Scientific Background Paper

for the Foundation of the

Berlin Workshop in Institutional Analysis of Social-Ecological Systems (WINS)

Konrad Hagedorn
Humboldt University Berlin
Division of Resource Economics
Philippstr. 13; 10099 Berlin

Phone: 00-49-30/2093-46360/46362
Fax: 00-49-30/2093-46361
k.hagedorn@agrar.hu-berlin.de
www.institutions-of-sustainability.hu-berlin.de

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Preface

This paper presents the main reasons for the foundation and development of an international centre, the "Berlin Workshop in Institutional Analysis of Social-Ecological Systems" (WINS) [1]. It discusses the state of the art regarding current research and main discourses on institutions and governance structures that regularize the interaction of human societies and natural systems, often by also employing other, i.e. man-made physical facilities. Various scientific communities deal with this subject area, however, they approach their research issues in quite different ways mainly because they use different analytical frameworks. Surprisingly, communication and collaboration across most of these scientific communities and analytical frameworks seems to be rather weak. This paper will look for the reasons behind this particular phenomenon. From these explanations it will draw conclusions on how this scientific action situation could be stimulated by integrative discourses and interdisciplinary research to increase the quality of knowledge generation - and how the "Berlin Workshop in Institutional Analysis of Social-Ecological Systems" (WINS) could contribute to such progress.

This is what defines the core task of WINS. This paper does not deal with organizational and practical issues of establishing the Workshop. These are discussed in two separate papers. The first one develops a concept of the initial set up and further development of the WINS, after having given a brief overview of the scientific background and strategic outcomes as presented in this paper. The second one explores the option to establish the Workshop together with "IRI THESys", the new Integrative Research Institute in Humboldt University devoted to "Transformations of Human-Environment Systems".

1 Introduction

Whether or not interaction between human actors and their social, natural and physical environment produces, maintains or weakens sustainable systems, crucially depends on their behavior. The patterns of behavior humans follow and in particular their economic choices rely to a large extent on what social constructions actors and societies have developed over time and how these in turn have shaped their reasoning and visioning. It encapsulates the ubiquitous interdependence between structure and agency that has found its expression in how institutions such as traditions and religions, norms and rules, languages and discourses, trust and commitment, mental models and believes emerge, are practiced and change. Such processes of social construction and deconstruction are crucially conditioned and influenced by attributes of the physical and natural environment. Those physical stocks and natural systems from which humans want to extract matter or energy, on which they want to grow living organisms, or into which they want to dispose waste, show a wide range of properties and are subjected to changing scarcities. The interconnected ecological, biological, geological, hydrological, marine and atmospheric subsystems of the earth system are extremely diverse and complex, ever changing and understood by humans only to a limited extent. This equally applies to the tools, technologies and infrastructures humans have developed - with an rapidly increasing speed of innovation and expansion over the last century - and set up to use, manage, cope with and also protect those systems - such as farm machines, irrigation systems, logging equipment and fishing devices.

[1] This paper has profited from discussions with members of the Workshop in Political Theory and Policy Analysis at Indiana University and of the Divisions of Resource Economics and Environmental Governance at Humboldt University Berlin. A former version has been presented to the Social-Ecological Systems Club together with Andreas Thiel, Professor of Environmental Governance at Humboldt University.

Given this natural and technological context it is obvious that regularizing and governing the interrelationship of humans that is mediated by the intertwined systems outlined above cannot be achieved in a simple fashion. This is even more evident when we keep in mind that they are interwoven with a variety of unsolved problems mankind is struggling with such as hunger, malnutrition and poverty social exclusion, social unrest and wars. In contrast, such diversity and complexity in natural together with associated technological systems which have been developed to use them require corresponding diversity and complexity in institutions and governance modes and structures. This is not only a plausible suggestion but has been theoretically and empirically substantiated in a by the Vincent and Elinor Ostrom Workshop at Indiana University (Ostrom 2005) and its associated research community.

A large extent and core elements of his research have been based on an analytical framework that served to organize research worldwide as a social process, the "Institutional Analysis and Development Framework" (IAD). Similarly, the Institutions of Sustainability (IoS) framework has been developed at Humboldt University and used for numerous research projects. The objective to transpose the IAD heuristic to the analysis of Social-Ecological Systems (SES) in general has led to the "SES framework" developed by the "SES Club" under the guidance of late Elinor Ostrom (2008) and driven by conceptual initiatives from the Ostrom Workshop. In this community, a Social-ecological System (SES) is seen as an "ecological system intricately linked with and affected by one or more social systems" (Anderies et al., 2004b). In such SES, it is institutions that "regulate relationships among individuals and between the social and ecological systems […and therefore] link social and ecological systems" (Gatzweiler and Hagedorn 2002: 3).

This discourse has not only emphasized the importance of institutional analysis, but also the role of technology and infrastructure because these are often established at the interface of natural and social systems. Strictly speaking, the focus of this concept therefore is an "Institutional Analysis of Linked Social, Ecological and Technological Systems" (SETS). However, as the term "Social-Ecological System (SES)" is now well established in various scientific communities, we will often use this instead of changing to "Social, Ecological and Technological Systems (SETS)" although this would be more precise. The main point of departure is the observation that different heuristics and languages have been used in (more or less profiled) analytical frameworks besides the IAD, IoS and SES frameworks. They prevail in different scientific communities which deal with approaches to the institutional analysis of the interaction of natural-technological and social-institutional systems. This gives rise to the research question as to what this situation implies for the development of a SES (or SETS) analytical framework which aims at general applicability.

This paper is organized as follows: First we will make explicit how we understand the role that analytical frameworks play for research processes in which they are intended to guide the arrangement of analysis. Then we will present several analytical frameworks and heuristics applied in the field of institutional analysis of linked social, ecological and technological systems. This will reveal similarities and differences in the way they are used in the corresponding scientific communities. Then we will extend on some aspects to show what is behind the differences in framing, languages and heuristics. By unpacking the activating role of the transaction-interdependence-institutions nexus in SETS action situations we develop an understanding of the emergence and existence of the many analytical frameworks and corresponding communities and disciplines respectively. This allows for some insights on what a science map on SETS analytical frameworks for institutional analysis might look like and to what extent the boundaries of their territories reveal segregated or integrated structures. Fi-

nally, we draw conclusions on what should be the main focus the Berlin Workshop in Institutional Analysis of Social-Ecological Systems, in particular how it should stimulate communication and collaboration across scientific communities using different analytical frameworks. By playing such an integrative role the Workshop is expected to serve as a vehicle for enhancing self-organisation of scholars in international networks and increase the quality of knowledge generation and dissemination.

2 Analytical Frameworks - Framing Action Situations in Research Processes

As a point of departure we refer to the SES framework developed by the SES Club which resulted from the main objective to set up a general analytical framework which uses a common scientific language for all disciplines involved in the analysis of social-ecological systems. It is supposed to serve as a research heuristic and a nested system of meaningful variables for different types of analysis, among others for the institutional analysis of social-ecological systems. The initial idea was that such an analytical framework should be "theory-neutral". It was expected to be open to different theoretical approaches and different empirical methodologies once it was applied by different research communities and disciplines. This premise seemed to be a plausible objective given the recognition that a general, cross-disciplinary and multi-method approach was necessary to do justice to the study of SES.

2.1 The Impossibility of an Analytical Framework to be Problem-, Theory- and Empirically or Methodologically Neutral

This paper does not share this understanding of an analytical framework mainly for two reasons. It first does not sufficiently take into account how analytical frameworks actually emerge in scientific communities and secondly it does not explicitly explore whether and how it might be feasible to generalize it across different scientific communities and what concrete method of generalization this would require, although this is seen as the final target. Both perspectives will turn out not to be compatible with the assumption that an analytical framework could be neutral with respect to the problems, theories, empirical application and methodologies used in a scientific community.

In contrast, we understand an analytical framework as a way of framing a research process on a research issue, which is an action situation in itself. "Framing is a process of structuring an action situation, and in that sense it governs 'meaning'" (Lindenberg 2001: 682). Lindenberg (2001: 682) uses "a theory on how the definition of an action situation (a 'frame') affects the selection of knowledge chunks, beliefs, attention to certain situational aspects, recall of situational aspects, as well as choice of action". In other words, meaning, intention to tackle a problem driven by goals, and relevance to a current or already experienced situation are main elements in this kind of understanding of an analytical framework. An analytical framework in this interpretation cannot be problem-neutral, theory-neutral and empirically-neutral.

Accordingly, any framing of a research problem in terms of an analytical framework has three implicit components: intention, meaning and relevance. Thus, when applying an analytical framework we need to be explicit how it treats the dimensions of intentions associated with it, meanings it is founded upon and the relevance claims it makes. Relevance implies a normative focus: What problems do we intend to solve with our analysis? Meaning is related to the theory which provides explanation of elements of the observed reality in which the problem is embedded. Relevance is also related to meaning through the empirical substantiation of the-

ories, both in a positive and a normative meaning – it reveals whether and how we understand the problem and how we aim to solve it, provided that the research process is able to produce not only substantiated explanations but also feasible solutions.

These components of scientific analysis shape the language we are using within a research process and the communication of its results. Language itself is an expression of empirically substantiated theory. In other words, the social construction of what is recognized as being part of the real world in a research process requires the construction of language and includes conventions on the terminology a scientific community uses. These insights are important for our interpretation of an analytical framework and scientific language use in these frameworks. They are developed in a process of interplay between theoretical approaches, empirical methodologies applied in a process of exploration and investigation which is driven by a specific normative background or framing.

Theories are expressing our always imperfect and fallible, reconstructions of reality and influence what part of reality we are able to observe and how we tend to interpret them (Popper, 1974; Sayer 1992: 602; Blaikie, 2000). Theory development represents the process of interaction between observation, empirical "surprises" and revision of theory critical preunderstanding of the problem concerned. These processes are crafted by creating scientific languages which are used in describing the problems, framing the intentions, crafting the theories and communicating the methodologies, and finally, the appraisal of results from which recommendations may emerge with the aim to solve problems. Human language itself is a theory developed by processes of trial and error for identifying elements of the social and physical world and to find an appropriate terminology. Even the very foundation of cognition, that is perception, consists of a process of generating and falsifying hypotheses by means of the system of symbols that constitutes human language (Albert, 1977: 114-119). This contradicts the idea of a theory-neutral basis for human experience and the language used for its description.

What therefore can only be collected and systematically arranged in an analytical framework is language that emerged from processes of theory identification, finding intentions, theorizing insights (being more or less empirically substantiated). Analytical frameworks as research heuristics entail different scientific languages and views on what an SETS is and how it is best analysed. To understand this we must be aware that these research-guiding approaches are developed as the outcome of iterative processes involving interaction between theory and empirical study. Theories are expressing our social constructions of reality and predetermine what parts of reality we are able to observe and how we tend to interpret them (Blaikie, 2001). Accordingly, analytical frameworks grow from the problems, the intentions and the theoretical and empirical background of their producers. They depend on disciplines and schools scholars belong to, theoretical and empirical process used, the specific object of research interpretative perspectives internalized by the researchers (mental models), and the scale at which analysis takes place. Therefore, in short, analytical frameworks differ in the intentions, meanings and relevance they carry within themselves.

In principle, McGinnis and Ostrom (2012) follow this recognition in their definition of a framework: "A 'framework' provides the concepts and terms that may be used to construct the kinds of causal explanations expected of a 'theory.' A 'theory' posits specific causal relationships among core variables, while a 'model' constitutes a more detailed manifestation of a general theoretic explanation in terms of the values of particular variables and functional relationships. Just as different models can be used to represent different aspects of a given theory, different theoretical explanations can be built upon a common conceptual framework."

However, this train of thought could, or even should, be extended: If we want to find a heuristic and a language for guiding research on a certain problem, we have to be aware that such an analytical framework is not only a premise but also an outcome of constructing theories, deriving models and applying empirical methodologies in the respective field of research. An analytical framework which has proven useful for framing research in one scientific community may fail when applied to the research issues of another scientific community.

Probably, we cannot neglect the question of boundaries as regards theories, models and empirical methodologies that can be reasonably allocated and employed within one analytical framework. This may expose scientific communities using different analytical frameworks for analysing (maybe their specific domains of) social, ecological and technological systems to obstacles of incommensurability (Kuhn, 1996; Feyerabend, 1975). Established analytical frameworks may play a paradigmatic role originating in the above mentioned categories of intention, meaning and relevance of different communities or schools. As a consequence, it cannot be simply assumed that "frameworks provide a meta-theoretical language that can be used to compare theories" (Binder, Bots, Hinkel and Pahl-Wostl, 2012). Instead, we have to investigate, as an empirical object, why and how research problems, theories, models and methodologies have brought about analytical frameworks and vice versa.

2.2 Bonding or Bridging as an Appropriate Method of "Generalisation"

Analytical frameworks with their incorporated heuristics and languages may only have meaning for some research communities and appear to be unreasonable or at least confusing to other research communities that also work on SETS, because they have developed their own analytical frameworks, heuristics and languages in other areas of problem solving, theorizing and empirical work. If this is the case, and this is what this paper aims to show, "generalizing" an analytical framework will only improve the research capacity of the different scientific communities addressed, if they find their problems, intentions, meanings and what is considered relevant by that specific community reflected in it.

A simple example for this problem: When we assume we would tell an expert from the research communities of agricultural sciences or agricultural economics that those actors in his research domain who are cultivating plants and raising animals are "withdrawing" or "extracting" "resource units" from a natural "resource system" when they are harvesting wheat or raising piglets. The expert will find this language taken from SES and IAD rather meaningless and maintain that his discipline has developed a long standing and proven terminology for these practices. The farmers themselves might say: "I have sawn the wheat by myself and I have raised the piglets by myself. I have not extracted them from an ecological, geological or hydrological system. What I have done is enabling growth processes based on caring for resource systems (what is the opposite of extracting from them) by feeding in nutrients, for example through fertilizers, and preserving ecosystem functions, for example through soil fertility. Thus, the cognitive schemata are rather different, and imposing those of one community on another community may create considerable confusion - and confusion is the opposite of what we want to achieve by means of analytical frameworks.

If we agree that analytical frameworks are transposing external objects of researchers into language that should have a "proper" internal representation in their minds, then the question arises whether such cognitive schemata exist in these individuals, or as social construction in the communities of individuals, that have developed similar mental models in the research processes outlined above. Composing an analytical framework by using terms that have

been generated by actors external to the action situation that constitutes a discipline may make sense as long as they are compatible with cognitive schemata in the communities involved or intending to use these frameworks and give sufficiently meaning and action orientation to them. But this congruence of existing framings probably has its limits. Therefore, the question arises how to translate between the different communities and how to reconcile their cognitive schemata - or in other words, how to bridge the different analytical frameworks including the heuristics and languages they provide.

Accordingly, instead of extending the applicability of one overarching framework by bonding, bridging may be at least equally important. For the SES framework bonding would mean to preserve the original heuristic and language and extend its influence by popularizing the technical structure but stick with the terminology and meaning predominantly inherited from the IAD framework. Bridging would require exploring other frameworks used in other scientific communities, engage pro-actively in a process of mutual and interdisciplinary learning and try to understand languages and heuristics and why they differ. The question arises whether this more open approach would be more constructive although it is probably also more demanding. It requires that those research agents in the action situation who intend to construct a general framework first have to know different analytical frameworks, heuristics and languages of other disciplines and secondly they have to negotiate commonalities and mitigate differences between in favor of increased commensurability, provided that this can actually be achieved. The challenge would be to make an overarching analytical framework comprehensible, reasonable and useful for different communities - or to settle with a group of analytical frameworks.

In the following, we will characterize two main research traditions in using analytical frameworks for the Institutional Analysis of SETS that specifically address “Natural Resource Institutions and Environmental Governance (Section 3.1) and “Economic Institutions and Political Governance in the Green Sectors” (Section 3.2). As we do not consider analytical frameworks being independent from the theory, models and empirical methodologies, we will pay particular attention to these linkages.

3 Analytical Frameworks for the Institutional Analysis of Social-Ecological Systems

Two research traditions in the analysis of Institutions and Governance Structures in SETS, in a wider sense, can be considered collections of research streams as they address the same set of objectives. The first tradition broadly aims to achieve sustainable use of natural resource systems and effective regulation of environmental pollution by crafting robust institutions and effective governance structures. Focuses of this tradition are, first, withdrawal of resource units from resource systems, and secondly, emissions into/impact on ecosystems governed by environmental regimes. In this research domain, the Ostrom School and its analytical framework have a guiding function.

The other research tradition in the analysis of Institutions and Governance Structures in SES is older, its contributions are more scattered, and appear less spectacular. The scholars in this area represent specific branches of agricultural, horticultural or forestry sciences. They are concerned with the way production and provision in the green sectors of the economy (in this proposal we use this formulation as equivalent with the agricultural, forestry, horticultural, fisheries sectors) is organized and comprise areas such as: the farm as an organization, the household as an economic institution of peasants, communal and cooperative forest management, land and labor institutions, contracts as core elements in input provision and supply

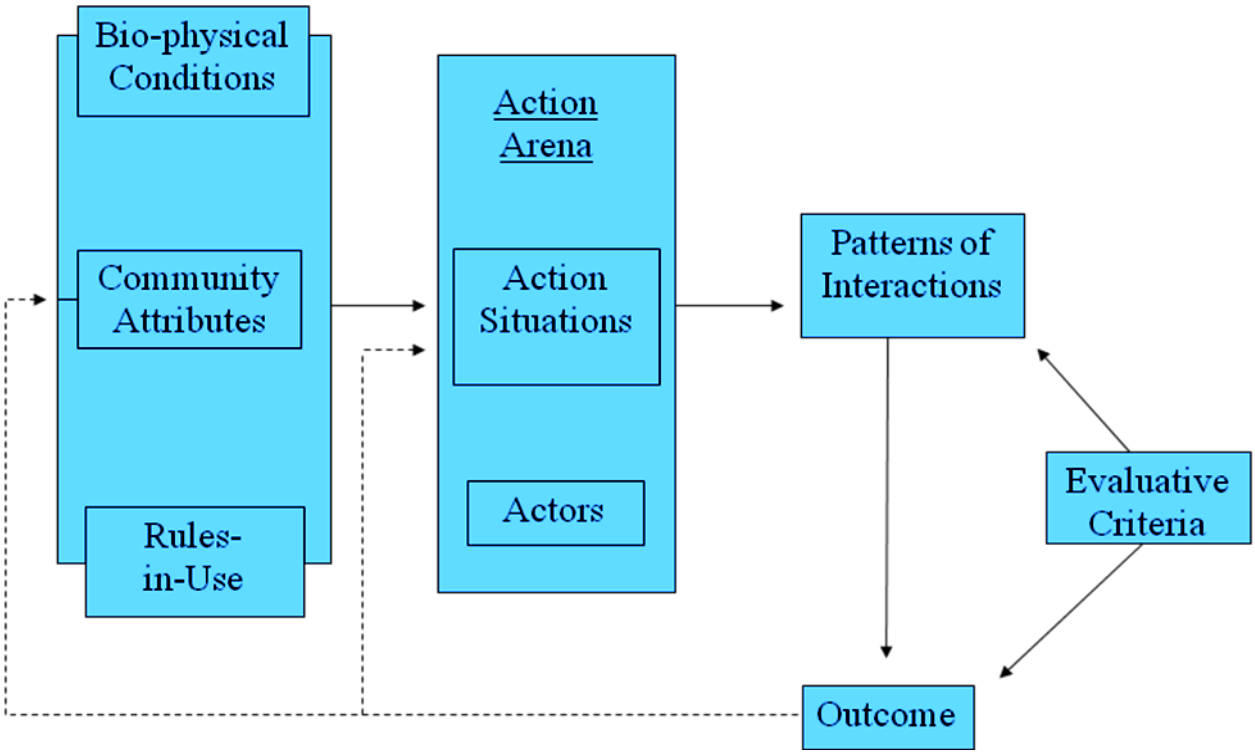
chains, cooperatives, self-organization and self-help, the political economy of agriculture, or the institutional analysis of post-socialist transition of agriculture. These strands of research share a focus on, first, production seen as transformation based on the use, and sometimes overuse, of ecosystems such as fertile soils by farms (rather than just withdrawal of resource units), associated with other activities institutionalized for channeling the produce to the consumer; secondly, the governance and political economy of nature-based production and provision systems and its biological and environmental implications. In this field, Günther Schmitt's work on the family farm has become very prominent.

The collection of analytical frameworks presented below is not complete. Some further frameworks are similar to the ones described below. Paavola and Adger (2005), for example, have introduced "Institutional Ecological Economics". Pahl-Wostl (2009) has developed a very advanced "Management and Transition Framework"(MTF) which adds to the IAD Framework, and extended it by a social learning approach combined with the concept of Adaptive Management Regimes (AMR) for water (Folke et al., 2005; Pahl-Wostl, 2007a,b,c; Pahl-Wostl et al. 2009). Kooiman (2008) and Jentoft (2007) use a „Governability Framework". Each of these analytical frameworks, although often similar to, or based on, one of the analytical frameworks describes below, would be relevant for this overview. However, in this paper we decided to focus upon a limited set of frameworks. Our purpose is here to illustrate how different frameworks can enrich the analysis of SETS and what are problems in trying to integrate across them in order to finally come to a proposal for ordering the existing conceptual maps that cover the territory and could therefore potentially enrich the analysis of SES.

3.1 Typical Approaches to Institutional Analysis in the Research Tradition of "Natural Resource Institutions and Environmental Governance"

(1) Institutional Analysis and Development Approach (IAD)

The IAD Framework focuses on action arenas, in which actors interact in an action situation, and are at the same time affected by exogenous variables - bio-physical conditions, community attributes and rules-in-use (see Figure 1). The outcomes produced in this way have feedback effects on the actors and the action situation (Ostrom 2005). Action situations can be interlinked and are described by a set of rules and variables. Among other methods, behavioural experiments were applied for analysing the choices of actors in SES (Janssen 2010; Janssen and Anderies 2011).



Source: Ostrom, Gardner, and Walker (1994)

Figure1: Institutional Analysis and Development (IAD) Framework

This analytical framework was developed as a response to Garret Hardin's ideas (1968) that the "Tragedy of the Commons" cannot be avoided without either privatizing Common Pool Resources (CPR) or managing them by government bureaucracy. Empirical evidence from numerous case studies has shown that cooperation works in the case of CPR, i.e. users of common pool resources are able to solve their problems by crafting rules and forming organizations. However, this depends on physical and social conditions. Explaining "the origin of self-governed common-pool resources", Ostrom (2001) points out several "attributes of resources and of appropriators … conducive to an increased likelihood that self-governing associations will form". Accordingly, the theoretical and empirical background against which the IAD framework has been developed (i.e. where the language and perceptions come from) common pool resources institutionalized as common property and jointly used by groups by collective action (e.g. common grazing land, commonly used irrigation systems).

(2) The Social-Ecological Systems Framework (SES)

The SES framework (which has already been mentioned several times) has been initiated by Elinor Ostrom and her colleagues from the Ostrom Workshop and further developed by discussions in the SES Club (www.cooperationresearch.eu/SES/). The objective was to develop a general framework and common language for analyzing the relationship between social and ecological systems. This implies that scholars from different disciplines and schools and with different theoretical and empirical approaches should be able to introduce their terms and perspectives into such an analytical framework. Thus, they are expected to assume language, heuristics, and understanding of the SES framework.

The starting point for this work on a cross-disciplinary language was the initial SES framework published by Elinor Ostrom (2007) that builds on the IAD framework and tries to recognize both social and ecological elements of SES more explicitly. It aims to be open-ended and reaches into great depth of system description by relying on a multi-tiered, nested hierarchy of variables. Due to the origins of the SES framework, it grew out of the research experience of the Ostrom Workshop (see McGinnis and Ostrom 2012) and derived a broad set of variables from the IAD framework which are interlinked by the idea that system are nested and can be decomposed. The present version is the result of a generalization process, although many elements of the framing use the terminology and main constructs of IAD; for example the notion of withdrawal of resource units as core physical transaction, well defined boundaries of resource systems as main spatial property of nature-related transactions or the emphasis of collective governance (see Figure 2). Section 4 will further reflect on this.

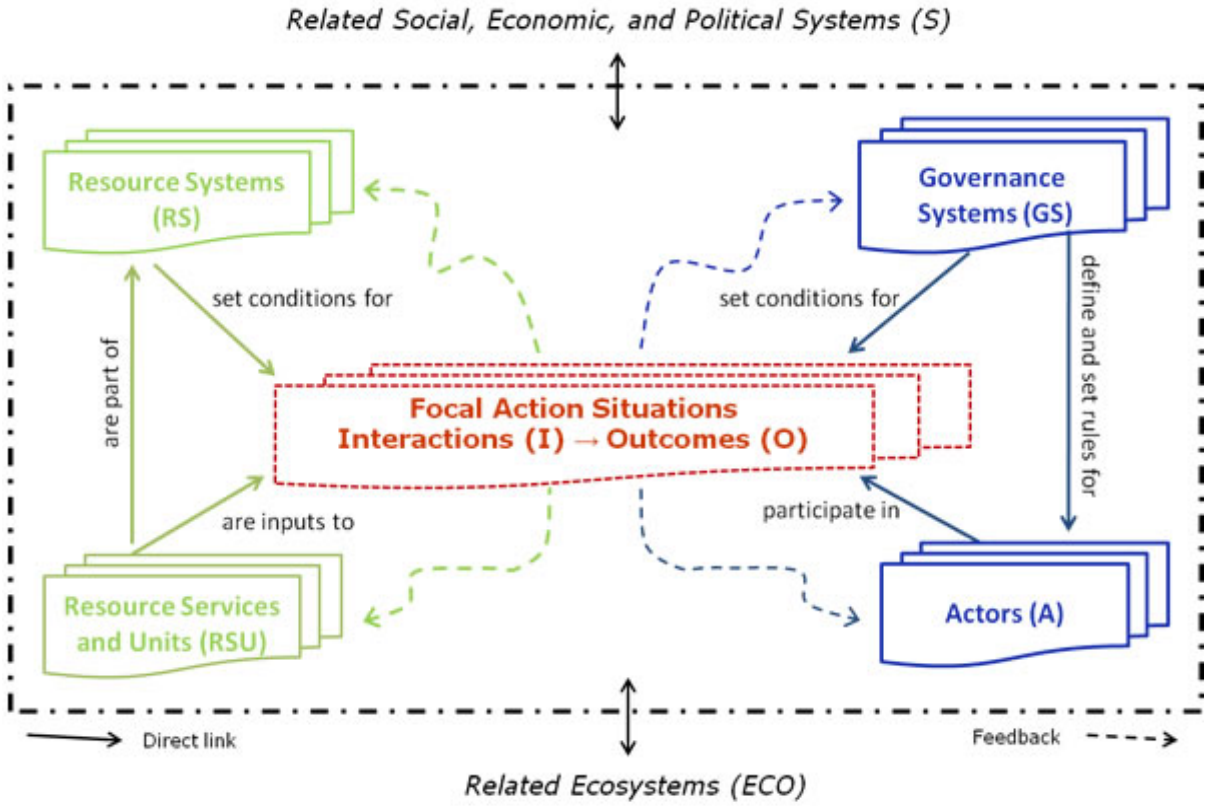


Figure 2: **Revised SES Framework with Multiple First-Tier Components**

(3) International Environmental Regimes Approach (IER)

In other than small-scale institutional settings, for example at international level, action situations often differ from local CPRs, e.g. externalities with distant impact on heterogeneous actors, logics of action selection differ, number of users and their heterogeneity differ as well as the institutions that define decision making procedures (Young 2002a: 7). In such settings, specifically complex bundles of property rights can be observed. The International Environmental Regimes Approach has emerged from a variety of observations, such as the existence of numerous international regimes that exhibit a ubiquity of mismatches. They are associated with difficulties of coordination across multiple scales, challenges resulting from heterogeneous interdependencies and dynamics of change in response to political and technological developments, and, last but not least, obstructive politics which are often driven by special interests of countries and interest groups.

"Fit, interplay and scale" are pillars of Oran Young's (2002) analytical framework for analyzing "the institutional dimensions of environmental change". Fit means that environmental regimes or resource governance systems should be compatible with the properties of ecological or bio-geophysical systems. There are temporal, spatial and functional scales of fit (Young 2002). Interplay between resource regimes can refer to vertical or horizontal relations between resource regimes. Misfits between ecosystem properties and environmental management regimes occur because of changes in ecosystems, special interests, rent-seeking activities, or "institutional stickiness". The approach focuses coherently on these issues, and SETS interactions are considered from the perspective of larger regimes; it seems to be less interested in the "micro-foundations", i.e. to explain actors' behavior in detail as regards the impact of attributes of nature-related transactions on institutional change and performance.

(4) Transaction Cost Economics (TCE)

Transaction Cost Economics which is a main approach in New Institutional Economics (NIE) is often considered only a theory, but as it provides a common language and heuristic to a large scientific community in New Institutional Economics it has distinct characteristics of a framework. Thus, for example the actor and transaction specific characteristics that determine transaction costs constitute a veritable research programme. In Transaction Cost Economics, "the transaction" is the unit of analysis. Governance of transactions is considered as an issue of contracting for private and public ordering and governance structures are optimized from a social perspective through competitive forces. The approach reduces the complexity of institutional problems to the main attributes of transactions and the characteristics of actors. Asset specificity, frequency of transactions and uncertainty are considered relevant attributes of transactions, and bounded rationality and opportunistic behaviour are presumed as defining characteristics of actors (Williamson 1985, 1996).

Transaction cost economics proposes that actors im- or explicitly match the capacity of institutions and governance structures to the properties of transactions in order to regularise the dependence between actors. In other words, "…transactions (which differ in their attributes) [are aligned] with governance structures (which differ in their costs and competencies) in a discriminating … way" (Williamson 1996: 46 f.). This idea has also frequently been applied to issues of provision of natural resources, however, without seriously considering that nature-related transactions have partially different properties than transactions related to engineered systems (see Hagedorn 2008). An area of where it has been successfully applied are the regulation of public utilities produced from natural resources (Spiller and Tommasi 2005), probably because natural resources have already been decomposed and commoditized in this area.

(5) Institutions of Sustainability (IoS)

The Institutions of Sustainability Framework (Hagedorn et al., 2002; Hagedorn 2008) has frequently been applied to institutional research on the green sectors and focuses on how to regularize human action that leads to transactions affecting the relationship between natural and social systems. Institutions (sets of norms and rules) and governance structures (forms of organisation) emerge either spontaneously through self-organisation or intentionally by human design. Their social construction has been conceptualised as outcome of interactions in what Ostrom calls action situations and depends on the properties of the transactions and the characteristics of the actors involved (see Figure 3). This framework includes elements of those frameworks previously described, but it also adds new concepts.

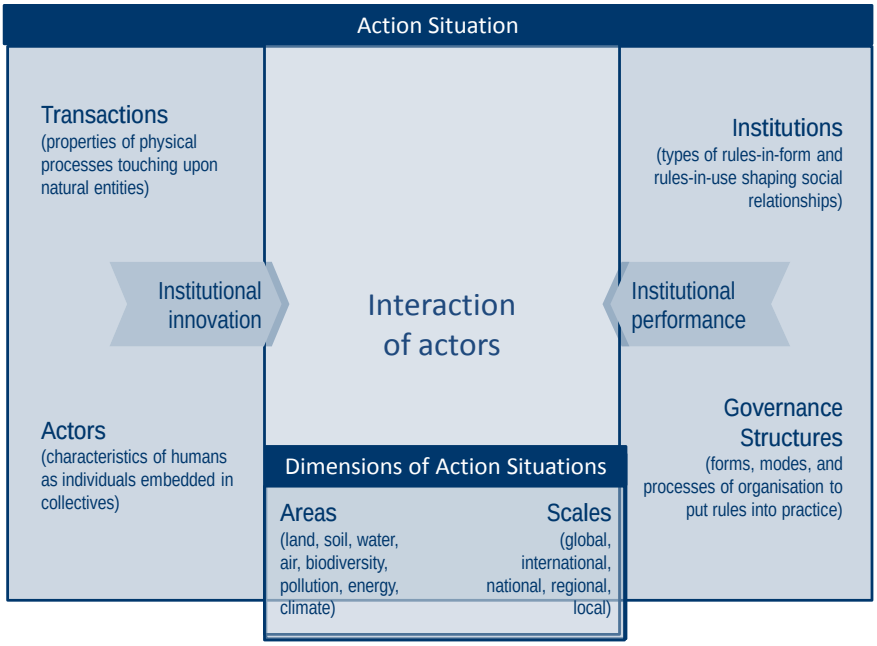


Figure 3: Institutions of Sustainability

One example for this are nature-related transactions (Hagedorn 2008) that have particular properties causing particular forms of interdependence between actors, which are the main cause for the emergence or design of institutions (Paavola and Adger 2005). These properties of transactions in ecological systems depend upon self-organized ecosystems. Linkages between activities due to the coherence of the system and the interconnectedness of its parts represent particular reasons why transactions have to be regularized by institutions and organizations. The IoS framework allows analyzing the implications of specific relations between characteristics of nature-related transactions and ways of organizing them because it addresses the micro-foundations of actors' behaviour in research.

(6) Adaptive Systems Heuristics (ASH)

In this paper we use the term "Adaptive Systems Heuristics" for three analytical frameworks which have emerged in research communities which have gained their theoretical and empirical experience in the analysis of ecosystems. Accordingly, they originate from different but closely related areas of ecological analysis: adaptive cycle, adaptive management and adaptive governance (see also Daedlow, 2013). The adaptive cycle framework (Holling and Gunderson 2002) together with four other heuristic concepts (resilience, anarchy, transformability, adaptability) have been developed in order to enable an understanding of social ecological systems behavior (Walker et al. 2006). The adaptive cycle in its original version introduced by Holling (1986, 2001) provides a framing for analysing how complex eco-systems respond to disturbance. This initiates a dynamic process within the system which Holling and Gunderson (2002: 34) decompose as follows: in the first stage of the adaptive cycle ecosystems move slowly from exploitation to conservation, then changes rapidly to release, followed by a phase of reorganization and finally returns to exploitation (Daedlow, Beckmann and Arlinghaus, 2011). After that either a new adaptive cycle begins or the system trans-

forms into a new configuration. This framework is claimed to be generally applicable not only to ecological and social systems but also to interacting social-ecological systems (Gunderson et al. 2002: 323).

Holling and Gunderson (2002), for example, have developed a variant of the adaptive cycle heuristic that is specially designed for analysing social systems. They consider connectedness and potential to be variables of mayor importance for explaining to what extent and in what way the system changes during an adaptive cycle (Holling and Gunderson 2002: 50). Connectedness describes the ability of a system to internally control its own destiny (Holling 2001: 394). It "reflects the strength of internal connections that mediate and regulate the influence between inside processes and the outside world … (Holling and Gunderson 2002: 50). Potential refers to "the inherent potential of a system that is available for change" (Holling 2001: 393). Such capacity can be described by social and cultural attributes such as the "accumulated networks of relationships – friendship, mutual respect, and trust among people and between people and institutions of governance" (Holling and Gunderson 2002: 49). Stocks of knowledge and skills are particularly relevant in this respect.

The guiding idea of adaptation being a core element in a system's dynamics producing outcomes not easily predictable reappears in the adaptive management framework (Holling 1978). Adaptation is not only characteristic of the systems' internal processes but also becomes an external strategy to be applied by social actors to influence systems. Accordingly, adaptive management requires "continually adjusting policies and practices by learning from the outcome of previously used policies and practices" (Carpenter and Folke, 2006: 309). However, similarly to the emergence of Public Choice Theory as a response to the lack of political feasibility of typically normative recommendations derived from the traditional theory of economic policy (Hagedorn 1996), adaptive governance can be seen as a response to the institutional and behavioural gap in the adaptive management approach. Whether or not SES research is able to yield fruitful recommendations crucially depends on human (individual and collective) behaviour, which to a large extent is regularized by institutions provided that rules become effective through appropriate structures and modes of governance.

In spite of this extension of the analytical framework, the main focus of adaptive governance still is how to cope with dynamics and uncertainty in social or ecological system or in SES. Accordingly, Carpenter and Folke (2006: 309) define adaptive governance as "institutional and political frameworks designed to adapt to changing relationships between society and ecosystems in ways that sustain ecosystem services; (it) expands the focus from adaptive management of ecosystems to address the broader social contexts that enable ecosystem-based management shocks". In this way, adaptive governance is considered suitable scientific response to the challenges that arise from the interaction of ecological and social systems (Dietz et al. 2003; Folke et al. 2005; Carpenter and Folke 2006; Mahon 2008).

Whether such an extension is sufficient and appropriate seems questionable. Daedlow (2013: 148), for example, criticises the definitions of adaptive governance because "their discriminatory power e.g., of institutions and governance is fragile, which impedes analytical purposes. In addition, the definitions show a rather normative bias in the direction how adaptive governance should be organized, and it rather assumes a positive outcome, i.e., as soon this concept is applied it will solve automatically problems in SES. This, however, makes it difficult in studying real world phenomenon which very often don't follow those visions, even thought they were derived from in a number of previous case studies. In fact, humans often do not act according to those ideal concepts, but rather decide based on individual interests.

Those interests can emerge in social dilemmas, where contrary positions exist and a solution is only possible when one position loses ground."

3.2 Typical Approaches to Institutional Analysis in the Research Tradition of "Economic Institutions and Political Governance in the Green Sectors"

Most of the institutions and governance structures which regularize - often directly and intensely - interaction of social and ecological systems can probably be found in the "green sectors" where interactions with resource systems predominantly take place on family farms and peasant household economies. These farming systems have outperformed other types of organization in many (not all) areas of agricultural production. However, because of their limited size family farms and peasant household economies depend on support provided by complementary institutional arrangements and various forms of contracting (e. g. agricultural research financed by governments). For example, input provision and output marketing, agricultural credits, exploitation of economies of scale are organized in farmers' cooperatives. Also, as small farms are specifically vulnerable to natural disasters, this has called for intervention from political hierarchies. Price fluctuations and structural adjustment pressure associated with income problems have also motivated political actors to introduce stabilizing policies and often led to agricultural protectionism. Below some of the main conceptual approaches and analytical frameworks dealing with the systems of family or family-managed farms and its historically grown institutional environment are outlined. We argue that in order to properly understand SES, engagement with this set of frameworks necessary. In many cases, their objects of analysis are bound up with and explain the motivations, and purposes of engaging in specific kinds of nature-related transactions. Further, they allow us to understand the way nature-related transactions are embedded into and explicable as a result of broader sets of institutions concerning the organization of production, provision or consumption of environmental goods and services at stake in nature-related transactions.

(1) Agrarian Institutions and Organizations (AIO)

In this area one well-known approach deals with the institutional and organizational analysis of the family or family-managed or peasant farm. It is based on the (theoretically interpreted) observation that agricultural production has particular attributes due to its close intertwinement with ecological and biological processes (Schmitt 1991; Allen and Lueck 1997; 1998; 2003). These nature-related transactions (Hagedorn 2008: 179; Thiel 2012: 631), as we would call them in the language of the IoS Framework, can best be governed by family farms, which are considered as an institutional extension of the existing social institution "family" or "household". Largely based on the transaction cost framework combined with principal agent considerations this research arrived at the conclusion that running a firm based on hired labor usually causes higher transaction costs in agriculture than in industry (e.g., Binswanger, Deininger and Feder 1996). Reasons are the importance of specific, traditional knowledge, the spatial dimension of farm production and the dependence on varying ecological, biological and weather conditions which explain why agricultural activities are to a large extent difficult to be organized in standardized processes. In this context family labor in small farms has a comparative advantage due to the superiority of individual ownership and low agency costs of agricultural production. However, in some agricultural production systems this does not apply, for example in intensive livestock production or plantation crops. In addition, delay in structural adjustment of family farming systems in the process of economic

growth occurs because of barriers to mobility. Hagedorn (2003) has shown that the reasons for this are institutional in nature. Family farms are integrative institutions causing institutional exit barriers for farmers and give rise to intensive political preferences to establish voice mechanisms.

In addition to this knowledge area of agrarian institutional analysis, other fields and specialized frameworks exist, in particular on marketing chains and networks in food and agriculture. Often, frameworks on agrarian institutions also look at “the institutional environment of farms”. This is closely related to research on agricultural cooperatives and contracts which will be briefly described in the following paragraphs.

(2) Agricultural Contracts (AC)

Allen and Lueck have established a theory on “the nature of the farm” from an institutional perspective. In their work, they mainly pay attention to agricultural contracts. They consider agriculture as a ”sequence of biological production stages, which in the broadest interpretation, could run from breaking land to restaurant services. More typically, agriculture is thought of as a narrower set of stages than these, usually from land preparation to food processing. Still others consider agriculture to span only those production stages controlled by the ‘farm’” (Allen and Lueck 1997: 2005). They distinguish between the farm as a “firm that essentially controls just the narrowest growth-based biological stages of production” and “the other manufacturing stages”, because the first ones are influenced by natural conditions (institutional and organizational responses outlined in the last paragraph) and particularly affect the institution of agricultural contracts (see Figure 4). Their special research area is contracting between farmers and landowners. Sharecropping is one of the frequently analyzed issues in this area.

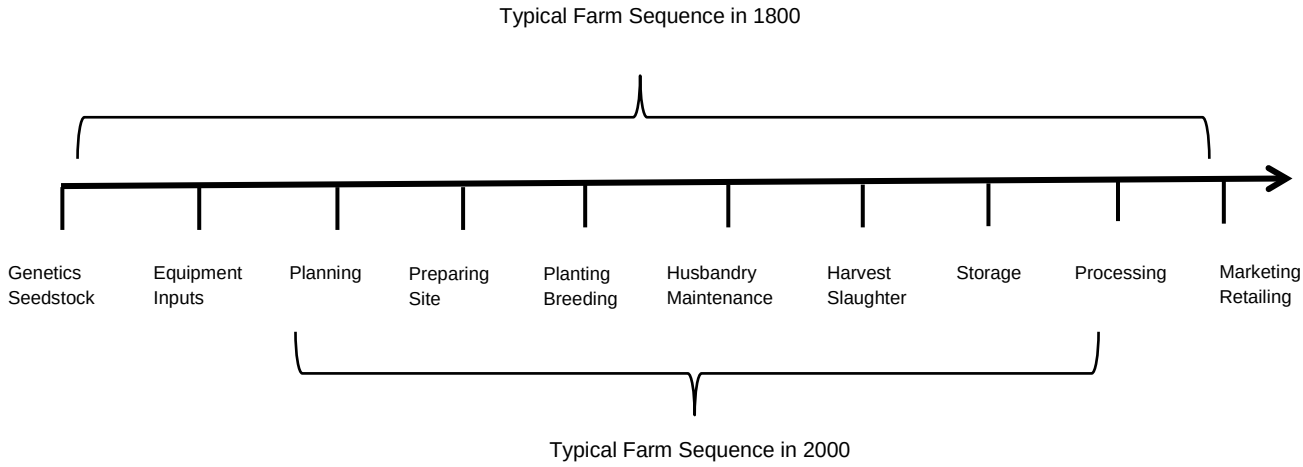


Figure 4: A Sequence of Typical Activities in Farming

Source: Allen, Douglas W. and Dean Lueck (2005): Agricultural Contracts. In: Ménard, Claude and Mary M. Shirley (eds.). Handbook of New Institutional Economics, Dordrecht: 466.

Of course, there are many other types of agricultural contracts, for example for equipment,

labor, marketing of products such dairy, fruits, sugar and vegetables (Hobbs 1997). In contract farming farmers depend strongly on the regime of the processor because techniques and inputs of production are contractually regulated. Contract farming in developing countries has developed as a special theme in agricultural economics literature. It is considered as an opportunity to integrate smallholders into the market despite often unequal bargaining power vis-a-vis the processors or traders (Key and Runsten 1999).

(3) Agricultural and Consumer Cooperatives (ACC)

As the advantages of a family farm often outperform other types of agricultural production, farmers combine the advantages of independent farming with the advantages of marketing or processing in one unit co-owned by members (Ben-Ner 1986). Cooperatives can be interpreted as hybrid governance structures. 'Pooling, contracting and competition' (Ménard 2004: 347f.) represent the basic constitution of hybrids such as described cooperatives (see also Van Huylenbroeck 2003). Partners pool some of their resources without collectivising property rights and coordinate individual choices through contractual arrangements. As the partners are subjected to competition, arrangements for benefit sharing and dispute resolution are required (Ménard and Valceschini 2005: 424). However, this research stream does not discuss the view that cooperatives can be only based on *artificial* pools of resources but also on *natural* pools of resources as demonstrated by the CPR studies of the Bloomington School. Approaches from New Institutional Economics are used by several authors dealing with cooperatives (Cook 1995, Ollila 2009; Nilsson and Hendrikse 2011).

Cooperatives often emerged in situations where important elements of markets (e.g. access to information about goods, qualities, and prices) were not available to small farmers. However, because of changes in the economic and socio-political context nowadays most cooperative organizations operate in highly competitive business environments (Hanisch, Rommel and Bijman 2012; Bijman 2003) making them similar to investor-owned companies and questioning whether traditional cooperatives are an "endangered species" (Nilsson, Kihlén and Norell 2009). The corresponding literature analyses internal rules and organisation of cooperatives (Hendrikse, 2005) or the role of member's trust and social capital. In summary, the small scientific community conducting research on cooperatives mainly follows frameworks of New Institutional Economics.

(4) Political Economy of Agriculture (PEA)

In agricultural economics, Günther Schmitt (1984) and Michael Petit (1993) belonged to the first scholars who emphasized the importance of understanding the behavior of political actors in the agricultural sector. Günther Schmitt stimulated this debate in his path-breaking article on: „Warum die Agrarpolitik so ist, wie sie ist, und nicht wie sie sein sollte" [Explaing why agriculture functions the way it does and not the way it should do] (Schmitt 1984). In line with these scholars, Hagedorn (1996; 1991) made a comprehensive attempt to develop a coherent positive theory on agricultural institutions and the political economy of agriculture in developed countries. The institutional approaches developed referred to the emergence of intensive agricultural policy preferences in structural adjustment processes, electoral behavior and party competition, belief systems in policy arenas, and agricultural interest groups.

Voting inflexibility and strong party preferences for conservative parties are explained by the socio-psychological situation of farmers founded on permanent adjustment pressure, and

fears to lose economic and social status. As a response, farmers gained a strong group identity and voted for promises to preserve agricultural structures. Nonetheless, according to Public Choice Theory (PCT), for political entrepreneurs favoring farmers by means of redistribution policies will cause too high opportunity costs in terms of votes because relatively more votes could be mobilized with the same favours in groups with higher voting flexibility. Protection against electoral opportunity costs has been institutionalized by means of legitimation systems, which neutralize opposing voters' preferences or even change them into solidarity with agriculture. Agricultural protection is seen as a social contract where agriculture provides food security, reliable food quality, environmental protection, social stability, and other external benefits. In return, they are given equal participation in income and wealth.

Relying on the Advocacy Coalitions Approach (ACA), Birner and Resnick (2005: 303f.) similarly refer to the association of agriculture with particular value judgements. In addition quantitative public choice explains agricultural policies in developed countries (Anderson and Hayami (1986); Swinnen, Banerjee, and de Gorter (2001). In the corresponding literature on developing countries one important focus is the insufficient influence of small-scale farmers on agricultural policies favoring their interests (Binswanger and Deininger 1997).

(5) Post-socialist Transition of Agriculture (PSTA)

The analysis and advice on the transformation of socialist agricultural systems, in particular property rights reforms (Hagedorn 2004), have raised awareness about the outstanding role of institutional settings for the performance and transformation of Green Sectors. As can be seen from the broad literature on post-socialist agricultural transition (see, for example, Beckmann and Hagedorn 2007), the institutional approaches applied were diverse and not only taken from New Institutional Economics but also followed the IAD Framework (e.g., Theesfeld 2004; 2009). Special attention was paid to emerging differences in methods of land reform, for example restitution of historical boundaries or privatization by vouchers, auctions or per capita distribution (Swinnen 1997).

(6) Institutional Analysis of Forestry (IAF)

A very actively used analytical framework for the institutional analysis of forestry has been developed by The International Forestry Resources and Institutions (IFRI) Research Program (www.sitemaker.umich.edu/ifri/home) which investigates how sets of rules and modes of organisation influence forestry outcomes. At the same time, it tries to contribute to the understanding of how formal and informal institutions can improve livelihoods and the adaptive capacity of people Other aspects that play a role are enhancing sustainability, conserving biodiversity, and providing carbon sinks. Within the program, Indiana University in Bloomington and the University of Michigan in Ann Arbor offer training combined with fieldwork.

IFRI research is to a large extent based on the application of the IAD framework (Andersson 2006) and has a special focus on decentralization of forest governance and the involvement of communities in forest management, polycentricity in governance of forest and its multifunctionality (Nagendra and Ostrom 2012). However, also other approaches of institutional analysis can be found such as the "Four Levels of Social Analysis" and Transaction Cost Economics by Williamson (Behera and Engel 2006). In addition, Forest Cooperatives have been a frequent research subject in different disciplines of social sciences (e.g., Dedeurwaerdere 2009).

4 Some Examples of Potential Incommensurability between Analytical Frameworks

This section will not describe all similarities and differences between the analytical frameworks outlined in the previous section, but it focuses on specific aspects which can be considered issues of incommensurability. Incommensurability occurs when scholars are rooted in paradigms which cannot simply be changed by processes of falsifying hypotheses because they originate in different basic views on reality. This is in accordance with the above mentioned framing categories intention, meaning and confirms the relevance of different schools.

4.1 The Physical Dimensions of Activities Related to a Resource System: well defined boundaries?

Language and meaning in some of the described analytical frameworks can be traced back to the context of common pool resources institutionalized as common property and governed by collective action. This also and particularly applies to most of the elements of the SES Framework as already mentioned in Section 3.2, (1) and (2). A condition that is usually emphasised is well defined boundaries of the resource system. However, this raises the question whether bio-physical boundaries or structures can be sufficiently identified by their spatial dimension. Ecological systems have many attributes which we may link with spatial definitions or not. The spatial properties of the individual ecosystem attributes may be very diverse, so that no clear de-lineation between separable domains may be possible. This can be illustrated by examples like flows of surface and ground water in water systems, change of biodiversity in soils, the ways of emergence and dispersal of genetic resources, distances of transport of top soil by wind or water and the transposition of sediments, landscape structures that create a micro-climate, the range of migration of wildlife or fish, or the distant and diffuse effects of the many types of non-point pollution, degeneration of mires by drainage and land reclamation, or emission of methane from permafrost soils. The heterogeneous dimensions and attributes of such ecosystem functions can hardly be standardized according to spatial criteria.

Common pool resources (e.g. fish in a lake, water in an irrigation system, pastures jointly grazed by the cattle of a clan, tribe or village), at least as they are managed in traditional ways without modern inputs, may have a privileged position because the boundaries and properties of the main nature-related transactions (use, harvest, withdrawal, management, maintaining infrastructure) coincide often with physical and spatial phenomena. However, resource systems are often more complex and less transparent, and when they are exposed to human activities, also other properties of nature-related transactions may become relevant. It seems necessary to extend the notion of a resource system on which analytical frameworks are built.

4.2 Prevalence of Non-collective Use of Natural Resources: The example of agriculture

There is diversity of institutions and polycentricity of governance structures that have developed for regularizing SETS interaction and which have shaped the language scholars are using in their specific context. Although group formation and cooperation play a large role in those sectors of the economy that directly use natural resources (the “Green Sectors”), non-

collective arrangements dominate. In general and for most of the land area in the world, decisions on farming or grazing are not made by a "group" but by individual farmers operating family farms, partnerships or farm companies, such as limited or joint stock companies. Registered production cooperatives only play a major role in some post-socialist agricultural sectors.

As can be seen from the broad literature on post-socialist agricultural transition (see, for example, Beckmann and Hagedorn 2007), it is one of the best documented experience in agricultural economics that collective agriculture has practically not survived after the collapse of most communist systems after 1990. It just continues to exist in some communist countries (North Korea, Cuba), but disappeared in others (e.g., China and Vietnam where collective agriculture has been transformed into family farming). To avoid misunderstandings, cooperative arrangements such as marketing and service cooperatives are important elements of the "institutional environment" of family and peasant farms which are as relevant for their historical success. However, such cooperatives play a minor role as forms of organisation regarding agricultural production itself.

4.3 Recognizing the Heterogeneity of Human Activities in Resource Systems

Actors related to ecosystems perform various activities. They convert, protect, dispose of waste, pollute, cultivate, drain, fertilize, spray, harvest, degrade, increase fertility, etc. natural resources (see also Table 1). In contrast, the research heuristic driving from research on common pool resources predominantly refer to "users" who "withdraw" some "resource units" from the resource (withdrawal). Accordingly, the main interdependence originating from this is that different users want to acquire the same resource units (representing a cause of conflict which needs to be settled by rules and organization). Generalizing the users towards actors who conduct very different nature-related transactions (intentionally or non-intentionally, voluntarily or non-voluntarily, with or without mutual agreement) seems more adequate.

Transactions affecting resource systems are often very diverse, e.g., the difficult impact chains in the case of water pollution, or the indirect effects on the diversity of plant genetic resources which may be caused by Genetically Modified Organisms (GMOs). Increased use of a resource may not lead to depletion of a resource, but to its preservation and improvement, i.e. have the opposite impact. For example, agro-biodiversity is maintained in this way and decreases by non-use of existing genetic resources. The positive impact of the green revolution was associated with a change from many varieties to only a few varieties with high yields. In the case of biodiversity, many actors may never use a resource but insist on having the property right on the option value of wild plants, for example for future plant breeding.

4.4 Transaction Cost Economics: an analytical framework developed for engineered systems

For answering the question whether or not transaction cost economics can be successfully applied to the institutional analysis of social ecological systems, the way how transactions are conceptualised in this approach is crucial. "A transaction occurs when a good or service is transferred across a technologically separable interface. One stage of activity terminates and another begins" (Williamson 1985: 1). This focus on the characteristics of a transaction may be too limited, because it explains the need for a transaction to be governed by institu-

tional and organisational arrangements mainly in terms of frictions between activities. By contrast, linkages between activities are equally important reasons why transactions require institutions and governance structures (Hagedorn 2008a). Both frictions and coherence can cause interdependencies between actors that have to be governed by institutional and organisational arrangements that are usually not costless. Not only 'friction costs' (Williamson, 1985: 18f.) but also 'coherence costs' are relevant for institutional choice.

To understand this we must be aware that transaction cost theory originated in research processes that focused on industrial / commercial sectors. Transactions are different in nature-related sectors (agriculture, horticulture, fishery, forestry, resource management, nature conservation). Transaction cost theory usually focuses on transactions that can be seen as transfers of 'commodities', i.e. goods predominantly produced by engineered processes within designed systems set up by humans. By contrast, institutional analysis in nature-related sectors often focuses on 'non-commodities'; that means resources, goods and services whose transactions involve processes of self-organisation in ecosystems not completely engineered by humans (Hagedorn 2008a).

Obviously, transaction cost economics can contribute to exploring the micro-foundations of institutional analysis in Social-Ecological Systems. Conventional transaction cost economics does not sufficiently take into account the properties of transactions that are typical for a natural system. Similarly, the view on governance structures (market, hierarchy and hybrids) seems to be too rigid to cover the heterogeneity of governance structures which can be observed in the area of environmental governance and natural resource institutions.

4.5 Reinforcing Microfoundations by Linking Nature-related Transactions and Actors' Interdependence

Main analytical elements that need to be taken into account to arrive at an understanding of institutional change have been assembled in the Institutions of Sustainability (IoS) Framework (see Section 3.1 and Hagedorn et al. 2002). Nature-related transactions (Hagedorn 2008a) cause particular forms of interdependence between actors, which are the main cause of institutions to come into being (Paavola and Adger 2005). Furthermore, as the properties of transactions related to natural systems differ largely from those related to engineered systems, also the institutions and governance structures may differ. We will come back to this important aspect in Section 4.7.

The IoS framework covers aspects that have not sufficiently be taken into account by other analytical frameworks in the area of institutional analysis in Social-Ecological Systems. Thus it can add elements to the general SES framework and, above all, bridges between existing analytical frameworks. For example, by looking at transactions as endogenous driving forces of rule making in SETS, it helps explaining the diversity and dynamics in action arenas. This follows the example of a central element in the IAD framework which has detailed the micro-foundations as regards the characteristics of actors. We argue that this could be equally done for the properties of transactions (for a conceptual map in this regard see Section 6

There are two main extensions to transaction cost economics which could make it more suitable to contribute to analyzing social-ecological interaction: (1) IoS can add the properties of transactions from bio-physical and ecological systems including associated infrastructure and technologies and that way make properties of transactions endogenous in a way the SES framework does not address it thus far, and (2) it helps overcoming the rigidity of predefined standard types of organizations and actors usually analyzed in Transaction Cost Economics

and that way opens up to a diversity of constellations of interdependence between actors, institutions and polycentric governance.

4.6 Integrative institutions in Nature-related Sectors?

Although some analytical frameworks, in particular those originating in the Bloomington School, recognize that institutions that regularize human-environment relationships require particular concepts to frame their analysis, micro-foundations in this regard are rare. We suggest that they could be derived from the following hypothetical causality already mentioned above: As transactions are different in nature-related sectors (agriculture, horticulture, fishery, forestry, resource management, nature conservation), the properties of transactions and the actors' interdependence associated with them are likely to be also different as pointed out in Section 4.5. This raises the question whether institutions and governance structures for governing nature-related transactions also differ from those existing in other (or less nature-related) sectors. There are some indications that such an alignment can be found following the dichotomy of 'integrative and segregative institutions' (Hagedorn 2008). An example which suggests that this is actually relevant is the family farm or the peasant household economy.

According to conventional theory in agricultural economics, delayed structural change and disparity of factor incomes (the persistent "agrarian problem") is explained by low opportunity costs of production factors employed in agriculture due to obstacles to factor mobility and exit barriers. Hagedorn (1996; 1997; 2003) offers an alternative explanation by comparing integrative and segregative institutions. In processes of factor re-allocation, family farms respond to equal opportunity and mobility costs, respectively, (for a factor unit comparable to other areas the economy) in a different way than members of most other branches do.

Referring to the typical action situation of family farms, Hagedorn (1996; 1997; 2003) distinguishes two categories of transaction costs: "transaction costs of decision making without major structural change" and "transaction costs of decision making affected by structural change". For institutional choice in the long-term historical development of the a farm as an agrarian institutions, the first category of transaction costs was relevant, whereas the "institutional failure" of the family farms system in the process of structural adjustment of agriculture is a typical phenomenon in later phases of economic growth. It is argued that compared with the segregative institutions, which prevail outside agriculture, the integrating agrarian institution "family farm" is able to co-ordinate decisions belonging to the first category at lower transaction costs for reasons outlined in Section 3.2, Subsection (1), but can co-ordinate decisions belonging to the second category only at higher transaction costs.

The integrative institution "family farm" influences decision making related to factor reallocation and factor incomes in a particular way because the following elements are interwoven: (a) the family of the farmer as a social system, (b) the joint household of the family members being their economic organisation and (c) the farm as their technical production unit. As a consequence, the co-ordination mechanisms for farming are not separated from those of the family and the household. The farm family owns several production factors (labour, land, human, physical and natural capital), it also provides the management of these assets, reconciles activities for family, household and job, economic decisions for the private household and the firm are taken in close interdependence, agricultural production and "household production" can be easily harmonised, work time and free time are not subject to collectively

agreed and formally fixed schedules and proximity of farm and housing facilitates mutual penetration of private and professional concerns

Farm families working in an integrating institutional system have to internalise a larger number of transactions – and accordingly also higher transaction costs – into their decision making processes, and are only able to externalise less of them than economic actors working in segregating institutional systems. Thus, integrating institutions like the family farm usually reduce transaction costs, but lead to an "institutional cumulation of transaction costs" when factor mobility is required, because they not just accrue to the individual members of the economic organisation "family farm" in a separated way, but are as a whole taken into account in the collective decisions on factor re-allocation. In segregating systems such decisions are taken in a separated way, and are correspondingly based on a smaller amount of total transaction costs.

This integrative social construction produces an "inclusion effect of the family farm system" in processes of structural adjustment - institutionally established exit barriers for farmers and their families - and motivates actors in the farming sector for „substitution of exit by voice mechanisms". - they prefer political intervention to avoid structural change what results in well-known agricultural protectionism (for a more detailed description and examples of the inclusion mechanism see Hagedorn 1996; 1997; 2003; for the political impact see Hagedorn 1991; 1996; 1998). This example of framing institutional analysis of nature-related transactions in SES regarding the prevailing institutional arrangement of farming once more shows the relevance of differences in analytical frameworks. This calls for bridging the existing gap between analytical frameworks in general and, in particular between the SES framework and frameworks that analyse organisation of production, provision and consumption related to the Green Sectors.

5 Bridging and Bonding Scientific Communities Using Different Analytical Frameworks

What can we conclude from this characterization and comparison of analytical frameworks? First the communities applying these frameworks learned from analyzing different ecological, technological and social elements regarding SETS. Second, they found different theories and methodologies adequate. Third, this explains that they differ in how they understand, and accordingly what language they use for the linked ecological, technological and social elements in natural, technological and social systems, and the relationship between these elements. Fourth, some of the frameworks and languages are similar while others are not. Reasons could be that they are based on different theoretical assumptions and/or empirical background.

5.1 Reasons of Differences in Framing, Languages and Heuristics

We argue that the rapidly progressing research stream on institutional analysis of SETS is specifically prone to such differences between framing, languages and heuristics. Of course, there are very large disciplines communicating in this field which necessarily, because of the subject area, had to combine knowledge from social, natural and technical sciences such as agricultural economics and sociology, forestry economics and nutrition economics; however, for most disciplines in social sciences this is a novelty. It is not easy to understand the natu-

ral science and technical disciplines interrelated with the Green Sectors. However, it is unavoidable that social scientists acquire at least some knowledge in these fields if they want to engage in SETS analysis.

These reasons may produce a tendency among social scientists working on SETS to select those technical and natural fields which are relatively easy to understand (e.g. withdrawal of water or fish in contrast to the complex production and provision processes and its environmental implications in intensive cropping or specialized dairy farming). Single research communities on SETS may only develop familiarity with a particular area of natural resource use. Thus SES research communities may only learn from selected parts of ecological and technical systems and therefore develop narrow perspectives resulting in non-commensurable processes of framing which find their expression in contrasting analytical frameworks, languages and heuristics. Any attempt at generalizing may also therefore have limits.

This seems to be the key to an understanding of the situation outlined above. Analytical frameworks that link social, ecological and technical systems should properly integrate all three components into the micro-foundations of SETS research, even if this puts significant strain on researchers because it requires lengthy engagement into understanding the underlying intentions, meanings of different analytical frameworks and spelling out what the corresponding research communities consider relevant. For social systems, social scientists usually do not have a problem in this respect. This can easily be seen from the high level of differentiation of the A/M relationship in unpacking the IAD framework (Ostrom 2005). On the other hand, for the ecological system, the IAD framework - to stay with this example - has located this aspect among the *external* variables. Ecological and technical knowledge only enters into the analysis on a case by case basis. In contrast, as suggested above in our treatment of the IoS framework, we consider it productive to make the relationship to resource systems endogenous as it distinguishes a variety of nature-related transactions.

5.2 Beyond a Single Analytical Framework: An extended view

Some authors in institutional economics, in particular Bromley and Vatn, go beyond the conventional framing of institutional change processes. They do not emphasize one analytical framework, but rather show the necessity of several analytical frameworks for organising research processes. Vatn (2005a) argues that the actors' mode of action selection (Ostrom, 1994) crucially depends on the institutional context as well as on the framing of decisions as these may either be made for individual or collective gains (Vatn 2005b; 2007). For example, increased division of resources into individually owned properties operating in sectors with rapid structural change have facilitated an unprecedented level of economic growth because individuals strived for increases in income. This strategy has produced increasing 'externalities' or 'cost shifting practices' because distinct de jure properties cannot avoid de facto interconnections in nature-related transactions. To cope with this ecologically detrimental development Vatn recommends common property structures to internalize shifting of costs between decision units (Vatn 2010). Vatn and Bromley (1994) apply a similar approach regarding the role of property regimes in producing rational choices and efficient outcomes of actors' interactions in natural resource exploitation.

Bromley (2006) reveals the significance of such an understanding of institutional analysis by providing a micro-analysis on how institutional change actually works. Institutions are the outcomes of collective decisions on ways to regularize interdependence between actors, which is associated with from nature-related transactions, by sets of rules and forms of or-

ganisation. They are means of actors to organize their interdependence in activities of natural resource use - such as extraction, withdrawal, production or provision of goods and services - in a way that follow individually or socially constructed and preferred “visions” of economic organisation. Such visions or “created imaginings” can be considered more or less valuable and are sanctioned by epistemic communities (Bromley, 2006). Their choice depends on the rules that structure collective decision making on institutions and they change when actors perceive pertinent institutions as unaligned with the social constructions they prefer. In other words, institutions and their change require explanations exogenous to the realm in which they operate (Bromley 2008).

If we seriously want to take into account such relationships, which are crucial for processes on institutionalisation and de-institutionalisation, we have to recognise the need for several analytical frameworks for organising research processes. Moreover, any adequate understanding of SETS (comprising all the activities which will be shown in Table 1) needs to integrate the analysis of sectors external to the domain where institutions become effective.

5.3 The Activating Role of the Physical Link to Ecological and Technical Systems as in Action Situations: the transaction-interdependence-institutions nexus

What does it mean to make the ecological and technical systems an integrative part of the action situation in SETS? To illustrate this, the IAD framework can be taken as a brilliant example. Its “A/M relationship” analyzes in depth how characteristics of actors influence action situations (Ostrom 2005). It segregates an action arena into the following components: “the set of participants, the positions to be fulfilled by participants, the potential outcomes, set of allowable actions and the function that maps actions into realized outcomes, the control that an individual has in regard to this function, the information available to participants about actions and outcomes and their linkages and the costs and benefits – which serve as incentives and deterrents – assigned to actions and outcomes”.

Similarly we make an attempt to detail the logic as to how the properties of natural and technological systems affect an action situation. Even more, as research on SETS explicitly focuses on questions where humans impact upon natural systems, most frequently via technical systems, where they are in turn affected by (profiting or suffering from) by feedback loops, the consequences of these activities are at stake. In other words, it is the decisions taken by at least one actor which cause nature-related transactions. Within their structured context, nature-related transactions are operationalised through their biophysical material context and the means of technology and infrastructures, which stimulate actors to think about their potential choices and to respond by taking action, i.e. this makes the action situation work.

This is a core relationship, the **Transaction-Interdependence-Institutions Nexus:** Actors take decisions which - via technical devices - produce nature-related transactions that cause interdependence between actors which makes them mutually dependent and possibly motivates them to interact and engage in rule-making. If there are no transactions, there is nothing relevant to talk and negotiate about, and there is no reason for designing or crafting institutions.

For example, if the use of natural resources such as land, water, air, atmosphere, biodiversity, etc. in a community does not put any constraints on the claims other citizens have on the natural resources, people are rather indifferent. However, if the choices the farmer takes causes nature-related transactions (by means of his cropping and livestock technologies)

and induces, for example, relocation of sediments from soil erosion to roads or rivers, pollute drinking water by pesticides, diffuse odors from his hog stables and manure spreading, reduce biodiversity and landscape amenities by monocultures, then the farmer and his fellow citizens will enter into strong interdependence. This may lead to a very lively action situation with fierce debates in the community. If this community has the communicative and coordinative capacity to transform this interdependence into institutional and organisational innovation, this may yield satisfactory results for all. This requires that they are able to actively build institutions and governance structures; in the most cases such problems can only be solved by social construction at various levels.

6 Unpacking the Activating Role of the Transaction-Interdependence-Institutions Nexus in SETS Action Situations

The micro-foundation we intend to introduce is based on detailing the logic of the causal connection between (1) actors who take decisions within specific types of nature-related action contexts, (2) thus initiate transactions that have a nature-related attributes, which (3) create intended or unintended nature-related interdependence between actors (4) that may lead to rule making and in this way regularize decision making and interdependence. This micro perspective raises the question what decisions of actors eventually impact on natural systems via infrastructure or technological systems and what decisions therefore affect other actors in a way that the interdependence created stimulate interaction and communication in the action situation.

To enable an understanding of the variety of differences between such processes mobilizing action situations we have arranged different action situations according to typical properties of physical transaction. In other words, induced by conscious or unconscious choices of actors, core activities take place in which humans interact - mediated by resource systems and the use of technological systems - and provoke specific types of action situations. A physical transaction leads to interdependence between actors and may finally cause what could be called as social transaction that means the provision and change of social organization in order to cope with the physical transaction. This concept of sequencing of institutional and organizational analysis builds on the “alignment principle” and “micro-foundations”, where actors either individually or from a social welfare perspective try to minimize the perceived transactions and production costs and maximize the benefits involved into the organization of nature-related transactions.

Such a conception of micro-foundations refers to an explicit analysis of physical transformations and transactions, and to the alignment principle which puts forward the idea (inspired by transaction cost economics) that de facto governance structures align with properties of transactions and capacities of institutions and actors. Specifically, the attempt at structuring research that follows this hypothesis presented here addresses the question of how to capture and structure the analysis of relevant transactions (including transformations involved) that are to different degree “nature-related”, and how to describe their characteristics.

Thus, the question arises now **how to develop a reasonable ordering of transformations and transactions** which stimulate actions arenas in linked natural, technical and social systems. We suggest arranging this according to what we call nature-related core activities of humans. They cause physical transformations and physical transactions in resource systems, eventually with the help of technical systems that contribute to the emergence of interdependencies between actors which in turn may stimulate action situations. The principle of

ordering is a decreasing deep and active intrusion of human influence in natural systems proceeding from very active behavior of humans to rather passive behavior vis-à-vis natural resources and the natural environment. Nevertheless, different ways of ordering these activities could also be chosen such as categorizations in relation to extractive or non-extractive use of the environment and their relation to environmental flows.

The result of this ordering of core activities is presented in Table 1. As most brutal intervention into natural system we consider *conversion* of the use of natural resources, for example, from agricultural land use to urban land use for housing or traffic. These activities involve the entire resource system and change its overall properties. Changing the entire resource system is also relevant for *conservation,* however the direction of influence is the opposite. This is followed by *extraction* of *non-renewable* resources (resource units), for example from units of crude oil or natural gas, and *withdrawal* of units *renewable* resources, for example, from a water canal or forest. These activities only deal with components of the resource system by taking out resource units which are part of larger resource systems. The following group of activities only affects a part of the resource system, for example the upper layer of the earth crust by posing in it units of matter or energy by *waste* disposal and environmental *pollution*. In this case, units "flow" into the resource system and affect it.

The following group of activities preserves and influences the entire resource system or specific stocks of resource units to profit from biological processes which are controlled or even manipulated for that purpose. Activities in this category could be *growing* livestock and *cultivating* crops which rely on exploitation or even manipulation of ecosystem functions and processes catered for by the resource system. These activities are still in close physical contact with natural systems, i.e. they still rely predominantly on biophysical processes. The next category of activities does not directly rely on ecosystem functions. Thus, activities are largely detached from the resource systems and deal with decomposed commodities. They are gained from the above mentioned partly controlled biological processes such as cultivating maize or wheat. *Marketing* and *processing* for example of agricultural goods or electricity belong to this class of core activities. However, such decomposed commodities will sooner or later return into biological and ecological systems after they are consumed by humans, for example as food or textiles, or they even produce waste throughout consumption. Therefore, also these detached activities have an important nature-related impact.

However, humans are also *using natural systems directly*, for example by enjoying landscape amenities. The last activity in this attempt to logically derive an ordering of core activities aims at enhancing *living condition for humans* in resource systems through enhancing natural processes or detaching humans from resource systems or stocks of resource units. This refers to favorable natural conditions, in which humans and other living organisms can flourish such as micro-climate and finally protecting humans against natural disasters such as earthquake, flooding and heat waves,

These core activities which are of central importance in linked natural, technical and social systems are grouped according to the logic of decreasingly deep and active intervention of humans in non-human natural systems. Obviously, throughout such an attempt of ordering empirical phenomena in a structured fashion, certain inconsistencies may remain. Given the complexity and diversity of linked social, natural and technical systems, we consider this unavoidable. Thus we continue by characterizing these activities according to four additional criteria:

1. First, whether these activities are associated with *physical transformations* which can happen either within a *natural system* only being induced by humans but only to a limited extent controlled by them; or whether transformations can occur in *engineered systems* where humans have more or less complete control of transformation processes. In addition, human activities may not cause any major transformation but only undertake physical transfers (transact) within the resource system which leads to the transformation of functionally interlinked parts of it. These physical transformations (or rather transfers) may be incorporated in physical transactions that only implicate one intentional actor, for example, when a farmer fertilizes and nitrogen leaches into the groundwater, which will then be chemically transformed into nitrate which is beyond his control.
2. Secondly, the nature of the dominant structure that determines the *physical transaction* between two actors. Such transactions can be *nature-related, production-related or provision-related*. For example, reduction of biodiversity by monocultures is a nature-related transaction, organizing corn harvesting by combines according to the seasonal timeliness is a production-related transaction and selling fruit or vegetables, which are perishable commodities, on a farmers' market in a city is a provision-related transaction.
3. Finally, this classification of core activities and nature-, production- or provision-related physical transactions, is complemented by a classification of characteristics of transactions. According to the alignment hypothesis, they provoke specific processes of communication, interaction, conflict resolution or seeking cooperation in an action situation. In addition they are crucially shaped by characteristics of actors (for definitions, see box 1 below),
4. A typology of properties of transactions may fruitfully be based on the criteria of modularity and functional interdependence as suggested by Hagedorn (2008). These properties may involve dimensions of jointness and absence of separability, coherence and complexity, limited standardizability and calculability, dimensions of time and scale, predictability and irreversibility, spatial characteristics and mobility, adaptability and observability, etc. It needs further empirical investigation to explore this means for the actors involved, individually and collectively, and their capacity to craft institutions.

Definitions of Nature-, Production- and Provision-related Transactions

The definitions start from the general definition of a transaction: "A transaction occurs when a good or service is transferred across a technologically separable interface. One stage of activity terminates and another begins" (Williamson 1985: 1).

(1) Definition of *nature*-related transactions

An action situation emerges because (at least) two actors interdepend mediated by (a part of) a natural system from which humans acquire what are (a priori) non-commodities into stages of activity that are linked that way. Thus two stages of activity must be distinguished:

Stage 1 implies that an actor involves a (part of) a natural system from which humans acquire non-commodities into his activity. This may occur intentionally or unintentionally. The activity may be purposeful or not and it may be production-related or provision-related.

A second activity involving another actor must exist which involves (part of) a natural system from which humans acquire non-commodities into his activity. This may occur intentionally or unintentionally. The activity may be purposeful or not and it may be production-related or provision-related.

(2) Definition of *production*-related transactions

An action situation emerges because (at least) two actors involve the same entire or a part of an engineered system producing commodities into their hereby linked activities. Thus two stages of activity must be distinguished:

Stage 1 is that an actor involves (a part of) an engineered system producing commodities into his activity. This occurs intentionally and purposefully. The actor may also involve (a part) of a natural system from which humans acquire non-commodities into her activity although he has not chosen to do so.

Stage 2 is that an actor involves (a part of) an engineered system producing commodities into his activity. This occurs intentionally and purposefully. The actor may also involve (a part) of a natural system from which humans acquire non-commodities into her activity although he has not chosen to do so. In this case, in addition to the production related transaction a nature-related transaction is unleashed and more than only the first two actors are involved.

(3) Definition of *provision*-related transactions

An action situation emerges because (at least) two actors involve the same (part of an) engineered system providing non-commodities or commodities into their hereby linked activities. Thus two stages of activity must be distinguished:

Stage 1 is that an actor involves (a part of) an engineered system providing non-commodities or commodities into her activity. This occurs intentionally and purposefully. The activity may also involve (a part of) a natural system from which humans acquire non-commodities into her activity although she has not chosen to do so but it happened as an unexpected side effect.

Stage 2 is that an actor involves the same (part of an) engineered system providing non-commodities or commodities into his production or consumption activity. This occurs intentionally and purposefully. It may also involve (a part of) a natural system from which humans acquire non-commodities although she has not chosen to do so. In this case, in addition to the provision related transaction a nature-related transaction is unleashed and more than only the first two actors are involved.

In the case of each of the three types of physical transactions, actors cannot achieve the outcome of their choices as expected because of the activity of the others. In this way, a physical transaction has caused interdependence between the actors. A social transaction is required, i.e. institutions, for example property rights, would regularize/ organize to what extent each of them is allowed to involve the same (part of) a natural or engineered system into her activity, intentionally or unintentionally.

As nature-related transactions have specific properties, actors' interdependence may also be specific and require correspondingly differing institutions and governance structures. Applying the alignment principle to nature-, production- or provision-related transactions may lead to different outcomes.

Table 1: Stylized Ordering of Transformations and Transactions in Stimulating Action Situations in Linked Natural, Engineered and Social Systems

Decisions by actor(s) impacting on entire or parts of a natural resource and thereby affecting other actors			**Examples - physical transformation of the entire or parts of the natural resource involve a …**			**Examples - physical transactions mediated by natural and technical systems are …**			**Examples - typical and relevant properties of the types of transactions are …**		
Resulting category of activity	**Impact on the resource system or stock**	**Cases to illustrate activity**	**Natural system (internal)**	**Engineered system (external)**	**No major transformation**	**Nature-related**	**Production-related**	**Provision-related**	**Nature-related**	**Production-related**	**Provision-related**
Activity involves the entire resource system or stock											
Conversion	Strong disturbance, beyond adaptive capacity, resilience endangered	Land for housing; lake for recreation; sea for oil platforms or wind turbines	Degradation response of ecosystems due to conversion	Conversion by use of machinery and infrastructure	-	Reduction of biodiversity and pollution of water	Sealing of land for traffic, housing, industrial and commercial sites	Land for developers, lakes for tourists, marine territory for energy companies	Irreversibility of loss of species	Asset specificity of buildings	Low frequency
Conservation	Reduced disturbance, stays within adaptive capacity, resilience facilitated	Protecting species, water bodies, wadden sea and natural forests	Maintaining or recovery of ecosystems, water harvesting	-	-	Fencing, guarding, stopping impact from intensive crops cultivation	_	Landscape amenities, wildlife, biodiversity, less soil erosion	Interconnectedness and complexity	-	-
Activity deals with components of the resource system or stock by taking out resource units											
Extraction	Non-renewable resources, increasing depletion	Peat, coal, crude oil, natural gas, minerals	-	Re-cultivation	-	Digging, excavating, drilling, pumping	Refining	Using pipelines and tankers	Modularity of peat, coal, oil, gas, etc.	Asset specificity of plants	Extremely long distances

Withdrawal	Renewable resources, depletion avoidable	Water, fish, wildlife, trees, NTFP	Watershed manage-ment	Re-forestation	-	Pumping, logging, hunting, salinization	Sawing	Hauling timber	Mobility of game and fish	Insecurity, variability, observability	Water is flowing head enders and tail enders)
Activity directly uses sink and absorption capacities of natural systems for discharge of matter or energy											
Disposal	Returning into natural systems	Solid waste, waste water, nuclear waste, ma-nure	Disposal uses sink functions	Reuse of waste mat-ter	-	Absorption into flows or stocks and transforming into harm-less/ harmful forms	Recycling processes, e.g. com-posting	Offering recycled commodities	Complexity and limited predictability of chemical impact	NIMBY	-
Pollution	Emitting into natural systems	Greenhouse gases, diox-in, smog, acid rain, FCKW	Emission mobilizes absorption mechanisms	Originates in production + consumption processes	-	Absorption into flows or stocks, harmless or causing damage	Technology avoiding pollution	-	Point or non-point, regional or global, sta-tionary or mobile	-	-
Activity preserves and influences the resource system or stock to enable partly controlled biological processes											
Growing livestock	Raising mobile living organisms	Horses, cattle, milk, sheep, hogs, goats, hens, eggs, shrimp, fish	Intended biological processes, changing genetic re-sources	Livestock farming	-	Animal wel-fare implica-tions	Breeding, in-semination, feeding, milking, fattening	-	Re-product-ion phases, high variabil-ity	Difficult to standardize, attention intensive, timelines of insemination	-
Cultivating crops	Raising immobile living organ-isms	Rice, maize, rye, wheat, barley, oats, beets, trees, potato, fruit, vegetables	Intended biological processes, changing genetic re-sources	Crop farm-ing	-	Nutrients leaching	Breeding, seeding, plowing, fertilizing, harvesting	-	Seasona-bleness, high variabil-ity	Difficult to standardize, attention intensive, timeliness of machine employment	-
Activity is detached from the resource system or stock and deals with decomposed commodities gained from the partly controlled biological processes											
Marketing	Providing inputs and	Delivering seeds, ferti-	Unintended biological	-	Limited con-trol of dura-	-	-	Collecting, drying, stor-	Perishable-ness	-	Spatial ex-tern, long

	outputs	lizer, bread, milk, electricity transmission	processes		bility			ing, cooling, transport, distribution			distances,
Processing	Preparing final use by transformation processes	Electricity generation, making butter, flour, cake, jam, sausages	Intended biological processes	Processing technologies	-	Biological and biochemical preservation	Slaughter, milling, baking, churning, canning, packing	-	Influencing biological and biochemical attributes	Constrained by biological and biochemical attributes	-
Activity uses the decomposed commodities which indirectly enter natural systems and benefit from their sink and absorption capacities ans											
Consuming commodities	Using natural systems indirectly	Eating meat and plants, wearing cotton, using timber	Intended and unintended biological processes	Household production	-	Human reproduction	Preserving and preparing food	-	Complexity, health implications	Integrativeness	-
Consuming non-commodities	Using natural systems directly	Basic life-support Functions and amenity services	Range of temperature humans can exist in, minimum water input	Landscape amenities from crop structures	-	Resilience mechanisms	Multi-functional agriculture	-	Non-excludability	-	-
Activity aims at protecting human livelihoods from the impact of resource system or stock											
Protection of humans	Natural conditions	Severe cold, blistering heat	Global warming	Air conditioning	-	Greenhouse gas impact	Numerous and diverse	-	Ubiquitousness	Energy intensity	-
	Natural disasters	Earthquake, flooding	Changing hydrology	Secure buildings or dikes	-	Changing landscape structures	Numerous and diverse	-	Insecurity	Early warning issues	-

7 Conclusions for Designing the Berlin Workshop in Institutional Analysis of Social-Ecological Systems (WINS)

This concept for establishing the Berlin Workshop in Institutional Analysis of Social-Ecological Systems is based on the discovery that analytical frameworks used by scientific communities in the area of institutional analysis of SES show major differences. They are neither neutral as regards the theory used by scientific communities nor independent from their empirical field of application and the methodological tools used. They embody differences in intention, meaning and relevance. Characteristic for an analytical framework are the dimensions of intentions associated with the research it guides, the meaning it attributes to the research objects and the relevance claims it makes. Relevance implies a normative focus: What problems do we intend to solve with our analysis? Meaning arises from theories which provide an explanation of the domain of perceived reality in which the problem occurs. Relevance derives from the empirical background of theories, both in a positive and a normative perspective, as it raises the question whether we actually understand the problem including context and causalities and, based on this, whether we can make reliable and feasible recommendations how to achieve solutions which we may desire to be sustainable, efficient, robust or what else evaluative criteria may be applied by the scientific community in question.

7.1 Recognizing the Reasons for the Existing Diversity of Analytical Frameworks

This leads to an important strategic conclusion: Any attempt at developing a general framework for the most important institutional constructions that shape societies relationships to its biophysical, non-human environment are deemed to fail, if it is predominantly based on an analytical framework - including its specific framing, heuristic and language - that just one scientific community or group of scholars has developed and is used to. Furthermore, generalizing an existing framework in this manner necessarily will lead to misunderstandings and resistance by communities that did not develop them, as well as it is likely that such a generalized framework will not speak well to the settings they are to analyze. Therefore, we argued in favor of exploring the background of analytical frameworks that are used by other communities in order to analyze institutional settings which in one way or the other are highly relevant to the most important aspects that shape societies' physical relationships to its biophysical, non-human environment.

For illustrative purposes we singled out analytical frameworks for institutional analysis that address interaction between (human) actors mediated by natural systems, and facilitated by technical ones, either predominantly by nature-related transactions (the tradition of Natural Resource Institutions and Environmental Governance) or also by organizing production and provision-related transactions most visible in economic sectors that strongly depend on such linkages (the Green Sectors of the Economy, such as agriculture). The subsequent treatment of these analytical frameworks elucidated the intentions, meanings and categories of relevance that characterize each of these analytical frameworks, as well as their genesis and some of the main authors and theorists in the field. As the paper specifically addresses to scholars that are familiar with the framing underlying the SES analytical framework and its grounding in the IAD analytical framework, we subsequently highlighted aspects that we found throughout our treatment of various analytical frameworks which the SES framework seems to have specific difficulties in addressing thus far.

First, as such we highlighted connectedness of the framing of SES and IAD to local SES, which largely neglect cross-scale and cross-sectoral interactions between action arenas and

governance arrangements, and which have difficulties in capturing dynamics in management of large scale SES. Furthermore, because of case driven data gathering large samples to generalize the role of categories addressed by the SES or IAD have not been gathered yet. This is said to undermine the possibility to generalize its findings.

A second set of weaknesses of our benchmark approach, the SES analytical framework, is associated with our observation of spatial heterogeneity and often diffuse boundaries of resource systems and flows of resource units. We emphasized that common pool resources (i.e. the empirical field of application where the IAD and SES frameworks predominantly originated, e.g. fish in a lake, water in an irrigation system, pastures jointly grazed by the cattle of a clan, tribe or village), at least as they are managed in traditional ways without modern inputs, may have a privileged position because the boundaries and properties of the main nature-related transactions (use, harvest, withdrawal, management, maintaining infrastructure) coincide often with physical and spatial phenomena. However, resource systems are often more complex and less transparent, and when they are exposed to human activities, also other properties of nature-related transactions requiring different modes of governance may become relevant.

Third, the institutional and organizational forms that affect societies' physical relationships to its biophysical, non-human environment often differ from those inherent in the SES framing. Therefore, the SES framework does not allow us to properly capture these categories, which many scholars consider important. This becomes specifically evident in the Green Sectors of the economy where SETS are often not institutionalized in a collective way but where institutions concern interactions between individual actors or between individuals and the state. While cooperation remains important it often follows a different logic than the type of collaboration presumed in the SES framework. Another, new form of organizing human-environment interactions that has important implications are schemes associated with commoditizing nature by Payments for Ecosystem Services and coping with the drawbacks of this popular approach when put into practice (Vatn 2010), which we did not mention here in more detail.

Fourth, activities of actors that have an important effect on the natural system are much broader than only withdrawal from and discharge into the natural system (while the latter is also difficult to capture in the categories of the SES). For example, other activities may be the conservation of ecosystems, the exploitation of productive capacities of natural systems by controlling biological processes for livestock raising and crop cultivation, the enhancement of or the detachment from SES in order to maintain people's living conditions. Thus, we argue that it is difficult to use the SES analytical framework in order to properly capture such diverse institutional and organizational choices that differ from predominantly collaborative arrangements for overall benefits of voluntary collaborators, or described alternative activities. However, we consider it important that the analytical framework for institutional analysis we use is able to represent the most important aspects of SETS, such as types of institutions and forms of organization and activities that shape actors' underlying motivations and purposes of action, and finally the impacts of their actions on the environment. Therefore, we essentially suggest ways to build bridges between analytical frameworks that address different forms of organization and activities.

Fifth, through illustrating Transaction Costs Economics and its extension to questions of how the farming sector addresses the organization of production and its transformation, and the performance of either integrative or segregative institutions in these contexts, we found that the IAD framework, while strong on detailing the role of actors' characteristics and institutions, treats properties of human-environment interactions (nature-related transactions) as

exogenous. In contrast, the SES framework suggests some categories to address differences in resource systems. However, from the perspective of the focal action situation they remain exogenous. In contrast, we suggest that properties of transactions have a significant effect on the way coordination problems involving the non-human environment are solved and how they perform. In a last step, which we played down in this paper, this would also require an in-depth analysis of actors and their capacities to shape these interactions and the institutions that regularize them. The IoS analytical framework opens up to such a research agenda which is why we discussed the merits of combining this approach with the analysis of action situations in this paper.

7.2 Mapping, Micro-foundations and Bridging of Analytical Frameworks

This collection of arguments calling for an integrative procedure is surely incomplete but may be sufficient to conclude that it seems recommendable to refrain from bonding by generalizing just one framing of the institutional analysis of SETS. Instead a welcome culture towards scientific communities using (different and perhaps very specific) SETS analytical frameworks in their disciplines should be institutionalized by employing a bridging strategy. In order to illustrate such an approach we subsequently developed what we call a map of the analytical frameworks of activities involving human-nature interdependence. It suggests differentiating between the ways activities relate to processes involved in transformation and types of physical transaction. Our map of the analytical frameworks regarding activities provides a way to order transactions according to the four dimensions shown in Table 1 (core activities, transformations, physical transactions and properties of physical transactions).

This concept of ordering helps us to understand in what fields of activity actors can make choices that cause different types of transactions - which may or may not embody different categories of transformation -, where the transactions again have properties which may be arranged according to a reasonable system of classification. Thus, this set of analytical approaches addresses the way properties of types transactions shape governance structures. Provided that this way of mapping this specific micro-foundation for how transactions stimulate action situations will mature, this exemplifies the following opportunities:

1. First we can make the unfolding the Transaction-Interdependence-Institutions Nexus operational and contribute to the micro-foundation of SETS institutional analysis in a variety of action situations which correspond to the developed structural units. In addition we can show how this occurs as a result of the work of scholars in different disciplines and in fields that relate to the core activities which have served for structuring this specific map of an analytical framework (Table 1).
2. Secondly, doing research on all fields of the map structured by Table 1 would exceed not only the cognitive capacity of individual researchers but also the organizational capacity of single scientific communities. As a consequence, there are disciplinary boundaries between (clusters of) structural units, where the understanding of SETS institutional analysis has been construed differently by scientific communities. In the case of this specific activity- and transaction-related map of analytical frameworks bridging these boundaries will only be possible if scientific agents understand the differences and specificities of the described activities, transformations, and transactions and the particular properties thereof in terms of underlying intentions, meanings and relevance.
3. Third, the developed structure can - in particular if it would be further developed according to the methodology of “science maps” (Börner, Glänzel, Scharnhorst and van den

Besselaar 2011) - provide SETS institutional analysis with a specific “science map of analytical frameworks” (MAP) that explains the locations and networks of knowledge which has shaped a particular analytical framework in the areas defined by the ordering procedure. From this, answers to the following questions can be derived:

Following these arguments, it seems recommendable to develop a welcome culture towards all scientific communities that use (different and perhaps very specific) analytical frameworks for the institutional analysis of SETS and to engage in a bridging strategy. Accordingly, WINS will conduct a MAP Project from which the following questions may arise:

- Why have different analytical frameworks arisen in particular territories of MAP?
- Which communities and disciplines work in the respective territories of MAP?
- How does micro analysis of the core activities investigated by the disciplines linked to the transaction-interdependence-institutions nexus explain its “territorial claims”?
- Why have the analytical frameworks developed differently as they are driven by the research questions and research processes in the respective disciplines?
- How can these orientations be interpreted as an outcome of intention, meaning and relevance that have guided the work of scholars in the disciplines?
- What heuristics and languages do these disciplines use and for what reasons were they considered appropriate for framing their research-related action situation?
- Are the analytical frameworks separated or overlapping in MAP, does their relationship show cross-cutting the cleavages or parallel cleavages?
- What impact does this have on the political economy of a bridging strategy?
- Can advocacy coalitions for such bridging efforts be built to achieve mutual gains?
- What efforts does bridging between the frameworks and its proponents require?
- Whether and how could this contribute to improving the SETS analytical framework?
- What sets of rules and modes of organization would make the bridging strategy work to the benefit of a general analytical framework for SETS institutional analysis?
- What benefits can be expected from the bridging strategy and how can they be identified and attributed to different elements of the bridging practices?
- Do such benefits arise only in scientific communities or also in those fields of application where practitioners expect to receive fruitful and feasible recommendations?

Tackling such issues by targeted, direct analysis certainly is a straightforward conclusion. However, it may sometimes be equally fruitful to engage in a practice of bridging in communication, analysis and teaching, a process which will also provide answers to the above mentioned questions, for example in processes of applied or comparative research on relevant topics in the area of SETS. In other words, WINS researches will engage in both MAP-related research questions as mentioned above, in particular in the first phase, and in applied and comparative research that is interdisciplinary in nature in accordance with the guiding notion explained above to institutionalize cooperation between scholars from different communities used to different research framings. To this end, WINS needs to embark on a broader agenda including communication, research and education.

7.3 The Integrative Strategy of the Berlin Workshop in Institutional Analysis of Social-Ecological Systems (WINS)

This agenda starts with a well-organized process for collecting expertise from scholars working in different scientific communities or networks, who are familiar with specific analytical frameworks and the problems, theories and empirical methodologies from which they

emerged. It requires identifying people worldwide and making them interested in such an endeavor. As this could be facilitated by a funded network project, WINS may focus a collaborative effort for attracting such a network grant. As main elements of the agenda, we will combine:

1. Integrative Discourses for institutionalizing communication between members of several research communities
2. Interdisciplinary Research for conducting studies guided by one or more, single or linked analytical frameworks
3. Advanced Studies addressing both junior and senior researchers

In preparation of both the Integrative Discourse and the Interdisciplinary Research activities the above mentioned analysis of existing relationships and interaction among scholars and their communities for providing a science map (MAP) will be conducted. This serves to obtain a clearer view regarding the communities working on SETS institutional analysis, what analytical frameworks, theories, empirical approaches and communication channels they use, and what relationships they have to other scientific communities.

The Integrative Discourse activities aim to include scholars and PhD students from different traditions. They will be involved in discourses by the following measures (which will not all be taken immediately, but stepwise put into practice over a longer period of time):

- Starting workshop to inform about WINS and its particular nature and for including scholars and PhD students in working groups and the organization of future workshops
- Formation of “Interdisciplinary Group” with mixed membership from communities with different research traditions who advise the foundation process
- As an incentive for participation, members of the Interdisciplinary Group may use this opportunity to initiate funded research projects together with other affiliated faculty groups
- Inviting visiting scholars who can participate in WINS activities, in particular in setting up joined research projects, organized communication and advising young researchers
- Series of thematic workshops which focus on relevant issues and topics and seek participants’ commitment to initiate and contribute to these research processes
- Working groups which focus on selected issues and topics and as an incentive for participation apply for funding of collaborative research projects or teaching activities
- Internet forums which facilitate continuous discussions from the workshops and exchange within and between the working groups
- Publication workshops with limited number of participants to support particularly young researchers to publish in journals and for the edition of special issues
- Conferences for disseminating research results and maintaining the WINS network
- Introduction of an Online Journal as a potential, medium-term objective

The Interdisciplinary Research activities of WINS are expected to review and integrate the various lines of research that are part of the research traditions mentioned above in a way that helps overcome parcelled conceptions of SETS analytical frameworks. To explore whether, why and how comparing and bridging the analytical frameworks of scientific communities make sense, and subsequently develop new analytical strategies to that end, the following types of research are planned:

1. Illustrative Review of Existing Studies of the research traditions described above in order to reveal complementarities and conflicts

2. Empirical Focus Studies on Key Questions relevant for the integration of the research traditions analytical frameworks
3. Advanced Studies beyond Conventional Paradigms to demonstrate the potential of advanced analytical frameworks, theories, empirical approaches and improved communication achieved by the integration efforts.

Decisions on the choice of *concrete* topics within these classes of research will be made as the research process unfolds. This will be supported by the Interdisciplinary Group which will discuss conflicts and complementarities between strands of research. At the same time, working groups may form and develop their own initiatives. In particular, topics that members of THESys and the affiliated faculty of WINS are working on and are familiar with, or interested in, will be taken into consideration. Of course, the choice of topics also depends on opportunities and successful collective action to attract funds. The following list of examples (which is incomplete, of course) may illustrate what *topics areas,* where *problem-oriented and comparative studies* are needed*,* might be considered as being relevant:

- Capacity and vulnerability of natural resources in securing world nutrition
- Provision of energy from natural resources and its rivalry with food provision
- Land management and soil protection including land conversion and conflicts
- Water management and protection of water including irrigation and drainage
- Climate change impact, mitigation and adaptation strategies, climate engineering
- Institutions, organisation and policies in fishery, forestry and wildlife
- Economic incentives for maintaining or reinforcing ecosystem functions across sectors
- Nature conservation, biodiversity, genetic resources and genetic engineering
- Natural resources in social and political systems in deep transition
- Natural resources and development, resource use and sustainable livelihoods
- Specific resource use systems such as GMO agriculture or converting peat land
- Political responses to natural disasters such as flooding, drought and famine
- Institutional change due to urbanization with resource scarcity and climate change

This process of theory building and methodological innovation will also engage a high-level international academic community in Advanced Studies and Teaching. This is a precondition for establishing the critical mass which is necessary to address the role of institutions and governance structures in regularizing actors' behaviour in coupled social, natural and technical systems. A Colloquium in Institutional Analysis of Social-Ecological Systems will be introduced. A course dealing with the main knowledge areas of WINS, i.e., Institutional Analysis of Social-Ecological-Technical Systems, may become a core element of the Advanced Studies. Visiting scholar will attend this course and contribute themselves to training and education. The Advanced Studies and Teaching activities may also be appropriate to complement the THESys Graduate Program.

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