Chapter 4 Systems thinking and systems approaches

4.1 Introduction

This is the first in a series of four chapters concerned with identifying a suitable systems approach for application to the ICT4D case study. Chapter 4 in addition provides the systems background for a thesis based on systems thinking. It contributes to the first part of the research question below:

- How does the literature approach social systems, from systems thinking and from social theory perspectives?

The aim of this chapter is to survey the field of systems thinking, searching for ways of thinking as well as particular systems methods that could be used to describe and investigate social systems within an ICT4D context. The ICT4D context in this study entails the meeting of different worlds: different languages, different cultures, different environmental and geographical settings, different knowledge bases, and different conceptions of authority, to name a few. Although there is no explicit conflict in the case study context, there is clear poverty and inequality and implicit ethical and normative concerns. Further, socio-economic development is a complex concern that cannot be reduced to aspects such as economic growth, or by a simplistic view of technology as an instrument towards development.

It has been shown in Chapter 2 that there is a clear lack of systems thinking in ICT4D, with very little guidance from existing literature on how to apply systems thinking in ICT4D. If one wants to use a systems approach to investigate the social context of an ICT4D project, and use the same systems description to assess the ICT4D project's impact on development, how does one choose between the available systems theories and approaches? There are some systems approaches that focus on dealing with multiple stakeholder perspectives, some approaches dealing with emancipatory concerns, and yet other approaches to deal with complexity – while all of these concerns are shown above to be found in the ICT4D context. Before deciding on a systems approach, or even before deciding how to decide, an overview of systems thinking applied to social systems is required. Also, an overview of systems thinking itself is required, to ensure that the ICT4D systems application does justice to the nature of systems thinking.

This chapter attempts to convey the distinctive characteristics of systems thinking, and give an overview of systems approaches. The systems landscape is categorised into hard, soft and critical systems approaches, loosely following the thinking of e.g. Jackson (2003) and Daellenbach and McNickle (2005). There are also sections dedicated to complexity thinking, postmodern systems thinking and multimethodologies. This chapter does not provide a comprehensive overview of systems methods, but rather traverses the variety of systems thinking available. Hard systems approaches are included, even if they are not candidates for use in an ICT4D context. They convey something of the classic nature of systems thinking and are the theoretical parents of subsequently developed approaches that may be more suited to deal with a social context.

4.2 Systems thinking: background and overview

This section provides a general overview of systems thinking since its inception up to recent applications in social systems. Apart from providing a concise history of the systems field, it discusses some definitions, distinguishing features of systems thinking as well as the benefits of using a systems approach.

4.2.1 Departure points

Systems thinking differentiates itself by adopting a holistic approach; that is, by studying the whole entity as a way to understanding its component parts (Checkland, 1999: 13). This is in reaction to “reductionist” thinking which attempts to understand an entity by studying its parts. The holistic approach assumes that a system has emergent properties that cannot be seen when studying the parts. Whether systems thinking is anti-reductionist or just “more than reductionist” is a point of disagreement among systems thinkers. The view that systems thinking is the holistic alternative to reductionist approaches is supported by Jackson (2000, 2003). On the other hand, Daellenbach and McNickle (2005), Ritchey (1996) and Barton and Haslett (2007) believe that the holistic and reductionist views of a system are complementary. According to Ritchey (1996: 8) the distinction between the two systems levels, that of the behaviour of the system as a whole and the relationship between its parts, is fundamental to the systems concept. The latter position will be taken from here on, namely that both the whole-view and the parts-view are needed for better understanding of the functioning of a system, whether manufactured or natural, and that systems thinking contains both holism and reductionism.

A second departure point for systems thinking is its transdisciplinary nature, as promoted by von Bertalanffy (1968). If, for example, the operation of a biological entity is described in an abstract language, and the principles discovered can be applied to other kinds of environments, such as organisations, this is regarded as systems thinking.

4.2.2 History of systems thinking

The philosophical basis for systems thinking was promoted by Greek philosophers, such as Plato, who observed that a ship is steered in the same way as the state. Other contributors included Kant and Hegel (Jackson, 2003: 4).

The first two formal systems movements developed more or less simultaneously during the 1940s (Capra, 1997: 96; Checkland, 1999: 14). The one was formed around von Bertalanffy's General System Theory (GST) and the other around cybernetics.

Between 1940 and 1968 the biologist von Bertallanfy developed his General System Theory (GST). He attempted to make abstract the properties and behaviour of biological systems so that they could be applied to other contexts. Among others, he introduced the concept of an open system, noting the importance of understanding a system's interaction with its environment (Jackson, 2003: 4-7). The GST school wanted to encourage the development of adequate theoretical models in areas that lacked them, eliminate duplication of theoretical efforts in different fields, encourage the transfer of approaches between fields of application, and improve communication between specialists (Hitchins, 2003).

Von Bertalanffy's counterpart in the cybernetics movement was Norbert Wiener, a mathematician and control engineer. Wiener defined the term cybernetics as the "science of communication and control in animal and machine" (Jackson, 2003: 7). His interest was in the control process, which requires a system with a goal orientation and negative (corrective) feedback. Communication is also important, since information needs to be transferred between the system and its controller. In the cybernetics movement, Wiener was joined by Ashby (1956) who introduced the concept of variety. Ashby's law states that the controller must have the same degree of variety as the controlled system in order to control it (Jackson, 2003: 7-9).

The GST movement is primarily associated with biological thinking, or the study of living systems. Cybernetics is associated with machine thinking (Olsson and Sjöstedt, 2004: 37) and has been used and informed by engineering, for example when control systems are designed and built. However, Buckley (1967) argues for the usefulness of cybernetics concepts to study social systems, and cybernetics has been applied by Beer to improve organisational design (Jackson, 2003).

During World War II, the original methods of Operations Research (OR) were developed, using mathematical techniques for the improved performance of military operations. OR incorporated systems principles into its mathematical toolkit, and grew into a strong domain of its own. The techniques developed in OR to improve military performance were subsequently applied to improve organisational performance, contributing to the field of Management Science (McLoughlin, 1999). Related to OR is Systems Engineering, established in the late 1950s and aiming to provide engineers with a systems toolset to assist during the entire lifecycle of a designed system (Olsson and Sjöstedt, 2004: 45-48).

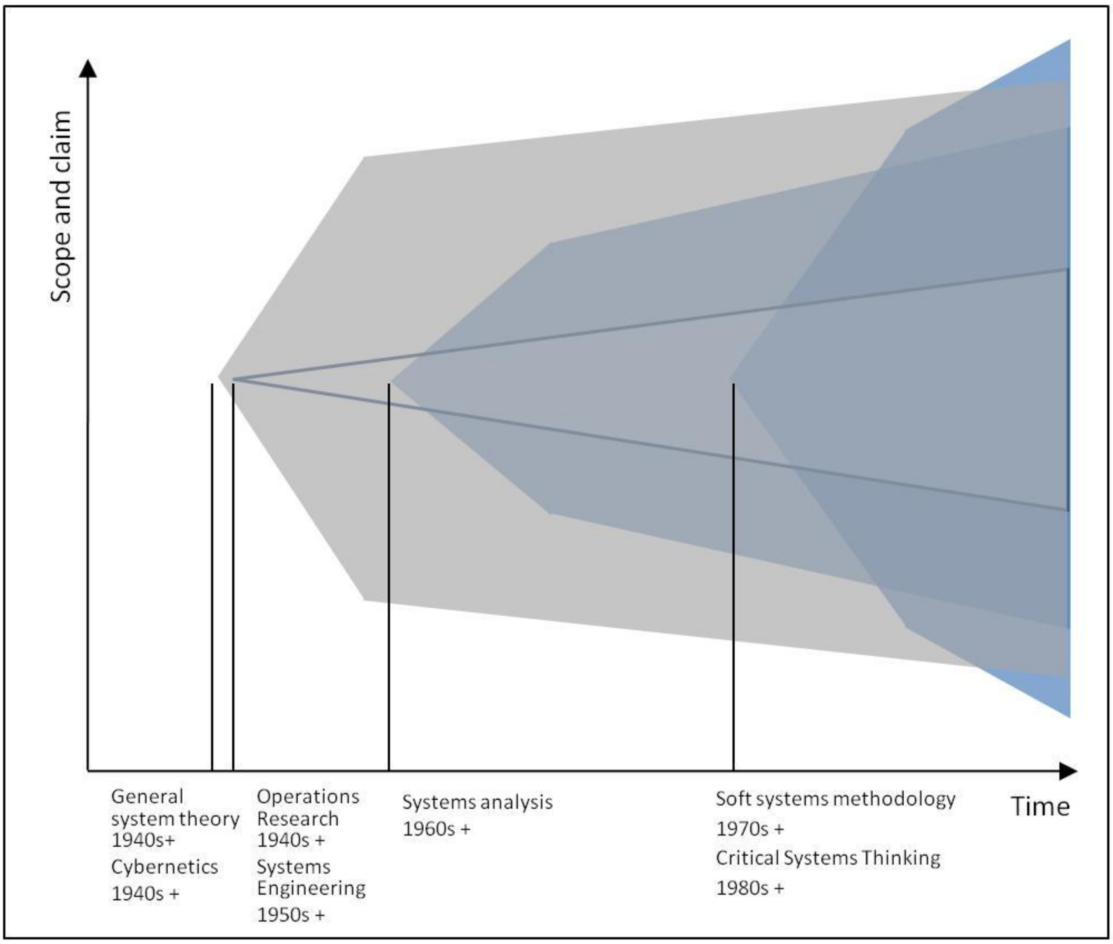

Figure 4.1: The relation between various “schools” of systems thinking (based on Olsson and Sjöstedt, 2004)

During the 1970s, there was an international trend to question positivism and the related thinking of social regulation. This trend influenced the systems thinkers, who realised that the objective, rational, analytic systems approaches, such as found in OR and Systems Engineering, had limited applicability to organisations and other social systems. In response, Checkland's Soft Systems Methodology (SSM) was developed in order to deal with systems that included people, with their varying worldviews and objectives (Rosenhead and Mingers, 2001). The Critical Systems movement went further by addressing not only plurality (many viewpoints) but also unequal (and unfair) power relations in social settings (Jackson, 2001).

Figure 4.1 is based on Olsson and Sjöstedt's (2004: 34) interpretation of how the various schools of systems thinking are related. It gives an indication of the dominance of certain kinds of thinking in approximate time periods. For example, the middle of the twentieth century is associated with the thinking of positivism, and this is the time during which Systems Engineering and Operations Research started growing in significance. SSM and CST both developed later in the twentieth century in reaction to the shortcomings found in positivist systems approaches. Note that some schools of systems thinking are grouped together in Figure 4.1 because of similar scope and claims, even if they originated in slightly different time periods.

4.2.3 Defining a system

Systems thinking, as manifested in design, engineering, development, or analysis, is usually applied when dealing with "real" systems. However, the view taken here is that systems thinking refers to a mental exercise (Olsson and Sjöstedt, 2004: 20-21; Checkland, 1999). A system is a mental construct or a model of reality. The particular systems approach that is applied, is chosen to fit the purpose of the study or project.

Jackson's (2003: 3) concise definition of a system is "a complex whole the functioning of which depends on its parts and the interactions of those parts." Jackson's emphasis on systems thinking as holism is clear from this definition.

According to Hitchins (2003: 26), a system is "an open set of complementary, interacting parts with properties, capabilities and behaviours emerging both from the parts and from their interactions".

Daellenbach and McNickle's (2005: 27) definition also highlights the relationship between the properties of a system and those of its components: each component influences and is influenced by the system as a whole, and each component contributes uniquely to the emergent behaviour of the system. Furthermore, components may be subsystems.

4.2.3.1 Systems vocabulary

Some general systems terms are discussed below. Other vocabulary, which is specific to a particular systems approach, will be introduced together with that approach.

Boundary: indicates the separation between the system and its environment. According to Daellenbach and McNickle (2005: 29), the selection of the boundary is the most critical part of the systems process. It involves not only logical but also value judgements, so that a large portion of the energy of the critical systems movement is spent on questioning boundary choices.

Function (input → transformation → output): a system is usually described in terms of its functionality and/or its structure. In systems design or analysis, the functional description is completed before the structural design. The functional view states the transformation function of the system, or how it changes inputs into outputs. A system transforms energy, matter and/or information. The main transformation function can be decomposed into secondary functions, all contributing to the execution of the main function.

Structure (hierarchy): a structural description will focus on the components, how they are arranged in a hierarchy of subsystems, components and elements and how all of these are connected. In general, a system is always part of a supersystem or relevant environment, beyond which the further environment is ignored. Within, it always contains a lower-level arrangement (Daellenbach and McNickle, 2005: 27-29). According to Hitchins (2003: 24), hierarchy and emergence go together; that is, system properties at a higher level in the hierarchy emerge from the units at the lower levels.

Feedback: Feedback loops can be planned or unintended; they can form within a system or in relation to the system's environment. Feedback loops are either positive (reinforcing) or negative (corrective). Positive feedback can lead to instability or self-destruction if a system's variable(s) take on increasingly larger and larger values, for example, temperature, speed, or size. Negative feedback is a form of regulation. It assists in maintaining or bringing a system closer to a desired state (Daellenbach and McNickle, 2005: 43). Most natural and manufactured systems rely on negative feedback as a means of control. A self-regulated system contains an internal control mechanism. An example of self-regulation in a natural system is homeostasis, such as the maintenance of a desired temperature in a mammal's body despite external changes in temperature. Feedback control in a manufactured system is normally by means of an external or control system, such as anti-skid technology that is added to a car's steering function to prevent it from sliding out of control.

Emergence: the behaviour of the system that results from the interaction between its components, that is not reducible to any of its individual components or subsystems (Daellenbach and McNickle, 2005: 39). Emergent behaviour can be either planned, as is the case with designed systems, or unintended. Unintended emergence in a manufactured system is often undesirable (in which case the systems design must be adapted to manage it) but it might also be beneficial. In both cases, the investigation of unintended consequences can lead to a better understanding of the functioning of the system.

Open and closed systems: these concepts, introduced by von Bertalanffy, distinguish between systems interacting with their environment by means of inputs and outputs, and systems that are isolated from their environment (Daellenbach and McNickle, 2005: 41). A closed system is a theoretical construct that does not exist in reality. For the sake of simplicity or control, it might be assumed that a system is closed, or an attempt might be made to create a situation where a system is relatively closed.

4.2.4 Analysis and synthesis as part of a systems approach

According to Ritchey (1996: 7), the systems concept always distinguishes between two different levels, namely "the system as a functioning unit and the system as a set of interacting parts". The processes associated with these two levels, are analysis and synthesis. Analysis means "to loosen up" and synthesis "to put together". Ritchey regards analysis and synthesis as complementary and part of an ongoing cycle. The one is not more important than the other, but sometimes the one is more suitable. This is in direct contrast with what Ritchey calls misleading thinking, namely that analysis is bad and reductionist, and synthesis good and holistic.

Ritchey (ibid.), based on a groundbreaking study by the mathematician Riemann on the working of the ear, shows that Riemann's study was successful because he, other than previous researchers, started by first looking at what the ear *accomplishes*, i.e. its emergent properties. Riemann follows the analysis process as described below and is able to account for aspects of the working of the ear that could not previously be explained.

4.2.4.1 Analysis

The analysis process starts by investigating what a system does or accomplishes as a unit, and from there attempts to understand the inner working of the system. It seeks causes of given effects. Ritchey (ibid.) summarises the analysis process as follows:

- What problem is being solved by the system? I.e. what is the primary task of the system?
- What would the secondary tasks need to be that will help to achieve the primary task?
- Is this set of tasks/functions *sufficient* to perform the primary task? Are all of them *necessary*?
- In what manner can these tasks be implemented? In other words, what possible components can be used?
- Verify the conceptual design obtained from the above by a synthesis process: will this design lead to the outputs of the system as can be determined from experience?

What Ritchey refers to, is an analysis of function. He contrasts this with an analysis of structure, which he labels reductionist. Ackoff (1999: 17) suggests similar steps for a systems approach: first to identify the larger or containing whole of which the entity to be investigated is part, secondly to investigate the behaviour of the containing whole, and thirdly to investigate the behaviour of the part in terms of its role within the containing whole.

4.2.4.2 Synthesis

The synthesis process starts by investigating a system's components, internal structure and processes, and attempts to understand how these work together to create the system's outputs. It infers effects from given causes. The system is built up from its lowest level. Ackoff (1999) uses the word synthesis in a different way. It appears to the researcher that this is only a matter of semantics and that Ackoff's and Ritchey's arguments are actually the same.

The above discussion of the analysis and synthesis processes is based on the study of an existing system. It could also be applied to a designed system, where an analysis needs to be performed in order to design a system that will meet certain requirements, followed by a synthesis or construction of the system.

4.2.5 Developing systems hierarchies

The following are attempts to arrange or classify systems in a hierarchy, with increasing levels of complexity:

- Early in the 1800s, Comte suggested a hierarchy of the sciences that arranges mathematics, astronomy, physics, chemistry and the biological sciences with social science at the top (Checkland, 1999: 61).
- Boulding's classification, developed in 1956, identifies nine system levels, increasing in sophistication from static structures, through living organisms to societal systems (Hitchins, 2003).
- Miller's Living Systems Theory, published in 1978, recognises eight levels of complexity in living systems, namely cells, organs, organisms, groups, organisations, communities, societies or nations and finally supranational systems (Bailey, 1994).

In all the systems categorisations and hierarchies that have been studied, *social or societal systems are regarded to be the most complex*. August Comte, who founded the term "sociology", based his argument for a new scientific discipline to study social science on such a suggested hierarchy. As can be seen above, more recent contributions such as Boulding's and Miller's followed the same thinking, showing that social systems inherit properties from systems lower down the hierarchy, but they cannot be explained by reducing them to any of the lower levels.

4.2.6 The benefits of a systems approach

Jackson (2003: 13) presents four arguments to promote the systems thinking by managers. The first is systems thinking's emphasis on holism, which provides a major improvement on reductionist thinking, when having to deal with complex situations where understanding the relationships between the parts of a system is important. Second, systems thinking focuses on process in addition to structure, leading to a more open-ended design that allows for unforeseen situations and possibilities. The third argument is systems thinking's transdisciplinarity, which allows for drawing on strengths of concepts from other disciplines. Jackson (ibid.) argues that, even if analogies are not fully transferable, they can assist with gaining new insights into existing problems. Fourthly, Jackson argues that the systems discipline has proved itself more suited to dealing with management problems than any other individual discipline.

According to Daellenbach and McNickle (2005: 19), systems thinking provides a way to study the effectiveness of a system as a whole. It also provides a way to recognise and conceptually deal with unintended consequences. These motivations are similar to Jackson's first two arguments. Daellenbach and McNickle teach management science and decision-making by means of a systems thinking framework, which they believe provides an advantage to their students (Daellenbach and McNickle, 2005: xiii).

4.2.7 Useful systems concepts for ICT4D

Based on the discussions above, the following systems concepts are perceived as useful for studying a social system into which an ICT4D project is introduced:

- The view of a system as a subjective mental construct provides the ability to distinguish between a systems description and a real-world situation. It gives the analyst the freedom to develop constructs that make sense in the particular setting, and in the process to use theory of her choice. It also acknowledges the researcher's subjectivity;
- Systems thinking's transdisciplinarity, which allows for introducing theory or concepts from other disciplines in order to gain insight into a situation;
- Systems thinking's balancing of the whole-view and the parts-view;
- In line with the previous point, the process suggested by Ackoff, namely to first identify the larger or containing whole of which the entity to be investigated is part, then to investigate the behaviour of the containing whole, and lastly to investigate the behaviour of the part in terms of its role within the containing whole;
- In ICT4D, to apply Ackoff's thinking by identifying ICT4D's containing social system as the 'containing whole', then to investigate the behaviour of this containing whole, and lastly to investigate the behaviour of the part (the ICT4D project) in terms of its role within the containing whole;
- Systems thinking's focus on the effectiveness of a system as a whole, together with Ackoff's process, allows an ICT4D intervention's influence on the well-being (in this case, development and sustainability) of the larger social system it forms part of, to be assessed.

4.3 The various systems approaches

The main categories of systems approaches correspond with the three main research paradigms, namely positivist, intepretivist and critical. Table 4.1 below is an attempt to map and compare the categorisations that were done by a number of theorists, such as Habermas, Burrell and Morgan as well as Jackson. They have similar underlying thinking but somewhat different terminology.

Systems paradigm	**Hard**	**Soft**	**Critical**
Systems approaches	Systems Engineering Systems dynamics Cybernetics Systems analysis Operations Research (OR) Non-linear dynamics	Soft Systems Methodology Other Soft OR approaches: SODA, Strategic Choice Multiple Perspectives Approach	Critical Systems Heuristics (CSH) Total Systems Intervention
Sociological paradigm (Burrell and Morgan, 1979)	Functionalist	Interpretivist	Radical humanist
Habermas' classification of interests (Mendelsohn and Gelderblom, 2004)	Technical (formal societal systems)	Practical (communication)	Emancipatory
Jackson's (2001) classification of challenges	Complexity	Subjectivity	Conflict and inequality
Goal	Efficiency of system	Understanding	Critique of method Helping the marginalised/oppressed

Table 4.1: Comparing the categorisations of systems approaches

Burrell and Morgan's (1979) four sociological paradigms are commonly used as a frame of reference in Information Systems. If the researcher categorises the systems approaches making use of the four paradigms, the following is obtained:

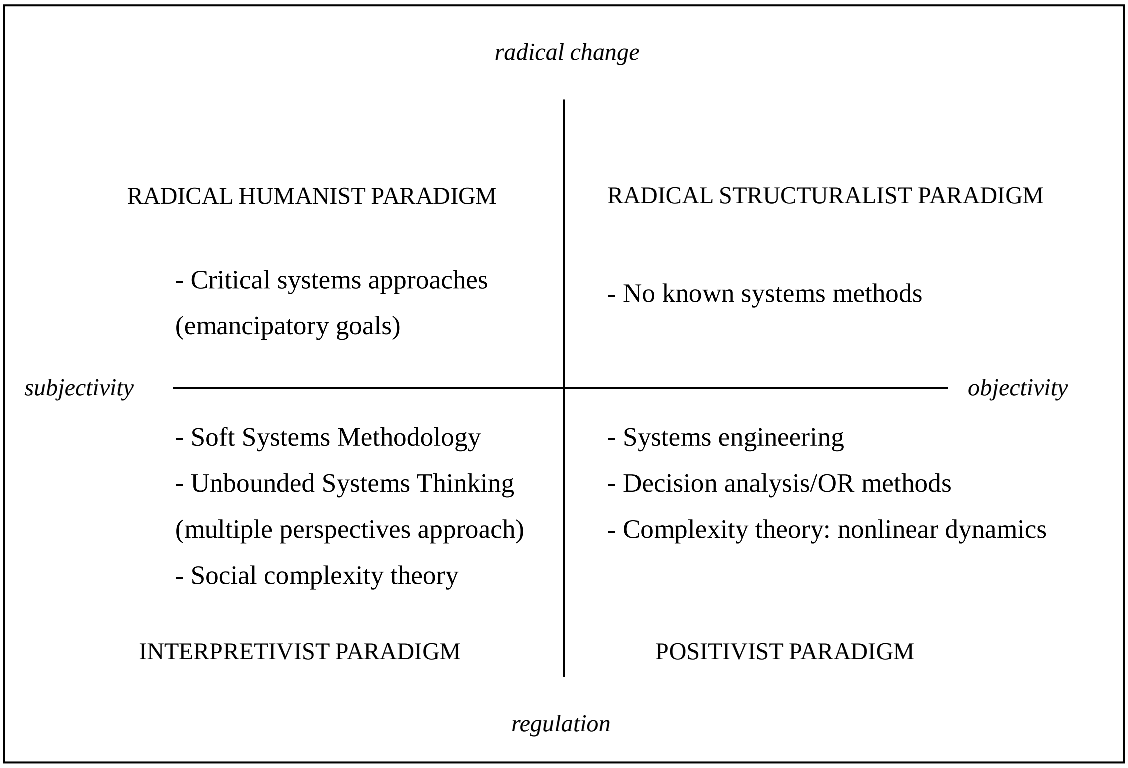

Figure 4.2: Systems approaches mapped to Burrell and Morgan's sociological paradigms

Arguments in support of the mapping in Figure 4.2 are the following:

- Checkland (1999: 280) motivates for hard systems thinking to be associated with positivism, and SSM with the interpretive paradigm.
- Jackson (2000) presents a classification similar to the above, but distinguishes between the emancipatory approaches and his own work on Critical Systems Thinking, which he regards as a meta-systems approach.

A few things about this mapping are unsatisfactory. Firstly, only three of the four blocks are used; no systems approaches have been identified which correspond to the radical structuralist paradigm. Secondly, some systems approaches do not comfortably map to an exclusively positivist or interpretivist paradigm; they contain elements of both. An example discussed in Section 3.2.5 is that of complex systems, which are self-referencing and in addition adapt to and manage an external environment. According to Alter (2004), the *nature* of systems research does not lend itself to a comfortable fit in either the positivist or interpretive paradigm (see Section 3.2.5.).

Jackson's (2003: 24) System of Systems Methodologies (SOSM) is a tailor-made categorisation framework for systems approaches. The SOSM is presented in Table 4.2. On the one axis it considers the complexity of the problem itself and on the other the level of harmony in the social environment. In the social environment, participant agreement is classified as follows: people in a unitary relationship agree on goals and values, those in a pluralist relationship differ on viewpoints and goals but may come to a common understanding about the way forward. People in coercive relationships experience directly conflicting views and goals (Jackson, 2003: 19). According to Jackson, the major systems approaches map to his SOSM as follows:

		Participant agreement		
		Unitary	Pluralist	Coercive
Type of system	Simple	Hard systems thinking	Soft Systems approaches	Emancipatory systems thinking
	Complex	System dynamics Organisational cybernetics Complexity theory		Postmodern systems thinking

Table 4.2: Systems approaches related to problem contexts (Jackson, 2003: 24)

The approaches developed over time from left to right: first hard systems thinking during the middle decades of the previous century, followed by soft systems approaches from the 1980s onwards, and soon afterwards the emancipatory approaches. Vertically, they have originated in the direction of 'simple' to 'complex'. New methods are appearing and existing methods are growing in sophistication across the spectrum of this table. For example, hard systems thinking is not becoming outdated but is being further developed in order to serve its problem domain better. What has changed with the addition of new kinds of approaches is the recognition that certain problem domains are better served with the newer approaches.

The temporal development of the table indicates the more recent systems research focus areas. On the one hand, there is an increased recognition of complexity and a search for appropriate methods to deal with complexity. On the other hand, there is a continual search for more effective ways to apply systems approaches in environments of social tension.

Jackson's categorisation will be used as a basis for discussing the various types of systems approaches.

4.4 Hard systems thinking

The "hard systems thinking" paradigm, as introduced above, generally refers to approaches associated with Operations Research, Systems Analysis and Systems Engineering (Jackson, 2003: 48). Hard systems thinking follows a scientific approach to solving problems in the real-world or operational domain. According to Jackson, they replace the science laboratory experimentation environment with a set of models, often mathematical in nature, that are used to emulate reality and to decide what decisions to make. In this paradigm, optimal solutions are sought to management problems.

Two examples of hard systems thinking are discussed below, namely systems engineering and organisational cybernetics. The reason for selecting these among a number of other candidates is that they represent aspects of classic hard systems thinking. Systems engineering is a theoretical parent of Soft Systems Methodology, and has also been directly applied to social systems. Organisational cybernetics is an example of applying cybernetics principles in a social and specifically a management context.

4.4.1 Systems Engineering

Systems Engineering (SE) is one of the most comprehensive methods known in the "hard systems thinking" paradigm. The International Council on Systems Engineering (INCOSE) web site defines SE as follows:

"Systems Engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem: Operations, cost & schedule, performance, training & support, test, disposal and manufacturing" (INCOSE, 2008).

SE aims to increase the probability of success of a project, reduce risk and reduce total life-cycle cost. SE is normally used by engineers when dealing with technical systems with high fidelity requirements, although SE principles are more generally applicable and have been applied in economical, organisational and environmental systems (Turpin et al., 2005). Central to the SE process is the SE lifecycle, illustrated in Figure 4.3: The Systems Engineering lifecycle below.

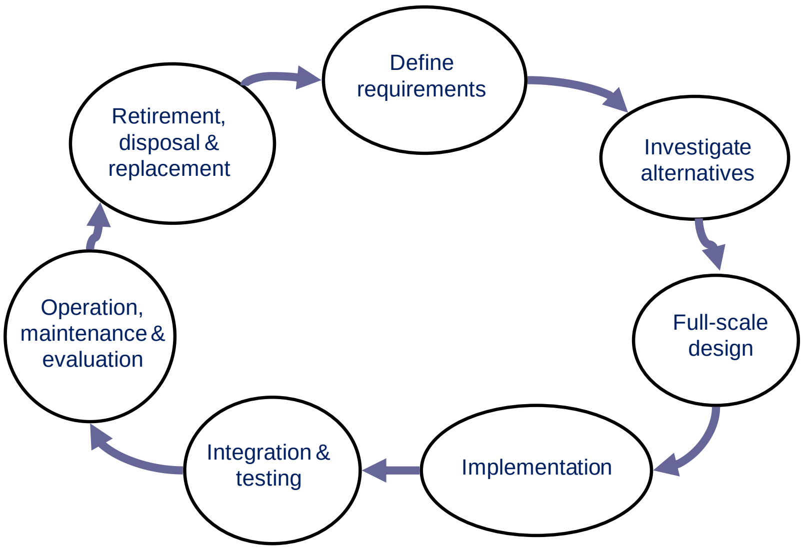

Figure 4.3: The Systems Engineering lifecycle
(Smit, 2004)

4.4.1.1 The Systems Engineering design phase

Of all the steps in the SE process, the design phase is probably its most significant contribution. Figure 4.4 below shows how system requirements are translated into several design concepts. The concepts are evaluated during a process involving the customer and by means of decision analysis. For each of the designs, a functional as well as physical decomposition needs to be performed. The decompositions are presented as systems hierarchies, or sets of interacting subsystems to be built up from basic components to the complete system.

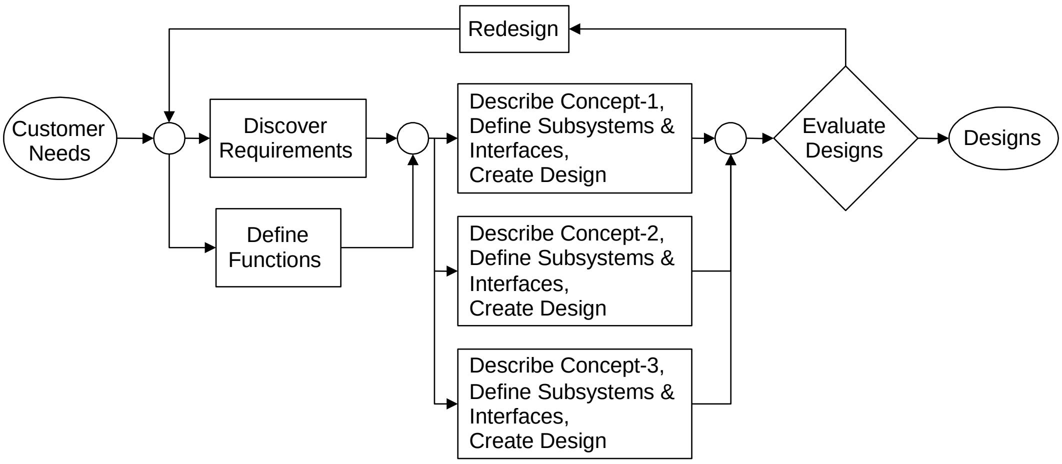

Figure 4.4: Systems Engineering: the design phase (Smit, 2004)

4.4.1.2 The social application of systems engineering: an assessment

As mentioned, SE has been applied to economical, environmental and organisational systems. Its application to address socio-economic concerns in a developing country is rare but it has been done. Examples are Gaynor (2004) who considers socio-economic conditions in Jamaica, and Nyamvumba et al. (2011) who address policy making in Rwanda. The researcher has been involved in a project where SE was applied to investigate the poverty alleviation system in South Africa (Turpin et al., 2005). The conclusion of the exercise was that SE provided valuable insights of a systemic nature, but needed to be supplemented with methods that could better deal with the social nature of such a system, such as the differing views of multiple stakeholders. SE's strength is in the design and lifecycle support of technical systems, and on its own it is not suited as a social systems approach.

4.4.2 Organisational Cybernetics

Stafford Beer's Viable System Model is referred to by Jackson (2003) as "organisational cybernetics". Beer's attempt to deal with complexity in an organisational context is of significance: Beer has taken some fundamental systems concepts from mainly cybernetics and developed an approach that is applicable to organisations, which are social systems.

Cybernetics is defined as the science of communication and control in animal and machine. It treats a system as a black box and attempts to control it by means of negative or corrective feedback (Jackson, 2003: 7). Initially, this thinking was only applied in an organisational context by recognising that negative feedback was necessary to help an organisation steer towards its goals. Stafford Beer, a British operations researcher, proceeded to found the field of Management Cybernetics (Rosenhead, 2006: 577). Beer expanded the applicability of cybernetics into organisations and later other social systems, by means of his Viable Systems Model (VSM). He proved the VSM to be generally applicable to all systems (Jackson, 2003: 86) and with it provided a generic method which can be used to design organisations which can survive in a changing environment (Rosenhead, 2006: 581). According to Rosenhead (2006: 578), he was concerned with the development of appropriate feedback loops into social systems, and committed to a holistic approach to complexity.

An assumption of organisational cybernetics is that there are general, nature-like laws governing every complex system. One of these laws is that complex systems have a *recursive nature*, so that "the organisational form of higher level systems can be found repeated in its parts" (Jackson, 2003: 87). This means that one can zoom in or out of an organisational hierarchy and observe the same system characteristics, whether for the organisation as a whole or a subsystem at any level. The implication is that one has to manage only one level at a time within an organisation, reducing the burden of top management and increasing the autonomy of sub-units. Another law that is recognised is the theory of autopoiesis. Beer maintains that organisations are *self-producing*, although only at the higher and more autonomous levels of operation. According to autopoiesis theory, the organisation of a system is more important than its particular structure; a well organised system could have different possible structural decompositions, all of which could be feasible. The third cybernetic law is that of *requisite variety*. In order for an operational unit to exhibit the variety required to deal with unexpected changes in the environment, it should be as autonomous as possible from the system's management structure. The management should be limited to ensuring the operational units all work towards the system goals in a cohesive way (Jackson, 2003: 88-90).

The VSM always zooms in at one level of recursion, or system of interest, at a time (Jackson, 2003). The system of interest's direct superstructure is recognised, as well as the elements of its substructure. The substructure elements are treated as black boxes but any of them could be the system of interest in another analysis. The organisation of the system of interest consists of five functions that are necessary for viability, namely *implementation*, *co-ordination*, *operational control*, *development* and *policy*. The VSM can be used to design an organisation and also as a benchmark against which to diagnose the problems in the design and functioning of an existing entity. Further, Beer has devised a set of systemic performance measures that go beyond the usual monetary measures. According to Jackson (ibid.), VSM is usually used in single organisations, but has also been applied at a larger scale, such as when Beer was an advisor to the Allende government in Chile.

4.4.2.1 Assessment of VSM's application to social systems

A personal assessment of VSM is that although evidence has been supplied of its application to larger social systems, this is still in a very specific context, namely sanctioned organisational design, involving well-defined entities that need to be administered according to the needs of management. As Jackson (2003: 108) states, it remains a functionalist model that will not easily adapt to the other systems paradigms; it cannot accommodate the human aspects (whether in interpretive or critical fashion) to fully deal with the nature of a social system that differs substantially from a formal western organisation.

4.5 Soft systems thinking

Soft Systems Thinking, also referred to as Soft OR, refers to a number of approaches developed to deal with human and social aspects for which hard systems thinking was found to be inadequate, in particular when applied to complex problems that were messy and ill-defined and where conflicting viewpoints were held on the same issue (Daellenbach and McNickle, 2005). The two soft systems approaches described in this section are the Soft Systems Methodology (SSM) and the Multiple Perspectives Approach (MPA). SSM is the flagship of soft systems thinking. The MPA is selected because of its inclusiveness at philosophical level.

4.5.1 Soft Systems Methodology

Peter Checkland's SSM is one of the most widely researched and well-founded in terms of systems theory and its philosophical base, as well as one of the most widely used and documented (Daellenbach and McNickle, 2005).

4.5.1.1 Classification of systems and appropriate vehicles for analysis

Checkland (1999) classifies systems into four kinds:

Natural systems are the physical systems that make up the universe, from subatomic systems to the living earth. These systems follow the laws of nature and the scientific method is an appropriate vehicle to research and analyse these systems. Natural systems provide us with examples from which we can learn more about systems and their dynamics.

Designed physical systems are the tangible systems that people have built. These systems, ranging from hammers to rockets in space, are the result of conscious design. Systems engineering is a vehicle developed to design, analyse and manage such systems.

Designed abstract systems are the non-tangible systems people have designed, such as mathematics and music. These each normally have an own "rule set" which is used to interact with such a system.

Human activity systems are the ones that have human role-players, whether as individuals or organisations. They can be socio-technical, socio-economic or social, and vary in scale from a human working with a machine to an international political system. Human activity systems differ from the other categories in the sense that there are multiple perspectives on how to understand and analyse them. Also, the human actors in the system have free wills to act, so the "operations" of such systems are less predictable.

Checkland (ibid.) later in his work mentions that a *social system* has characteristics of both a natural system and a human activity system, without discussing the matter in more detail.

Checkland developed SSM as a means to deal with human activity systems, building on the concepts of Systems Engineering as well as traditional modelling and OR methods.

4.5.1.2 The Soft Systems Methodology

SSM is a participative, facilitated process that aims to surface the various views and perceptions on a problem. It does not lead to an "objective" answer, but rather to a conclusion as agreed by participants. The outcome is not necessarily a synthesis of all perspectives. The problem-solving process is regarded to be more important than the outcome. The seven stages of SSM, shown in Figure 4.5, are discussed below, drawing on Checkland (1999: 163) and Daellenbach and McNickle (2005). Checkland makes it clear that one can improvise in the way SSM is applied, and that he regards SSM as a guiding framework rather than a recipe.

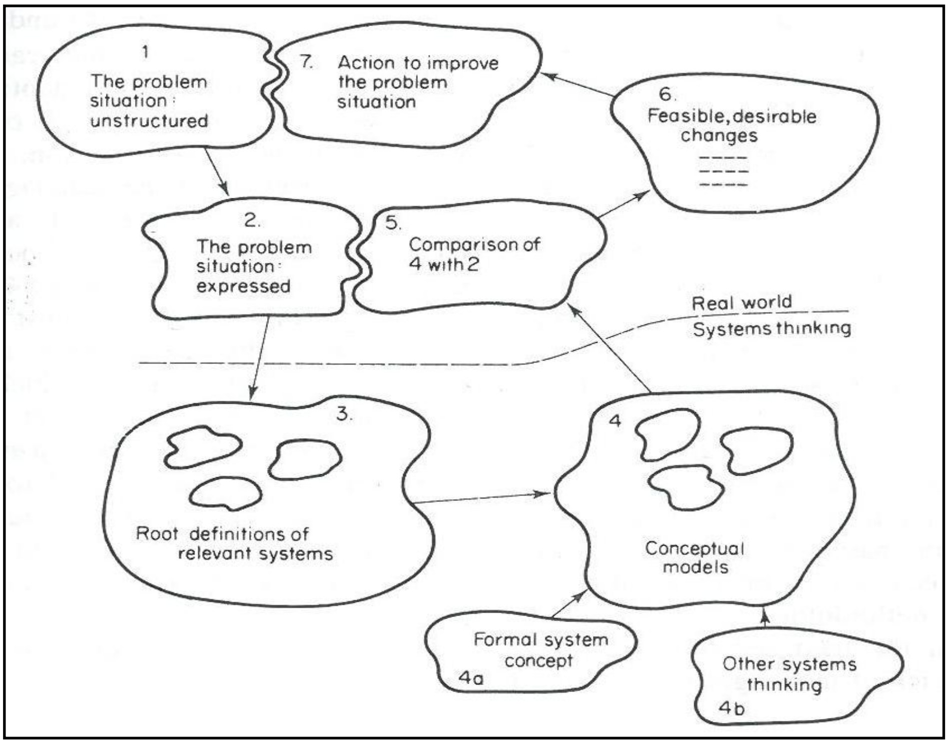

Figure 4.5: A flow diagram of the Soft Systems Methodology
(Checkland, 1999: 163)

The method alternates between "real-world" and "systems thinking" activities. Stages 1 and 2 involve expressing the situation in a rich manner, capturing elements of structure and process. Stage 3 involves identifying alternative systems related to the problem situation, and stating what these systems are, rather than what they do. Root definitions are sought for each, specifying the owners of the problem (O), the prime system transformation (T) to be achieved by the users/actors (A), the owners' world views (W) about the transformation, the customers (C) or victims/beneficiaries of the system, as well as the environmental constraints or assumptions (E). These aspects all spell the term "CATWOE" which is used as a memory aid. Stage 4 entails developing conceptual systems models based on the respective root definitions: For each view, a conceptual model is designed using the root definition as functional requirement. The activities needed for the specified transformation process to happen are first described in English verbs. Following this, the human activity systems can be more formally modelled using recognised systems approaches developed elsewhere. It might be necessary to include subsystems for monitoring and control. In stage 5, the conceptual models are compared with real-world situations. The purpose is to prepare for a debate within the stakeholder group, which takes place during stage 6. Possible changes are debated; in particular, it needs to be seen whether and which concepts are systematically desirable and culturally feasible. Stage 7 involves taking action, by implementing the suggestions agreed upon by the stakeholders. According to Checkland, the implementation may constitute or lead to a new problem, for which the methodology can be repeated.

The systems cycle described above is viewed by Checkland as a learning cycle rather than as a lifecycle. The work being done during this process is not that of an analyst, but it is done by representatives of stakeholders. The analyst in this case is a process facilitator. It is also possible for the analyst to execute SSM as a mental exercise, by imagining him/herself in the role-players' situations (Daellenbach and McNickle 2005: 181). Daellenbach and McNickle (ibid.) note that the main challenges facing SSM are that of formulating effective root definitions, as well as the fact that there is no way of guaranteeing that role-players will reach consensus.

4.5.1.3 SSM's application to social systems: an assessment

Since SSM takes into account the nature of a human activity system, in particular recognising multiple stakeholder perspectives on a problem situation, it is well suited to application in a social domain. A comparison of the SE design process (Figure 4.4) with the SSM process reveals how Checkland has beautifully re-crafted the SE process to take into account multiple stakeholder views rather than multiple technical solutions. SSM is an interactive process, ideally used as part of action research, the way Checkland himself did (Oates, 2006: 156). Its desktop use is second prize; however, its loose assembly of sub-methods, for example its use of rich pictures to express a problem situation, and the CATWOE mnemonic to develop a root definition for a system of interest, has been found useful by the researcher on previous occasions. Of interest for this study is Checkland's statement that a social system contains characteristics of a human activity system (for which SSM was designed) as well as of a natural system.

In Chapter 2, among the ICT4D papers surveyed for their use of systems thinking, SSM is shown to be the method that has been most frequently applied or referred to.

4.5.2 The Multiple Perspectives Approach

Similar to SSM, the Multiple Perspectives Approach is also founded on accommodating different perspectives on a problem situation. Its underlying philosophy is unbounded systems thinking. The beauty of this philosophy is a key attraction of the approach; it attempts to be a truly holistic systems approach.

4.5.2.1 Introduction

The multiple perspectives approach is based on a way of thinking that Mitroff and Linstone (1993) refers to as unbounded systems thinking. This is in turn based on the philosophy of Singer, who believes in the interconnectedness of all systems and the interrelatedness of all problems. The multiple perspectives approach is an attempt to be as holistic as possible when analysing a problem, and trying to simultaneously accommodate as many views on a situation as can be found. These views are not only analytical; it also encourages the collection and analysis of organisational, personal, ethical and aesthetical perspectives.

4.5.2.2 Inquiry systems

An inquiry system is defined as “a system of interrelated components for producing knowledge on a problem or issue of importance” (Churchman, cited in Mitroff and Linstone, 1993).

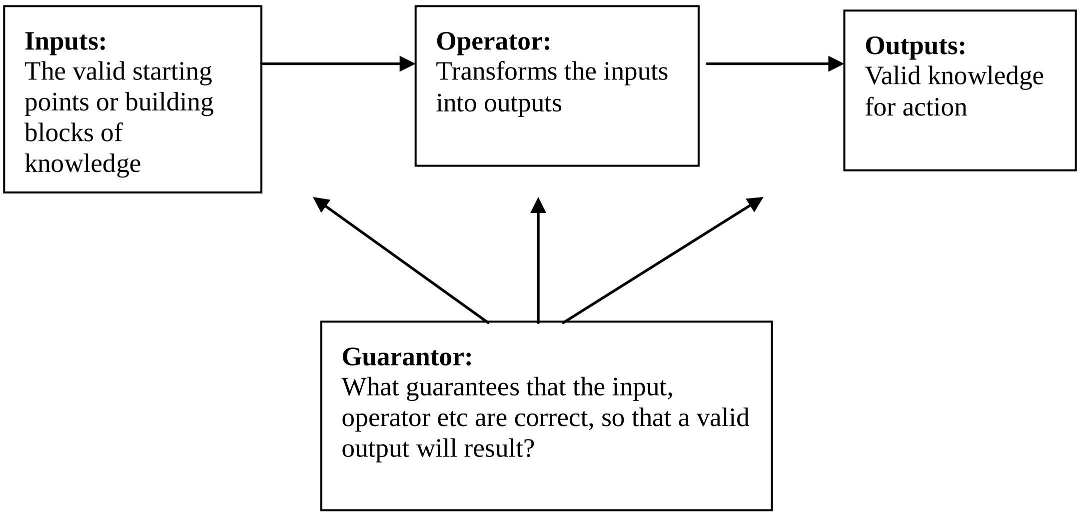

Figure 4.6: An inquiry system
(Mitroff and Linstone, 1993: 31)

The particular inquiry system used in a problem-solving exercise will determine what kind of information is being collected, how it is collected, and how the information is processed in order to arrive at knowledge which will be used as the basis for decision-making. Mitroff and Linstone (1993) discuss five types of inquiry systems[4]:

Inductive-consensual inquiry systems are designed to assist a group of experts in reaching agreement. The inputs into the inquiry system are facts, observations or the various judgements of experts. The guarantor (see Figure 4.6) would be the definition and identification of experts, since the validity of the system assumes the sound judgement of the experts, as a proxy for an objective conclusion. The operator would be something like the Delphi technique, and the output would be a consensus.

Analytic-deductive inquiry systems seek for a single best answer to a stated problem and derive that answer through rational means. Inputs are the given facts as well as axioms or self-evident assumptions. The guarantor is the set of logical rules to be applied. Rational decision-making processes fit into this category, using methods such as decision analysis, quantitative analysis or applying the rules of logic to a qualitative situation.

Multiple-reality systems recognise different views on the same problem by different kinds of experts or subject disciplines. In a multiple reality inquiry system, information and observations are not separable from the theory or model we construct of a problem. Different theories or models will collect different data on the same problem. Inputs to the multiple reality system are a range of theory/data couplings that represent various views or representations of the problem. The purpose of the inquiry is not to arrive at an answer, but to allow the decision-maker to act. The operator is not a purely mathematical one; the decision-maker will need to apply qualitative traits such as experience and wisdom in the process of generating a synthesised view.

The *dialectic* inquiry system can be seen as a variation of the multiple realities inquiry system. Two or more models are created, with views that are in the strongest possible opposition to each other. Rather than building convergence into the system, such as when the Delphi technique is used, the extremes or "outlier" viewpoints are brought to the surface. It is assumed that as a result of witnessing an intense debate between polar positions, the observer will be in a stronger position to know the assumptions of the adversaries and as a result clarify

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[4] The discussion that follows is taken from Turpin (2006).

his/her own assumptions, and subsequently be in a stronger position to inform his/her own position. The output does not have to be a change in the decision-maker's position. It could also be a clarification and deeper entrenchment into the initial position, based on the consideration of the opposite(s).

The *multiple perspectives* view is based on Singer and Churchman's work (Mitroff and Linstone, 1993), which refers to the interrelatedness and inseparability of all systems. It criticises man-made categorisations, such as, academic disciplines or any limiting description of a problem or situation. Accordingly, the multiple perspectives view attempts to "sweep in" all possible perspectives from all possible professions. In particular, it needs to sweep in the previously discussed inquiry systems or problem perspectives. It suggests that perspectives can be categorised as *technical*, *organisational* or *individual (personal)* in nature. *Technical perspectives* involve the use of the scientific method. It includes the analytic-deductive inquiry system, as well as the multiple realities view. It is recommended that more than one technical view of a system is obtained. The *organisational* and *personal* perspectives are represented by including the views of as many of the role-players and stakeholders as possible. Role-players functioning in defined groups (such as companies or unions) are dealt with under the organisational perspective. Within these organisations, or separate from them, are people whose behaviour is driven by their individual needs and agendas. In as much as they act as individuals, these role-players' individual or personal perspectives are taken into account. Apart from the technical, organisational and personal views, Mitroff and Linstone (ibid.) advise that *ethical* and *aesthetical* perspectives should also be kept in mind. Even if a decision makes sense from a technical perspective, or a particular group of organisations endorses it, the decision might not be ethical.

4.5.2.3 Towards a new decision-making paradigm

Based on the multiple perspectives inquiry system as discussed by Mitroff and Linstone (1993), Courtney (2001) suggests the process in Figure 4.7 as a new decision-making paradigm. The T, O and P blocks in Figure 4.7 refer to technical, organisational and personal perspectives:

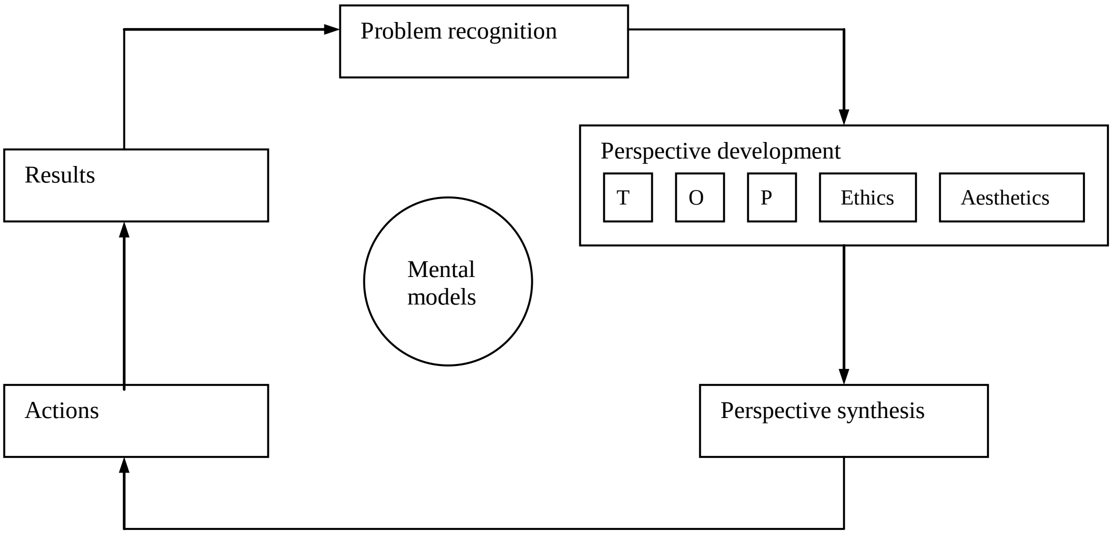

Figure 4.7: A new decision-making paradigm for DSS
(Courtney, 2001: 31)

This process is less detailed than SSM, where alternative systems concepts are designed for each major perspective and only when action plans are discussed are all options reviewed in order to arrive at a consensus action plan. On the other hand, the perspective development phase shown above is more comprehensive than what was done in the first two steps of SSM with the rich picture exercise.

4.5.2.4 Critique of the multiple perspectives approach

An attempt to apply the Multiple Perspectives Approach (MPA) on a case study at the CSIR (Meyer et al., 2007) has shown challenges in its implementation. Among the challenges was that its philosophical beauty did not translate into to a straightforward methodology for implementation. For example, it was not clear what methods were to be employed to generate an organisational perspective. The technical perspective, which covered most of the project team's already known information collection and analysis methods, was most easily understood. Generating an ethical perspective was less straightforward, not to speak of an aesthetic one. Further, how does one integrate perspectives generated from truly different paradigms? Based on the learning that took place, a suggested way of using the MPA in practice is discussed by Turpin et al. (2009). The researcher later learned of Linstone's (1984) guidelines to assist with applying the MPA, yet does not believe that many of the challenges the project team encountered could easily have been avoided.

Based on its underlying philosophy, the MPA is suited for application to a social system. However, care needs to be taken that the purpose of a systems description exercise can be practically met, since the method can become clumsy because of its philosophical inclusivity. In Chapter 2, among the ICT4D papers surveyed for their use of systems thinking, it can be seen that the MPA is referenced and at least partially applied by two of the eight papers discussed.

4.6 Critical systems thinking

4.6.1 Theoretical background

Critical or emancipatory systems thinking is aligned with the critical paradigm of social theory. The critical paradigm's origins lie in the work of the Frankfurt School, formally known as the Frankfurt Institute of Social Research in Germany which operated from 1923 onwards. This group of social theorists built on the work of Max Weber, who thought that the process of rationalisation in modern society had the potential not only to free humans but also to limit and oppress them (Gelderblom and Martin, 2005: 162). They also use the thinking of Karl Marx, who argued that capitalism is a means of oppression and exploitation of labourers. Marx advocated for labourers to organise against such oppression. Broadly speaking, the Frankfurt School aimed towards the emancipation of individuals from the dominance of societal regulation, as found in, for example, capitalism (an economic system) and bureaucracy (an administrative system).

4.6.2 Critical systems approaches: CSH and TSI

Critical systems thinking developed as a means to introduce critical social theory into systems thinking. The critical stream in systems thinking developed as a result of the work of mainly Ulrich, Flood and Jackson, from the 1970's to the 1990's. It indicates some shortcomings of other systems approaches (such as the way system boundaries are selected) and provides suggestions to deal with these. Critical approaches have a particular concern with the marginalised parties in a system and attempt to create an awareness of such parties or aspects.

According to Daellenbach and McNickle (2005), critical systems thinking is the collective term used for the two major streams of work that called for a critical approach to systems thinking. The first stream is the work of Ulrich on Critical Systems Heuristics (CSH). Its core emphasis is boundary critique. The second stream is the work done by Jackson and others at

Hull University in the 1980's, who have appropriated the term Critical Systems Thinking (CST) for their work. They attempted to create critical awareness of the strengths and weaknesses of systems methodologies, and how these related to the nature of the problem investigated. They placed specific emphasis on power relationships and wanted to put mechanisms in place to neutralise the effect of coercive power. Also included in the five commitments of CST was pluralism, on the methodological as well as theoretical level (Jackson, 2004: 281). The output of this stream that will be discussed further in a section below is Total Systems Intervention.

4.6.2.1 Critical Systems Heuristics

As mentioned, the main concern of CSH is the choice of system boundaries. Ulrich's point of departure is that boundary choices are always subjective and influenced by value systems. The choice of boundary can lead to improvements in a narrow system of interest at the cost of a worse overall system performance. A well known example from South African history is the apartheid system, where seemingly noble objectives, such as promoting the cause of poor Afrikaners, were to the detriment of society at large because of boundaries that were chosen too tightly, demographically and geographically. Since one has to choose boundaries and determine a system of interest, and there is no absolute "right" boundary, Ulrich suggests that boundary choices should always be critically examined. In the CSH approach, Ulrich poses twelve questions. The questions progress from those typically included in systems design, to questions aimed at exposing assumptions around boundaries and marginalised parties. Each has an "is" and "ought to" component. The questions concern the following (Flood and Jackson, 1991: 213; Daellenbach and McNickle, 2005: 197):

- The actual client of the system to be designed;
- The actual purpose of the system;
- The measure of the system's success;
- The decision-maker, who has control over the measure of success;
- The aspects that are controlled by the decision-maker;
- The aspects not controlled by the decision-maker, or the systems environment;
- The planner of the system;
- The experts involved with planning;
- The guarantee of the system being successful;
- The representation of those affected but not involved;
- The opportunities of those affected but not involved, to actualise their concerns; and

- The world view underlying the design, compared to the world view of the affected.

The initial questions, in particular the first three, are in their "is" mode similar to what is typically asked in other systems approaches. The last three questions, dealing with parties excluded from the system, is one of the differentiating characteristics of CSH. Another, the "ought to" mode of questions, is meant to surface assumptions, in particular, boundary related assumptions.

Midgley (1992) contributes to the CSH stream by arguing that different ethical positions lead to the choice of different boundary choices, to the extent that these boundary choices become institutionalised within groups. On a housing services project, Midlgely and fellow researchers indicated how vulnerable stakeholders could be better accommodated by the careful choice of systems design methods (Jackson, 2003: 221-226).

4.6.2.2 Total Systems Intervention

TSI is a meta-methodology developed by Flood and Jackson (1991). It is meant to critically assist in the systems intervention process. Flood and Jackson have derived principles for acknowledging TSI as a meta-methodology, aimed to deal with problem situations that are too complex and multi-faceted to be addressed by a single view or methodology (Jackson, 2003: 285). It involves the phases of creativity, choice and implementation. During the creativity phase, the following metaphors are suggested to describe the problem context (Daellenbach and McNickle, 2005):

- A machine, with a clear hierarchical structure and chain of command, exemplified by a bureaucracy or a military unit;
- An organism, with interrelated parts and sub-goals but where the primary goal is the well-being of the larger organisation;
- A brain, promoting learning, enquiry and creativity, exemplified by a learning organisation or an R&D department;
- A culture, where individuals have shared interests and interact with a community-like spirit, as in a Community of Practice or a sports club;
- A political system, where coalitions have different vested interests, such as a parliament;
- A coercive system, which is totally authoritarian, such as a prison.

During the choice phase, a systems methodology or combination of methodologies are selected. These are the ones judged to be the most suitable to the problem situation and the metaphor. The last phase is the implementation phase. Here, the chosen methodologies are used to develop and implement proposals for change (Jackson, 2003: 287).

4.6.3 Critique of the critical approaches

A weak point of TSI is that it requires thorough theoretical knowledge and experience of a wide range of other methodologies in order to add any value (Daellenbach and McNickle, 2005). Of the few people doing problem structuring, most are well versed in only one methodology. In addition, it does not guarantee that the "critical" ideals are met, such as improving judgement around boundary values. Daellenbach and McNickle (ibid.) believe that TSI is more ambitious than CSH in delivering the critical ideals, but less successful.

In principle however, it is clear to the researcher that CSH and TSI are both applicable to social systems. Their potential contribution in an ICT4D context is in the surfacing of emancipatory concerns. In Chapter 2, among the ICT4D papers surveyed for their use of systems thinking, it was found that the two papers that promote a pluralist approach (Nepal and Petkov, 2002; Turpin et al., 2009) both include critical systems thinking within such an approach.

4.7 Complexity thinking

Complexity thinking is an umbrella term that refers to a number of loosely related phenomena that were identified and studied in the second half of the 20^{th} century. These include concepts from chaos theory, fractals and the non-equilibrium thermodynamics of open systems. Jackson (2003: 116) identifies six "key theoretical notions in complexity theory: sensitive dependence on initial conditions, strange attractors, self-similarity, self-organisation, the edge of chaos and the fitness landscape."

Edward Lorenz, a meteorologist and pioneer of chaos theory, discovered by accident that his weather forecast simulation, consisting of three coupled nonlinear equations, was extremely sensitive to initial conditions. Although this meant that the weather was unpredictable in the long term, there were interesting regularities displayed by the nonlinear equations. A pattern or trajectory was formed by the equations, never repeating itself yet returning to the same vicinities. These vicinities are called strange attractors (Capra, 1997: 132; Jackson, 2003: 114).

The same nonlinear equations show behaviour which is called self-similarity, or fractal behaviour. Although related to chaos theory, fractal geometry was independently discovered and developed by Mandelbrot (Capra, 1997: 136). It refers to the notion that when you zoom into a graphic representation of an equation, the geometrical shapes are identical to the shapes observed before zooming in. This phenomenon can also be observed in nature, such as with the edges of clouds, mountain ranges, coastlines, as well as snowflakes and ferns.

Another significant theoretical contribution, initiated by Prigogine, was that of non-equilibrium thermodynamics. The second law of thermodynamics specifies that in a closed physical system there is a trend towards disorder, also referred to as energy dissipation, randomness or thermal equilibrium. Prigogine showed that in open chemical systems, it is possible that they can *self-organise* into a new state of orderliness and maintain themselves in a steady state or dynamic balance, far from equilibrium (Capra, 1997: 49; Jackson, 2003: 118). Lovelock subsequently showed the same for ecological systems, leading to the Gaia hypothesis. The notion of self-organisation is not to be confused with that of self-production, the latter associated with autopoiesis (Maturana and Varela, 1987).

The notion of the 'edge of chaos' refers to the narrow zone between order and chaos, where interesting new emergent behaviour is likely to initiate. This includes patterns of self-organisation as discovered by Prigogine. Other work in the field of complexity lead to the concept of 'fitness landscapes', referring to a dynamic landscape of mutually co-evolving systems, where each is on an unpredictable trajectory going through peaks of relative fitness and valleys of being disadvantaged in its stage of development (Jackson, 2003: 118).

A question with no clear answer is whether the theory of autopoiesis (Maturana an Varela, 1987) belongs in the basket of complexity theories. Jackson (ibid.) does not mention autopoiesis in his list of complexity theories. Leleur (2008), on the other hand, loosely refers to autopoiesis under the heading of complexity theories. Capra (1997: 189) discusses some commonalities between Prigogine's work and that of Maturana and Varela. For the purpose of this study, autopoiesis is not associated with complexity theory *per se*; it is discussed and used as a separate theory.

4.7.1 Application in the systems domain: an assessment

Jackson (2003) describes various ways in which management science has appropriated the concepts of complexity, teaching managers to release their tight control and allow for self-organisation and emergence, ideally at some point at the edge of chaos. The researcher's personal assessment of these is that such application remains metaphorical. Jackson (ibid.) indicates how some of the complexity concepts have found their way into systems approaches, such as Beer's VSM which makes use of the fractal concept of self-similarity. It appears to the researcher that, of all the complexity concepts mentioned by Jackson, the concept of non-equilibrium dynamics in open systems is probably of most significance to the systems community at large. Bailey (1994) describes how von Bertalanffy incorporated Prigogine's early work into his General System Theory, stating that living systems are open systems and maintain themselves in a steady state or dynamic balance, far from equilibrium. The non-equilibrium dynamics of open systems also had a significant influence on the work of the sociologists Buckley (1967) and Bailey (1994), who each applied systems concepts to social systems.

Leleur (2008) claims that complexity theory warrants an entirely new paradigm in systems thinking, in addition to e.g. functionalism and interpretivism. He argues that complexity thinking has characteristics distinct from the other paradigms, and that enough work has been done to develop this paradigm. Jackson (2003), on the other hand, believes that complexity thinking remains in the functionalist domain, where its origins are. The researcher has not personally encountered complexity theory applications in ICT4D. In Chapter 5, which concerns the use of systems thinking in social theory, the concept of non-equilibrium dynamics is revisited when discussing the work of sociologists such as Bailey (1994).

4.8 Postmodern systems thinking

Postmodern systems thinking is listed by Leleur (2008) as a separate systems paradigm. He associates it with the third or most recent wave of systems thinking paradigms, together with the emancipatory and complexity paradigms. Its potential value will be explored as such.

All systems approaches, whether positivist, interpretivist or emancipatory in nature, can be seen to conform to the nature of modernist thinking (Jackson, 2003: 255). Modernism, which we inherited from the Enlightenment, is characterised by rationality, or reason. According to Weber, rationality is about always searching for the "most efficient, calculable and predictable means to achieve a defined end” (Mendelsohn and Gelderblom, 2004: 11). Thus, one has a goal and then looks for a better, or the best, way to achieve it.

According to Jackson (2003: 255), postmodernism rejects all rationality associated with modernism. It not only rejects instrumental rationality, which is associated with hard systems thinking, but it also rejects communicative rationality, which is associated with emancipation and both soft and critical systems thinking. It does not believe in science as a way to grow an objective knowledge base, nor does it believe that communication can be fair and transparent and lead to consensus. Postmodernism wants to surface diversity, conflict, disorder, paradox and indeterminacy. With postmodernism being against reason and method, Jackson (2003: 261) infers that a systems approach and postmodernism do not have much in common. However, he suggests two ways in which the two can collaborate. One is to apply existing systems methods in a postmodern spirit, embracing for example pluralism, pragmatism and playfulness. Another way is to apply the approaches or tools suggested by postmodern thinkers.

As a possible postmodern approach, Jackson (2003: 261) suggests Taket and White’s PANDA: “Participatory Appraisal of Needs and the Development of Action.” PANDA loosely suggests a process, which can be said to resemble a traditional decision-making approach, since it contains, among other things: “defining purpose, identifying and comparing options, deciding on action, monitoring and evaluation”. Of importance are the underlying values with which it needs to be applied, such as inclusivity (of participants and ideas) and improvisation. According to Jackson (ibid.), Taket and White’s approach is somewhat of a recipe book from which they encourage users to mix and match, while following the value-based general guidelines.

4.8.1 Assessment of postmodern systems thinking

The researcher’s conclusion from Jackson’s (2003) overview is that the overall guiding values of postmodernism may be of use in the so-called post-industrial business world. These include having fun (as per the “carnival” metaphor associated with postmodernism), experimentation, questioning prevailing “grand narratives”, and promoting diversity and creativity. However, the value of the postmodern methods advocated appears to be in supplementing other, more solid systems approaches. Further, the developing country context of ICT4D is far removed from the post-industrial business world, and does not contain the modernity that postmodern thinking is aimed against. Hence, it is not clear what its value will be when applied in ICT4D.

4.9 Multimethodologies

4.9.1 Context, definition and motivation

"The world has material aspects that can be measured and counted, but it also has social aspects that must be shared and understood, and indeed personal and individual aspects that must be experienced and expressed. This calls for the judicious and knowledgeable combination of a variety of research and intervention methods" (Mingers 2006: 198).

Mingers has published widely on multimethodology, e.g Mingers and Brocklesby (1997) and Mingers (2001); the latter in an IS context. Mingers's (2006) work is a recent contribution that appears to be representative of his multimethodology work, and will be used henceforth in the discussion. Multimethodology refers to the use of more than one method or methodology (Mingers, 2006: 199), particularly in the OR/management science domain. Many of the OR methods are also systems methods. Mingers distinguishes between single-paradigm and multi-paradigm multimethodology, depending on whether the methods used are from the same paradigm or not. He also distinguishes between methodology combination and enhancement. Methodology combination refers to the use of multiple methods on largely equal footing, while enhancement implies one main method enhanced by the use of other(s).

The arguments for a multimethodology approach are as follows (Mingers 2006: 199). Firstly, as per the quote above, the world simultaneously harbours material, social and personal aspects. These relate to the three worlds described by Habermas. A single methodology usually focuses on one of these worlds (depending on the goals of the project and the characteristics of the system studied) and will be blind to the other. This is because the nature of our interaction and ways of collecting information differs for each world. For example, a radar can be used to detect and measure distances to material objects, but cannot measure human experiences, perceptions and emotions. Secondly, a project or intervention usually comprises of a number of phases, each with different requirements. Mingers distinguishes between the phases of appreciation, analysis, assessment and action. The phase of appreciation will require a descriptive method, while the action phase requires a method that can be used to recommend an intervention. Thirdly, multiple methods can assist with triangulation and lead to new insights.

4.9.2 Challenges

According to Mingers (2006: 203), multimethodology also poses some challenges that need to be recognised. Methods from multiple paradigms can lead to philosophical problems if the respective philosophical assumptions are not reconcilable. However, Mingers believe that different paradigms are not necessarily mutually exclusive, and that “paradigms are permeable at the edges”. Furthermore, conceptualisations such as Giddens’ structuration theory that integrates the objective-subjective dualism into a duality, show that different paradigms need not be irreconcilable and can in fact enrich the philosophical grounding. A second challenge is that within one’s particular discipline or community of practice, multimethodology may not be well accepted. Some paradigms are usually preferred over others, and these preferences change over time. A third challenge is that people with certain personalities may be more at ease with particular methods, and uncomfortable when having to complement these methods. For example, a highly analytical person may not be comfortable when having to do people facilitation in addition to statistical analysis. The last challenge is that of practicality. It is difficult to try and work across boundaries of philosophy, research approaches and methods in practice, and then in addition to disseminate such research to audiences who are not familiar with it. Despite the mentioned challenges, Mingers believes such work is possible, and that there is evidence of its increased application.

4.9.3 A framework for selecting methods

Mingers (2006: 219) provides a multi-dimensional framework for selecting appropriate system method(s). First, he provides a number of criteria that concern the mutual relations between the problem situation, the available approaches/methodologies and the agent(s) performing the intervention. For example, his framework considers the skill and preferences of the agents related to the available methods, the perceptions and influence of the agents related to the problem situation, and the receptiveness of the organisation representing the problem, towards particular methods. The questions are meant to stimulate continued debate and reflection among role-players, rather than being a once-off tick list.

For the framework to map methods, Mingers (ibid.) considers two variables. The first is the kind of world addressed by the method: material, personal and/or social. The second variable refers to the different phases of an intervention, namely appreciation, analysis, assessment and action. The resulting matrix is as follows:

	Appreciation of:	**Analysis of:**	**Assessment of:**	**Action to:**
Social world	Role, norms, social practices, culture and power relations	Norms, practices, culture and underlying social structures	Ways of changing existing practices and culture	Generate enlightenment of social situation and empowerment
Personal world	Individual beliefs, meanings, values, and emotions	Differing world views and personal rationalities	Alternative conceptualisations and constructions	Generate understanding, personal learning and accommodation of views
Material world	Material and physical processes and arrangements	Underlying causal structures	Alternative physical and structural arrangements	Select and implement best alternatives

Table 4.3: Framework for mapping methods
(Mingers 2006: 220)

Mingers continues to list a variety of “hard” and “soft” OR methods, ranging from mathematical programming through SSM and CSH to Drama Theory. Before mapping them onto the framework above, he classifies each method according its characteristics and philosophical assumptions, including its ontology, epistemology and axiology.

In the final step, Mingers draws a copy of the framework in Table 4.3 above for each method. The characteristics of the method are then used to colour or shade the table, for each method. One can expect the mapping for a “hard” systems method to be shaded for one or more blocks next to “material world”, depending on which stages of an intervention it supports. Darker shading means the method supports the activity well. For SSM, all the blocks next to “personal world” are shaded, with the analysis and assessment blocks shaded dark.

The result is a visually accessible display of the comparative strengths of each method, per block of the framework. Of the 11 methods assessed by Mingers (2006), none have the appreciation of the social world shaded dark. The analysis of the social world is shaded dark for the methods of Interactive Planning, CSH and hypergames. (Appreciation and analysis of the social world is relevant to this thesis, which seeks to describe and analyse social systems.) Mingers concludes to say that the mapping is meant for comparison and discussion purposes rather than to be used in an absolute sense.

4.9.4 Assessment

There are clear similarities in thinking between Mingers' position on multimethodology, the MPA and Jackson's TSI. Further, the selection framework, as well as the criteria posed along with it, provides a useful way to also select single methods from the large variety of methods available, whether they are OR methods, IS research methods or systems approaches. Few researchers or practitioners have the general knowledge of their field that is required to do a method comparison such as presented in Mingers (2006). Therefore, an existing comparison such as Mingers' is useful, although it remains generic and does not take the detailed requirements of a particular project into account.

What makes Mingers' contribution attractive is that it recognises the same philosophical inclusivity as the MPA and TSI, but makes suggestions that are more practical than that of the MPA, for selecting appropriate methods. Further, the selection criteria suggested by Mingers above appear to have benefit for this study. These criteria are revisited in Chapter 5, when developing criteria for selecting a social systems approach.

4.10 Conclusion

This chapter presented an overview of the characteristics of systems thinking, as well as different kinds of systems approaches, in the search for an approach to describe social systems in ICT4D. From the introduction and overview of systems thinking, useful concepts or ways of applying systems thinking in ICT4D have been identified.

For each systems approach discussed, an assessment was made of its applicability to social systems, keeping in mind the ICT4D context. While even systems engineering has been applied in a social context in developing countries, it has been assessed to not be a suitable approach for this study unless it forms part of a multimethodology. The soft and critical systems approaches are more suitable candidates, with SSM already having a track record in ICT4D. The work on multimethodologies by Mingers (2006) was argued to be not only helpful when attempting to combine methodologies, but also to assist in selecting individual systems methodologies, such as for this thesis, where a descriptive/analytical approach is sought to be applied to social systems.

Before making a decision on a suitable systems approach, or combination of approaches, the second half of the research question below needs to be considered. It deals with social theories that apply systems thinking, and will be discussed in Chapter 5:

- How does the literature approach social systems, from systems thinking and from social theory perspectives?

The combined conclusions of Chapters 4 and 5 will be used to determine criteria for selecting a systems approach, as well as to suggest an approach.