Thinking about Sustainable Development: Engaging with societal and ecological concepts

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Abstract

The concept of sustainable development has increased in importance ever since the coming to prominence of environmental critiques of development in the 1980s. The very concept of sustainability has evolved as research on the dynamics of ecological systems challenged the dominance of the stable equilibrium view that underpinned the thinking about sustainable ecological systems and led to the emergence of resilience thinking. The concept of resilient systems has been rapidly adopted in many areas, including business, and has been discussed in the ICT for development (ICT4D) field as well. Resilience thinking is based upon three key concepts: people exist within and depend on social-ecological systems, these systems are complex adaptive systems (CAS) that can exist in alternative stable states or regimes in which the function, structure and feedbacks are different and resilience is the key to the sustainability of these systems. Resilience is the capacity of a system to absorb disturbance; to undergo change and still retain essentially the same function, structure and feedbacks. One of the major implications of resilience thinking for ICT4D is that the resilience/efficiency trade-off focuses attention on the common driving force experienced by ICT4D projects to find a unique, most cost-efficient or "sustainable" model, instead of exploring and establishing a diversity of models that would increase long term resilience. A resilience perspective highlights the importance of "economies of scope" strategies in, for example, providing ICT services in resource constrained environments. The concept of panarchy (linked set of hierarchies) focuses attention on the various linked scales in any ICT4D system and the possible impact of modularity and feedback loops on the systems resilience. Recommendations for future research include the use of resilience thinking (with its emphasis on systems dynamics) to improve the assessment of the sustainability of ICT4D projects.

Key words: resilience, ICT4D, sustainable development

Introduction

The purpose of the paper is to introduce the key features of resilience thinking that has emerged from ecological research on sustainability and to discuss some of the implications of resilience thinking for the sustainability of ICT for development initiatives. Development and sustainable development are contentious concepts and therefore a brief historical overview of these concepts is provided as background.

The concept of development can be approached from many different angles (economic, social, anthropological) and a field of development studies has been developed, but Payne and Phillips (2010, p. 4) argue that the concept needs to be re-grounded within the wider, and indeed even older, intellectual tradition of political economy". The history of theories of development can be traced from classical theories of development such as liberal economic theory and historical materialism of the eighteenth and nineteenth centuries to the 'catch-up' theories of development after the great wave of industrialization in Western Europe, followed by the post World War II era boom in development theories and the current "alternative theories" deriving from critiques of all forms of development theory based on human development, gendered, environmental and postmodern viewpoints (Payne & Phillips, 2010, p8). According to Payne and Phillips (2010, p. 135) "environmental critiques of mainstream development …gained ground in tandem with the basic needs, human development and gender critiques" and by "the end of the 1980s, environmental issues had also been incorporated squarely into the discourse of development practice, clothed in the concept of 'sustainable development'". The iconic definition of sustainable development is the Brundlandt definition: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 43). The concept has undergone continuous development and has been vigorously critiqued. Ismail Serageldin, an ex-vice-president of the World Bank, identified an economic, a social, and an ecological dimension of sustainability and referred to "the 'triangle of sustainability'–its economic, social, and ecological dimensions" (as cited in Fuchs, 2010, p. 37). In recent years a further shift in the thinking on sustainability has occurred, especially in the EU and the UN and sustainability now includes ecological, economic, social, and institutional dimensions that are mutually independent (Fuchs, 2010).

The relationship between Information and Communication Technologies (ICTs) and the idea of sustainable development is a complex and ever evolving one and the topic of long standing debates. A recent issue of the Information, Communication & Society journal (February, 2010) is devoted to this relationship and interesting critiques are presented of the view that sustainability consists of the above mentioned four mutually independent dimensions. The critique is developed from ecological (Hilty & Ruddy, 2010) and social theory (Fuchs, 2010) perspectives. Hilty and Ruddy critique the notion of four mutually independent dimensions of sustainability since they are not on the same conceptual level: the economic system is a subsystem of society, and culture is the process of societal development. In addition, the multi-dimensional view tends to underplay the fundamental importance of the environment and “creates the impression that if we do not succeed in one segment of sustainability (e.g. ecological sustainability), we could compensate for this flaw in other segments (e.g. economic sustainability)” (Hilty & Ruddy, 2010, p. 11). This points to the sustainability dilemma; all of us cannot consume as much as we do now and expect that the world can carry the consumption burden indefinitely. The sustainability dilemma is fundamental to the achievement of all the other sustainability goals (e.g. economic sustainability). The fundamental ecological sustainability dilemma is that the world does not have the natural resources to carry the current consumption burden indefinitely (Hilty & Ruddy, 2010). A fundamental critique of the Brundlandt report (WCED, 1987) is that growth was not abandoned but seen as having to be made compatible with the achievement of other goals, which excluded the option of environmentally driven zero-growth goals (Payne & Phillips, 2010). Ecologists have moved from a protectionist view of sustainable development where economy, society and environment as separate pillars need to be sustainable, to an embedded view of sustainability where economic systems are embedded in social systems, which are embedded in ecological systems (Nel, 2010).

From a social theory perspective Fuchs (2010) views Hilty and Ruddy’s approach as being ecologically reductionistic and argues for a two-level model for society: an economic base and the political and cultural superstructure. The economic base which consists of the interplay of labour, technology and nature, is necessary, but not sufficient for the superstructure. Fuchs (2010, p. 43) calls for a participatory, co-operative, sustainable information society “in which knowledge and technology are together with social systems shaped in such a way that humans are included in and self-determine their social systems collectively, interact in mutually benefiting ways, and so bring about a long-term stability that benefits all present and future generations and social groups”.

The ICT4D literature has identified five main sustainability types: financial, social, institutional, technological, and environmental and Ali and Bailur (2007) argue that given this wide variety of “contributors to sustainability”, the pre-dominant failure of ICT4D projects is not surprising, that sustainability might not be possible, and instead suggest a bricolage approach. Ciborra (cited in Ali & Bailur, 2007) calls bricolage “...tinkering through the combination of resources at hand. These resources become the tools and they define in situ the heuristic to solve the problem”. It is all about improvisation: local people using existing tools and routines to solve problems. This is supported by the analysis done by Heeks (2002), who attributed the high rates of failure of information systems (IS) projects in developing countries to a design-actuality gap where there is a mismatch between the desired systems state of the IS designers and the local actuality of the users. Moving up from the project level, Thompson and Walsham (2010, p. 113) call for a broadening of the “developmental” agenda of IS research, “from a focus on 'point' design and implementation to a wider critique that includes broader institutional, regulatory and political infrastructures”. The importance of ICT4D, as a development imperative at societal level, has been underscored by research done by the World Bank (2009) on the impact of broadband services in 120 countries: a 10% increase in broadband penetration contributed a 1.3% increase in economic growth and this growth effect was more significant in developing countries.

To conclude the introduction, in this paper the focus is on ecological research on sustainability that has enriched the concept and shifted the focus. Research during the 1960-1970s on the dynamics of ecological systems challenged the dominance of the stable equilibrium view that underpinned the thinking about sustainable ecological systems and led to the emergence of the resilience perspective (Folke, 2006). The concept of resilient systems has been rapidly adopted in many areas, including business, and has been discussed in the ICT for development (ICT4D) field as well (Heeks, 2009).

The paper introduces the key features of resilience thinking, followed by a discussion of the implications of selected aspects of resilience thinking for ICT4D which includes the introduction of additional resilience concepts. Examples of existing ICT4D strategies that illustrate resilience thinking are also provided. The potential for future research is outlined in the concluding remarks.

Key features of resilience thinking

The understanding of ecological systems as developed during the 20th century has been based on the notion of an equilibrium state to which a system will return if subjected to change (Walker & Salt, 2006, p. 30). The equilibrium state itself might change over longer time scales. The concept of an equilibrium state led to the idea that people living in an ecosystem can extract goods (e.g. water) and services (e.g. water purification) from the ecosystem, and it will recover, provided that this use did not lead to the destruction of the system. This way of thinking supports an optimizing approach where the understanding of a component of the system is used to control the system to increase the output of interest. This approach to optimization has not proven to be sustainable and resilience thinking is “an alternative view to understand social-ecological systems” that utilizes systems thinking to focus on a longer term view, in contrast to short term optimization-driven views (Walker & Salt, 2006, p. 31). Resilience thinking is based upon three key concepts (Walker & Salt, 2006, pp. 31-32):

- People essentially exist within social-ecological systems on which they depend. Changes in either the social or ecological domains have impact on the other domain. The system is linked and the dynamics of the two domains cannot be understood in isolation form each other.
- Social-ecological systems are complex adaptive systems (CAS) which do not change in a predictable, linear, incremental fashion. These systems can exist in alternative stable states or regimes in which the function, structure and feedbacks are different. Shocks and disturbances can drive these systems across the threshold of the current regime to a different regime (an example is a lake changing from a clear water state to a persistent murky water state).
- Resilience is the key to the sustainability of these systems. Resilience is the capacity of a system to absorb disturbance; to undergo change and still retain essentially the same function, structure and feedbacks. A resilient social-ecological system in a desirable or preferred state (e.g. a productive agricultural region) would have a greater capacity to remain in this state even if subjected to shocks.

Resilience in itself is not necessarily desirable since a system in an undesirable state could also have a high degree of resilience and be very resistant towards efforts to change the state (Walker & Salt, 2006, p. 37).

Resilience thinking uses two ways of understanding social-ecological systems, namely the metaphor of adaptive cycles and the thresholds model which is described with the metaphor of a ball in a basin (Walker & Salt, 2006, p. 52). A brief overview of these metaphors is provided here.

Thresholds

Systems are described using variables commonly called “state variables” which could be the percentage of grass coverage, the percentage of woodlands coverage, the amount of people living in the area and the number of cattle. This would describe a four-dimensional system (one for each variable) which can be described as a number of basins in this space as shown in figure 1 (Walker & Salt, 2006, pp. 53-54).

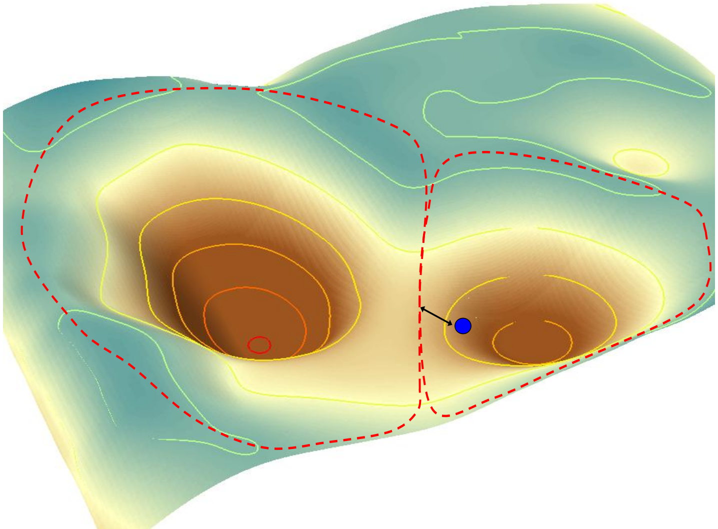

Figure 1 A social-ecological system as a ball-in-the-basin model (Walker, 2006)

The ball shown in the basin of attraction represents the particular combination of the current value of each of the n variables the system, which is the current state of the system in the state space of the system. The state space is formed by all the possible states the system can be in. In the basin (or regime) the ball would tend to roll to the bottom, which, in systems terms, represents some kind of equilibrium state. This state is constantly changing as the shape of the basin is deformed by changes in external conditions, and the ball will be in constant movement, never settling at the bottom. The resilience question is how much change can occur to the *shape* of the basin and to the *trajectory* of the ball (the system's succession of states) before the ball moves out of the basin over the threshold to an adjacent one (and the system changes to a different regime). Ecological resilience describes how much disturbance and change a system can take before it loses the ability to stay in the same basin (Walker & Salt, 2006, p. 63). The issue is not about whether the system can recover quickly, but about the ability to recover at all. The focus is on what happens at the edge of the basin, not what happens near the ever changing equilibrium represented by the bottom of the constantly deforming basin. The measure of a system's resilience is its distance from the thresholds (as indicated by the arrow in Figure 1). Managing for resilience is all about "moving thresholds, moving the current state of a system away from a threshold, or making a threshold more difficult to reach" (Walker & Salt, 2006, p. 59). The capacity of the role players in the social-ecological systems to manage resilience (as described) is called adaptability.

If the system's thresholds or the current trajectory is too difficult or expensive to manage the nature of the system might need to be transformed by introducing new state variables, e.g. moving away from cattle farming to game farming (Walker & Salt, 2006, p. 62). Transformability is the capacity to create a fundamentally new system when ecological, social, economic and political conditions make the existing system untenable (Walker & Salt, 2006, p. 62).

Resilience in social-ecological systems is different from "engineering resilience", which focuses on "how quickly a system can return to some point of equilibrium when disturbed", and personal resilience, a person's "ability to bounce back" quickly after a shock (Walker & Salt, 2006, p. 62-63).

Adaptive cycles, the other key way of understanding change in social-ecological systems, is discussed next.

Adaptive cycles

Ecosystems have been observed to move through recurring cycles (called adaptive cycles) which consist of the following phases: rapid growth, conservation, release and reorganization (Gunderson & Holling as cited in Walker & Salt, 2006). In each of these phases the "strength of the system's internal connections, its flexibility and its resilience" is different and interventions need to take this into account (Walker & Salt, 2006, pp. 75-76). The term "creative destruction" (originally created by economist Joseph Schumpeter) is used to describe the destruction of stability and the resultant release of the locked-in resources that occur periodically in the cycle (Walker & Salt, 2006, p. 75). The description that follows is based on Walker and Salt (2006).

In the *rapid growth phase* (also called the r phase) new opportunities and resources are rapidly exploited, the components of the system are weakly interconnected and the internal state is weakly regulated. The pioneer plant species (e.g. weeds) and the human pioneers (innovators and entrepreneurs) flourish and seize every opportunity.

The *conservation phase* (also called the K phase) follows as a gradual transition in which existing actors accumulate resources and mutually reinforcing connections develop between them that buffer against variability and ensure efficient use of resources. As a result the internal state of the system becomes more regulated and new entrants are excluded. Specialization and efficiency increases, but flexibility and resilience decreases. Capital is accumulated that is stored as biomass in ecosystems, while in human systems the capital is developed in different forms such as human capital and financial capital. The system becomes more stable, but within a narrower range of conditions.

The *release phase* (also called the Omega phase) can be very rapid as the system receives a shock that it cannot absorb (e.g. a fire or a stock market collapse), resulting in a breakdown of the mutually reinforcing connections and a release of the accumulated capital (creative destruction). It is a chaotic phase.

In the *reorganization phase* (also called the Alpha phase) novelty and chance thrive and new species can invade the ecosystem, and new entrepreneurs can seize business opportunities. The phase ends when, as described by systems terms, a new basin of attraction develops that constrains the dynamics of interactions and signifies the start of a new rapid growth phase.

It is important to note that systems do not necessarily always pass through the four phases of the adaptive cycle in order. Transitions from, for example, the conservation phase to the rapid growth phase can occur. The adaptive cycle can be viewed as two opposing modes (as shown in Figure 2): a "development (or 'fore' loop) and a release and reorganization loop (or 'back' loop)" (Walker & Salt, 2006, p. 81).

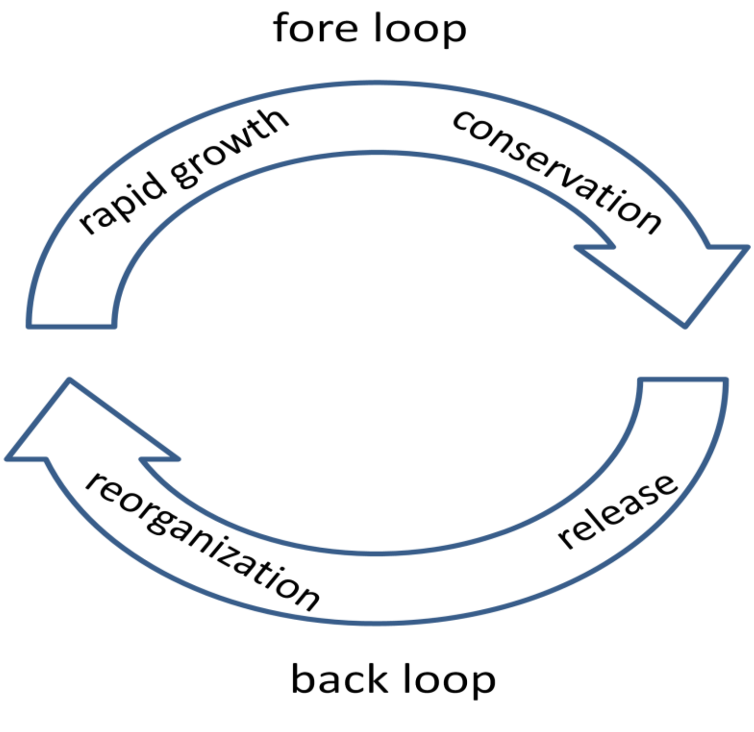

Figure 2 The adaptive cycle (redrawn from Walker & Salt, 2006: 82)

Stability and conservation of capital occurs in the fore loop while uncertainty and creative destruction characterizes the back loop. During the latter part of the fore loop and the whole of the back loop the system is most sensitive to disturbance such as human action.

Adaptive cycles occur at different scales and any system is (Walker & Salt, 2006, p. 88-89):

> actually composed of a hierarchy of linked adaptive cycles operating at different scales (both in time and space). The structure and dynamics of the system at each scale is driven by a small set of key processes and, in turn, it is this linked set of hierarchies that govern the behaviour of the whole system. This linked set of hierarchies is referred to as a 'panarchy'.

In the next section the implications of selected aspects of resilience thinking for ICT4D are explored and at the same time additional resilience concepts are introduced.

Some implications of resilience thinking for ICT4D projects

Since humans exist within social-ecological systems ICT4D projects need to consider not only the interaction with and development of socio-technical systems (Whitworth & De Moor, 2009) but also that of social-ecological-technical systems. The very embeddedness of our society in ecological systems cannot be ignored. As part of a discussion on what the next wave of ICT4D is, Richard Heeks (2009) has acknowledged this concern as well. Security concerns, fragility of economic growth and environmental sustainability are the three major issues on the development agenda that Heeks (2009, p. 11) groups together into the idea of "resilient development" which produces the following key questions for the next phase of ICT4D 2.0:

- ”How can ICTs ensure development that is resilient in the face of threats such as insecurity, economic fluctuation, and climate change?
- How can ICTs provide development that is sustainable?"

A response to the last question that focuses on economic growth aspects, is called decoupling. The strategy of decoupling economic growth of economies from the use of natural resources (with the associated negative impact on biological diversity) is essential in reconciling environmental protection and economic growth (Giljum et al., 2005). One of the strategies for decoupling is dematerialization which aims to achieve an absolute reduction of resource use by, amongst other strategies, increasing the 'metabolic efficiency' of companies and regions (Giljum et al., 2005). The role of ICT to assist in increasing the metabolic efficiency of production and consumption processes (Hilty & Ruddy, 2010) need to be considered in every project. In addition, ICT systems are increasingly important consumers of resources such as electrical power and need to increase energy-efficiency and use of renewable energy sources, as called for via the concept of Green IT (Murugesan, 2008).

Heeks' first question: "How can ICTs ensure development that is resilient in the face of threats" is discussed below.

Social-ecological systems are complex adaptive systems and shocks and disturbances can drive these systems across the threshold of the current regime to a different regime. ICT4D projects normally operate in contexts where shocks are frequent due to the lack of resources. Furthermore, ICT4D projects shock local systems by adding new resources. This shock can be large enough to push the system into a new regime. One of the biggest and probably the most frequent shock occurs when project funding ends: the project team withdraws, the inflow of resources are reduced or curtailed and hence the system may revert back to the previous regime or move to a new regime.

Resilience is the key to the sustainability of social-ecological systems. ICT4D projects attempt to induce change in striving for "development". Resilience is all about embracing the inevitability of change while retaining "essentially the same function, structure and feedbacks". The question is what kind of development the project team has in mind? And what kind of impact can ICTs make on a country's development?

Avgerou (2009) analyzed the literature on Information Systems in Developing Countries research and could distinguish two perspectives on ICT-enabled development: progressive and disruptive perspectives. The progressive perspective "considers ICT as enabling transformations in multiple domains of human activities, but they can be accommodated within the existing international and local social order", while the disruptive perspective is "premised on the highly political and controversial nature of development, both as a concept and as an area of policy for international and local action, and reveal conflicts of interest and struggles of power as a necessary part of IS (information systems) innovation in developing countries" (Avgerou, 2009). These two perspectives are analogous to ecologists describing systems as delivering desirable ecosystem services which should be retained or a system might need to be transformed to create a fundamentally new system when ecological, social, economic and political conditions make the existing system untenable (Walker & Salt, 2006). In both the progressive and disruptive perspectives resilience thinking would focus the attention on what makes the systems resilient (either to keep it in a desirable regime or what would it take to get the system out of the undesirable state) and how to manage the thresholds between regimes. Jeffrey Sachs (2008, p. 209) describes undesirable resilient states when he refers to economies that “remain stuck in the poverty trap of subsistence farming, while others experience economic development”. An understanding of the dynamics of the social-ecological-technical system is encouraged by the focus on thresholds: the status quo is not assumed to be stable and the imperative is to understand what changes in which aspects would drive the system over a threshold into a new regime.

The question regarding what kind of impact ICTs can make on a country's development, can be refined by asking: How do ICT4D interventions influence which key aspects of a system in order to move it to a new (desirable) regime? In order to analyse papers describing the use of ICTs in Africa to further development, Thompson and Walsham (2010) used United Nation Development Programme proposals regarding developmental constraints and Sen's developmental “freedoms” to propose four “enabling” strategic dimensions for ICT in transformational development:

- ICT as institutional enabler;
- ICT as enabler for governance, accountability, and civil society;
- ICT as enabler in service production and economic activities, and
- ICT as enabler for access to global markets and resources.

This is a valuable starting point to use in describing and categorising the systemic impact of ICT4D interventions.

Social-ecological systems are influenced by many different kinds of variable, but only a sub-set of these actually drive the system’s behaviour- the key controlling variables which are often slow-moving (Walker & Salt, 2006). Along each of these variables are thresholds that delineate the regime in which the system is. In ecological terms, the key aspects of a system, as referred to in the previous paragraph, are these key (slow) controlling variables , one example being the concentration of phosphorus in a lake’s water (Walker & Salt, 2006). It is difficult to spell-out what the equivalents are in the social-ecological-technical systems in which an ICT4D intervention takes place. A possible departure point is the eight well-known Millennium Development Goals (MDGs): end poverty and hunger, universal education, gender equality, child health, maternal health, combat HIV/AIDs, environmental sustainability, and global partnership (UN, n.d.). The recognition that these goals are interconnected and the adoption of Amartya Sen's arguments for a multidimensional approach to poverty has led to the development of a multidimensional poverty index (MPI) with three dimensions, namely, health, education and standard of living, that are measured via ten indicators (Alkire & Santos, 2010). An example of an education indicator is years of schooling, with a household considered deprived if no household member has completed five years of schooling. This is a possible example of a “threshold” value in a key controlling “variable” as used in social-ecological systems. The MPI “reflects the overlapping deprivations that members of a household experience" and have been used to identify poverty types that show "different regular patterns of deprivation, or poverty traps" (Alkire & Santos, 2010, p. 3) and has led to the suggestion that "countries can follow different pathways to reduce multidimensional poverty (Alkire & Santos, 2010, p.33). The analogy between poverty traps and the different possible regimes of a social-ecological system seems to hold. From this work it seems that agreement is developing that there are probably a few generic variables describing poverty (or more specifically, poor households) but each context could also have its own unique set of variables. An experienced ICT4D analyst has observed that lack of knowledge of the local context is one of the major reasons for failure of ICT4D projects (James, 2010). As mentioned previously, Heeks (2002) also emphasised the local context, attributing the failure of information systems (IS) projects in developing countries to a design-actuality gap between IS design and the local actuality of users. Resilience thinking provides a particular perspective on just what is the essential knowledge of the local system that needs to be acquired, e.g. knowledge of the key controlling variables. An ICT4D project team needs to study the history of the local systems in which interventions are planned in order to identify the slow variables of the local context and to determine the threshold values beyond which the system will behave differently. The indicators of the MPI could serve as a general guideline to what are the types of variables and associated threshold values.

Resilience, efficiency and sustainability

The danger of an optimizing approach to increase the outputs of a system was mentioned at the start of this section. Optimizing for efficiency (in a narrow sense) often leads to "the elimination of redundancies – keeping only those things that are directly and immediately beneficial" (Walker & Salt, 2006, p. 7). If the drive towards efficiency is applied to "only a narrow range of variables and a particular set of interests it sets the system on a trajectory that due to its complex nature, leads inevitably to unwanted outcomes (Walker & Salt, 2006, p. 7). Walker and Salt (2006, p. 8) state that "there is no sustainable, 'optimal' state of an ecosystem, a social system, or the world. It is an illusion, a product of the way we look at and model the world. It is unattainable; in fact…it is counterproductive, and yet it is a widely pursued goal". The danger is that "the more you optimise elements of a complex system of humans and nature for some specific goal, the more you diminish that system's resilience. A drive for an efficient optimal state outcome has the effect of making the total system more vulnerable to shocks and disturbances (Walker & Salt, 2006, p. 9). Sustainability requires enhancing the resilience of the system as a whole and not just the optimization of isolated components (Walker & Salt, 2006, p. 9).

Funding and time constraints induces ICT4D project teams to focus on efficiency. This could lead to unwanted outcomes as essential functions such as liaison and general communication with the community do not get funded. For example, an ICT4D project that optimizes telecommunications infrastructure without paying attention to other aspects of the system such as ICT skills development could reduce the resilience of the local system. Funding constraints also limit the scope of ICT4D projects. Project consortiums need to be formed with a variety of partners that can focus on different components of the system or the project's activities need to be aligned with the work of existing role players in the system such as NGOs and government. At the very least, resilience thinking leads to the asking of questions such as: What are the (unobtainable and counterproductive) optimal system states that ICT4D project teams have in mind? An example could be the desire to leave behind self-sustaining highly-skilled communities that will never ask for outside assistance to resolve technical problems. One could also ask: In what way does striving for an optimum reduce the sustainability and resilience of the entities established by the project?

Managing general resilience

From a systemic perspective the question of how to manage the resilience of a system is very important. A focus on managing the thresholds is referred to as targeted or specific resilience, which could be problematic if it leads to optimization (Walker & Salt, 2006, pp. 120-121). The general resilience of the system is influenced by three key factors (Walker & Salt, 2006, p. 121):

1. The diversity of the system which expresses the variety of species, people and institutions that exist in the social-ecological system and includes both functional and response diversity.
2. The modularity of the system relates to the way in which the components of the system are linked. A degree of modularity in the system allows individual modules to keep functioning even when some loosely linked modules fail. The system as a whole can self-organise and therefore display a greater capacity to absorb shocks.
3. Tightness of feedbacks refers to "how quickly and strongly the consequences of a change in one part of a system are felt and responded to in other parts". Tight feedbacks are largely determined by institutional and social networks. Centralised government and globalisation can weaken feedbacks and hence delay response.

Diversity – Functional diversity refers to the existence of different entities that perform the same function in the system. These entities should (ideally) also respond differently to changes in the environment, thus increasing the response diversity of the system. ICT4D projects need to explore and establish many different business models for delivering the same services (functions) to the community. This is contrary to the common driving force experienced by ICT4D projects to find a unique, most cost-efficient or "sustainable" model, and then to replicate only this particular model to achieve economies of scale. The need to replace economies of scale with economies of scope in resource constrained environments has been mentioned as a desirable outcome in the development of ICT services for rural micro-enterprises (Van Rensburg, Smit & Veldsman, 2007). According to Baumol (cited in Tschang, Chuladul & Thu Le, 2002) the aim of economies of scale is to add product types and achieve an increasing rate of additional returns from each added product type. A micro-enterprise should sell many different products and services in order to increase income.

Modularity - Reducing dependencies on donors is a common aim for ICT4D initiatives. ICT4D projects should aim to establish entities that are well networked in the local context, with many loosely linked connections, but do not fundamentally depend on other entities for their survival. Within an organization modularity should also be designed in. The question needs to be asked: who are we dependent on and how will we survive if they fail?

Feedbacks - ICT4D projects are in the unique position that the use of ICT can enhance communications. Key feedback loops between institutions need to be identified and supported with appropriate technology. The focus should shift away from internal project communication and the reporting function to project sponsors and donors to the establishment of communication channels with key players in the local and national contexts. Social network software should be used to enable everybody's voice to be heard and to enable peer-to-peer communication and support amongst the ICT4D practitioners and the community participants. The monitoring and evaluation strategy of ICT4D projects should identify indicators of undesirable change in the system. In the monitoring and evaluation methodology called Outcome Mapping, the focus is not on assessing the changes in the state of development of a social-ecological-technical system (e.g. reduced poverty levels, cleaner water), but on outcomes as behavioural change in the actors (people, groups and organisations) with which a project interacts directly (Earl, Carden, & Smutylo, 2001, p. 1). Progress made by the actors in changing their behaviour is monitored, via the creation of progress markers which are "sample indicators of behavioural change" (Earl et al., 2001, p. 54). This methodology creates feedback loops via personal interactions in monitoring behavioural changes that are very valuable in aiding rapid learning as to "what works or does not" and focuses the intervention on what are the really sustainable changes that will change the system to a new state, namely the behaviours of the actors after the project team has left.

The way in which multiple stakeholders are involved in managing a system is very important and the three key factors mentioned above (diversity, modularity, feedbacks) need to be combined. Walker and Salt (2006, p. 138) concludes from a case study that:

> the adaptive capacity of a social-ecological system is enhanced when complex issues are dealt with by a network of loosely connected stakeholders located at different levels of society. Such a dynamic structure allows for flexible coordination and cross-scale responses to solving problems because there is experimentation and learning going on across the network. Such experimentation, combined with the networking of knowledge, creates a diversity of experience and ideas for solving new problems. It stimulates innovation and contributes to creating feedback loops at different scales.

Walker and Salt (2006, p. 148) recommend governance structures that are “messy” and includes redundancy, with a “mix of common and private property with overlapping access rights”. The drive for efficiency via top-down governance structures decreases the response diversity, flexibility and the ability to respond to cross-scale influences. The voices of local people with their intimate knowledge of the local context need to be heard. ICT4D projects are often torn between the need for ownership by the community and the need to get the project done on time. It is very easy to slip into a centralised governance model during the project phase which can jeopardise the long term resilience of the social-ecological-technical system that remains when the project ends.

The need for rethinking relationships in the ICT4D context has been investigated by Van Rensburg et al. (2007) who has described a “marriage” approach to the linking of research and technology development actors with the “natural daily life/work environment” of Small Medium and Micro Enterprises in order to create an environment within which technical and business incubation services can be delivered. The marriage metaphor is used to emphasise the long term commitment of this relationship beyond the boundaries of a project. The challenges that were to be addressed via this approach include the need to go beyond piloting and concept demonstration, the development of lasting value propositions for the “marriage partners”, the phasing of the marriage and the roles and responsibilities of the marriage partners in each phase (Van Rensburg et al., 2007). The project was executed in the context of a rural Living Lab in the Sekhukhune district of the Limpopo Province in South Africa.

Living Labs are systemic initiatives, which focus on creating multi-stakeholder collaboration between government, academia, business and citizens/users in different stages of the research, development and innovation (RDI) process. The concept refers to a research and development methodology where innovations such as services, products and application enhancements are created and validated in collaborative, multi-contextual empirical real-world settings (Eriksson, Niitamo & Kulkki, 2005). The focus is on empowering users to become active partners in RDI processes rather than passive recipients (Herselman et al., 2009). The Living Lab approach, with its emphasis on establishing institutional collaboration can play an important role in increasing the resilience of ICT4D interventions. Processes of institutionalization have been found to be crucial in digital inclusion projects in developing countries and four key processes of institutionalization have been identified: getting symbolic acceptance by the community, stimulating valuable social activity in relevant social groups, generating linkage to viable revenue streams, and enrolling government support (Madon, Reinhard, Roode & Walsham, 2009). The Living Lab approach provides new ways of thinking about the benefits of institutional networking in support of user-driven innovation, while resilience thinking highlights the benefits of overlapping governance relationships within these networks in increasing flexibility and the ability to respond to cross-scale influences.

Pathways of development initiatives

In the previous section the managing of the general resilience of a system by focussing on the thresholds was discussed. An additional strategy is to focus on transitions. Systems move though adaptive cycles and the transitions between these phases can also be managed. According to Walker and Salt (2006, p. 82):

> clever managers (of ecosystems or of organizations) often engineer this in order to prevent a large collapse in the late conservation phase. That is, they avoid a release phase at the scale of concern (the whole forest or the organization) by generating release and reorganization phases at lower scales thereby preventing the development of a late K phase at the scale of concern.

The system at a higher scale in the panarchy, namely the forest or the organization, survives.

As discussed in the previous section, Van Rensburg et al. (2007) developed a network of Small Medium and Micro Enterprises that are supported by technical and business incubation services. This network is called the Infopreneurs™ network and is a group of ICT4D practitioners that include "service sector SMMEs operating in a franchise-like manner at community level to render a range of services as 'social' entrepreneurs, i.e. doing it in a entrepreneurial, sustainable manner but with a clear commitment to the development of the community in which they operate" (Van Rensburg et al., 2007). The system as a whole was developed over a long period (more than 14 years) and is designed to have at least three levels: community level entrepreneurs (called Community Infopreneurs™), supported by Master Infopreneurs™ delivering business incubation services, which in turn is supported by a head office which could be at regional or national level (Van Rensburg, Veldsman & Jenkins, 2008a, Van Rensburg, Veldsman & Lähde, 2008b). The system can be viewed as a panarchy. The community level entrepreneurs deliver a variety of services and provide a flexible and adaptable interface to the communities. This entrepreneurial model can be contrasted with a head office/branch office/employer/employee model where central command and control is exercised. The Infopreneurs™ network structure can avoid a release phase of the whole network though the natural release and reorganization phases that occur at lower scales, at the level of the community level entrepreneurs, as services are adapted and as entrepreneurs succeed or fail.

Conclusion

Resilience thinking enriches the sustainable development discussion by focussing on how to deal with change. The concept can be applied to society as a whole and to project and initiative level interventions. Within the scope of this paper the application of resilience thinking in the ICT4D project context could only be explored briefly. The concept of a multidimensional poverty index (MPI) with its ten household focussed indicators seems promising as possible examples of "threshold" values in a key controlling "variable" as used in social-ecological systems and the analogy between poverty traps and the different possible regimes of a social-ecological system is striking and requires further investigation. The concept of a resilience/ efficiency trade-off is particularly important as it focuses attention on the common driving force experienced by ICT4D projects to find a unique, most cost-efficient or "sustainable" model, instead of exploring and establishing a diversity of models that would increase long term resilience. This also introduces a new perspective on "economies of scale and economies of scope" strategies. The concept of panarchy has been introduced and it focuses attention on the various scales in any ICT4D system and the possible impact of modularity and feedback loops on the system's resilience. The implications of resilience thinking on the relationships, especially the benefits of overlapping governance relationships in Living Lab contexts, need further research. The assessment of the sustainability of ICT4D projects and the current monitoring and evaluation methodologies used can be improved by critical engagement with resilience thinking. An analysis of the factors influencing the sustainability of ICT4D projects within a resilience thinking framework would be useful in highlighting the systems dynamics of ICT4D projects.

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