Chapter 16

Systemic Interventions in Sweden: Some Discernible Patterns

Mats-Olov Olsson and Gunnar Sjöstedt

1 Introduction

In this chapter we attempt to assess some recent applications of systems thinking, or *systemic interventions,* in Sweden. The aim is *not* to discuss Swedish particularities but rather to use a selection of examples from the Swedish scene in order to illustrate some general characteristics of systemic interventions. In that specific sense this book can be regarded as a comparative case study.

The assessment of systemic interventions will be made against the background to the field of systems thinking that was offered in Part I of the book, and with reference to the examples of systemic intervention described in the chapters comprising Part II. In so doing we identify a number of fundamental "perspectives" that we believe are relevant for characterizing scientific approaches in general, and systems approaches in particular. The principal function of the cases is to illustrate real-world manifestations of these perspectives. In fact, the cases go some way towards answering the questions *what systems thinking is, what it does* and *what it achieves.* This chapter will primarily focus on how systems thinking goes about doing what it does.

Since we only have a limited number of cases to compare (the thirteen chapters in Part II), we can obviously not expect to arrive at any definite general conclusions concerning the performance of the systems approach. The selection of contributions to Part II of the book is far from comprehensive and thus not entirely representative of the systems analytical work performed in Sweden today and during the last 10–20 years. For example, we lack descriptions of many common types of application of the systems approach, such as, transportation analysis. The comparison of cases has largely an exploratory direction as it aims at a general characterization of systems thinking and analysis, which can be expected to call for more detailed description and assessment.

However, a comparison of the chapters in Part II is still helpful, even if it does not offer a comprehensive analysis pertaining to a general understanding of systems thinking. The cases contribute two kinds of information or knowledge that is relevant for

M.-O. Olsson & G. Sjöstedt (Eds.),
Systems Approaches and Their Application: Examples from Sweden, 313–335.

an evaluation of systems thinking. Firstly, some of the chapters offer complete and detailed expert accounts of how real-life systemic interventions were actually conducted in a number of different contexts with varying objectives and results. Secondly, the case descriptions also provide detailed illustrations of various general aspects of applied systems thinking. Accordingly, description, analysis and comparison of cases have served as a useful instrument to deepen and extend the general discussion on systems thinking that was developed in Chapters 1 and 2.

An assessment of systems thinking and systemic interventions ultimately assumes a comparison with other scientific approaches. It is difficult to attribute an absolute value to, say, the usefulness of systems thinking. It would be more meaningful to determine whether – and if so, perhaps to what extent – systems thinking is more (or less) applicable and effective in specific problem situations than available alternative approaches. Such an assessment by means of comparison is, however, obstructed by the fundamental difficulty of separating systems thinking from other approaches. This follows from the broad range of possible applications of systems thinking, the many types of objectives it can pursue, the manifold functions it can perform and the considerable variation with which it may be framed for analysis, decision making or design.

However, a broad characterization of the systems approach is still meaningful. A point of departure may be a recapitulation of what characterizes studies that are clearly *not* using a systems approach. Such studies basically consider their object of study (be it a thing, a phenomenon, or a behavior) in isolation, without much reference to its external environment. Such studies often proceed by way of successive disassembling of the object of study into (ultimately) its smallest component parts. There is not much interest in the context in which the object of study is embedded. One example may be various forms of bi-variate causal analysis.

Systematic studies outside the realm of systems thinking are not, however, necessarily focused on the interplay between only two variables. Take, for example, a socio-psychological investigation of the attitudes in a population towards various kinds of risks, such as risks related to smoking, increased immigration or nuclear power stations. Such risk studies have been undertaken for decades, they include a multitude of factors, they have been very systematically conducted and, for social-scientific projects, they have often been designed in a technically advanced form. Nevertheless, this kind of project does not fit all the qualifying criteria derived from the general discourse on systems theory. Notably, the research objective is to compare the basic elements of the problem area – such as the attitudes to various risk factors – rather than to study the interaction between these factors, as the systems approach would require.

A systems approach emphasizes context, it sees its object of study in its relation to other objects and the environment in which it is embedded. It focuses on relations between the object of study, other objects, and the environment. In other words, it is taking a *holistic approach,* focusing on *interaction* between the objects (or *agents* as they are sometimes called). A prerequisite for this approach is that the object of study has been identified in the context of a system – that is, that it has been possible to establish a system boundary as part of the inquiry.

All cases reported in Part II of the book fit this general understanding of systems thinking. Together these examples provide a number of interesting observations and assessments regarding the comparative merits and drawbacks of applied systems thinking.

2 Reasons for Using a Systems Approach to Problem Solving – Characterizing the Contributions to this Volume

In this section we make use of several perspectives in order to compare the cases of systemic intervention presented in Part II of this volume. We have identified *six main perspectives* with the help of which the use of a systems approach in science can be characterized. For each one of these six perspectives we have distinguished several possible positions regarding the decision to make a systemic intervention, i. e., to use a systems approach in an effort to improve on a problem situation.[1] Thus, we find that a specific systemic intervention can be characterized according to:

1. the objective of the approach;
2. the function of the approach;
3. the context of the approach;
4. the "capabilities" of the systems approach that are (mainly) used;
5. the level of intervention that is given main attention in an approach; and
6. the way of dealing with various "generic issues" (as outlined in Chapter 1).

We let these perspectives structure our assessment of the case studies reported in Part II. After discussing the meaning and relevance of each perspective we illustrate and compare how various authors have dealt with crucial aspects of relevance for the perspective in question. The purpose of this assessment is to characterize how they have made use of systems thinking in their research.

The issue of the existence and nature of "real-life" systems (ontology) and the related issue of how we can know anything about systems (epistemology) are of fundamental importance in this context, since the views on these issues held by an analyst using a systems approach may profoundly affect the choice of study "object" (problem situation) and the methods chosen for analyzing the situation. In a few of the cases of systems analysis reported in Part II some observations can be made about ontological and epistemological positions and assumptions. However, these comments illustrate rather than develop the discussion about systems thinking on ontology and epistemology that was introduced in Chapters 1 and 2. An important insight is that the systems approach nowadays seems to be ubiquitous in science. The epistemological foundation for the systems approach has been successively elaborated since the canonization

1 Here "problem situation" is used to designate any situation or simple fact that is considered to be in need of improvement in some respect. Thus, a "problem situation" may refer to an unresolved scientific issue, uncertainties concerning an issue requiring a decision by a public or private decision maker, the perceived need for rules to guide (some aspect of) people's behavior (i. e., institutions), or some piece of machinery or other device that would potentially improve people's daily life, etc.

of General Systems Theory and Cybernetics around the middle of the previous century. The common epistemological stand today is one of "radical constructivism" as elaborated in, for instance, von Glasersfeld's (1995) "theory of knowing." This theory *assumes* that there exists a reality which is independent of human consciousness. But there is no way for us to know anything about this reality other than through our mental constructs, developed *in interaction with* reality and other cognizing subjects. The "external reality" is basically revealed to us only in the form of *constraints* on our actions. During the last twenty years acceptance of the constructivist epistemology has made the systems approach more relevant than ever also for social science research.

Thus, today there seems to be general agreement that the system that is analyzed is fundamentally a *mental construct.* The legitimacy of this construct – which is a construct of human mental activity, sometimes developed in physical interaction with the object of study – is itself "constructed" through the interaction (negotiated agreement) with other individuals.

A crucial difficulty in this context, and one on which agreement must be reached, concerns the boundaries of the "constructed" system. Thus, a basic prerequisite for the application of a systems approach is that suitable system boundaries can be established. This can be achieved through the act of "boundary critique," through which a solution to the "boundary problem" can be attempted (cf. Ulrich, 1983; Midgley, 2000). When adopting this perspective it is also important to realize that any constructed system boundary is in principle imposed for a specific purpose. This purpose may be – but is not always – (primarily) related to scientific demands. Quite different concerns may determine or generally condition how a system is delimited and identified. Nevertheless, it is only when agreement about the "boundary problem" has been reached that the researcher can look for adequate ways of studying the "constructed" system. In searching and arguing for suitable methodologies (and methods) the analyst will be guided by various existing constraints (both of an "intra-" and "extra scientific" nature). The methodology and methods that seem most promising for the purpose are chosen from among a multitude of available ones. This approach is underpinned by Critical Systems Thinking (CST) and its call for methodological pluralism.

A question that often surfaces in this connection is where the constructivist onto-epistemological stance leaves "objectivity." Radical constructivists do not talk about objectivity in research, for them the *viability* of the constructed concepts and approaches represents the critical issue. The results of research have to prove viable over time, in the "interaction" (confrontation) with other scientific results pertaining to the same "object of study" and in everyday *practice.*

2.1 The Objectives in Applying a Systems Approach

The thirteen contributions to Part II were grouped into three broad categories reflecting what we consider to be the three main objectives in applying a systems approach to a problem situation. Thus, in general, systems thinking, or a systems approach, may be adopted in order to arrive at (*i*) better theory (knowledge), (*ii*) better practice (decisions and their implementation), and/or (*iii*) better designs or constructions. Obviously, assessing the efficacy of adopting a systems approach for these different objectives may require different criteria, or, in the case of multiple objectives, the importance of the criteria used may vary depending on what objective is considered to be dominant or most important in a specific case. While, for example, "feasibility of implementation" (in the sense of putting the results of a study to practical use) ought to be a central criterion for assessing the value of using a systems approach in the design and construction of systems/artifacts enhancing people's quality of life (type *iii* objective), it might be of little relevance for assessing the value of using such an approach to understand a scientific problem (type *i* objective). The criteria we need in order to assess (or compare) the value of using a systems approach for these various objectives should primarily pertain to the results of a systemic intervention.

When assessing such outcomes, several "traditional" implementation criteria may be useful. Since the goal of the assessment is to see whether – and if so, to what extent – the actual outcome of a particular systemic intervention corresponds to the intended outcome, questions like the following lie behind the criteria used: did the intervention achieve what it set out to achieve, did it do so on time and at the proffered cost, were quality requirements met? The answers to these and similar questions provide criteria with the help of which an intervention can be assessed, and compared with interventions using other approaches.

However, this kind of outcome assessment does not always generate very encouraging results. Often outcomes do not correspond to prior expectations according to one or more assessment criteria used. Interest among implementation researchers has therefore shifted towards questions pertaining to the causes of actual performance. The research question can thus be rephrased: In *which way* do outcomes depend on *how* the intervention was performed? The assessment becomes primarily *process oriented.* Given a decision to perform a specific task, the question that we are interested in here is why a systems approach should be chosen to perform this task in the first place.

This perspective produced a fairly clear-cut grouping of the cases of systems analysis in Part II into three categories. Four cases – or chapters – fell into the first category (theoretical objective), seven chapters into the second category (practical objective), and two chapters into the third (design and construction objective). This classification was fairly straightforward, but still at least three chapters might have been categorized differently. Anders Eriksson's chapter on "Scenario-Based Methodologies for Strategy Development and Management of Change" (Chapter 7) may be seen to have a "theoretical" almost as much as a "better practice" objective. The chapter by Harald Sverdrup and Mats Svensson entitled "Defining the Concept of Sustainability" (Chapter 6) deals with ways of operationalizing the sustainability concept to enable it to be used for practical policy purposes. Such a focus might make us want to refer this chapter to category two (practice objective). But the actual treatment of the topic made us look upon this chapter as having a much more "theoretical" objective than a "practical" one. Finally, the chapter by Anna Björklund on "environmental systems analysis research" (Chapter 10) discussing systems for dealing with industrial waste has been classified as having a practical objective, although the analysis of this case has clear implications for design and construction.

Thus, the cases recall that systems thinking and analysis may often be driven by more than one basic objective simultaneously. However, the examples also include cases driven by a single basic objective. For example, the systemic analysis of the brain as a biological system by Hans Liljenström and Peter Århem (Chapter 5) clearly has only a research objective. The systems study of Sweden's future environment reported by Anita Linell (Chapter 8) was also clearly designed to support complex, forward-looking decision making. Rune Gustavsson and Martin Fredriksson clearly focus on systems design and construction in their chapter on "Humans and Complex Systems: Sustainable Information Societies" (Chapter 14). These three unambiguous cases of systems analysis demonstrate:

(*i*) the great impact and conditioning effect of the objective driving systemic thinking;
(*ii*) the possible great variation in the basic character of individual cases of systems analysis, due to the varying direction of their basic objectives; and
(*iii*) the existence of important common features, even when highly dissimilar cases are compared, such as the study of the human brain and long-term oriented environmental planning.

2.2 Functions of Systems Thinking in Applied Research

Any application of systems thinking is here regarded as a form of intervention which may manifest itself differently depending on the circumstances at hand but which is still quite distinct from other approaches. The choice of a systems approach in an intervention hinges on the view (hypothesis) that such an approach can perform certain desirable *functions* better than other approaches. The special functional qualities that are sought after when a systems approach is applied pertain to "learning," "decision support and management," and "design and construction."

There is a logical sequence in establishing the criteria for the assessment of a systems approach in real-life interventions. Once we know the quality of the outcome of a systemic intervention we may go on to look at how the systems approach has managed to attain its achievements in particular cases. Successful and unsuccessful cases may then be compared in order to distinguish what makes the systems approach *function* the way it does, what makes it conducive to efficient learning, decision support/management and design/construction. A reasonable hypothesis, based on our overview of systems thinking and the "systems tradition" in Part 1 above, is that the systems approach can perform these functions because it facilitates – even enables – communication and (stakeholder) participation.

Our conceptualization of basic functions of applied systems thinking is illustrated in Figure 16.1.

These functional categories are broad and general. They may be studied in a *process* as well as in a *result oriented* perspective. Thus, one may see "learning," *both* as learning about a specific problem situation and the way to address it *and* learning in the form of generation of generalized knowledge (or formulation of theories) about a problem situation and the ways it can be dealt with. The same goes for "decision support/management." The systems approach can *both* be seen as support of decisions

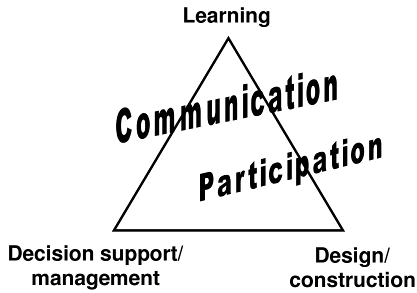

Figure 16.1: The systems approach and its functions.

and actions (implementation) pertaining to how a specific problem situation should preferably be studied and improved, *and* as offering conclusions about how the outcome of a systemic intervention leads to new decision support technologies and new ways of managing the situation as a consequence of the intervention. Likewise, in the case of "design/construction," we can apply a similar "dual" perspective. A systemic intervention may result in specific designs and constructions but may also generate more generalized knowledge and experience about the development of such designs and constructions.

Figure 16.1 highlights the crucial role of communication and participation for the performance of each of the basic systemic functions, *learning, decision support/management* and *design/construction.* Generally, *effective communication* means that two or more actors are able to exchange information in such a way that a joint activity like research, planning, decision making, technological development or construction is supported. The stronger the support, the more effective the communication. The cases reported in this study offer some indications regarding the relationship between communicatation and systems thinking. Notably, systems thinking helps to structure and package the information and knowledge pertaining to a given problem in a clear and simple way, thus facilitating inter-actor communication (see, e. g., Chapter 6 by Harald Sverdrup and Mats Svensson). As demonstrated by the case study on the human brain (cf. Chapter 5 by Hans Liljenström and Peter Århem), this structuring function may be significant also when the information/knowledge concerned is highly scientific and sophisticated. A special but important function of communication organized by systems thinking is *complexity management,* the purpose being to attain mutual agreement among stakeholders on how to cope with or reduce complexity by, say, introducing certain abstractions making the analysis of the problem situation manageable. Modern schools of systems thinking, like Soft Systems Methodology (SSM) and Critical Systems Thinking (CST), but also recent developments in traditional systems "schools" like Operations Research (OR), Systems Engineering (SE) and Systems Analysis (SA),[2] today convincingly emphasize the importance of *stakeholder participation* in systemic

2 See Chapter 2 in this volume for an overview of various schools of systems thinking.

interventions. The communicative function of the systems approach in fact enables and stimulates such participation. This perspective has been explored in several of our contributed chapters. It is especially pertinent in the chapter by Anita Linell [8] but is also very prominent in the chapters by Anders Eriksson [7], by Semida Silveira [12], and by Lena Ewertsson and Lars Ingelstam [15]. It is less conspicuous, but still important in the chapters by Gunnar Sjöstedt [13] and Rune Gustavsson and Martin Fredriksson [14]. As could be expected, the "participation function" is not discussed much by the authors of the four chapters whose primary objective is to develop better theories/knowledge (Chapters 3–6). As seen in a more practical prespective, systems thinking may help to organize and facilitate the distribution of work and cooperation when more than one person is engaged in the same project. Ultimately, the capacity of systems thinking to facilitate communication stems from the basics of systems philosophy with its elaborated general framework of analysis (a focus on *interaction* between *agents* belonging to an identified system – in short, *organization*) allowing a "holistic" view of a problem situation (cf. Chapters 1 and 2).

The one function of using a systems approach in systemic interventions that all contributors to this volume find valuable is its ability to produce "learning," both procedural insights useful for framing investigations of unknown phenomena, and generalized knowledge about a phenomenon. This agreement is perhaps not surprising since this group of authors is mainly active in the sphere of research and education. However, the function of learning is not equally important or manifest in all contributions. It is central for the authors who mainly reflect upon the value of systems approaches in their own research (cf. the chapters by Stefan Anderberg [3], Semida Silveira [12] and Lena Ewertsson and Lars Ingelstam [15]). These authors support their arguments for a wider use of the systems approach by showing interesting examples of what has been done in the field or what could (and should) be done. But similar arguments are also advanced by several of the other authors reporting on their current research. Chapter 14 illustrates the kind of accumulation of knowledge that is facilitated by systems thinking. Dealing with the development of advanced computer supported systems intended to make life easier for people with health problems, Rune Gustavsson and Martin Fredriksson strive to make good use of, and at the same time advance, generalized knowledge gained in earlier systems analytical studies of interactive information systems, their design and implementation.

Several of our contributors report on projects where their analysis was intended to produce knowledge to be used to back up "decision support/management". These authors were "practitioners" rather than researchers. Hardly surprisingly, this function is of less interest for the authors reporting on research and making contributions to "better theory" (Chapters 3–6). The prime example of systems thinking as "decision support" is the chapter by Anita Linell on "Sweden in the Year 2021" [8]. Recall that the purpose of the described project was to produce knowledge and new ideas for an environmental policy plan subsequently to be decided on by the Swedish government. In principle, the function of decision support was also important in the research reported in the chapters by Anna Björklund [10], Göran Finnveden *et al.* [11] and Gunnar Sjöstedt [13]. Even if the results of the research reported in the two latter chapters did not directly impact actual decision making processes, the knowledge produced may (and indeed should) influence how future decision making processes in the fields of, respectively, polluting waste materials handling and international trade negotiations should be conducted in order to produce better results. The decision support function is implicitly prominent also in the chapter by Anders Eriksson [7], where the focus of interest is on how society ought to handle risk assessments in a decision making context. Here the author is contributing to the generalized knowledge about how decision making could cope with security risks inherent in today's increasingly uncertain international political environment by adopting a new outlook on the available options and maintaining maximum flexibility for different response actions. Likewise, the decision support function is implicitly central in the chapter by Harald Sverdrup and Mats Svensson [6]. Their suggestions for an integrated assessment of the three pillars of sustainability (nature, economy, and society) may come to have a great impact on the contents and procedures of both public and private decision making, if this assessment is sufficiently developed and implemented.

Two chapters are specifically concerned with the "design and construction" function of systems thinking. These are the chapters by Rune Gustavsson and Martin Fredriksson [14] and by Lena Ewertsson and Lars Ingelstam [15]. It is emphasized in both chapters that the systems approach is particularly valuable in applications where a multitude of factors are assumed to co-exist or even interact and collaborate in order to make the design and construction of complex artifacts possible. The significance of the learning factor is also pointed out.

It is interesting to note that the "design and construction" function is also indicated in several other chapters, whose primary objective is to contribute to "better practice" primarily by means of decision support. While the authors of these contributions mainly focus on how to improve decision making by analyzing and suggesting new or improved methods for producing high-quality decision support, it is evident that their findings could potentially be used for the design and construction of artifacts "embodying" the knowledge produced in their research. This knowledge could, for example, be used to produce tailor-made IT machinery simplifying earlier tedious and low-productive manual administrative routines, or to draw up "blueprints" for implementable models for efficient multi-agent decision making (that might be used in international negotiations on trade agreements or environmental commitments, or for producing efficient development aid, etc.). Chapter 7, by Anders Eriksson, and Chapters 10–13, by, respectively, Göran Finnveden *et al.*, Anna Björklund, Semida Silveira, and Gunnar Sjöstedt, are all good examples of this more or less implicit use of the "design and construction" function offered by the systems approach.

The generic function offered by the systems approach and that which enables all three of the above-mentioned functions ("learning," "decision support and management," and "design and construction") is its ability to facilitate *communication* between representatives of different scientific disciplines and between scientists and "science customers," such as decision makers and funders of research. The communication function offered by the systems approach is important for all the contributors to Part II of this book. Some authors, for instance Anita Linell [8] and Gunnar Sjöstedt [13], especially note the importance of this function making collaboration possible in complex decision situations involving a large number of actors (stakeholders).

2.3 Four Contexts of Application

The types of systemic interventions described in Part II of this book may also be characterized in terms of their *contexts of application.* Systems thinking may be thought of as a "horizontal axis" through a whole spectrum of disciplines, ranging from the humanities and social sciences to the natural sciences. It may also serve as a "bridge" between science and practice, or pertain to practice alone. In other words, systems analysis has important inter-disciplinary qualities. This analytical approach can be employed in research areas that use very different theories within their traditional domains and typically rely on diverse research methods. Thus, one aspect of the inter-disciplinary character of systems analysis is *commonality:* it offers an approach that can often be shared regardless of substantive issues or analytical orientation. Commonality in this sense may represent important symbolic values of inter-disciplinary understanding and hence serve as a basis for cross-disciplinary cooperation.

An especially important function of systems thinking is to facilitate the management of complexity. This function may represent different objectives and levels of ambition depending on context and actors. At least four types of context are discernible: research, policy making and management, "bridge building" in policy making and development of technology.

2.3.1 Research

Systems thinking was first established in science with the emergence of General Systems Theory and Cybernetics. Systems thinkers have, however, always emphasized the importance and usefulness of applying the systems approach to complex problems encountered in the "real world." The early development of Operations Research (OR) and Systems Engineering (SE) bears clear witness to the practical applicability of the systems approach. Nevertheless, systems thinking has awakened renewed interest on the part of scientists during the last 15–20 years. The likely reason is that the progress made in information sciences and the rapid development of computer technology have offered entirely new possibilities for the development and empirical application of advanced systems theories addressing complexity.

The cases reported in this book highlight the special significance of research as a context for systems thinking. Systems thinking in research easily spills over into decision support or design and construction. With one possible exception (Chapter 8 by Anita Linell), all cases reported in the book emanated from the *research* sphere.

Both natural and social sciences are represented among our contributed chapters. Formal models as well as more suggestive scientific approaches have been displayed. The use of systems analysis for sophisticated empirical research and related theory building has been described (as, for example, in Chapters 3 and 5), as well as the employment of the systems approach as a means of structuring a complex problem area (cf. Chapters 6 and 13).

A distinction needs to be made between natural and social science. A comparison of the chapter discussing the brain as a biological system (Chapter 5) and the one discussing the World Trade Organization as a negotiation system (Chapter 13) clearly illustrates the point. In the former chapter the systems approach is implemented through highly specified and detailed models. The systems approach provides general, organizing principles that attain their meaning and usefulness only when employed for an actual task. The main function of these organizing principles is to help structure a highly complex problem for analytical purposes. One implication is that the systems model as such is given concrete content and meaning through the "injection" of extremely detailed but also initially fragmented knowledge, which has been organized with the aid of sophisticated computer models. Likewise, in the case of the recurrent WTO trade negotiations an important task for the systems approach is to integrate different and separate variables/factors into a comprehensive, holistic conception. However, the level of complexity is dramatically higher in the brain study than in the WTO analysis. In the latter case the ambition is essentially to attain a consistent holistic *outlook* as compared to the holistic *understanding* searched for in the brain study.

Comparing the two chapters discussing the brain and the WTO highlights the quite different roles that the systems approach may have in the natural and the social sciences, respectively. These differences are obviously important in their own right. So far, natural scientists as well as engineering students have been able to use systems approaches in a much more advanced way than social scientists, economists included. Economic geography is an exception among social sciences with its tradition of sophisticated systems analysis that has unfolded in recent decades (cf. Chapter 3 by Stefan Anderberg).

2.3.2 *Policy making and management*

Since the 1960's, when systems thinking was introduced on practically all levels of the American administration and cybernetics proved its value for business management (cf. Chapter 2 above), the systems approach to policy and enterprise management problems has been very widely used. While these uses originally were often related to the establishment of various accounting schemes for the provision of selected information as a basis for decision making (this often entailed the creation of advanced computerized information systems), today this does not represent the only – or even the main – use of the systems approach in policy making and management. The focus has instead shifted towards issues related to stakeholder participation in the design and implementation of institutional prescriptions ("rules-in-use").

Today, systems thinking represents one possible response to the mounting difficulties of policy makers when it comes to coping with increasingly complex problems, typically characterized by a growing number of issue dimensions. Particularly complex issues constitute one category of application, at least if the systems approach is given a fairly general and "open" interpretation. Thus, for example, some analysts would consider many cost-benefit analyses of public investments as a kind of systems analysis. In these cases the principal function of systems analysis is simply to provide a general framework for a systematic overview of a host of separate factors.

If the notion of systems analysis is given a very strict and constrained interpretation it may be said to have one main function: it represents a powerful instrument that can be employed to attain a comprehensive outlook and, ultimately, analysis capable of bringing fragments or separate pieces of knowledge together into a holistic image.

The cases of systems analysis reported in the book typically pertain to the sphere of research. It should, however, also be noted that a few chapters report on research conducted on the initiative of, or in association with, people and organizations outside the research sphere concerned with policy making. This is true of the chapters by Anita Linell [8], Semida Silveira [12], and Gunnar Sjöstedt [13], as also of the chapter by Harald Sverdrup and Mats Svensson [6].

2.3.3 *"Bridge building" in policy making*

In the context of policy making the communication function is of particular significance. As seen in this perspective communication is at the core of the systems approach. It enables stakeholder participation in systemic interventions and it entails organization, construction, and management of complexity. These are qualities of the systems approach that policy makers can use in order to establish a coherent dialogue and a fruitful collaboration with the scientific community, but it can also facilitate joint actions of policy makers to cope with complex situations spanning several traditional policy areas. This would mean that the systems approach has a special capacity to support policy making in complex situations (contexts) where little or no policy measures could earlier be taken. Recent trends in handling environmental problems testify to this fact.

This kind of "bridge building" context, in which systems approaches can be expected to be of use, is relevant for *all* our contributions. Sometimes the "bridge building" is manifested between different scientific disciplines, as illustrated in the chapters by Magnus Boman and Einar Holm [4], Hans Liljenström and Peter Århem [5] and Lena Ewertsson and Lars Ingelstam [15]. But more often the systems approach bridges distances between research and policy areas or gaps between different areas inside the policy sphere. This is illustrated by some of our contributions, notably the chapters by Stefan Anderberg [3], Harald Sverdrup and Mats Svensson [6], Gunnar Sjöstedt [13], and Anita Linell [8]. It is also an important context for Sofia Ahlroth [9], Göran Finnveden *et al.* [11], Semida Silveira [12], and Rune Gustavsson and Martin Fredriksson [14].

2.3.4 *Technology development*

Systems approaches have always been important for developing and constructing advanced technology. Witness, for example, the long tradition in Systems Engineering. It seems evident that the multifaceted qualities of systems analysis should be very apt both for working out the designs of – and subsequently for constructing – advanced machinery (such as modern aircraft), large-scale infrastructural networks (such as power grids or highway systems) or sophisticated systems making people's lives easier (such as "intelligent houses"). Systems thinking is also highly pertinent in the current rapid development of information and communication technologies.

In the present volume systems thinking for "technology development" is primarily illustrated in the chapter by Rune Gustavsson and Martin Fredriksson on "Humans and Complex Systems" [14]. But even in this case the study is mainly related to events preceding the actual construction of new technology and to the post-implementation phase in which benefits and deficiencies of the new technology are assessed. Such studies may evidently provide important (even necessary) information to be used in the further refinement of the new technology, and in this capacity they can be seen as a part of the total process of technological development. The context of "technology development" is also highly pertinent in the chapters by Anna Björklund [10] and by Lena Ewertsson and Lars Ingelstam [15].

2.4 Capabilities of the Systems Approach

What is it in the "functional anatomy" of systems analysis that makes its use attractive for research, decision support or the development of technology? Expressed in general terms an application of the systems approach – a systemic intervention – may choose from of a number of analytical *capabilities* offered by a systems framework. A distinction can be made between the "substantive-theoretical," the "methodological," the "technical," and the "organizational" capabilities employed in a systemic intervention.

The substantive-theoretical capability pertains to generalized knowledge about the issue, or problem situation, that is the object of analysis, be it garbage handling, regional planning in a particular area, or the functioning of the human brain.

During its history of use systems theory has produced a large body of *generalized, substantive knowledge* and a systems approach may be primarily motivated by the access it gives to this knowledge. It seems that this accumulated generalized knowledge is something that is of importance for several of the authors of the contributed chapters in Part II of this book. Thus, Harald Sverdrup and Mats Svensson [6], Stefan Anderberg [3], Magnus Boman and Einar Holm [4], Semida Silveira [12], Gunnar Sjöstedt [13], Rune Gustavsson and Martin Fredriksson [14], and Lena Ewertsson and Lars Ingelstam [15] all make valuable use of the generalized knowledge offered by systems thinking.

The methodological capability represents the theoretical and methodological arsenal used for framing an issue, problem or task in order to make it available for analysis and subsequent intervention. This also bears upon the system boundary problem or the identification of endogenous system dynamics.

All our chapters make extensive direct or indirect use of the methodological capability of systems thinking, providing important help in the framing of the problems and tasks that were analyzed. Thus, this is a capability of the systems approach that is of central importance for all contributors.

The technical capability is closely related to the methodological capability but can still be regarded in separation. It manifests itself in the techniques and technologies supporting and facilitating systems analysis, but which can also be used for many other purposes. Specific modeling techniques constitute one example of such a capability, another is information technology.

Over the years systems thinking and systems practice have produced (or incorporated) a large arsenal of such *analytical techniques,* which have been of use in practical analysis in a variety of contexts. This capability is important in real-life systemic interventions, where hands-on results are expected to be produced within a specific (often rather short) period of time. In general, however, the chapters in this volume do not go into great technical detail. Rather they discuss various problems and the application of a systems approach to come to grips with these problems in a non-technical fashion, focusing on general aspects of systems thinking, the opportunities offered by the systems approach and the challenges that still lie ahead. Nevertheless, the perspective is (at least implicitly) prominent in the four initial chapters that describe research whose primary objective is to produce new and better theory. It is also very relevant for describing systemic interventions with a very specific purpose, as exemplified in the chapters by Sofia Ahlroth [9], Anna Björklund [10], and Rune Gustavsson and Martin Fredriksson [14].

The organizational capability of systems thinking manifests itself in guidelines for the distribution of work or cooperation between different parties (individuals, organizations) involved in the same project. A distinction can be made between process and structure impacts. Firstly, the organizational capability may directly affect the actual performance of the parties jointly engaged in a systems analysis, for example how they communicate between themselves. Secondly, systems thinking may direct the construction of institutions for the accomplishment of a project of research or planning/decision making, or for the implementation of the results of a systems analysis. The usability and significance of the organizational capability is primarily elucidated in the chapter by Anita Linell [8] but also indicated in the chapters by Semida Silveira [12], Gunnar Sjöstedt [13], and Rune Gustavsson and Martin Fredriksson [14].

2.5 Levels of Systemic Intervention

The three levels of inquiry proposed by John P. van Gigch (1999) (cf. Chapter 1, especially Figure 1.2) bear a close resemblance to the three themes that Gerald Midgley (2000) discusses in his recent book on *Systemic Intervention,* viz. the themes of "philosophy," "methodology," and "practice." These categories represent an ultimate "dimension" or "standard" according to which we may compare the cases of systemic intervention that are presented in Part II of the book. In principle, all systems thinkers should take a position on all these themes. However, essentially the case study authors do not reflect much on the philosophical foundations of their studies despite the fundamental importance and implications of these foundations. The primary focus in most of our chapters is on the methodological theme. No doubt this has to do with the fact that all the authors are researchers and as such they look upon theory and methodology as the basic conditioning factor of a systems analytical approach. Several of our chapters do, however, also discuss the theme of practice, i. e., the level at which actual systemic interventions take place. This is especially true for two chapters, the one by Anita Linell [8] and the one by Gunnar Sjöstedt [13], and it is the very foundation of the chapters by Anna Björklund [10] and Göran Finnveden *et al.* [11].

The fact that the case study authors remain silent on the theme of philosophy impedes a profound comparison across cases generally, and particularly between systemic interventions representing "research" and those representing "decision support." A systematic comparison has to be limited to the spheres of "methodology" and "practice."

2.6 Problematic Issues in Real-Life Systemic Interventions

In Chapter 1 we identified seven types of "generic issues" to which analysts using a systems approach have to relate. These issues had to do with (a) type of system; (b) system boundaries; (c) system linkages; (d) system properties; (e) the "toolbox"; (f) actors and participation; and (g) implementation. Looking over what our contributing authors have to say on these issues we have merged them into three groups.

2.6.1 Type of system, system boundaries and system linkages

The issue concerning which *type of system* our authors are dealing with in their research might be discussed on many different "levels." At a superficial level it is a question of whether a "natural system" or a "social," "political," "economic," or perhaps even a "socio-economic system" (or some other "hybrid" variant of system) is being studied.

One may also distinguish between other defining characteristics of the type of system studied, such as whether it is a small or a large system, a static or dynamic system, a living or a non-living system, a chaotic or a self-organizing system, a simple or a complex system, a physical, a biological, or a chemical system, etc.

The discussion of a systems typology is also closely related to the basic ontological and epistemological questions: What kind of system *can* be made the object of study? Can we, in fact, study a system as it exists in reality without the result being affected by our observations? Is it not obvious that the systems that we make objects of study are systems identified by our "mental work," through our theoretically founded ability to make distinctions among, and interpret, our sensory impressions? Thus, the systems we study are "mental constructs" (models) with the help of which we try to learn something new about a given situation. The systems are not, and cannot be, direct manifestations of that situation.

A related issue concerns the delimitation of a system's "extension," the *system boundary.* If the analyst has adopted the position that the system to be studied is in fact a mental construct, a "model" of a part of reality, and not something existing independently of the observer, then the system boundary issue immediately comes to the fore. It is critical for a systems analysis where and how the system boundary is set. The choices made in this regard predetermine the results of the study in significant ways. The cases reported indicate that the establishment of system boundaries is a complex process which is influenced by a large number of considerations of both a scientific and a non-scientific nature.

The issue of *system linkages* is highly related to the boundary problem. Together, the type of system identified and its external boundary (extension) determine what kind of linkages a given system can have to its environment and other systems that are "living" there. Viewing the studied system as a "mental construct" means that the objective of the study and the analyst's skills and hidden inclinations ultimately determine which linkages (of those that *could* be distinguished ("observed") between the studied system and other systems) will be taken into account in the analysis. Often these choices are not explicit, unless, of course, the study especially strives to focus on linkages.

In general, it seems that the question of a systems typology and the boundary and linkage issues have been most explicitly discussed by the authors of chapters describing research performed with the primary objective to produce "better theory" (cf. our categorization above). But in all fairness it should be added that these issues are of some importance in most of our contributed chapters. All three issues are highlighted in the chapters by Magnus Boman and Einar Holm [4], Hans Liljenström and Peter Århem [5], and Harald Sverdrup and Mats Svensson [6]. In these chapters a main task is precisely to identify and interlink different kinds of systems, or various levels of the same hierarchical system. In these studies it is crucial to be very clear about the character of the system that is being analyzed, about how it has been identified (where the system borders are), in order to determine whether – and if so, how – the studied system ought to be linked to other systems, with which it interacts. In Chapters 4 and 5 the authors' arguments basically aim at showing the benefits of using (numerical) mathematical models to achieve methodological strength, showing that theoretical and methodological advances are possible with modern computer technology. In this process new hypotheses are generated about the reality that the models are designed to simulate. In Chapter 6 the goal of the systems approach is rather to use the analysis of system type, system boundaries and system linkages to generate a consistent approach in order to arrive at an operational definition of the concept of sustainability. By "decomposing" the properties of sustainability the authors arrive at the conclusion that the concept should be seen as emerging from the joint operations of three interdependent "macro systems," which they label the "natural," the "economic," and the "social" systems. Thus, the authors have conceptualized a framework for the solution of their task using the systems approach. (The actual linking of the three systems and the analysis of how they together determine "total sustainability" is not finally elaborated, however.)

The chapter by Anita Linell [8] on the elaboration of a proposal for a new Swedish environmental policy employs a systems approach to inform and support the design of the study and to set up an organization to carry out this project. Thus, the final design of this study actually was a result of a systems analysis through which it was established that the future environmental status of the country was critically dependent upon the performance of several separate but interacting systems in nature and society. The study aimed at gaining knowledge about how these systems worked and interacted. The study group engaged stakeholders in the various identified, interdependent systems in order to bring them into the analysis and to let them participate in the discussion about the goals and measures of a new environmental policy. In the design stage of this study and well into its work phase the study management and the analysts were wrestling precisely with problems relating to the issues of system type, borders and linkages. It is interesting to note that the same basic issues of system delimitation and system linkages reappear in Chapter 10, in which Anna Björklund deals with the rather well-defined and "narrow" problem of the handling of polluting waste materials.

2.6.2 System properties and the systems analyst's "toolbox"

Certain inherent *system properties* must be taken into account and "handled" in a real-life systemic intervention, for example in a decision support project. Examples of such properties are resilience, redundancy and path dependence. They constitute restrictions on the "behavior" of a system, they affect the system's performance. In order to understand how a system functions it is necessary to be aware of how these restrictions work.

The "toolbox" contains a set of analytical methods available for the analyst to use in a real-life systemic intervention. It certainly seems as if methodological developments during the last 10–20 years have added a significant number of "tools" of great potential value in the application of systems thinking for the solution of practical problems (cf., for instance, Bauch, 2001). Methods have become more advanced, easily accessible and manageable. A primary reason is the dramatic progress made in information technology (mainly high-performance PC's) but also in analysts' increased knowledge of methodology and methods. The two trends are of course interdependent.

The recent development of the systems analytical "toolbox" has influenced most of the research reported in the case studies. However, it is not quite as obvious that the new opportunities have made an equally clear impact on the way various generic system properties are handled in real-life systemic interventions. This is not entirely surprising, since the design of the models to be used on the new advanced computers is not (primarily) governed by the same factors as those governing the development of the computer hardware. The discrepancy between the technological development and theories of application may, however, merely be due to a time lag. Theories of application may therefore be "catching up with" the advanced capacities offered by information technology. Thus, with time we will probably see how more of these generic issues are explicitly incorporated into the analysis, making it more realistic and better suited to cope with the non-trivial effects of their influence on the system's behavior, which are difficult to trace today.

The chapters by Magnus Boman and Einar Holm [4], Hans Liljenström and Peter Århem [5], Rune Gustavsson and Martin Fredriksson [14], as also the chapters by Anna Björklund [10] and Göran Finnveden *et al.* [11], illustrate how systems analysts today are making good use of the advances offered by modern computer technology. Issues related to the generic properties of different kinds of systems are pertinent in the research reported by Harald Sverdrup and Mats Svensson [6], Rune Gustavsson and Martin Fredriksson [14] and Lena Ewertsson and Lars Ingelstam [15]. For instance, in the first two of these three chapters the authors have had to wrestle with the issue of "redundancy." One may see the whole system design to operationalize the sustainability concept proposed by Sverdrup and Svensson [6] as an illustration of the function of redundancy. In their conception sustainability emerges as a result of the operations of three interacting systems, where each one (in principle) could ensure sustainability but where two additional systems are kept in order to "build in" some degree of redundancy, to ensure a safe functioning (in this case the "production of sustainability") if some (but not all) "sub-systems" fail. The redundancy issue is also important for the "intelligent houses" studied by Gustavsson and Fredriksson, where modern information technology is used in the provision of certain health services (e-health). Such automatic systems must contain a certain degree of redundancy as a safety measure to ensure a stable service provision in the case of (partial) systems failure.

2.6.3 Actors and participation – the implementation issue

As we have seen, modern schools of systems thinking (cf. Chapter 2) pay increasing attention to actors' *participation* in systemic interventions. During the last 15–20 years applications of the systems approach have made it increasingly obvious that the participation of various actors who can affect, or are affected by, a system's performance (collectively called "stakeholders") is essential for a deeper understanding of the system's behavior. This is only part of the picture; stakeholders ought to be allowed to exert a decisive influence already at the stage of identifying the system to be studied. This is important for the possibilities of carrying out the analysis successfully as well as for the possibilities of actually *implementing* the interventionist measures suggested by the analysis. Stakeholders' influence on the objectives, design, performance, and results of a systemic intervention can hardly be overestimated. And this is true for systems approaches applied in the social as well as in the natural sciences, which may not be obvious at first glance.

Among the contributions to Part II of this book the discussion of stakeholders' participation is most prominent in the chapter by Anita Linell [8] on the preparation of a proposal for a new Swedish environmental policy. In this case a large number of stakeholders were engaged and furthermore very active. They represented various sectors in society, such as public services, business, environmental organizations. Their participation started already in the design phase of the project and many of these persons subsequently took part in the deliberations of a large number of working groups dealing with various aspects of this highly complex problem situation. The case study author (who was one the participants) discusses the problems encountered and the benefits obtained by a broad stakeholder participation. She also touches upon the benefits of having stakeholders engaged in the implementation of (some of) the measures suggested by the study. Even if the authors do not elaborate on the issue, the stakeholder perspective is also prominent in the chapter by Rune Gustavsson and Martin Fredriksson [14] discussing the development and implementation of modern computer support to health service systems. In their chapter Lena Ewertsson and Lars Ingelstam [15] also discuss actor participation, referring to earlier studies in their survey of research on technological development. Clearly, issues of actor participation are important in studies investigating decision processes or other forms of human interaction.

* * * * *

The way the issues discussed in this section are handled in real-life systemic interventions is often conditioned by the "ambition" of the study, i. e., by the time and money allocated for the purpose. The framing of the problem, the methodological choices, and the actual analysis performed are unavoidably constrained by the amount of resources available. The use of unsophisticated (but fast) methods in a systems analysis may reflect resource constraints rather than lack of competence or carelessness on the part of the researcher.

3 Shifting the Perspective – Emergence

A common approach is to assess systems analysis as something akin to machinery. Research is typically focused on what happens *inside* a given system. A typical research approach is to study how the interaction between systemic elements can be defined and assessed in terms of systemic functions or how the communication between a system and its external environment works. A fundamental question is, hence, *what* a system does, and *how.*

In the following section a different perspective is introduced. The basic idea is to use systems thinking to understand how a given phenomenon has come into existence – how it has *emerged* from a system. In principle, anything that happens in the world (any event) can be envisaged as an emergent property or outcome of the performance of a suitably designed system (remembering that systems reside in our minds, that they are models whose specification and boundaries can be varied to fit our purpose). While systems thinking in principle can be applied to any emergence, it is (what we believe to be) *meaningful emergence* that should be at the focus of interest. The obvious question here is of course: *who* is to determine what is meaningful, *how* can it be deterimined, how *ought* such decisions be taken? This selection problem has many similarities with the boundary problem mentioned above.

The focus on emergence helps to widen the framework used for comparison and assessment of the cases of systems thinking reported in the book.

The concept of emergence is associated with the quality of the "output" of the performance of a system, that which makes it in some sense *more* – or *better* – than the sum of its parts. The aim of the systems analyst is to understand, explain or make use of *emergent properties* or *emergent behaviors* that it is meaningful to focus on because they are important to us for some reason or other.

Assume that we – in our capacity as "systems theorists" – have taken note of a phenomenon or situation that we believe needs to be explained or changed (improved), for example a rapidly increasing rate of mortality of a certain fish species in the Baltic Sea. In order to "explain" the phenomenon, or learn how to cope with it, we want to understand how it emerges as a result of the workings of an underlying but still unknown system. For example, we want to find out what factors in and around the Baltic Sea interplay to cause the alarming fish death. The approach to explain this phenomenon is to delimit and construct a system whose internal processes can be seen as a "cause" of the emerging phenomenon – fish death. When we have a sufficiently detailed and coherent understanding of the workings of the system we may claim that the phenomenon has been explained or that we are in a position to improve on the identified problem situation.

A similar procedure may unfold when we want to construct things that do not exist, be it new versions of existing artifacts or entirely new things (innovations). To proceed we need to have (or develop) an idea about what we want to "produce." Then we have to elaborate this idea to the point where it becomes possible to construct a production process for the still imaginary artifact. When we have a sufficiently elaborated mental "image" of the artifact we are looking for we will be in a position to devise a system embodying the constructed production process. We will then have built a system of which our imagined artifact is the emergent outcome or behavior.

Needless to say, the unexplained emergent phenomenon (and the entailed system whose functions can explain it) or the not-yet-existing artifact (and the system required for its construction) can itself be anything from a very simple to a very complex entity. So, either we "see" something out there in real life, or we imagine something that we would like to see constructed. We conceive of this something as an "emergent property" or "outcome" of a system of some kind. The crucial problem is to reconstruct a (minimally complex) system capable of producing these emergent qualities. This means that the systems approach takes the form of *systems design,* i. e., we identify (imagine, invent, design) a system capable of explaining or producing a certain emergent phenomenon. Thus, the "building-blocks" of this design may be either already existing things or systems, or things or systems that need to be put together if the new design is to produce the required emergence. Obviously, the delimitation of the system is a critical factor in this connection.

The criterion for evaluating the success of a systems approach (be it for explaining a phenomenon, improving on a problem situation or constructing a new artifact) is that it works, i. e., that the explanation or the construction process is *viable,* that it explains what it is supposed to explain or produces what it was expected to produce.

4 Concluding Remarks

The selection of cases of systems thinking reported in this book has in principle been made arbitrarily. The book does not claim to offer a comprehensive picture of systems thinking and systems analysis in present-day Sweden. Nor does it identify any brand-new developments in systems thinking. However, the overview and partial comparison of the cases included in the book has generated significant and indicative impressions. One such signal concerns the impressive breadth of systems thinking, which, in turn, is associated with an enormous variation which is a function of three main fields of application (research, decision support and design/construction) in various issue areas for the achievement of many different objectives with the use of different approaches and analytical techniques. Systems thinking may be employed to attain new knowledge ("better theory"), to produce a solid basis for decision making ("better practice"), and to design and construct artifacts making people's lives easier ("better design"). Sometimes the approach is used simply to sort out complex problem situations, to frame a problem in order to make it accessible to analysis.

Another impression relates to the general standing of systems thinking. Generally speaking, systems analysis is well established in research and decision support, as well as in design and construction. In many areas systems thinking in its various forms is a part of standard operating procedures. In laboratories where computer programs are constructed or research in natural science is carried out, systems approaches are part of the day-to-day work, not attracting special attention or causing great debate. Hence, the employment of systems thinking is widely spread among manifold institutions for manifold uses. As a consequence the development of systems thinking in Sweden is not driven from a single core sector but rather manifests itself in the most varying contexts. Thus, the variation between two specific projects employing a systems approach may be considerable or even stark. However, at the same time systems thinking retains a unitary quality with a few basic characteristics that are reflected in all applications of the approach. This is possible because these characteristics are of a general nature, highly adaptable to greatly varying situations. Systems thinking also has a great capacity to combine, and integrate, different kinds of knowledge and information.

The systems approach can be used for various purposes. Primarily, it provides an *analytical framework* with the aid of which complex problems may be addressed in research and other similar activities. Furthermore, systems thinking may be employed to manage complexity, which may be done in different or even contradictory ways. On the one hand, systems thinking may be employed to deal with a high degree of complexity in the description and explanation of a phenomenon, as demonstrated by the brain analysis reported by Hans Liljenström and Peter Århem (Chapter 5). On the other hand, the systems analysis of Sweden's future environment reported by Anita Linell (Chapter 8) illustrates an opposite approach in that it helps to structure a problem area in order to reduce complexity to manageable levels for planners and decision makers.

Several of the case studies in this book demonstrate a growing demand for instruments and methods with a capacity to elucidate or manage complexity. Difficult problems have often remained unresolved for long periods of time because of the lack of instruments for analysis or management with a capacity to cope with the inherent complexities of the situation. The increasing complexity of many world phenomena has created a demand for advanced approaches to problem solving that do not require that a problem area is broken up into smaller elements before analysis becomes feasible.

Simultaneously, the "supply" of instruments for the exposition or management of complexity in terms of systems thinking has also become upgraded by providing new abilities in this respect. The last 15–20 years have produced a number of advances in systems methodologies making the systems approach increasingly capable of dealing with complex problem situations. Many practical applications (such as those described in the chapters in Part II of this book) bear witness to this fact. Behind these advances lie a theoretical development (mainly in complexity theory) and a tremendous increase in computing power made available through advances in information technology. With the increased accessibility of computing power, knowledge and inventiveness have also expanded, allowing a wider use of the opportunities that this development is offering.

A final impression from a comparison of the cases of Part II is that systems thinking is being moved forward by different "drivers," with important interaction effects between them. Examples are the general technological development and that of the IT sector, the rapidly growing ability of researchers, planners and decision makers to use new techniques relevant for systems approaches in research, decision support or construction, the creation of "knowledge pools" which can be integrated in systems models and the continued institutionalization of systems approaches in certain state agencies concerned with long-term planning.

The significance of these drivers is extremely hard to assess, and the strength and value of synergy effects are notoriously difficult to estimate. Another difficulty is that a particular development may have quite different meaning and significance for different actors involved in systemic interventions. For example, new computer technologies and programs may represent important new favorable conditions for natural scientists or model builders but at the same time be irrelevant for planners in a national agency working on complex policy plans. For these decision makers it may be more important to have access to advanced computer software making it possible to describe and illustrate complex relationships to other persons involved in the same project. There is a risk that the prospects for systems approaches may be underestimated and also underexploited because of a failure to comprehensively assess their costs and benefits. Thus, there is a need for a systems approach to attain a comprehensive, holistic and systematic evaluation of what systems thinking can do. The results of such an assessment should be easy to communicate to the many types of actors that may participate in projects adopting a systems analytical approach.

How systems analysis should best be systematically supported, taught at universities and trained for practical purposes is an important and complicated issue. The person or organization taking on this task is confronted with a dilemma. Should a separate discipline for systems thinking be developed? Or is it better to develop systems thinking in the context of other academic disciplines, or other fields of application, for which it can offer methodological support?

Systems thinking might be regarded a discipline in its own right. Chapter 1 and 2 of this book have demonstrated that there exists a fairly coherent and still developing body of literature on systems analysis and other aspects of systems thinking. This evolving knowledge is certainly broad and deep enough to sustain special university teaching programs. In this way, it would be possible to continuously turn out university graduates specially trained in systems thinking. Another advantage would that the teaching and training of systems thinking could be structured and further developed on its own terms. However, such a strategy also has significant drawbacks.

The chapters of this book have demonstrated that a strong feature of systems thinking is its great adaptability allowing it to fit into various contexts and to serve different goals. The specific form of an applied systems analysis may vary greatly ranging from general conceptual analysis to the employment of technically highly complex models. Many of the systems analyses reported in this book have similar features but their "common denominator" is of a fairly general and, one may add, somewhat philosophical character. Typically, systems thinking becomes specified, targeted and operationalized when combined with some subject-specific theory or analytical tool. This situation indicates that it is not sufficient to have special university courses in systems thinking. The approach will also have to be taught in the traditional academic disciplines where systems thinking may make a useful contribution. For example, methodology courses may contain basic and/or more advanced elements of systems thinking. It is, however, a disadvantage if teaching and research on systems thinking is fragmented in order to attain specialization benefits, risking to make it increasingly marginalized in the competitive world of university disciplines and research funding. To continue its highly important task of assisting research, policy planning and technology development in a multitude of contexts and issue areas systems thinking needs to lean on some core institution, e. g., a research council with a special responsibility to support systems thinking as a general approach in science as well as an approach for solving applied research tasks.

Mats-Olov Olsson, Centre for Regional Science (Cerum), Umeå University, SE–*901 87 Umeå, Sweden, email: Mats-Olov.Olsson@cerum.umu.se.*

*Gunnar Sjöstedt, The Swedish Institute of International Affairs (*UI*), Lilla Nygatan 23,* SE–*111 82 Stockholm, Sweden, email: sjostedt@ui.se.*

References

Bauch, K. C. (2001). *The Emerging Consensus in Social Systems Theory.* New York, Boston, Dordrecht, London, Moscow: Kluwer Academic/Plenum Publishers.

Gigch, John P. van (1991). *System Design Modeling and Metamodeling,* New York and London: Plenum Press.

Glasersfeld, E. von (1995). *Radical Constructivism: A Way of Knowing and Learning.* London, Washington, D. C.: The Falmer Press.

Midgley, G. (2000). *Systemic Intervention; Philosophy, Methodology, and Practice.* New York, Boston, Dordrecht, London, Moscow: Kluwer Academic/Plenum Publishers.

Ulrich, W. (1983). Critical Heuristics of Social Planning; A New Approach to Practical Philosophy. Bern, Stuttgart: Verlag Paul Haupt.