Beyond Economic Efficiency and Towards Coping with Complexity in Biodiversity Conservation

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Abstract

Biodiversity conservation is a complex task at the interface of social and ecological systems. This paper aims to explain why it is important to move from economic efficiency to complexity-led approaches for the purpose of biodiversity conservation. Economic values of biodiversity are not a sufficient reason for deciding to conserve biodiversity. Achieving economic efficiency requires the internalization of values of biodiversity which are outside the economic system and a rational choice among conservation alternatives in favor of those with higher net benefits. But economic valuation methods are themselves 'value articulating institutions' influencing the outcome of the valuation exercise. As biodiversity conservation confronts us with very complex social-ecological systems, the choice of the 'value articulating institutions' needs to consider their various features and functions. The choice of conserving biodiversity or not can not be made on the grounds of economic valuation alone because that choice itself requires addressing a second-order problem: the choice of a valuation method. Methods are required which help to understand systems' behavior, that are able to bring together multiple stakeholders and initiate deliberative, social processes of choice-making. The choice of valuation and decision making tools needs to match the complex nature of the task. Therefore, the question involved in successful biodiversity conservation is not only which conservation strategy is economically preferred but also which method should be used to articulate and account for people's biodiversity values. This involves a choice of the type of rationality and the type of social process applied in the decision-making process. Institutions and governance structures at all scales are needed to conserve biodiversity. This process begins with the choice of an adequate mix of valuation methods ranging from balancing costs and benefits to processes of awareness building, communication and negotiation. The Vester Sensitivity Model was used to model the socio-ecological system "coffee forest" with stakeholders in Ethiopia, and facilitate first steps in a participatory and deliberative process towards biodiversity conservation.

Key words: biodiversity conservation; efficiency; complexity; value articulating institutions; second-order problem

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Introduction

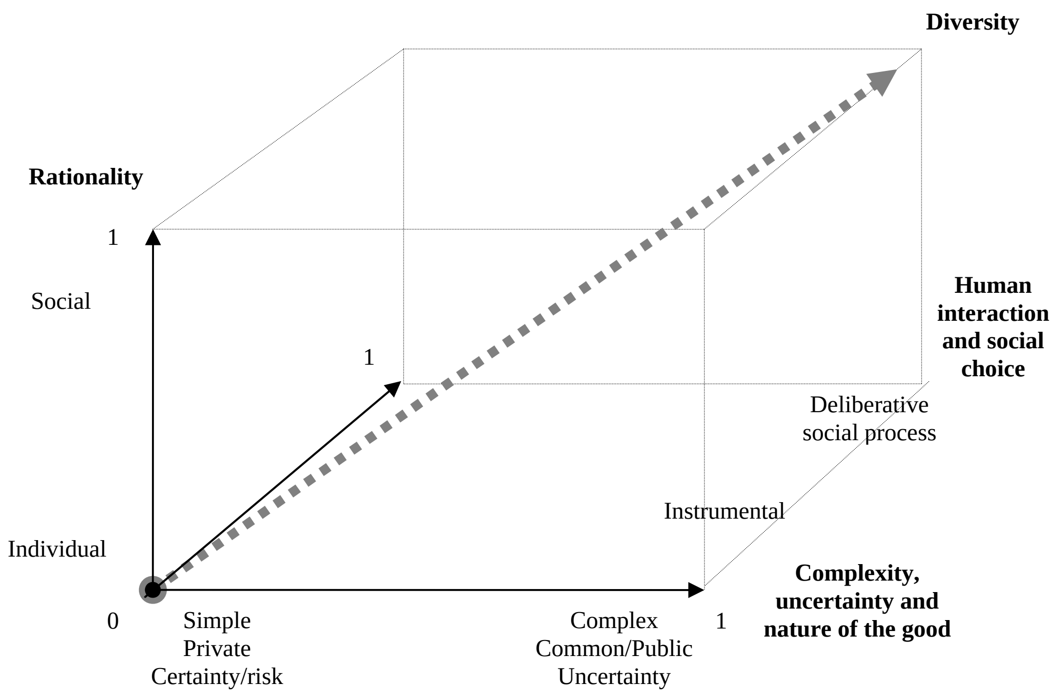
Many attempts have been made to explain the worldwide decline of biodiversity. Economists and ecologist have approached the question from different angles. They have assessed, monitored, and valued biodiversity; they have discovered ecological dynamics and economic, institutional and political failures as reasons for biodiversity decline and have met in creating new institutions for protecting biodiversity. But the closer look one takes at the diversity of life and the more detailed analysis is pursued, the less we know about biodiversity as part of the entire socio-ecological system or "web of life" (Capra 1996). Logic does not lead us from an increasing amount of facts [about biodiversity] to norms or values of how we should live [or conserve biodiversity] (Capra, 1996: 12) "Even if ecologists knew more about how particular ecosystems function, and knew how those functions would change with human modification, economists would not know what to do with this information." (Roughgarden 1995: 150). And while ecologists are still afraid that economists could underestimate the value of biodiversity (ibid), economists continue to ingeniously calculate impressive monetary estimates for biodiversity values (Costanza et al., 1998; Hein and Gatzweiler, 2006), hoping that policy makers are impressed by these figures and take biodiversity conservation policies more serious. Despite these efforts politicians and leading decision makers generally disregard valuation studies with the effect that to date the majority of resource allocation decisions in most countries have not been made on the basis of resource valuation (Byron and Bennet, 1999). Others again think that with regards to biodiversity "we should be more in awe than in arithmetic" (O'Riordan, 2002, pp. 3).

In this difficult and contradictive terrain, characterized by knowledge gaps and claims, it is not easy to keep in sight what actually matters and who's values and views count. One widely held argument, especially among economists is that whatever strategy we choose to conserve biodiversity, it should be done efficiently. The consistency and clarity of logic is appealing and nicely presented in Baxter's (1974) book entitled "People or Penguins – The Case for Optimal Pollution". Baxter addressed the question in his "Case for optimal pollution" by arguing that in dealing with a problem like pollution it is important to know what one is attempting to accomplish. According to Baxter, biodiversity conservation is not an end in itself , rather it is a means to achieve "a more general community goal", such as that "every person should be free to do whatever he wishes in contexts where his actions do not interfere with the interests of other human beings". He defines this "higher community goal" in order to avoid the "why"-question: Why should we conserve biodiversity and how much biodiversity should we conserve? Baxter avoids these questions by defining a higher goal which, according to him, make the "why" question "no longer seem admissible" and by defining criteria which he uses to frame "solutions to problems of human organization". These criteria are "oriented to people, not penguins", which means that preserving penguins (or biodiversity) is simply irrelevant if it is not for the sake of people, who enjoy seeing them "walking about rocks". Pinguins walking about rocks is used by Baxter as a metaphor to illustrate that people regard nature as useful and important. Nature, in his view, will be preserved "because and to the degree that humans do depend on it.

The economic problem of biodiversity loss describes the fact that most efforts to conserve and sustainably use biodiversity are not economically rational. Most land use decisions which lead to biodiversity loss only consider private costs and benefits, whereas economically rational decisions would also consider social costs and benefits. The consequence of social costs being higher than private costs, are external costs - the private land user who, e.g., converts forest into agricultural land does not feel and consider the negative consequences of his actions for the larger society. Market and policy failures are identified as causes of biodiversity loss when, e.g. there is no market which could translate the willingness to pay for biodiversity into actual income for farmers or when a subsidy further reduces the private costs of converting a forest and thereby increases the difference between private and social costs of conversion. Valuing ecological goods and services, creating new markets (e.g. ecotourism), regulating markets by trade restrictions (e.g. environmental standards), or international transfers (e.g. debt-for-nature swaps) are examples for measures to internalize external costs and thereby reduce or even avoid market and policy failure (Marggraf, 2005: 3). Therefore, from an environmental economists' perspective, in a world where policy and market failure would not occur, biodiversity would not be lost. The underlying concept of rationality and the values being taken into account are not being questioned.

In the following we will portray Baxter's view as the environmental economists' view or the '**economic efficiency stance**', as opposed to the ecological economists' view or the '**complexity stance**'. We will examine both stances with regards to the task of biodiversity conservation and place criteria which define them into a 3-dimensional space (Figure 1). The criteria are similar to those defined by Arild Vatn (2005: 419): 1) rationality, 2) complexity, and 3) type of social choice. Institutional diversity can be regarded as a forth dimension resulting from the other three. The more complex systems get, the more difficult it is to organize them with a single set of institutions and governance structures (Gatzweiler, 2005a, b), so that institutional diversity would increase with increasing levels of the three criteria. Each criteria is a fuzzy concept which is expressed different degrees between the two extremes of totally existent (1) or not (0).

Fig. 1: Trajectory of change (in rationality, nature of the good, type of human interaction and social choice mechanism) in coping with the task of biodiversity conservation



Source: Adapted from Vatn (2005)

What we are dealing with when addressing the challenge of biodiversity conservation are complex socio-ecological systems, composed of multiple system components with multiple functions and interactions. Understanding the behavior of these systems involves a trade-off between vagueness and precision, between isolated relationships of few system components and holistic system behavior[i]. With increasing precision about single system components and their causal relationships, knowledge of overall system behavior becomes increasingly vague[ii]. Regarding the feature of fuzziness, Magurran (1988) states that "[bio]diversity is like an optical illusion. The more it is looked at, the less clearly defined it appears to be and viewing it from different angles can lead to different perceptions of what is involved". Zadeh stated the principle of incompatibility in fuzzy set theory, which says "As the complexity of a system increases, our ability to make precise and significant statements about its behavior diminishes until a threshold is reached beyond which precision and significance become almost mutually exclusive characteristics" (Zadeh, 1987, 1975a,b; Weiling and Lee, 1995)[iii]. The "value of the world's ecosystem services" (Costanza et al., 1998) is a good example: the authors calculated a number on the grounds of assumptions of the efficiency stance, which, taken their own discussion into account, is meaningless, but better than no number at all.

In this paper we argue that beyond efficiency, it is important to understand complex socio-ecological system's behavior[iv] in order to conserve biodiversity effectively and in order to do so vague knowledge about single isolated system relationships can (or even needs to) be tolerated. Biodiversity conservation is a challenging organizational task which involves: 1) the diversity of ecological systems, their components which have multiple attributes, e.g. with regards to their nature (private or public goods), and 2) the diversity of social systems, multiple stakeholders, their behavior, interactions, and rules. Coping with complexity in biodiversity conservation, not only requires an understanding of the nature of the good to be conserved but also of how people perceive it and organize to deal with the task of conservation. The argument we are bringing forth is, that in order to cope with this challenge we need to move along the trajectory of change towards diversity (the dotted bold line in Figure 1). This shift can not be exclusively guided by the rule of economic efficiency and 'one-dollar-one-vote' democracy. It involves a shift in the perception of rationality from individual to social, a shift in the type of human interactions from instrumental to communicative and deliberative processes and a shift towards dealing with complex rather than simple systems.

The case we are referring to is the loss of coffee genetic resources in the montane rainforests of SW Ethiopia. The world's Coffea arabica originates from wild populations growing in these rainforests in Ethiopia, which are their natural habitat. Deforestation heavily endangers their existence. A project funded by the Government of Germany (CoCE) has set out to develop concepts for their sustainable use and conservation.

Complexity: types of biological and institutional diversity

Ellis (2005a, b) holds that complexity has no clear theoretical definition but complex structures consist of hierarchically ordered "modules" which are more or less independent and who's structures can be studied in their own right, e.g. cells and bodies or individuals and groups of resource users "who are linked to each other and to multiple resources that occur across multiple scales through multi-level governance arrangements" (Janssen et al., 2003). Berkes et al. (2003, pp. 6) further state that "problems and solutions of [biodiversity] conservation at the generic level are considerably different from those at the species level or landscape level. Different groups of conservationists focus on different levels; they may use different research approaches and may recommend different policies. Biodiversity can be considered at different levels of scale. However, because there are strong feedbacks among the genetic, species and landscape levels, there is coupling between different levels, and the system should be analyzed simultaneously across scale." Complex systems are not only defined by structure and scale but also by change. Causal relation within systems can change and the relative intensity of these relations can also change. Common and Stagl (2005) describe complex systems as systems in which causal relations between components change, and which are able to adapt and evolve. The changes of species distribution and - composition as response to changing from industrial to organic agriculture, is an example.

The 'efficiency stance' neglects complexity to a large extent. Although Baxter (1974) recognizes that some component of the ecosystem (Penguins) may be important to humans, as soon as this relationship is not evident or known, it becomes irrelevant. Given that the human actor has imperfect knowledge about complex social- and ecological systems, uncertainty prevails. Different possible outcomes of his actions may be known but probabilities can not be assigned to them (Common and Stagl 2005: 380). Lugo (1995), for example suggest that trying to quantify sustainable harvest levels in tropical forests, rarely leads to ecosystem sustainability. This is because the entire socio-ecological system is in a state of constant change. Change and disequilibrium rather than equilibrium are the dominant system conditions (Berkes et al. 2003: 7) we are dealing with in biodiversity conservation.

Complex systems are also defined by diversity. Generally, ecologists take the view that biological diversity promotes the resilience of systems (Common and Stagl 2005: 55). Different groups of species take over different functions in a system and therefore the persistence of ecosystem function over time (i.e. the resilience of ecosystem function) depends on the diversity of species within functional groups (Gunderson and Holling 2002). Gunderson and Holling (2002: 407) distinguish two forms of diversity within function groups: *functional compensation* and *functional reinforcement*. Functional compensation occurs when one species goes extinct and is replaced by another species with similar function but which is less sensitive to environmental change/disturbance. Such compensation occurs at the same or within a narrow range of scales. Functional reinforcement occurs when species perform similar functions across very different scales. Small birds, for example, that feed on larvae help regulate insect infestation and when the larvae becomes a worm, different large birds perform the same task, however at a different scale. The two types of diversity effects can be described as follows: 1) Similar species at similar scales with similar functions but different sensitivities to disturbance, 2) Different species at different scales with similar functions and different sensitivities to disturbance. This "within-scale and between-scale diversity produces an overlapping reinforcement of function that is remarkably robust" and which the authors call "imbricated redundancy". System resilience (the ability of an ecosystem to re-establish itself after disturbance) critically relies on this redundancy and it is a serious error to assume that minor, redundant species can afford to be lost, because their importance may only be detected when they are needed, following a disruption.

If we regard these two types of diversity and their effect on system resilience as organising principles, we find surprisingly similar effects in social systems. Similar to the idea of "imbricated redundancy" of species within and across scales is the idea of institutional diversity and multi-level governance for biodiversity conservation (Gatzweiler, 2005a), or "a hierarchy of cascaded institutions" (Martin, 2003). Apart from the creation of a "scattering of strong local jurisdictions" and the promotion of the economic value of biodiversity resources this institutional structure is required to match jurisdictional imperatives and Martin (2003) argues that it is a condition for effective, stable and equitable conservation at the national level. Ostrom (1998) had argued along the same lines that in order to govern complexity in ecosystems appropriately, the respective nested and multi-layered institutions will be complex because of the "Law of Requisite Variety" Ashby (1960), which states that any regulative system needs as much variety in the actions that it can take as exists in the system it is regulating.

Governing complexity

Elinor Ostrom and Roger Parks (in McGinnis, 1999: 284) studied mixed systems of metropolitan organization and concluded: “the more social scientists preach the need for simple solutions to complex problems, the more harm we can potentially cause in the world.” This warning refers to the same type of mistake pointed to by Gunderson and Holling (2002: 408) who warn that seemingly redundant species can not be afforded to be lost. Despite this warning, one widely held argument, especially among economists is that whatever way we choose to conserve biodiversity, it should be done efficiently; the criterion being defined with the below mentioned narrow understanding of individual rationality. Similarly, in the context of public service reform, individuals had argued on the ground of efficiency that many local jurisdictions should be merged into a single unit of government. Ostrom, Tiebout and Warren (1961) challenged that presumption by stating that the consolidation argument need not hold “if agencies offer similar but differentiated services that impinge upon diverse communities of interest.” Advocates of polycentric governance argue that polycentric systems, “because of their nested and overlapping structures, can be sized to respond to the preferences of publics that may vary enormously in scope” (Bikers and Williams 2001: 94).

Low et al. (2003: 83) investigate the role of redundancy in genetic, ecological and governance systems and define functionally different kinds of redundancy, which are very similar to those types described by Gunderson and Holling (2002). They also distinguish intra-level (within level) and inter-level (across multiple levels) redundancy and suggest conditions which make redundancy advantageous or efficient. However, depending on the conditions and dynamics of the system, redundant systems can be con- or destructive. Their final message is that prescriptive approaches are not useful and that “it is crucial to analyze the level of diversity, types of risk, and location of important information in diverse locations before making any judgement about the impact of specific kinds of redundancy in a governing system”.

Despite the absence of simple solutions for governing complexity in ecological and social systems there are principles and lessons we have learnt. The first principle refers to context specificity. Because of the great variability in the attributes of actors and features and functions of ecosystems, there are no organisational “quick fixes”. This has been repeatedly confirmed, for example in a recent “Comprehensive Assessment of Water Management in Agriculture” by the International Water Management Institute or in the works of the International Forest Resources and Institutions Network. The other principles, also build on lessons learnt in water management (Ostrom 1992) but also from forest management (Gibson et al. 2000). The following enabling conditions are supportive for successful governance of biodiversity: 1) User groups need the right to organize, set and change rules, 2) the boundaries of the resource must be clear, 3) Criteria for group membership must be clear, 4) use rules should be environmentally conservative, need to be easily enforceable, 5) infractions must be monitored and sanctioned, 6) decision-making rules need to be viewed as being fair, 7) conflict resolution methods need to be available.

From individual to social rationality

The individual rationality of the ‘efficiency stance’ says that rational behavior exists when a person’s choice is one that is the best for himself. Choices are ruled by the rationality of maximizing one’s own utility or well-being. This “rational egoist” (Ostrom, 2004: 94) lives in an environment with stable, competitive conditions where people are completely informed, are able to attach values to a range of possible actions, and after a complete analysis of all involved costs and benefits, will choose an action which maximizes his own net benefits. But as Gode and Sunder (1997) show, it is the set of rules constituting a market which leads to efficient choices and not necessarily the individual's calculative behavior. That is an indication that the institutional arrangements within which people act and make choices, rather than human behavior itself is the root cause of biodiversity loss. Institutions define the logic or rationality of a specific choice (Vatn 2005).

Let us look at this 'rational egoist' who needs to attach values to biodiversity components in order to make a choice of whether to conserve it or not. These values cover a wide range from use to non-use values. In his institutional setting the rational egoist is not allowed to waste scarce resources, so he needs to make a choice based on the net benefits he is likely to derive from his choice of action. In addition, he will discount the expected benefits because using them now is more worth to him than using them tomorrow, especially in the face of risk. Next, in the process of making a decision, our 'rational egoist' is endowed with super-human abilities: he is able to foresee and take all contingencies into account and calculate the optimal course of action. He can do that in an instant and at no cost[v]. Further, the assumption of the 'economic efficiency stance' is, that if we aggregate the preferences of the individual, we will know about the preferences of society: the social entity is the sum of its individual parts.

This mode of making choices is one that constantly weighs costs and benefits and is in permanent search of optimality. It is deeply rooted 1) in the way we define people (e.g., "homo oeconomicus" or "homo politicus"), 2) what we take into account as data, and 3) which data processing tools we use. Vatn (2005) defines "value articulating institutions" (VAI) by these three components[vi]. In our attempt to value biodiversity we are free to choose the type of VAI which we think ought to be applied. That is, as mentioned earlier, a normative, 2nd order problem and which VAI to choose depends on the following core questions (Vatn 2005):

- Is the issue or good individual or common?
- What is the degree of complexity?
- Is the issue or good characterized by one or plural value dimensions? Are preferences given or may they change?
- What is a logical aggregation procedure given answers to the above? E.g.: the whole is the sum of its parts.

Also among institutional economists, efficiency has been an issue. For governance structures to work efficiently the transaction cost approach has been used. For example, Wittmer and Birner (2000) used that approach to develop efficiency oriented institutions for sustainable resource management. They approached the questions of how the efficient level of decentralisation and devolution can be determined and how the comparative efficiency of different forms of governance involving public and private sector institutions at different levels can be assessed. One of the major hypotheses of transaction cost economics is that the performance of an organizational form depends on its alignment with the characteristics of respective transactions (Williamson 1996, 2005). Birner and Wittmer (2000), however, also note that transaction cost economics has limitations "in situations where the empirically observed governance structures […] have to be considered as outcomes of power-oriented political processes rather than of efficiency-oriented institutional choice." Another limitation of such approach is the fact that costs accrue for transactions between people. The costs of transactions between people and the ecosystem, however, are more difficult to assess and brings us back to the problem of externalities.

As suggested by Gatzweiler (2005a) biodiversity conservation is a complex task which requires collective action. For collective action to work the rationality of human actors trying to achieve the task of biodiversity conservation needs to shift from an individual to a social type. In biodiversity conservation people need to communicate about second order problems, meaning, they need to come to an understanding of what should be achieved and how, and they need to come to such an understanding together. Habermas (1984) termed this kind of reasoning communicative rationality: communication about what should be achieved together. Or, as Vatn puts it (2005: 125): "It is about reasoning together about which solution should be sought for the collective sharing of the common good. It is about developing, criticizing and testing arguments concerning which norms or behavioral rules should be supported….It is the argument that is the core of social rationality. Along the same lines, Etzioni (1988) distinguishes between behavior motivated by individual utility (the 'I') and behavior motivated by norms and moral reasoning (the 'We') about what is the right thing to do.

In contrast to social choices made on the basis of calculating the sum of individual choices, like is done in the 'efficiency stance', social rationality involves reasoned choices made by all stakeholders involved and decisions based on processes of deliberation.

From instrumental to deliberative social processes

A strong argument for conserving biodiversity is that it is of value to humans. That is why economists are usually called to calculate its "total economic value". What is often overlooked in doing so, is that the choice of a method for valuation also includes the choice of the "value articulating institution". Before calculating the values of biodiversity the second order problem needs to be answered: who's values count and how shall they be calculated? These questions refer to the assumptions made related to the capacity of people to clarify the issues involved and to do the necessary evaluations and computation as well as how to aggregate individual preferences or priorities (Vatn, 2005: 331). The choice of a value articulating institution, or a method to value biodiversity, needs to be made based on the type of goods to be valued, and the degree of complexity. The type of rationality is then defined by that institution. For example, if we choose to apply the willingness-to-pay and Cost-Benefit method, the rationality is that of the rational egoist and the type of ecological goods and services are restricted to those we know of being useful.

Cost Benefit Analysis is based on a mathematical and instrumental logic. Making a choice whether investments into a biodiversity conservation project are worthwhile, follows the cost-benefit rule and calculating the economic values of the goods and services to be valued is based on the willingness of people to pay for it. It is assumed that those people have the same amount of information about the valued goods and actually think it is reasonable to express values in monetary terms. In contrast, deliberative methods are based on the role of arguments and potential preference changes which may follow from communication about what should be done. O'Connor (1998) describes the deliberative methods as the "democracy perspective" and defines it as an epistomological stance. In contrast to the "one dollar – one vote" democracy of Cost Benefit Analysis, it describes a process where people express their individual views freely, debate and discuss in a process of deliberation. Methods include citizen's juries, discourse analysis, institutional analysis, stakeholder meetings and combinations of these methods (Atlee 2003).

In the face of biodiversity loss and other global threats, Ehrlich and Kennedy (2005) identify "collective actions of individuals"[vii] as lying "at the heart of the dilemma" and suggest the establishment of a forum which enables the analysis of individual motives and values, which are critical to solving these global threats. In such a forum a global discussion of key ethical issues, human cultures, their views and values related to environmental sustainability and what kind of changes might enable a shift towards an ecologically sustainable, peaceful and equitable global society, would be discussed. The authors argue that history has shown that the collapse of past societies were rooted in maladaptive cultural tradition or "an unwillingness to count the clearly measurable costs of their actions" (Diamond 2005). Also they point to the fact that the "tragedy of the commons" is no one-way dilemma, as the works of Vincent and Elinor Ostrom has proved to sufficient detail and that the "rational choice" paradigm as propagated by mainstream economists has been challenged (Kahnemann et al. 1982). A global forum for discussion, debate, negotiation and communication could facilitate the adaptation to global changes and not move towards the collapse of social and ecological systems (Ehrlich and Kennedy 2005).

Table 1: O' Connor (1998) has compared different features of the "efficiency stance" and the "democracy stance".

Distinguishing features	**Efficiency stance**	**Democracy stance**
Human rationality and motivation	Utility maximizers with a given preference structure	People with mixed motives and indeterminate values
Engagement of subjects	Subjects are reactive, isolated and individual. Their views are private and not open to challenge. Subject is confined to one role	Subject is interactive group member; views are public and open to challenge; subject is free to try out different roles
Promulgation of the framing of issues	Questions are decided by the researcher	Questions evolve through negotiation between researchers and stakeholders, jurors.
Relation between subject and policy maker	Subject is customer; policy maker's role is to satisfy and accommodate customer's preferences; policy maker is invulnerable; relationship of mutual benefit	Subject is a citizen with whom the policy-maker shares responsibilities of decision-making; policy-maker is vulnerable; relationship of trust
Outcomes	Quantified, consistent outcomes about people's concerns which can be used to validate policies or estimate likely compliance with a policy	Rarely quantified outcomes with unclear or inconsistent logic which reveals how people understand the issue
Information handling	Information is (largely) anonymous and unquestioned	Information is owned, defended and contradicted
Information and knowledge	Quantity of information provided	Quality of how information is construed
Methodology	…is sovereign; process is theory driven and circumscribed	…is fluid; process is creative, dynamic and open ended
Distributional issues	Condones existing distributions of rights; silences some voices (protest bids, income effects); open to manipulation by researcher	Can challenge existing distributions of rights; silences some voices; open to manipulation by participants (participation)
Validation	…through precedent, consistency with previous studies, convergence and methodological rigour	…through argument and mutual acknowledgement among participants/stakeholders

Institutions for assimilation of results	Digestible by bureaucratic and financial structures	Can be indigestible to traditional bureaucratic and financial structures; open to create new institutional structures
What's the point?	Point of exercise is to come to an outcome within given institutional infrastructure	The point of the exercise is the outcome and the process as well as the active/innovative institutionalization of collective action
Significance	Fosters 'customer' habits and managerial society	Fosters civic habits/identity and democratic values

"The priority must be to allow people to feed themselves - not to achieve efficiency."

Siegfried Pausewang, XI World Congress of Rural Sociology, Trondheim, Norway
July 25-30, 2004

Coping with complexity – Conservation of wild Coffea arabica forests in Ethiopia

A series of workshops carried out by the Ethiopian Coffee Forest Forum, the Amber Foundation and the Center for Development Research in 2005 brought together Ethiopian policy makers, NGOs and scientists to model the complexities of coffee forest governance in Ethiopia. The objective was stated in the expression of the following vision: "Acknowledging the past importance of coffee forests and their current threats, they shall be conserved in a manner which improves local livelihoods, ensures income generation, and sustains forest ecology/biodiversity. This should be achieved for present and future generations by the participation of local communities."

Ethiopia has a very young and "imperfect" democratic, formerly socialistic government (Economist, 2005). Local communities in rural areas are strongly connected to tradition, ethnicity and their local cultures and the instability of political leadership has created a relationship of suspicion and mistrust between people and politicians. The "donor darling" of the international aid community, Ethiopia, is now attempting the conservation of its remaining rainforest resources by different governance approaches in different areas, supported by different donors. The first challenge towards achieving the above stated objective was to cope with the diversity of actors in the same field, stepping on each others toes or not knowing of the activities of each other. The coffee forests can be described as an experimental field for testing which governance approach to forest management works.

The strict exclusionary, command and control approach is applied in three forest areas which are less densely populated (Geba-Dogi near Metu in Yayu district, Boginda Yeba near Bonga in Kaffa Zone, and Kontir-Berhan near Mizan Teferi in Sheko district). The co-management approach is tested through the help of foreign NGOs by implementing Participatory Forest Management Projects (PFM) in more densely populated areas: Belete Gera, Bonga, Bale. Participator Forest Management (PFM) projects in Ethiopia, despite local success stories, are better described as state-prescribed projects facilitated by state-approved NGOs (of which 2/3 are not Ethiopian and the rest are state-controlled) in which communities are told how to participate and where new institutions are built often neglecting traditional structures. Participatory forest management can be described here as being socially engineered. How sustainable community forest management can be achieved beyond the strict control of the project scale in all forest areas and without the massive external inputs of foreign NGOs is still an open question (ECFF, 2005). Local community governance is also practiced. But it is not practiced as a deliberative process of a civil society. Self governance of forest resources is rather a necessity which has evolved from local power structures, legacies of the socialist past mixed with ethnic and cultural traditions and driven by the immediate need to achieve food security. Self governance has evolved from a status of tolerated illegality (Stellmann 2005) and from the certainty that state support is unreliable or absent.

Further steps taken to cope with the challenge of complexity were to understand the components and relationships within the respective system. This was done by the support of the Sensitivity Analysis developed by Frederic Vester (Vester 2002: 185, Volkmann et al., 2005, AMBER, 2005). The analysis is based on the concepts of system dynamics and fuzzy logic. It facilitates the modeling of the system's complexity in a participatory manner and, if done properly, can give the right impulse or incentives for systems to regulate themselves (Vester 2002: 154). Different policies can be simulated and the sensitivity of system components (variables) can be tested. The Sensitivity Analysis also allows to evaluate the resilience of a modeled system and to identify the criteria which (de)stabilze the system. In contrast to reductionistic approaches which start with assumptions of a well defined and reduced version of reality, this approach starts with initial complexity and reduces it in the course of the exercise to fewer but key relationships within a system.

In a 3-day workshop with Ethiopian stakeholders, 24 variables were selected to describe the system "coffee forest conservation". Each variable was defined to ensure that the participants of the exercise had the same understanding of their meaning. Based on expert knowledge and research findings the actual and/or potential influence of each variable on one another was defined in a so-called cross-impact matrix (annex Figure 2). The cross impact matrix shows which marginal effect a change of variable A has on variable B. Thereby "0" stands for no effect, "1" means weak under-proportional effect, "2" means proportional effect, and "3" means: "a change of 1 in variable A causes an over-proportional change in variable B." All the effects were discussed and evaluated in the group.

After creating the cross-impact matrix it is possible to visualise the position of each variable in a three dimensional space (annex Figure 3) showing the systemic role of each system variable. From the cross-impact matrix it is possible to calculate active (AS) and passive values (PS). Active values are the sum of effects of one variable on others and show how strong one variable affects all other system variables. Passive values are the sum of effect of all other variables on a specific variable and shows how strong the variable is affected. The active/passive ratio (Q value) says whether a variable has an active or reactive character. Finally, the P value (=AS x PS) expresses to which extent a system variable is connected into the system and with the other variable. The higher the P value is, the more critical it is, because a change of that variable would cause changes of many other system variables as well. And this can destabilize the system. If the P value of a system variable is low it contributes to the buffering capacity of the entire system.

Figure 4 (annex) shows different components of the system "coffee forest conservation" and their relationships. The representation of the actually observed relationships in the effect system, shows, that there were 51 negative feedback loops and 67 positive feedback loops. A positive feedback loop is one with each two the same, either opposing or confirming feedbacks between two variables. A negative feedback loop is one with two different relations (one opposing and one confirming) between two variables. As there are more positive feedbacks, the system is unstable and will eventually run out of control. In Figure 3 the drawn through arrows represent confirming relations ("if A increases B increases" or "if A decreases

B decreases") whereas the dashed arrows represent opposing relations ("if A increases B decreases" or if "A decreases, B increases").

The outcomes of the Vester Sensitivity modelling exercise led to two important insights: 1) the enabling environment, consisting of several variables, such as "governance" and "policy implementation" is an important issue to deal with in governing complex systems and 2) the process of defining a common vision and collectively working together in designing the model is in itself an important step towards governing complexity. Especially in the area of biodiversity conservation process-oriented methods can be more important that target-oriented methods because the target needs to be defined commonly in advance. Defining this target is not easy if biodiversity is not merely a means to another (higher) end which needs to be achieved efficiently, but also an end in itself.

Conclusions

Successful biodiversity conservation depends on two systems which are complex in nature, and interwoven: Ecological and social systems and their linkages. Each of these systems consists of a hierarchy of multiple cascaded subsystems. In contrast, the foundations of economic efficiency rest on the assumptions of the division between human and ecological systems and behavior of economic man, which continue to be those of reductionism, rationality and egoism. That model of reality in which economic efficiency is calculated has narrow but well defined boundaries and is simple enough to deal with well-defined segments of biodiversity. But biodiversity is a combination private, common pool and public goods and services-each with various features and functions. Under these conditions, efficiency can not be the only useful criteria for biodiversity conservation, because biodiversity conservation requires taking account of multiple complex systems, each having different functional properties across different levels.

Beyond efficiency at the micro scale (e.g. costs and benefits of different land use options) the task of biodiversity conservation requires investments into communication, collaboration, education and processes of deliberation which can be very transaction costly and which involves changes at all levels of society. Social and ecological conditions on the local level are embedded into the broader national political system. In order for policies to be effective and adaptive micro and macro levels need to be linked, e.g. by communication activities and capacity building. The rate of return on such investments, which are hardly predicable, are likely to be transaction cost ineffective, because the returns from those investments can only be expected in the future, if at all.

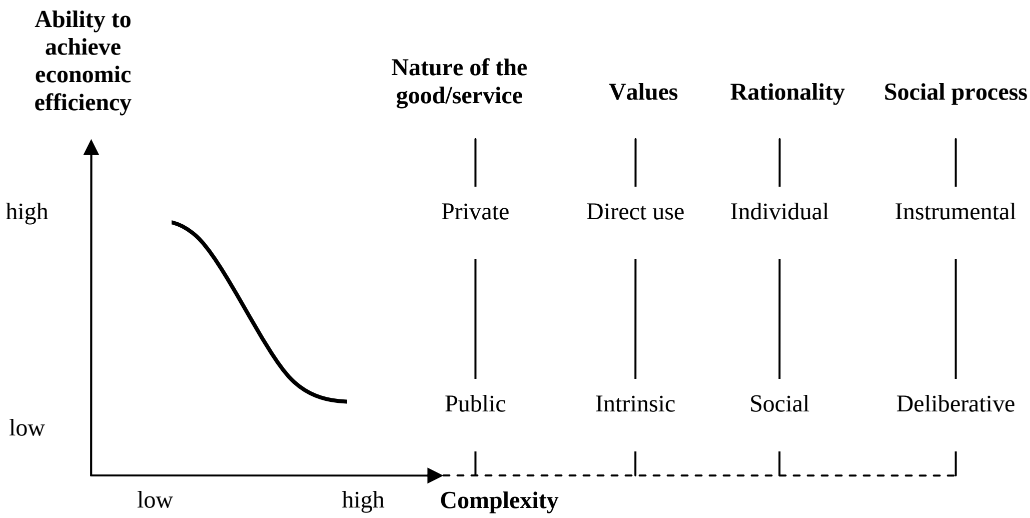
We have argued that because of the nature of biodiversity features and functions and the characteristics of people trying to achieve biodiversity conservation, the shift from individual to social rationality and from instrumental to deliberative types of social processes are imperative if biodiversity conservation is to be successful. This provokes the question to which degree biodiversity conservation can be achieved in authoritarian regimes where basic democratic freedoms, such as freedom of speech and association are regulated by the state and participation is state-prescribed and controlled. The Ethiopian case demonstrates how difficult in-situ biodiversity conservation can be when no difference is made between common and state property.

Economic valuation and subsequent cost benefit analyses can help in coping with the governance of complexity in biodiversity conservation because economic values, once known, can initiate a social process of awareness building. That is different from presenting the results of a valuation study to decision makers who are then supposed to make rational decisions. Getting the economic values right as compared to getting the institutions right can therefore be regarded as necessary but not sufficient for dealing with complexity in biodiversity conservation. If economic values are to be transformed into actual benefits, institutions at multiple levels need to be built or evolve which facilitate this process. Economic values can serve as a reason for a process of social change.

Experiences with modeling complex systems, such as the Ethiopian coffee forests by means of the Vester Sensitivity Analysis show that the results are less important than the process of modeling, communicating and achieving incremental advances in understanding the respective system complexity. Each time the modeling exercise was carried out it led to different system behaviors. The expectation that sophisticated computer supported modeling can deliver the answers as to which variables need to be "fixed" to improve the system's functioning, is an illusion and belongs to that kind of social engineering thinking which is inappropriate for dealing with the governance of complexity.

Supported by literature and by the Ethiopian example of modeling the coffee forest conservation we conclude with a hypothesis: the more complexity is taken into account in biodiversity conservation, the less able are we to achieve efficiency among a growing number of system components. The ability to achieve economic efficiency decreases with the number of different types of goods and services (from private to common pool to public), the number of different types of values of these goods and services (from direct use to non-use to intrinsic, latter which is outside the realm of economics) and with the number of system boundaries being crossed (from local to national to global). That hypothesis is pictured in figure 3.

Figure 5: The ability to theoretically achieve overall economic efficiency in biodiversity conservation decreases with increasing socio-ecological system complexity. This complexity is defined by the nature of biodiversity goods and services, their values, people's rationality and the social processes applied to govern biodiversity. The more we are dealing with public goods and services, intrinsic values, social rationality, the less relevant economic efficiency as a decision support tool and the more important become deliberative social processes.



Annex

Figure 2: Cross Impact Matrix

	Influence by ↓ to →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	AS	P
1	Governance	X	2	2	2	1	2	1	2	2	2	2	2	2	2	0	2	1	1	0	2	2	2	2	2	38	608
2	Policy Implementation	1	X	1	1	2	2	1	2	2	2	2	1	2	2	1	2	1	1	0	2	2	2	2	1	35	1015
3	Policies	2	2	X	1	2	2	1	2	2	2	2	1	2	2	1	2	2	1	1	2	2	2	2	2	40	1360
4	Community Participation	1	2	1	X	2	2	3	3	3	1	3	2	2	2	2	0	1	1	2	1	2	2	2	2	42	1764
5	Population Dynamics	1	2	2	1	X	2	1	1	2	2	2	2	1	1	0	2	2	1	1	2	1	1	2	3	35	945
6	Benefit Sharing	0	1	1	2	0	X	0	2	1	2	2	2	2	2	2	2	2	3	1	2	2	2	2	2	37	1591
7	Culture	2	1	2	2	2	2	X	2	1	2	2	2	1	1	0	1	1	1	1	2	1	2	2	2	35	700
8	Gender Senitivity	1	2	2	2	2	2	1	X	2	2	2	2	2	2	0	1	1	1	1	1	2	2	2	2	37	1147
9	Infrastructure	2	2	2	2	3	2	2	2	X	3	3	2	3	3	2	3	2	3	2	2	3	2	2	2	54	2106
10	Access & Use Rights to Res.	1	2	2	3	1	2	0	2	1	X	3	2	2	1	1	2	2	1	1	2	2	2	2	2	39	1443
11	Livelihood	1	1	2	2	3	3	2	3	2	1	X	2	2	2	1	2	2	2	1	2	2	2	2	2	44	2244
12	Income Diversification	1	0	2	2	2	2	1	1	2	1	2	X	2	2	2	2	2	2	1	2	2	2	2	2	39	1716
13	Agric. Landuse Practices	1	1	2	2	1	2	1	1	1	1	2	2	X	2	1	2	2	1	2	2	2	2	2	3	38	1596
14	Capacity Building	2	2	1	2	1	2	1	2	3	2	3	1	2	X	1	2	2	3	2	2	2	2	2	2	44	1760
15	National/Int. Markets for NTFP	0	1	1	1	0	1	0	0	1	1	2	2	2	2	X	2	2	2	1	1	2	2	2	2	30	930
16	Local Markets	0	1	1	2	0	2	0	0	2	1	2	2	2	2	2	X	2	2	1	0	2	1	2	2	31	1302
17	Marketing Forest Coffee & NTFP	0	1	1	2	0	2	0	0	2	1	2	2	1	2	2	1	X	2	1	1	1	2	2	2	30	1230
18	Product Quality	0	0	1	2	0	2	0	0	2	1	2	2	2	2	2	2	2	X	1	1	1	2	2	1	30	1200
19	Pests and Diseases	0	0	1	1	0	0	0	0	0	0	2	1	1	1	2	2	2	3	X	1	2	2	2	2	25	775
20	Ecological Services	0	1	1	2	0	1	0	1	1	2	2	2	1	1	1	2	2	1	3	X	2	2	2	2	32	1280
21	Extension Services	0	2	1	2	1	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	X	2	2	2	41	1640
22	Biodiversity	0	0	2	2	1	3	1	1	2	2	2	3	2	1	2	2	2	2	2	3	1	X	2	2	40	1800
23	Forest & Coffee Forest Manag.	0	1	1	2	1	2	1	1	2	2	2	3	2	2	2	2	2	2	2	3	1	3	X	2	41	1927
24	Deforest. & envir. degradation	0	2	2	2	2	1	2	1	1	2	3	2	2	1	2	2	2	2	2	2	1	2	3	X	41	1886
	PS	16	29	34	42	27	43	20	31	39	37	51	44	42	40	31	42	41	40	31	40	40	45	47	46		
	Qx100	238	121	118	100	130	86	175	119	138	105	86	89	90	110	97	74	73	75	81	80	102	89	87	89		

Figure 3: Systemic role of system variables and system condition

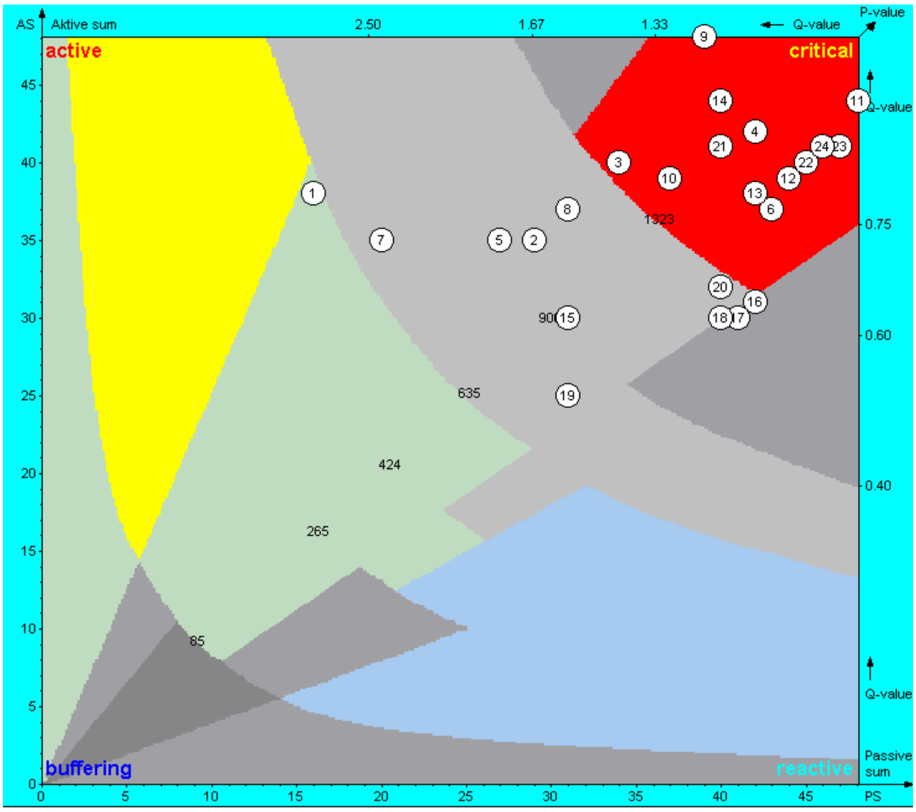
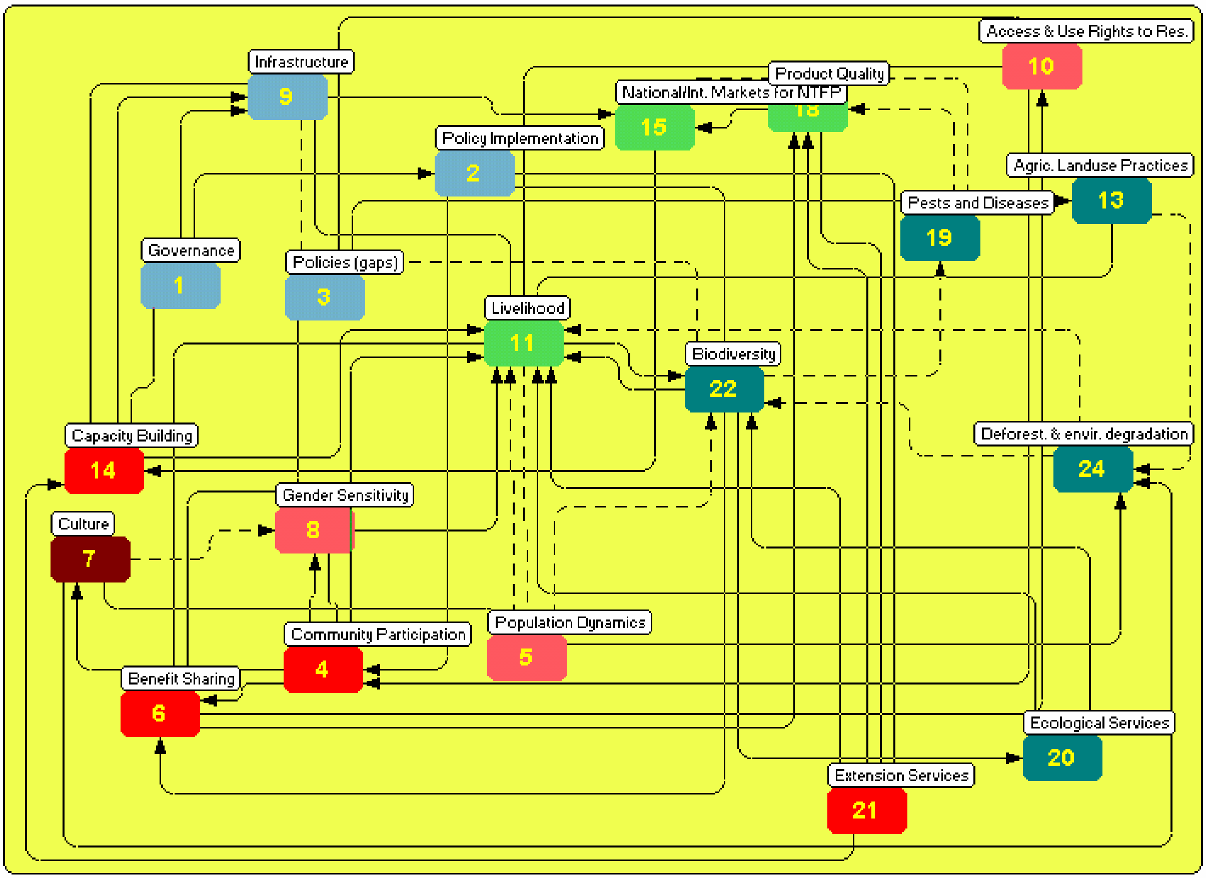


Figure 4: The effect system



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Endnotes:

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[i] This trade-off is analogous to the Heisenberg trade-off which tells us that we cannot simultaneously know with one hundred percent certainty about an electron or atom's position and velocity. Position and velocity are mutually exclusive aspects of reality. Furthermore, by observing reality the observer also influences reality. If we want to know about the position of an atom, we are able to find an atom in a certain position. If we want to know about its movement, we are able to determine a certain speed of the atom. Both, however, are never precisely observable. "Kosko (1993) pictured Heisenberg's uncertainty principle as a relationship between two graphs. One graph shows the knowledge of a car's position in relation to the probability. The other graph shows the knowledge of a car's velocity in relation to the probability. Both graphs show bell curves, which depict the variance in knowledge about velocity or position. The wider the bell gets, the less one knows. The uncertainty principle says that as one curve peaks ("gets thinner"), the other one spreads ("gets wider"). If the position curve peaks and we have total knowledge of position, then the velocity curve will flatten and we have total uncertainty (infinite variance) of speed." (Gatzweiler 2003: 22).

[ii] What fuzzy logic tells us is that, in order to understand complexity, it is necessary to understand not the separate parts themselves but their relationships which tell us about the functioning of a complex entity. Imprecise but highly relevant (hence, valuable) economic predictions determined by common sense are often expressed by experienced economists in linguistic terms; e.g., "the price of oil is not likely to increase substantially in the near future" (Klir and Yuan 1995). We have applied the same principle in our attempt to initiate the development of sustainable use and conservation concepts for the coffee forests in SW-Ethiopia

[iii] Note Zadeh's (1975a, 1975b) early thoughts on this: "…the ineffectiveness of computers in dealing with [biological] systems is a manifestation of what might be called the principle of incompatibility—a principle which asserts that high precision is incompatible with high complexity. Thus, it may well be the case that the conventional techniques of system analysis and computer simulation…are intrinsically incapable of coming to grips with the great complexity of human thought processes and decision-making. …Indeed, it is entirely possible that only through the use of [approximate reasoning] could computer simulation become truly effective as a tool for the analysis of systems which are too complex or too ill-defined for the application of conventional quantitative techniques." Depending on what we want to know about biodiversity, it can be viewed as a resource or as a condition. It can be viewed from a compositional or functional lense (Callicot et al. 1999).

[iv] The Vester Sensitivity Analysis is a computer supported tool to help building, simulating and understanding complex systems.

[v] This ability is referred to as 'perfect rationality'.

[vi] Or, the normative and epistemological predispositions of every method.

[vii] See also Gatzweiler 2005a