamental attractor patterns (Rowe and Hogarth, 2005).

Fitness of landscapes

According to Penprase and Norris (2005) the leaders and managers in the organization have the role to:

- decipher trends and patterns,
- determine and create the purpose of their organization,
- set short-term and long term goals,
- set a clear vision that will also enable the organization to remain flexible and adaptive to both internal and external changes,
- assist and encourage staff to accept and adjust to changes,
- support coordination of the different elements of change,
- assist and support the different departments to maintain their focus and identity as it moves through a range of changes and adaptations.

Feedback loops

As employees self-organize and engage in conversations across boundaries, connections are made and direct, non-linear feedback occurs outside officially designated channels. This approach creates an awareness where agents recognize core opportunities and threats, and are empowered to focus on core, relevant and interesting issues (Espinosa and Porter, 2011; Rihani, 2002). When employees learn from and interact with each other through self-organization, they co-evolve with the environment which leads to emergence. Employees process information and modify behaviour based on the information which they receive. Non-linear interactions imply that input does not directly equate to output and sometimes relatively small changes might result in big changes (McDaniel, 2007, Penprase and Norris, 2005).

All the interactions, interrelationship and interdependencies between different people and between different groups of people, different units, or different organizations form webs of feedback loops (Espinosa and Porter, 2011; Nishiguchi, 2001; Goldstein *et al.*, 2008; Holden 2005; Penprase and Norris, 2005). The relationship feedback loops which are formed between individuals and between different groups or departments are more important than the different individuals themselves. Feedback loops are very important for both formal and informal communication networks within an organization as they release new information to all levels in the organization (Penprase and Norris, 2005). Based on this line of thinking it is very important that leaders and managers not only allow but also actively encourage both formal and informal communication networks to develop within an organization. Some strategies could include interdepartmental formal projects and informal get together (even on a social level).

For any feedback to be effective it should be direct, as soon as possible after the event, specific and constructive. Feedback loops should operate at all times, for both good and inadequate performances (Tan *et al.*, 2005).

Co-evolution

A CAS approach to SD management initiates a co-evolutionary dialogue where there is a continuous learning process driven by mutual and reciprocal interactions between the interlinked sub-systems and agents. Parallel to the co-evolutionary dialogue, the ability to form new relations, interactions and emerging properties enhances the chances of adaptive change (Rammel *et al.*, 2007). Co-evolution includes the dynamic interactions between two or more interdependent systems, which mutually affect each other's development. Therefore, co-evolution is regarded as an evolutionary process between two or more elements and/or sub-systems/systems and is driven by reciprocal selective pressures and adaptations between these elements and/or sub-systems/systems. In addition, co-evolution includes a range of nested hierarchies, inevitable uncertainties, multi-dimensional interactions and responses, and emergent properties. All this forms an essential part of human-environment interactions where both sides modify each other continuously through mutual feedback which creates a dynamic process and is shaped by qualitative change, learning and adaptation (Jeffrey and McIntosh, 2002; Berkes *et al.*, 2003; Rammel, *et al.*, 2007). In an effort to capture the co-evolutionary dialogue, management needs to invest in and design comprehensive systems of perception and monitoring (Walker *et al.*, 2002; Rammel *et al.*, 2007). Management for SD needs to address the key notion of adaptive capacity (the ability to perceive information and to send responses for adaptive change) in order to deal with dynamic change in a socially, economically and ecologically sound way. Organizations shape their environment and in turn are shaped by their environment (Rammel *et al.*, 2007).

Emergence

Emergence is characterized by organizational learning through the empowerment of bottom up and emergent processes to generate new and innovative ideas, progress to innovative development, trial projects, and adopt relevant new innovations (Espinosa and Porter, 2011; Rihani, 2002). The overall notion is to create the conditions within which new and innovative ideas would emerge. Strategies include reflection, debate and challenge, formal and informal workshops, encouraging development of multiple and diverse new relationships, an education programs designed to fulfil the needs of employees (Rowe and Hogarth, 2005).

A challenge for management is to cultivate and encourage creative, emergent behaviour in non-crises

times through effective guiding principles which will stimulate innovative and emergent changes and adoption (Holden, 2005). No one knows in advance exactly what would happen as the outcome was emergent and unpredictable as it developed through a range of different interactions and was more than the sum of the different parts. Collaboration and working in different teams and joint projects across systems usually brings about emergent change (Mitleton-Kelly 2011). Allowing teams to form on their own, to build relationships and interconnections stimulates the emergence of new ideas and behaviours (Penprase and Norris, 2005).

Path dependence

Path dependence assists the translation of new innovations and developments from one context into others (Espinosa and Porter, 2011). Leaders and managers need to anticipate change rather than to fear it as unpredictability needs to become acceptable. Benchmarking offers an opportunity to compare different organizations within a similar environment and adopt the relevant changes (Penprase and Norris, 2005).

4. Further Research

It is clear that the CAS approach is not the answer to all management and leadership dilemmas in the current business context but could be used in combination with classical approaches to management in an attempt to provide a more holistic and deeper understanding of SD and the effective and successful management thereof at local, national and global levels. Simply replacing one system with another would create new sets of problems (Richardson, 2008). Therefore, more research is needed and both theoretical and practical levels to:

- Search for new, innovative approaches and models to address the complex local, national and global short and long-term challenges related to SD.
- Test and validate the possible approaches and models in different industries, within different size companies and in different countries.
- Ensure that practical, realistic and implementable strategies and activities are developed and tested to implement the validated approaches and models effectively and successfully.

5. Conclusion

A CAS approach is not static and allows for and encourages emergence as a result to the changing internal and external environments. As CAS is a process that allows for constant change and adaptation it could be compatible in the organization's SD challenge that is also constantly changing and

adapting in response to the internal and external environments.

Translating an integrated, holistic and CAS approach might require some cognitive, structural and political changes in the thinking about and understanding of how to deal with SD. The overall aim is to develop an organizational context that allows, encourages and supports adaptation and long-term SD through adaptable systems (Espinosa and Porter, 2011). Organizations which co-evolve with both their internal and external environments in an adaptive and SD manner modify their strategies, processes and operational rules over time based on previous experiences and lessons learned from these experiences (Rammel, *et al.*, 2007).

References

1. Alaa, G. (2009), "Derivation of Factors Facilitating Organizational Emergence Based On Complex Adaptive Systems and social autopoiesis theories", *E:CO*, Vol. 11, No. 1, pp. 19-34.
2. Baumgartner, R.J. and Korhonen, J. (2010), "Strategic thinking for sustainable development", *International Sustainable Development Research Society*, Vol. 18, pp.71-75.
3. Becker, J. (2010), "Use of backcasting to integrate indicators with principles of sustainability", *International Journal of Sustainable Development World*, Vol. 17, No. 3, pp.189-197.
4. Boerner, H. (2010), "Sustainability rises to top of strategy-setting for growing number of corporate leaders", *Corporate Finance Review*, Vol. 15, No. 1, pp. 32-34.
5. Batterley, R. (2004). *Leading through relationship marketing*. Australia: McGraw Hill.
6. Berkes, F., Colding, J., Folke, C. (Eds.), (2003). *Navigating social-ecological systems: building resilience for complexity and change*. Cambridge University Press, Cambridge.
7. Brooks, S. (2005), "Corporate social responsibility and strategic management: the prospects for converging discourses", *Strategic Change*, Vol. 14, pp. 401-411.
8. Byrch, C., Kearins, K., Milne, M. and Morgan, R. (2007), "Sustainable "what"? A cognitive approach to understanding sustainable development", *Qualitative Research in Accounting & Management*, Vol. 4, No. 1, pp. 26-52. DOI 10.1108/11766090710732497.
9. Chuang, C. and Liao, H. (2010), "Strategic human resource management in service context: taking care of business by taking care of employees and customers", *Personnel Psychology*, Vol. 63, pp. 153-196.
10. Cross, J., MacAllister, R., Abel, N., Stafford-Smith, D., Maru, Y. (2003), Australian rangelands as complex adaptive systems: a conceptual model and preliminary results. MODSIM 2003 Conference Proceedings, Townsville.
11. Cunha, M. P. and Cunha, J. V. (2006), "Towards a complexity theory of strategy", *Management Decision*, Vol. 44, No. 7, pp. 839-850.
12. D'Amato, A. and Roome, N. (2009), "Leadership of Organizational change. Toward an integrated model of leadership for corporate responsibility and sustainable development: a process model of corporate responsibility beyond management innovation",

- Corporate Governance*, Vol. 9, No. 4, pp. 421-434. DOI:10.1108/14720700910984972.
13. Daub, C., and Sherrer, Y.M. (2009), "Doing the right thing right: The role of social research and consulting for corporate engagement in development cooperation", *Journal of Business Ethics*, Vol. 85, pp.573-584. DOI 10.1007/s10551-009-0209-7.
 14. Denton, D.K. (2006), "What Darwin can teach us about success?" *Development and Learning in Organizations*, Vol. 20, pp 7-10.
 15. Desai, D.A. (2010), "Co-creating learning: insights from complexity theory", *The Learning Organization*, Vol. 17, No. 5, pp. 388-403. DOI 10.1108/09696471011059796.
 16. Elkington, J. (2006), "Governance for sustainability", *Corporate Governance*, Vol. 14 No. 6, pp.522-529.
 17. Epstein, M.J., Buhovac, A.R., and Yuthas, K. (2010), "Implementing sustainability: The role of leadership and organisational culture", *Strategic Finance*, Vol. 91, No. 10, pp.41-47.
 18. Epstein, M.J. and Buhovac, A.R. (2010), "Solving sustainability implementation challenges", *Organizational Dynamics*, Vol.39, pp. 306-315.
 19. Esquer, J., Velazquez, L. and Munguia, N. (2008), "Perceptions of core elements for sustainability management systems (SMS)", *Management Decision*, Vol. 46 No. 7, pp. 1027-38.
 20. Espinosa, A. and Porter, T. (2011), "Sustainability, complexity and learning: insights from complex systems approaches", *The Learning Organization*, Vol. 18, No. 1, pp. 54-72. DOI 10.1108/09696471111096000.
 21. Financial Times (1998), "Natural step to sustainability", *Financial Times*, 7 January.
 22. Goldstein, J., Hazy, J. and Silberstang, J. (2008), "Complexity and social entrepreneurship: a fortuitous meeting", *Emergence*, Vol. 10 No. 3, pp. 9-24.
 23. Hart, S.L. and Milstein, M.B. (2003), "Creating Sustainable Value". *Academy of Management Executive*, Vol. 17, No. 2, pp.56-69.
 24. Hawkin, P. (2007), *Blessed Unrest*, Penguin, New York, NY.
 25. Hazlett, S.A., McAdam, R., and Murray, L. (2007), "From quality management to socially responsible organisations: the case for CSR". *International Journal of Quality and Reliability Management*, Vol. 2, No. 7, pp. 669-82.
 26. Holden, L. M. (2005), "Complex Adaptive systems: Concept analysis", *Journal of Advanced Nursing*, Vol. 52, No. 6. pp. 651-657.
 27. Ison, R.L. (2009), *How to Act in a Climate Change World: Systems Practice, Systemic Inquiry and Action Research*, Springer, London.
 28. Jabbour, C.J.C. and Santos, F.C.A. (2008), "The central role of human resource management in the search for sustainable organizations". *The International Journal of Human Resource Management*, Vol.19, pp. 2133-2154. DOI: 10.1080/09585190802479389.
 29. Jamali, D. (2006), "Insights into triple bottom line integration from a learning organization perspective". *Business Process Management Journal*, Vol. 12, No. 6, pp. 809-21.
 30. Jeffrey, P., McIntosh, B. (2002), "Co-evolution as a conceptual model in search for sustainable modes of water management". Discussion paper prepared for the AQUADAPT workshop, Montpellier Octobre 25th–27th 2002.<http://www.aquadapt.net>.
 31. Kernick D. (2002), Complexity and healthcare organization. In *Complexity and Healthcare*. An Introduction (Sweeney K. & Griffiths F., eds), Radcliffe Medical Press, Abingdon, Oxon. pp. 93–121.
 32. Khandekar, A. and Sharma, A. (2005), "Managing human resource capabilities for competitive advantage", *Education and Training*, Vol. 47, pp. 628-638.
 33. Kriegesmann, B., Kley, T. and Schwering, M.G. (2005), "Creative errors and heroic failures: capturing their innovative potential", *Journal of Business Strategy*, Vol. 26, No. 3, pp. 57-66.
 34. Laughland, P. and Bansal, P. (2011), "The top ten reasons why business aren't more sustainable", *Ivey Business Journal*, Jan/Feb, pp. 12-19.
 35. Linnenluecke, M.K. and Griffiths, A. (2010), "Corporate sustainability and organizational culture", *Journal of World Business*, Vol. 45, No. 4, pp. 357-366. DOI: 10.1016/jwb.2009.08.006.
 36. McDaniel, R.R. (2007), "Management strategies for complex adaptive systems", *Performance Management Quarterly*, Vol. 20, No., 2, pp. 21-41.
 37. McKibben, B. (2007), *Deep Economy: The Wealth of Communities and the Durable Future*, Times Books, New York, NY.
 38. Mitleton-Kelly E. (2003), "Ten principles of complexity and enabling infrastructures," in E.Mitleton-Kelly (ed.), *Complex Systems and Evolutionary Perspectives on Organizations: The Application of Complexity Theory to Organizations*.
 39. Mitleton-Kelly, E. (2011), "A complexity theory approach to sustainability. A longitudinal study in two London NHS hospitals", *The Learning Organization*, Vol. 18, No. 1, pp. 45-53. DOI 10.1108/09696471111095993.
 40. Naude, M. (2011), "Sustainable development in companies: Theoretical dream or implementable reality?", *Corporate Ownership & Control*, Vol. 8, No. 4, pp. 352-364.
 41. Nishiguchi, T. (2001), "Co-evolution of inter-organizational relations", in Nonaka, I. and Nishiguchi, T. (Eds), *Knowledge Emergence*, Oxford University Press, Oxford, pp. 197-222.
 42. Patra, R. (2008), "Vaastu Shastra: Towards sustainable development", *Sustainable Development Journal*, Vol. 17, No. 4, pp.244-256.
 43. Penprase, B. and Norris, D.(2007), "What nurse leaders should know about complex adaptive systems theory", *Nursing Leadership Forum*, Vol. 9, No. 3, pp. 127-132.
 44. Pepur, M.; Pepur, S. and Viducic, L. (2010), "Theoretical reflection of psychological contracts in the context of global financial crisis", *The Business Review*, 15: 231-238.
 45. Porter, M. and Kramer, M. (2006), "The link between competitive advantage and Corporate Social Responsibility", *Harvard Business Review*, Vol. 84 No. 12, pp.78-92.
 46. Price, A.D.F. and Chahal, K. (2006), "A strategic framework for change management", *Construction Management and Economics*, Vol. 24, pp. 237-251.
 47. Rammel, C., Stagl, S. and Wilfing, H. (2007), "Managing complex adaptive systems — A co-evolutionary perspective on natural resource

- management”, *Ecological Economics*, Vol 63, pp. 9-21.
48. Regner, P. (2001), “Complexity and multiple rationalities in strategy processes”, in Volberda, H. and Elfring, T. (Eds), *Rethinking Strategy*, Sage, Thousand Oaks, CA, pp. 43-56.
49. Richardson, K. (2008), “Managing complex organizations: complexity thinking and the science and art of management”, *Emergence*, Vol. 10 No. 2, pp. 13-26.
50. Rihani, S. (2002), *Complex Systems Theory and Development Practice*, Zed Books, New York, NY.
51. Rowe, A. and Hogarth, A. (2005), “Use of complex adaptive systems metaphor to achieve professional and organizational change”, *Nursing and health care management and policy*, Vol 51, No. 4, pp. 396-405.
52. Samy, M., Odemilin, G., Bampton, R. (2010), “Corporate social responsibility: a strategy for sustainable business success. An analysis of 20 selected British companies”, *Corporate Governance*, Vol. 10, No. 2, pp. 203-217. DOI: 10.1108/14720701011035710.
53. Scott, W.R. (1987), *Organizations: Rational, Natural, and Open Systems*, Prentice-Hall, Englewood Cliffs, NJ.
54. Sawyer, R. (2005), *Social Emergence: Societies as Complex Systems*, Cambridge University Press, Cambridge.
55. Stead, W.E., Stead, J.G. and Starik, M. (2004), *Sustainable Strategic Management*, ME Sharpe, New York, NY.
56. Steurer, R., Langer, M.E., Konrad, A. and Martinuzzi A. (2005), “Corporations, Stakeholders and Sustainable Development I: A theoretical exploration of business-society relations”, *Journal of Business Ethics*, Vol. 61, No. 3, pp. 263-281.
57. Tan, J; Wen, J and Awad, N. (2005), “Health care and services delivery systems as complex adaptive systems”, *Communications of the ACM*, Vol. 48, No. 5, pp. 36 – 44.
58. United Nations. (1992), *United Nations Conference on Environment and Development*, Rio de Janeiro, 14 June, Agenda 21, 1992. Geneva: United Nations. <http://www.unep.org/>.
59. United Nations. (1997), *United Nations Earth Summit +5*, New York, 23-27 June, 1997. Geneva: United Nations. <http://www.un.org.esa/earthsummit/>.
60. Velazquez, L.E., Esquer, J., Mungua, N.E. and Moure-Eraso, R. (2011), “Sustainable learning organizations”, *The Learning Organization*, Vol. 18, No. 1, pp. 36-44. DOI 10.1108/09696471111095984.
61. Walker, B., Carpenter, J., Anderies, N., Abel, G., Cumming, G., Janssen, M., Lebel, L., Norbertg, J., Peterson, G., Protchard, R., 2002. Resilience management in social-ecological systems: a working hypothesis for a participatory approach. *Conservation Ecology*, 6:14. [online] URL: www.consecol.org/vol6/iss1/art14.
62. Wallis, A.M., Kelly, A.R. and Graymore, M.L.M. (2010), “Assessing sustainability: a technical fix or a means of social learning?”, *International Journal of Sustainable Development & World Ecology*, Vol. 17 No. 1, pp. 67-75.
63. Wals, A.E.J. and Schwarzin, L (2012), “Fostering organizational sustainability through dialogic interaction”, *The Learning Organization*, Vol. 19, No. 1, pp. 11-27. DOI 10.1108/09696471211190338.
64. Weldy, T.G. and Gillis, W.E. (2010), “The learning organization: variations at different organizational levels”, *The Learning Organization*, Vol. 17, No. 5, pp. 455-470. DOI 10.1108/09696471011059831.
65. White, L. and Lee, G. (2009), “Operational research and sustainable development: tackling the social dimension”, *European Journal of Operational Research*, Vol. 193, No. 3, pp. 683-92.
66. Wirtenberg, J., Harmon, J. and Fairfield, K.D. (2007), “HR’s role in Building a Sustainable Enterprise: Insights from Some of the World’s Best Companies”, *Human Resource Planning*, Vol. 30, pp. 10-20.
67. World Commission on Environment and Development (Brundtland Report). (1987), http://www.ace.mmu.ac.uk/ae/Sustainability/Older/Brundtland_Report.html; 1987.