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The overlooked importance of institutional economics to understand governance, adaptation, and resilience in renewable resource management: an analytical framework exemplified by recreational fisheries*

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Abstract

In a dynamic world, social-ecological changes continuously contest even well established management systems for renewable resources. As for recreational fisheries management, an increasing popularity of angling activities and therefore a potential higher pressure on freshwater fish resources imposes a significant challenge to the current management system presumably driving conflicts among different resource users and about maintenance of ecosystem services.
Key figures in solving those problems are the governance structures which agents are in charge for the choice of a particular management approach. The matter to investigate is in how far they are able to adapt the management on constantly arising changes in social-ecological systems. One important obstacle to better understand and solve such management problems is a rare use of established property rights, transaction costs, social capital, and institutional change theories. They help to identify reasons for success and failure of potential short- and long term adaptation strategies of agents within the different governance structures to regulate social and ecological problems in renewable resource systems.
The paper develops an analytical framework based on a brief review of the major theories. The framework aims to analyze how different governance structures may or may not respond on challenges and adapt to todays and future changes inherent in contemporary freshwater recreational fisheries. Further identified components in the framework are the institutional environment, the anglers as direct resource users, the fish resources which are embedded in more complex and spatially larger resource systems such as waters and the broader biophysical world. We propose four general propositions on the outcomes of resource management and how they depend on different governance structures considering both regulations and rules, and resource characteristics. We recommend these for testing in empirical studies to provide a basis for an in-depth understanding of management decision-making in recreational fisheries world-wide.

* Paper presented at the 2008 Berlin Conference on the Human Dimensions of Global Environmental Change, 22-23 February 2008, Berlin

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1. Introduction

Because of a constantly increasing anthropological use of renewable resources many ecosystems are at risk. The issue of concern is that the intensive use of renewable resources endangers ecosystem functioning and is indicative of a disorder between social and ecological subsystems, which can derogate the maintenance and future use of the ecosystem services for contemporaries and future generations (Costanza et al. 1997). This is also valid for marine and freshwater ecosystems (Holmlund & Hammer 1999) which are intensively used over decades by commercial but also progressively more by recreational fishermen, particularly in developed countries (Post et al. 2002; Arlinghaus et al. 2002; Coleman et al. 2004; Arlinghaus & Cooke 2005; Cooke & Cowx 2006). Furthermore, in a dynamic world, characterized by complexity and uncertainty, changing social-ecological interactions continuously contest even well established management systems for fish stock resources and imposes a significant challenge to current management systems presumably driving conflicts among different resource users (Arlinghaus 2005). Thus, the social and ecological crisis in fisheries worldwide might be to a high extent a result of management failure (Arlinghaus et al. 2002; Caddy & Seijo 2005).

There are many attempts to come off from an often insufficient non-management status in marine fisheries and wide-spread single-species approaches in inland fisheries and to implement more appropriate management approaches, such as multi-species, habitat, or ecosystem approaches, which stress out the holistic character of renewable resource management in face of complex and dynamic ecosystem characteristics (Arlinghaus & Cowx 2008). However, beside this advancement from a biological and ecological perspective sustainable resource management calls also for the improvement of social interactions in resource use such as the implementation of co-management approaches and the development of integrated resource management. Even so numerous attempts were made to improve fisheries resource management, fisheries professionals and scientists emphasise that resource management still fails to manage for sustainability (Pitcher 2005; for recreational fisheries: Sullivan 2003) and there is an urgent need to improve fisheries resource management research. Cochrane (2000) makes it very clear in his article about the failure of fisheries resource management and stresses the importance to investigate the reasons of that management failure.

Aiming improvement in renewable resource management social and political aspects get growing appreciations and cross-scale linkages from outside affecting fisheries make researcher calling for inter-disciplinary approaches in fisheries management research (Jentoft 2006; Hughes et al. 2005). However, renewable resource management research is still often one-discipline driven and dominated by natural science: “although the importance of understanding local social, cultural, and institutional contexts is acknowledged by policy makers, in practice, conservation projects are often designed and implemented by conservation biologists and natural resource managers with little or no input from anthropologists or other social scientists other than economists” (Nagendra 2007: 15219). The latter are often criticised by their neo-classical approaches which neglect e.g. social capital and transaction costs economics. But particular these institutional economic theories are often seen as a solution for analysing management pitfalls of common pool resources such as many renewable and especially fish resources are (Ostrom 2005, 1990; Imperial & Yandle 2005; Dietz et al. 2003; Agrawal 2001, 2003; for fisheries: Arlinghaus et al. 2002).

Key figures in solving renewable resource management problems are seen in the governance structures which agents are in charge for the collective choice of a particular management approach (Kooiman et al. 2005; Jentoft 2006; Symes 1997). These chosen rules of resource management are referred to as institutions (North 1990). Nevertheless, governance structures themselves are determined by rules as well. However, these governance structures are often alternatively organised for example on local, regional, or states level. Another matter of concern is in how far these different organisational levels regulate renewable resources over varying spatial scales. That means the characteristics of the resource to manage are crucial as well. This is important for the problem of fit between ecosystems and institutions in context of complex adaptive systems such as fisheries are (Folke et al. 2007). Almlöv & Hammer (2006) as well point out that a key issue of fisheries management is the appropriate distribution of management measures at varying spatial scales and organisational structures. Functioning interdependent adaptation processes between social (governance structures and institutions) and ecological (resource characteristics) systems (SES) can be named as resilient and the degree of their capacity to self-organize and learn in that system is defined as resilience (Gunderson & Holling 2002; Carpenter & Folke 2006).

Recreational fisheries are an exceptional example in this context. An increasing popularity of angling activities, e.g. nowadays the dominant user of freshwater fish resources in Germany (Arlinghaus et al. 2002), and therefore a potential higher pressure on freshwater fish resources cause major anxiety about potential harmful ecosystem impact through angling activities, fish stocking measures, and access and catch regulations (Cooke & Cowx 2004; Lewin et al. 2006). That also applies to fish and water use conflicts with other stakeholders (Arlinghaus 2005) and recreational fisheries management is increasingly challenged by this development. The spatial distribution of water resources might differ highly and has to be integrated in management decision as well. Additionally, resource characteristics of common pool resources, high rivalry and difficult exclusion, cause further embarrassments for management. Furthermore, there are manifold types of governance structures (in respect to all possible spatial scales) to regulate fish resource use varying for example between North American and Central Europe.

However, except some precursory studies institutional economic theories are not considered in recreational fisheries management research yet. Some authors identify the importance of actors' behaviour, of cooperation and communication (Plummer & Fennell 2007; Hart & Pitcher 1998), and of adaptation processes (Mahon et al. 2007), or invocate fisheries management research to focus on governance structures (Begossi 1998; Salmi et al. 2008), on decision making processes (Preikshot 1998; Policansky 1998), institutions such as property rights (Almlöv & Hammer 2006), and transaction costs (Pereira & Hansen 2003) to prevent further immersion in fisheries management crisis. Nevertheless, some of these and many of other studies miss one important step beforehand: to analyse WHY people don't follow certain kind of rules such as a 'wrong' incentive systems and thus WHY management regulations fail under certain kind of organisational structures or biophysical conditions.

For that reason, we point out that insights from institutional economics are essential in research about renewable resource management because they help to identify reasons for success and failure of potential short- and long term adaptation strategies of renewable resource management approaches. We argue that a comprehensive research based on institutional economics, composed of property rights, transaction costs, social capital, and institutional change theories, is needed to find ways out of potential fisheries management crisis and to understand the social-ecological relationship in ecosystem management in general.

This paper focuses on recreational fisheries and the relevance of institutions, governance structures, and resource characteristics for its sustainable management. It starts with a review of the previous literature on this topic and points out the research gaps in respect to institutional economic theories. Based on a brief review of major theories from institutional economics, the first objective of this paper is to provide an analytical framework that seems promising to analyse the potential problems inherent in contemporary renewable resource management in general and is exemplified by recreational fisheries management. It focuses on adaptation processes of governing agents in the social part of the SES as the approach to come closer to sustainable resource management. The second objective is to arouse this framework with institutional economics theories to delineate potential sources of management failure and success in SES. The framework focus on the governance structure because its agents, in charge for a collective choice of a particular management approach, are the key for solving potential problems in resource use. The generation of four general propositions on the outcomes of resource management is the third objective. They are derivated from institutional economics theories in respect to varying governance structures and resource characteristics in the SES. They discuss which level of the governance structure might be more successful in the maintenance of ecosystem services, solving social conflicts, and avoiding economic inefficiency in recreational fisheries, and might be more adaptive in recreational management considering varying resource characteristics on different spatial scales. We recommend these propositions for testing in empirical studies to provide a basis for an in-depth understanding of management decision-making in recreational fisheries world-wide. The outline of the paper follows these objectives.

2. Taking stock of recreational fisheries management research

The failure of management approaches for common pool resource in general (Adams et al. 2003) and in fisheries in detail (Pitcher 2005; Sullivan 2003; Arlinghaus et al. 2002) received extensive attention. Nonetheless, the inclusion of institutional economic theories in recreational fisheries research to explain management failure (or success) is broadly missing even so some elements are described in the literature such as the question of property rights allocation (Begossi 1998, Ruddle & Segi 2006) or communication and cooperation issues (Paul & Pitcher 1998). Some authors point out that there is a strong need for analysing the performance of institutions and organisations (i.e. agents of the governance structure) to find explanations for management failure in fisheries and consequently clues to find ways out of ecosystem crisis in marine and inland waters (Symes 2006; Kooiman et al. 2005). This is to be met for recreational fisheries management as well. However, the influence of governance structures on management performance is only considered in some precursory studies (Almlöv & Hammer 2006; Yandle 2007; Nagothu 2007; Salmi et al. 2008).

The following chapter summarizes and identifies research gaps in recreational fisheries management studies in respect to the four identified branches of institutional economics and together with vitally important topics in recreational fisheries management: first, the allocation of fishing rights and their relation to resource management responsibility; second, the occurrence of transaction costs in management decision-making and implementation; third, the value of cooperation, trust and communication between different stakeholders and interest groups on fish resources in co-management and integrative habitat management approaches; and fourth, the recognition of and the conditions for adaptation in recreational fisheries management. In all four parts the role of the governance structure is considered as well. Additionally, the main challenges of recreational fisheries management are addressed: the arrangement of property and fishing rights, fish stocking measures, and multiple stakeholder settings on water bodies and fish resources.

2.1. Fishing rights and management responsibility

Because of the generic traits of common pool resources, the long traditions in freshwater management systems, and an increasing use of fish resources in both

marine and inland fisheries, the clarification and investigation of fishing rights (access to the resource and use of the resource) is often considered in recreational fisheries management studies (Sipponen 1998; Young 1999; Kearney 2001; Sullivan 2003). As the basic management instrument both input control (who is allowed to catch fish) and output control (how much is allowed to catch) instruments are often used (Welcomme 2001).

However, institutional economic theories are rarely used to explain potential failure or success of recreational fishing rights and appertaining responsibility for sustainable management (at least in developed countries fixed as societal intent in fishery laws). Two outstanding case studies by Wang (2001) and Huitric (2005) on inland fisheries management identified adaptation process of property rights on fish resources within broader socio-economical conditions and in sequential development over time. Almlöv & Hammer (2006) identified similar changing use patterns at least partly for recreational fisheries. The influence of varying governance structures was early investigated by Begossi (1998) who identified a scale mismatch of resource users such as recreational fishermen with operating range of management.

2.2. Management transaction costs

In recreational fisheries management research the occurrence of management transaction costs is widely neglected besides some research evidence about transaction costs of fish stocking measures and enforcement of property rights. Fish stocking is the most widespread and abused management tool used in freshwater fisheries (Cooke & Cowx 2006) and it is a typical human reaction to fish stock decline which may be caused by many different reasons (Feunteun 2002). Some case studies point out that to reach such ecosystem services, better monitoring and information systems have to be established in fisheries management in order to only stock when the situation is appropriate (Welcomme & Bartley 1998; Holmlund & Hammer 2004) and to avoid stocking mere as a tradition (Klein 1996). The main problem of using fish stocking is that they are carried out without complete information about the actual or potential success of the exercise (Cowx & van Zyll de Jong 2004) or without any definition of the objectives (Cowx 1994).

The matter of transaction costs in fisheries governance in case of information gathering and unclear specification of use rights was outlined for example by Edwards (2003). Along with that Pereira & Hansen (2003) point out that the

complexity of resource systems and the diverse organisational structure of recreational fisheries make it problematic to provide effective enforcement of property rights. However, the influence of different governance structures on the transaction costs of for example fish stocking measures or other recreational fisheries management tools in varying resource characteristics and on different organisational levels is negligibly investigated yet.

2.3. Co-management and integrative habitat management

Participatory approaches (referred as co-management or integrative management as well) became a hallmark to environmental management approaches (Plummer & Fennell 2007). The same applies to recreational fisheries and fisheries in general as well (Brown 1998; Charles 1998; Noble 2000).

The problem that is addressed by this research is that regulating fisheries management on different spatial levels attaches different values to ecosystem services (Hein et al. 2006). Recreational fisheries are often confronted with a high level of complexity (many different interests in fish resource and water resource services covering different spatial scales) in their resource systems which cause diverse conflicts in this sector (Arlinghaus 2005). Many of those interests usually do not consider the existence of the fish stocks and their habitat requirements and might disturb angling activities at the water such as water traffic or hydropower facilities. Usually state authorities are involved in planning processes (Pomeroy & Berkes 1997). Measures for water use are usually planned and implemented at a regional and states' level and are carried out over many water basins. Hence, recreational fisheries management depends strongly on non-fishery players (Arlinghaus et al. 2002; Lewin et al. 2006). Additionally, trade-offs between different interests can emerge and questions arise about how to deal with such social situations. One often described example is the conflict between recreational fisheries and nature conservation projects and the question of interest is how governance structures deal with this situation (Goodchild 2004; Rauschmeyer et al. 2007; McPhee et al. 2008). Jentoft et al. (1998) for instance draws back on social and institutional theory to answer concerning about co-management (Schreiber 2001). The potential mismatch between collective action (societal intent) and individual self-interest is important to solve (Berkes 2006; Wilson et al. 2007). Many conflicts can be identified regarding different resource use interests (Bennett et al. 2001) and low-level management

measures are not able to react on those challenges properly (Lester et al. 2003), because other resource users are acting on the regional or states' level. However, regulations that are too stringent at higher scales can in turn also cause co-management failure (Carpenter & Brock 2004). The importance of communication processes, trust building between different stakeholders, and knowledge and information exchange (all parts of social capital theory) to foster management partnerships and to decrease opportunistic and self-seeking behaviour of individuals in management and resource use played a major role in many of these studies. The influence of low or high levels of recreational fisheries governance structures in varying resource characteristics remains still not systematically investigated.

2.4. Adaptive management

Similar to co-management approaches in light of an integrated view on fisheries systems (Wilson et al. 2006; Antunes & Santos 1999; Gaichas 2007) adaptive management approaches sprung up with the resilience concept which concentrates on change and feedback processes in uncertain and complex social-ecological systems. Both together are seen as the future of sustainable recreational fisheries (Aas & Schramm 2008). However, because of that many case studies were applying (active) adaptive management approaches in fisheries worldwide, Walters (2007) questions the success of this approach and identifies three main institutional problems: lack of resources to monitor adaptive management approaches; unwillingness by decision makers to admit uncertainty in policy choices; and a lack of leadership to implement new and complex management programs. All three obstacles could be investigated and to large extent explained by institutional economic theories. Since the adaptive management approach emphasize the functioning of the whole system the question of further investigation is does distinct governance structures organize themselves, experience learning processes and develop adaptation capacities in respect to different resource characteristics (Mahon et al. 2007; Marttunen & Vehanen 2004). The following theoretical approach and analytical framework aim on finding an answer on this question and to identify and explain scale matches and/or mismatches between and within organisational levels (social system) and spatial scales (ecological system).

3. Institutional economic theories

Wide-ranging research on institutional economic issues is needed to find ways out of the fisheries management crisis and to understand the social-ecological interaction in ecosystem management in general. Based on ecological economic research approach the central thought in institutional economics is that the function of ecosystems eventually can be destroyed through human activities, and the crucial question is how we can organize the use of renewable resources and, at the same time, maintain ecosystem functions and providing further resource use by humans. That maintenance can be named as resilience as well, defined as the ecosystem's ability to return back to its organizational structure intact after a perturbation (e.g. human activity such as overfishing) has taken place (Carpenter & Folke 2006). Securing the resilience and sustainability of an ecosystem depends on adaptive resource management, which considers the economic, cultural, and regulatory dimensions of the social system and the biological processes of the ecological system (Bromley 2007).

In this study, insights from institutional economics are chosen because "they regulate relationships among individuals and between the social and ecological systems, i.e. rights and duties as well as costs and benefits of actions. Therefore institutions link social and ecological systems." (Gatzweiler & Hagedorn 2003: 3) This theory considers market and non-market explanations such as regulatory, cultural, or behavioural factors for the success or failure of renewable resource management.

Following Vatn (2005) the core question of institutional economics is which choices people make within different types of contexts, both physically and socially. For example, which choices are made by angling associations or clubs when implementing management measures in one way versus another and why do they do so. These choices follow institutions. Institutions are defined as "the humanly devised constraints that shape human interaction. In consequence they structure incentives in human exchange, whether political, social, or economic." (North 1990: 3) They consist of informal (sanctions, taboos, customs, traditions, and codes of conduct) and formal rules (constitutions, laws, property rights) (North 1991: 97). This means traditions, rules, and regulations etc. related to fisheries management margin the interaction between angling associations or angling clubs and freshwater ecosystems (use of the fish stock resources). Thus, the institutional environment defines the

choice domain of certain kinds of management measures within which the members of society operate (Bromley 1989: 741). These members (individuals or groups of people) are called agents of the governance structure (or governance agency), which are organized in different alternatives and defined by institutions. However, the members also have the ability to define institutions. Thus, governance structures are the key for changing traditions, rules, and common customs. They consist of institutions incorporated by humans in discrete structural governance alternatives; classical market, hybrid contracting and hierarchy (Williamson 1996). In fisheries these alternatives are e.g. private ownership of fish stocks like commercial fishermen (classical market), common ownership like anglers associations or clubs in East and West Germany (hybrid), or governmental ownership (hierarchy). These governance alternatives mediate between individual formal or informal transactions (management measures) to align incentives that organize the allocation of (fish) resources.

The theory of institutional economics follows the assumption that the detailed arrangements of institutions matter and that their failure (or success) has a direct influence on a particular outcome of resource use (Vatn 2005). Those institutional arrangements are highlighted by different theories such as property rights theory, transaction cost theory, social capital theory, and the theory of institutional change, which are explained in detail on the following pages.

3.1. Property rights theory

Property rights are an institutional form (these can be also called rules) which regulate the access to and use of resources by humans. Those rights are enforced by the state as the "unit of coercion" (Bromley 1992: 3), which both defines the boundaries of property rights and observes holders of the property rights in their use of the renewable resource. Therefore, Bromley defines property rights as "a benefit stream that is only as secure as the duty of all others to respect the conditions that protect the stream." (1992: 10). Protecting the stream means for example that renewable resources are not squandered in anarchy and that the holders of the property rights invest in the resource to maintain future use. For example property rights holders can be required by law to manage their resources in a sustainable way. Thus, they might own resource use rights although they face duties in resource management as well. A functioning property rights system depends on well-defined and well-established property rights rules, which give the holders the security that

their rights are recognized by potential competitors in the present and the future (Ostrom & Schlager 1996). This security might ensure the development of long-term management plans.

To investigate the functioning of property rights, two key parameters have to be considered; the attributes of the resource and the attributes of the resource user (Paavola & Adger 2005: 356). Fish stock resources are common pool resources and are characterized by high rivalry and difficult exclusion of users. The difficulties of exclusion depend of the characteristics of the resource, for example whether it exists in approachable and lake-rich landscapes and provides the possibility of free riding, such as resource use in situations without fishery rights and the correspondently costs of its provision. This might imply consequences for the different approaches of recreational fisheries management. Furthermore, the property rights' holders are also challenged by the attributes of the resource user, i.e. the number, heterogeneity, and the social capital of anglers. For instance, a small number of anglers can be better observed by angling club managers, than a high number of users can be monitored by angling associations governing broader spatial scales. Thus, the performance of property rights is highly connected to the theory of transaction costs of management measures.

3.2. Transaction costs theory

The failure or success of management measures in GRF also depends on the amount of transaction costs incurred to achieve a particular outcome, for example management measures such as fish stocking or access restrictions. Transactions of management measures can be defined as "developing initial contracts between parties responsible for the production of the ecosystem services necessary for recreational fisheries" (Rudd et al. 2002: 47). Those contracts are e.g. capture limits or size limits and should be in line with both actors' preferences, goals and motivations and the maintenance of fish resources. However, the carrying out of such management measures has costs. In addition to the production and personnel costs there are so called transactions costs, which are broadly defined as the "costs of running the economic system" (Arrow 1969: 48). These costs are e.g. search and information costs, bargaining and decision costs, and monitoring and implementation costs (Richter & Furubotn 1999: 35). They are all assumed to have an influence on the success or failure of management measures by the governance structure. For

instance if regulations at the state or regional level do not fully conform to the attitudes of local resource users (top-down approach), the costs of monitoring and enforcement rise (Costanza et al. 1998). Therefore, the amount of transaction costs incurred might also have a strong influence on the resource managers' choice of which kind of management measure to carry out.

The amount of transaction costs incurred varies greatly among the different forms of the institutional arrangement (e.g. governance structures (Williamson 1991)), resource characteristics, human attributes (e.g. social capital concepts of bounded rationality and opportunism), and the degree of the resource use complexity (Paavola & Adger 2005). In different situations the transaction costs can be higher or lower. Resource characteristics also have a strong influence on transaction costs. In complex water bodies (e.g. lake-rich landscape covering larger spatial scales) search and information costs are incurred to obtain information on the status and change in fish stock populations. The monitoring and enforcement of access and use restrictions might also have much higher costs in these systems than in limited and easily observable small water bodies such as ponds or small lakes. Another parameter to consider in the governance structures are the attributes of the angler community (Arlinghaus et al. 2002, Arlinghaus 2004a, 2005, 2006). Their expectations about resources might influence decisions about management measures by angling associations and clubs managers more than e.g. ecological requirements of the resource system. In addition, the number and attitudes of anglers might have a strong influence on the effective implementation of management measures (Arlinghaus & Mehner 2005). For instance, consideration of varying attitudes, beliefs, and catch orientation of anglers might increase the bargaining costs in governance structure management decisions. However, it could also be the case that the inclusion of anglers' interests in management decisions reduces enforcement and monitoring cost because of the anglers' participation in management decisions.

3.3. Social capital theory

The often described problem in using common-pool resources is the so called social dilemma. This means for example that the decisions about and the use of fish stock resources highly depend on trust, reciprocity, and equity between the resource users and arise from the characteristics of common-pool resources (Ostrom 2005b). The success or failure of management systems to prevent rivalry in resource use and to

enforce restrictions on access depends highly on these values. Additionally, norms and traditions influence anglers' activities and management decisions. Furthermore, the lack of information and knowledge about the complexity in resource systems complicates the management of fish stock resources. The ability of different resource users to communicate and cooperate about problems arising from resource use also becomes a crucial consideration (Plummer & Fennell 2007). All these behavioural and cognitive traits of the resource users are difficult to consider in management decisions and are not easy to incorporate. It is also assumed that strategic behaviour (utility maximization) with complete information does not work in common-pool resource management (rational choice theory). On the contrary the bounded rationality of humans in using ecosystems services (fish stock resources) is obvious (Jager et al. 2000).

However, one way to solve these difficulties is the collective action approach. This approach departs from rational choice theory and points out the importance of sharing norms between different resource users. Similar to this approach is the concept of social capital (Paavola & Adger 2005: 363), which is defined as the "capacity of social groups to act in their collective interest" and this "depends on the quality of the formal institutions under which they reside." This is also seen as a central strategy for a resource user's adaptation to environmental problems. With respect to the resource use in recreational fisheries, this means that resource managers have to build up common preferences in fish resource use, consider all requirements for the different expectations of varying resource users and maintain the ecological system of fish stock populations. To achieve this societal endeavour they have to overcome challenges like communication barriers and the lack of resource knowledge and they have to deliberate the further use of traditional management measures (Arlinghaus 2006). A next crucial issue is the investment in human capabilities to achieve sustainable renewable resource management (Berkes 2006).

3.4. Theory of institutional change

Theories of institutional change are important for the question how potential management failure and deficiency can be overcome and move towards an adaptive management approach. Within institutional economics there are many explanations regarding institutional change. For instance transaction costs are often claimed to be

essential for change or stability in institutions (North 1990). For example high management transaction costs may be a reason for institutional change. Inefficient property rights, technological changes or market changes may also cause institutional change. However, this study focuses on co-evolutionary and collective action approaches to explain institutional change (Paavola & Adger 2005). Economic co-evolution is defined as “mutual adjustment and development of ecological and economic systems” and “social systems in turn reflect the peculiarities and constraints imposed by the resource on which they depend” (Paavola & Adger 2005: 361). This approach allows consideration of a broader range of reasons for institutional change. The central point is the assumption that human decisions follow bounded and imperfect rationality. The choice of resource management is understood as a learning process of trial and error and emphasizes the volitional decisions made by resource managers.

Central in this approach are feedback mechanisms between the user, the resource and the learning processes of resource managers about human resource use (van den Berg & Stagl 2003). Feedback mechanisms of the SES and learning processes influence the decision about management regulations and provide the basis for adaptive management systems. Adaptive governance structures can be defined as follows: “institutional and political frameworks designed to adapt to changing relationships between society and ecosystems in ways that sustain ecosystem services.” (Carpenter & Folke 2006: 309)

At this feedback mechanisms are a precondition for institutional innovation, i.e. a change in laws, rules or the behaviour of resource users, in order to provide new management approaches that are able to adapt to the changing requirements of social-ecological systems. Furthermore, it is central that the results of feedback information are considered in the decision-making process and that the agents of the governance structure are able to draw conclusions from them, i.e. to change currently failing management approaches to adapt to the requirements of the social-ecological system. Therefore, the knowledge, attitudes, and resources of fish stock managers (e.g. representatives of angling associations and angling clubs) have a high influence on change in the institutional environment, in management systems and in human behaviour and norms regarding fish resource use.

4. A framework to analyse renewable resource management

The here provided framework is supposed to guideline research about management failure in renewable resource use (in particular common pool resources and here exemplified by recreational fisheries). The beforehand encapsulated institutional economic theories are applicable to this framework, explaining the potential failure (or success) of the interactions between the single components and therefore the functioning of the whole system: If one or more parts of the system fail or are under pressure this cause direct or indirect changes in the other parts.

This framework shown in figure one draws heavily on the work of Elinor Ostrom (1990, 2005, 2007). It regards to both the "Framework for Institutional Analysis and Development" (IAD) and further enlargements towards a social-ecological system analysis (2007). The here proposed framework considers the influence of the institutional environment, rules, traits of actors and resource characteristics underlying a particular arrangement of management measures on resource use such as those mentioned in theoretical explanations described in part three of this paper. Furthermore, it takes into account intra-sectoral relationships of ecological systems between resource units and resource systems within the biophysical world, which feed signals back to the social world.

4.1. Managing human-nature interaction

An angler catching fish appears to be a simple transaction at the first glance, but there exists a web of more complicated relationships of human-nature interactions within the social-ecological system (SES). Some of them arise from the resource characteristics of fish stocks influenced by resource system characteristics. Fish stock populations as renewable natural resources can be framed as so called common-pool resources[1] and are characterized by a high rivalry for utilisation of the resource and problems in the exclusion of other (non-authorized) users. High rivalry derives from the fact that the use by one fisherman precludes the use by another (both cannot utilise the same fish). This can cause the so called "tragedy of the commons" as depicted by Hardin (1968). The "tragedy of the commons" arises in the following case. Without any regulation (=open access), there is a free run on the common-pool resource. Every angler tries to catch as many fish as possible and

[1] See Perman et al. (2003: 126) for a detailed description of public, private, club, and common-pool resources (goods).

every fish not caught is free to be harvested by another fisherman. Problems arise if growing numbers of anglers, improved angling technical equipment, and/or increasing demand for fish cause an overuse of the resource and disturb both the ability of the fish stock to reproduce and its provision of ecosystem services. As a consequence, the regulation of resource use among competing users to hinder these undesirable effects is needed.

The second major feature of common pool resources is the difficulty of excluding non-authorized users. Fish stock populations are nested in water systems. Water bodies are scattered over wide spatial scales which may be interconnected over large distances by things such as long rivers or connected lake systems. Furthermore, their importance for social and economic use makes it difficult to exclude potential users of fish stocks or water resources. For instance, other leisure activities such as hiking, swimming, canoeing, or camping utilize water resources makes it difficult to exclude non-authorized users (e.g. building a fence) from water and fish stock resources to avert things such as fish stock overuse.

The difficulties arising from these intrinsic resource characteristics are called first order dilemma in the literature. The difficulties of common pool managers to deal with these are called second order dilemma (or social dilemma) because many of the hitherto used management approaches failed and did not work out economic inefficiencies[2], social conflicts, or destruction of natural resources finally. To overcome these obstacles new management approaches such as the adaptive management approach need to be developed and implemented. The key to achieving this goal lies with the governance structure as the entity that decides how a certain resource management plan is carried out. The following figure (together with the following chapters) pictures our proposed framework to investigate first and second order dilemma in common pool resource use and management.

> Figure 1 here <

The two parts in the framework, the social and ecological system, do not imply contradicting positions. On the contrary both are strongly connected by everyday human-nature interactions, specifically through multiple interplays between numerous components of the system. Both adapt activities on each other and give feedback to

[2] Efficiency is defined shortly as follows: under a designed set of institutions, governance structures, and resource characteristics there is no management improvement possible (Pareto-efficiency). See also page 46.

the other part. This view on human-nature interaction is based on the integrated concept of “human in nature” perspective of social-ecological systems by Berkes & Folke (1998). The implication of this concept on resource management is that a sustainable use of natural resources needs the consideration of all three branches of sustainability: economic efficiency and success, social conflict resolution (both on the social part of the SES), *and* ecological resilience (the ecological part of the SES). These management objectives (or parts of it) could be the evaluation criteria of managers in the adaptive management cycle. Disturbances in one of these parts might have strong influences on the other parts and might cause social-ecological disorder and hence may hamper sustainable resource use altogether.

Problems in resource use arise with the daily human-nature interaction. This interaction consists mainly of human activity regarding natural resource use and the outcome fed through the ecological system as a result of this activity. A simple example would the following: too many anglers have access to a limited area of water. They cause a comparable high angling pressure with a high capture rate. The outcome would be a reduction of the abundance of the fish stocks, changes in fish population structure or in the fish community structure in all. This again has an influence on resource use. The anglers might gain lower catch amounts and might start to argue about the use of reduced fish stock populations (social conflict).

The investigation of management failure (and success) in renewable resource management requires the analysis of the performance and efficiency of the entities which are in decision and responsible for the management. Thus, this framework takes the perspective of the governance structure. Its agencies have the choice of how renewable resource uses should be organized and the right to set the rules of resource management and use. Because of their ownership of (and responsibility for) renewable resources, the agents of the governance structure are the key to carry out adaptive management. This is due to its (potential) ability to recognize management problems and undesirable effects on the resource and its power to change existing rules on resource use.

The permanent interactions and changes between resource users and resource units are nested in the resource system and the biophysical world. Sustainable resource use then requires an adaptive management system consisting of monitoring and assessment tools, and socially defined evaluation criteria to observe what is going on in the ecosystem. However, to complete the adaptive cycle it is necessary to make

use of feedback (and its information content). That means to learn what activities have an undesirable outcome with respect to the evaluation criteria and which rules and management instruments do not work accordingly. The adaptation is fulfilled when the managers are able to change those rules and resource use behaviour to reach the listed but not yet achieved evaluation objective. The consideration of the process of adaptation in resource management in the analysis of SES enables the investigation of the (potential) development of rules and norms over time.

Another key issue in GRF is the spatial scale at which the governance agency decides on and carries out resource management. The spatial distance to the resource unit and the resource system on the one hand and the organisational distance to anglers and the institutional environment on the other hand are supposed to have a high influence on the success or failure in sustainable resource management as well.

4.2. Collective choice inside the social system

The institutional environment – the margin of collective choice

Institutions are the rules of the game (North 1990). These rules, or also called norms, customs or traditions regulate human behaviour, such as fish stock resource use. The objectives of institutions are manifold. They protect the interests of different stakeholders, distribute costs and benefits, coordinate human behaviour, and enforce laws (Vatn 2005).

A major distinction in Institutional Economics is the separation of rules into the formal and informal. Informal institutions are, for example, sanctions, taboos, customs, traditions, and codes of conduct arising from the cultural and/or religious background of a society. Formal rules are, for example, constitutions, laws, and property rights, which are seen as more legally defined with sanctioning conditions (North 1991: 97; Vatn 2005: 65). Williamson (2000) classifies the informal rules in a level of institutional embeddedness which influence all other levels of social analysis: the institutional environment (formal rules), the governance structure (players and decision makers), and resource allocation. This analytical approach is comparable with the Ostrom's multiple levels of analysis (2005: 58), which consists of the meta-constitutional level, the constitutional level (rules in use), the collective choice level (governance structure), and the operational level (resource use). However, Ostrom does not follow the distinction between formal and informal rules because, she

argues that so called informal rules can be sanctioned and clearly defined as well. Alternatively, Crawford & Ostrom provide the approach of “a grammar of institutions” to analyze the rules which can be used to understand GRF management, described in detail on page 27 in the subchapter about the analysis of rules in use.

In GRF, multiple fishery laws, regulations on the state-level and special regulations for water bodies by angling organisations exist in written form, which can be comparable easily collected and analyzed. However, an assumption is made that there are additional non-written rules, norms, or strategies on local and regional level as well. These rules need to be determined through face-to-face in-depth interviews with managers of angling clubs or associations and members of fishing authorities as well.

On the following pages, the framework focuses on the property rights system as providing the rules that define which individuals or groups of people have access to and use rights of the resources. This system is used to determine who is in charge of resource management as well as the analysis of rules in use.

As opposed to a no property rights regime (open access)[3] according to Ostrom et al. (1999), there are three possibilities for property rights regimes to limit the access: individual-, group-, and government property. The rights of ownership or lease holding of fish resources incur the duty of managing the resource in a sustainable manner with regard to its ecosystem functions. This entails the obligation to mitigate the effects of environmental degradation and satisfying the recreational fishing community. To fulfil both objectives, management measures like access and use restriction (e.g. bag and fish size limits), fish stocking coupled with habitat maintenance or rehabilitation, or providing catch possibilities are carried out (Welcomme 2001: 15).

The distinction of rights between operational and collective choice level is important. Rights on operational level just allow exercising these rights. Rights on collective choice level in turn allow the owners of these rights to participate in the definition of all rights (Ostrom & Schlager 1996: 131). Owners of water bodies and fishing rights are therefore automatically defined as the governance structure of freshwater fisheries.

[3] Vatn (2005: 296) denominate these property rights regimes as follows: private-, common-, and state property rights.

The agents of the governance structure as collective choice entities

The agents of the governance structure in recreational fisheries who are responsible for resource management can be for instance managers of angling clubs or of angling associations. These can be seen as two structural alternatives in managing fish stock resources: the managers of angling associations on regional or states level and the managers of angling clubs on local level. It is assumed that this difference in the organisational structure has influence on the transaction of resource management. For instance, what it will be important to identify the costs for the angling association to collect information about aspects such as anglers behaviour on local level, or how long it takes until problems of resource use are reach the managers on states level.

The collective choice of both structural alternatives about a particular management approach can be analyzed by the "Institutional Analysis and Development Framework" (IAD) by Ostrom (1990, 2005). With this framework it is possible to model the choice of angling clubs and association managers in their particular setting of institutions and resource conditions. This management decision process is symbolized by the action arena, which includes the actors/agents/participants and the particular action situation. This situation is influenced by the institutional environment (rules in use), the attributes of the angling community considering the anglers view on resource use, and the attributes of the biophysical world.

A typical arrangement of this action arena causes certain patterns of interaction. Recreational managers might take decisions about detailed regulations of (e.g. fish size limits or seasonal closures). Their decisions then cause a certain kind of interaction in fish sock use, such as resulting angling activities on non-activities (e.g. seasonal closures). This interaction leads to a specific outcome. Outcomes of access and use regulations could be angler dissatisfaction in catch requirements caused by high restrictions, or the destruction of fish habitat or stocks resulting from high angling intensity caused by too low restrictions.

Important in this framework are as well evaluative criteria to monitor success or failure of management measures. They are a precondition for changes in the action arena and for change in the influencing factors such as rules and angler behaviour, but also in resource characteristics. Crucial at this point is to determine the evaluative criteria (e.g. anglers catch satisfaction or support of fish habitats) and are the actors willing and able to adapt to the existing use regulations on undesirable outcomes.

This important issue in resource management is explained in detail at the end of this chapter. The following subchapter gives attention to the analysis of the action arena to understand how resource managers come to a decision on regulations of fish stock use.

Analyzing choice in the action arena. Collective choice in renewable resource management is related to multiple aspects of management including: who makes decisions about resource use, what the position is of the participants, what the participants can actually do, what kind of information is available to them, what they can control, and what the expected costs and benefits of the potential outcome of their decisions are (Ostrom 2005: 33). Participants of the action arena can change existing rules in reaction to anticipated problems in resource use. Whether this happens depends highly on the single components in the action arena.

The "participants in an action situation are decision-making entities assigned to a position and capable of selecting actions from a set of alternatives…" (Ostrom 2005: 38). For example in recreational fisheries the managers of angling clubs or angling associations are the participants in the action situation. They are elected by the members of the clubs and associations and represent the angler's community. The number of participants can vary, because of the individual structure of the organisations. However, they all have a so called team status because their decision about resource management measures depends highly on the expectations of the anglers and the chance to be re-elected in future. Furthermore, the attributes of participants are supposed to influence the decision as well. This includes their knowledge about the resource, their negotiation skills, their experience in resource management, their leadership abilities, and the level of trust towards the other participants or to the angler's community. A crucial point here is the perception of the managers about the resource (Hanley et al. 2001). What do they think about fish habitat structures in lakes or rivers? Are fish species compensable or not? For instance, regarding fish stocking measures: do they think it is important to stock local endemic fish species or are fish species from elsewhere useful to stock as long as the price is acceptable?

The participants in an action arena are assigned to positions. This position, such as members of chair, managers, members etc. defines the standing of the participant in that situation: "the standing of a position is the set of authorized actions and limits on actions that the holder of the position can take at particular choice set in the

situations." (Ostrom 2005: 41) For instance, a manager in an angling association might have less influence on the decision-making process than a president of the angling associations by definition of their position. Managers are recruited to supervise the association and the particular resource management. Presidents and other members of chair are elected to assert the interests of anglers and have the right to define the particular management approach. Thus, it can be assumed that the decision for a certain kind of management measure will be more influenced by the president of this association.

The choice of the participants for one alternative as opposed to others in resource management can be named as undertaking an action in the decision process. This choice of a participant for a particular management approach depends on the information about the decision process, on the opportunity to control the action situation, and on the expected costs and benefits of the potential outcome of the management choice (Ostrom 2005: 33). The balance of costs and benefits of a particular management decision is presumed as a major point. An example could be the weight up of how much fish should be stocked in waters and rivers to increase (e.g. catch opportunities for anglers). The participants of the action arena could choose between two alternatives: on the one hand they could stock endemic fish species which are usually more expensive (because of costly production) or on the other hand they could stock other species which are cheaper in production and purchase. Given a fixed financial basis the decision for the former case means they can buy less fish or, in the latter case, more fish. However, if they consider anglers preferences for increasing their catch amount they might decide to purchase less expensive but more fish for stocking. But if they consider the possibility that the given habitat can bear only a limited amount of fish stocking (surplus stocked fish will die) and endemic species would fit better into the existing fish community, they could decide to purchase more expensive but less endemic fish species for stocking. The unequal distribution of information and power of control over the decision process by participants (e.g. to oppress other participants of the action arena) could influence the outcome as well. For instance, if the information about fish stocking success of endemic species is known and accepted only by one participant of the action arena, the person can be easily voted down by others. Furthermore, power relations between the participants can be crucial as well. Continuing the example, this could mean that this single participant, convinced about the stocking benefits of less but

endemic fish species in natural waters, has a high extent of control over the other participant. A reason for that could be that this person is the president of an angling association or club for many years and his knowledge is highly appreciated by other participants. Moreover, even private motives in the participants' relationship could play a role.

An action arena does not take place isolated or not always only at one point (Ostrom 2005: 53-64). On the contrary, quite often it needs more than one action situations to come to a decision in resource management. Moreover, the decision about different management instruments needs different action situations. In addition, the management outcomes need to be re-negotiated in future decision processes. If the decision processes are repeated games, participants start to use cooperative strategies because of former built trust or to increase future trust between them. They also might include the "Tit for Tat"-strategy (if one participant take a step back in one action situation, the other participant will take a step back in the next action situation). This strategy can save both the participant's own advantages and reduce the risk of loosing advantages. The future action situation controls the current action situation. Furthermore, an action situation can be embedded in other action situations on different organisational levels as well.

Choice on different organisational levels. Collective choice in renewable resource management might rest on different spatial scales as graphed by figure two. For example in recreational fisheries the decisions on how to regulate access and use restrictions, or fish stocking measures can be taken by angling associations at regional or states level or by angling clubs at local level. In the former case that means that angling associations own the fishing rights together with the liability to care for the resource. This organisational form is defined as **high-level governance structure** here. Angling clubs in those entities do not have direct decision rights on resource management. In the latter case the angling clubs are the owner of the fishing rights together with management responsibility. Angling associations as superior entities do not have influence on management measures on local level. Allow us to consider this as **low-level governance structure**. One essential condition for successful resource management is the match of management responsibility and regulations with the spatial scale of the resource to manage and the anglers using the resource.

> Figure 2 here <

Managing people or rather individual interests

The characteristics and attitudes of the angler community is a further decisive point in recreational fisheries management (Arlinghaus et al. 2002, Arlinghaus 2004a, 2005, 2006) and one major point often neglected is that managing resources means in fact managing people, such as anglers in recreational fisheries (Hilborn 2007).

Basically anglers are supposed to follow the regulations crafted by the agents of the governance structure on collective choice level. However, the compliance or non-compliance with the regulations on operational level (where the resource use and allocation actually takes place) depends highly on the characteristics and recognition of anglers. This should be taken into account by managers of angling associations in their decision about management instruments. Table one shows major second-tier variables to analyze anglers that should be considered in the management decision process. Apart from point five all other issues might be important for the success or failure of recreational fisheries management which is explained in the following paragraphs.

> Table 1 here <

The **number of anglers** is important for the allocation management of fish stock resources. For instance a limited abundance of fish populations needs access and bag regulations when too many anglers want to catch fish.

A further point is the **socioeconomic status** of anglers. The management needs to consider two points: the costs of fishing licenses and angling permits, and the objectives of anglers to catch fish. The socioeconomic status can vary highly. For instance unemployed anglers vote for cheaper angling licenses and angling permits. Their objective for angling is often to support their own food supply and aim to catch fish as much as possible. For other anglers fishing has a higher social status represented by using e.g. expensive angling equipment. Their **dependence** on fish resources might be less for food supply but more for recreational relaxation and the amount of the fish caught is less important than the trophy status of the fish.

Furthermore the **history of use** might play an important role in recreational fisheries management as well. For instance distinct angling organisations might refer to

different angling traditions. The former sees its roots in workers angling clubs established at the beginning of the last century to provide favourable access to fish resource for people of lower classes. The latter draws on the traditions of prior civic angling clubs which were more elitist oriented. This historical background might have influence on the self-conception of anglers and might cause a certain demand on managers of angling organisations to arrange e.g. access regulations.

The **location** of anglers and resources might play an important role in fish stock management insofar that anglers might have preferences to cover a short distance to closer located lakes or rivers. Additionally, certain kind of waters could be more popular than others. Thus, particular waters are more frequented than others and the consequently higher fishing intensity should be considered into the management decision process.

The **norms** of anglers and the degree of trust and communication within the anglers community is another crucial issue for the management. If managers of angling clubs or associations try to implement a particular management regulation, which is in contradiction to norms on local level, it might cause non-compliance within the angler's community. This could be even reinforced when anglers on local level have built a "sworn confraternity" where they carry out angling activities following their own rules. This situation might be intensified when the **knowledge** about fish resources of anglers are not considered in resource management decisions. There is scientific evidence that the inclusion of local or indigenous knowledge support sustainable resource management (Berkes & Folke 1998).

The **technology** used by anglers is a subject of management institutions as well. The limitations on angling tackles aim to reduce the fishing intensity. For instance, fishing nets are forbidden for anglers. They are only allowed to use a limited number of rods or lines. Technological progress is another important point. For instance the use of more effective angling tackles might have exhausting impacts on fish stock resources. In this case the management should monitor the altered impact on the resource and if problems arise such as resource overuse they should adapt rules on this new situation to reach their management objectives.

These major traits of anglers' behaviour should be considered in the management decision process. Their reflection in the arrangement of incentive systems in recreational fisheries to oblige self-seeking behaviour into collective interest frame is crucial for resource management success or failure.

4.3. Resource characteristics in the ecological system

Institutional analyses can not afford an investigation of resource systems functioning or resource unit's interactions within the biophysical world. This is a task for biologists, ecologists or other natural scientists. However, important for an analysis of institutions and governance structures in renewable resource management is to look whether the components of and changes in the biophysical world are considered by the agents of the governance structure, and how the social system reacts on changes in the ecological system.

This chapter is subdivided regarding the three major components of the ecological system and once again framed by recreational fisheries. The biophysical world means here the biological, material, and climatic attributes of the ecological system on wider spatial scale wherein water systems (resource system) and fish stocks (resource unit) are embedded.

The biophysical world

The influence of the biophysical world on water systems and fish stocks can be manifold. Ostrom (2007) identifies three major second-tier variables within the environment of related ecosystems: climate patterns, pollution patterns, and flows into and out of the focal SES (defined here as the water resource system with fish stocks). Climatic conditions could have strong impacts on renewable resources and consequently for their management (King & McFarlane 2006). For instance long dry periods or hot temperatures can reduce the water level and might put fish stocks under pressure and might cause fish diseases or mortality. Similar impacts might be caused by agricultural or industrial production situated close to waters which introduce pesticides or chemical ingredients in the ecological system (pollution patterns). Furthermore, predators such as sea ravens or other animals might have a high fish consumption in particular water spots and might cause a decrease in fish stock abundance (flow out of the resource system). These are only some examples. Renewable resource management should consider interactions like these within the biophysical world to be able to regulate or even avoid social-economic problems caused by these interactions.

The resource system

A further crucial factor in fish resource management are the characteristics of the resource system which are expected to exert high influence on the implementation of

specific management measures by the different governance structures (Berkes 2006, Carpenter & Brock 2004). Resource management has to consider the characteristics of waters such as lakes or rivers etc. Lakes are standing waters and bodies of water enclosed by land. They can be classified by size, origin, and/or nutrient richness status (oligotrophic, mesotrophic, eutrophic, dystrophic). Rivers are linear features of the landscape that transfer the water from mountain springs or runoff from precipitation on the land, to the sea. Rivers are open systems and have a hierarchical structure from small tributary streams to large rivers, with a highly seasonal natural state, alternating between periods of high and low flow (between rising and falling water). However, many rivers in industrialized countries are now controlled to the point where normal flooding of the lateral plains no longer occurs (Welcomme 2001: 17-28).

The geographical structure of landscapes differs and these show significant differences in lake and river characteristics and corresponding nested fish populations. Those different characteristics are suggested to have a high influence on the transaction costs of fish stock management, e.g. the control of access to fish resources and the use of fish resource regulations, or for fish stocking measures. For example in landscapes mainly characterized by large rivers, canal systems, and large, often connected lakes, the stocking of large amounts of fish by one stakeholder is very hazardous when other stakeholders at the water body can participate just through the characteristics of migrating fish stocks. Such featured water bodies should defined as **complex resource systems** here. In landscape with limited numbers of often very small lakes or larger dams, widely scattered over the countryside fish stocking measure might be safer in respect to the free rider phenomenon. Permit us to think such water bodies as **simple resource systems.**

The resource unit

Such as the influence of the biophysical world the particular characteristics of fish stocks should be considered in renewable resource management as well. Non-consideration of these characteristics (shown in table two) might cause inefficient resource management, social conflicts and destruction of fish habitats in recreational fisheries. However, the complex interactions can be only roughly described at this point.

> Table 2 here <

The varying resource system characteristics enclose different nested fish populations. They are separated into so called pilot fish zones which differ from upstream (fast waters) to downstream (calm waters). These pilot fish zones (listed from South to North: trout zone, grayling zone, barbel zone, bream zone) are dependent upon different water quality, ecological environment and habitat structure. The **mobility** of fish species can highly vary. Beside stationary species which are very faithful to their habitat, there are also species which extensively or locally migrate along rivers and connected lake systems. Some of them such as eel or trout are diadromous species that use both marine and freshwater habitats during their life cycle. This varying mobility of fish species has consequences for e.g. fish stocking management. Migrating fish stocks might flow to water areas where other stakeholders own the fishing rights. In this case recreational fisheries managers should make sure that their fish stocking measure benefit the own waters and anglers and not other fishing rights owner in the resource system. Furthermore, the construction of local hydroelectric facilities might restrict fish movement and might impair the abundance of fish stocks for angling activities.

Fish stocks are renewable natural resources and are reproducible. That means their reproduction rate is directly related to the size of the stock (Perman et al. 2003). Thus, the fish stock **growth rate** is exponentially increasing until limiting factors stops this development. Those influencing factors could be habitat competition, biotic or physiological reasons, or over harvesting by humans. However, renewable resources are exhaustible when the use rate is higher than their natural capacity of reproduction. When fish stocks are exploited to a certain level, the water habitat often provides enough food for the remaining fish. Their growth rate increase and anglers might have the opportunity to catch bigger fish. Fish with slower growth rate can be a sign of fish stock overpopulation. The fish compete for limited food and this impair their growth rate and anglers could catch much smaller fish. Considering the fact, that many anglers may like catch bigger fish, too high stocking rates in a limited water habitat would include the risk to waste investment for non-preferred small fish.

Interaction among the resource units, here mainly the interaction between predatory fish and prey fish, are influenced by angling activities and resource management as well. For instance, there might be a catch preference of anglers for predatory fish such as pikeperch, pike, perch, or eel. Furthermore, fish stocking

measure try to increase the abundance of these species in waters. In any case, too many or too less predatory fish in the water habitat will cause changes in the whole food chain.

The **economic value** of fish in recreational fisheries for anglers is often not "economic" in the proper sense because they are forbidden to sell caught fish. Their benefit lies mainly in the angling activity, the consumption of caught fish, or in the play with the fish. However, anglers are supposed to count up their angling permit costs with their actually caught fish and sometimes blame managers to neglect appropriate fish stocking measures. The economic value of fish for recreational fisheries managers plays an important role in those fish stocking measure. As previously mentioned they have to calculate the costs of stocked fish under a given amount of money, under a certain expectation of the angler community, and under the limits requirements of water habitats.

In recreational fisheries management the **size** of fish plays an important role as well because many use regulations are often connected to a limited size of the fish. Caught fish under a certain limit must be released. The reasons for this size restriction lies in the management approach that every fish should have the change to reproduce itself at least one time. On the contrary catch and release of fish above this limit is forbidden. That means bigger and faster growing fish is disadvantaged in the reproduction of the fish stock. This effect might be reinforced by angler's preferences on catching large fishes. Scientific studies show some evidence that this might cause stunted fish stocks and evolutionary changes in the fish stock structure (Birkeland & Dayton 2005, Munch et al. 2005), or indirectly on entire aquatic ecosystems (Post et al. 2002, Pauly et al. 2002).

For some renewable resources such as cattle herds **distinctive markings** are very useful to mark ownership rights on the single animal. However, this tool to identify resource ownership and to facilitate the implementation and in consequence the enforcement of ownership rights is not applicable for fish stock resources. On the contrary, their existence hidden in waters makes it more arduous to identify which fish stock resources are owned by a particular stakeholder. Additionally, this trait makes is complicated to assess the abundance and quality of fish resources for appropriate management measures. Furthermore, this "**invisibility**" causes a low perception of fish stocks in the public and makes it difficult for GRF managers to assert their interests in the society.

Caused by the varying mobility and the growth rate of different fish species the **spatial and temporal distribution** of fish stocks alter as well. A consideration of these characteristics needs a careful long-term monitoring in resource management. Local knowledge of anglers and/or angling club members might support the efficiency of the resource management as well. For instance, for some well-monitored lakes water maps with indicated spatial distribution of fish species are available. Such as other characteristics the varying spatial and temporal distribution of fish stocks makes it difficult to allocate property rights on particular fish as well. Before the fish are caught, anglers own fishing rights (angling permits) only on particular water. This provides an equal allocation within authorized users and the catch success depends on ability and fortune of the angler. After the fish is caught the angler gets the right on this individual fish.

4.4. Adaptation and resilience of social-ecological systems

Both social systems and ecological systems are characterized by complexity, change, and uncertainty (Berkes & Folke 1998, Wilson 2002). Complexity arises from uncountable single components which generate a SES. Change originates from the manifold interactions between these components influencing each other. Uncertainty comes from the limited ability of humans to understand or even recognize these manifold components and interactions[4]. So an adaptive management approach aims that agents of the governance structure are aware of essential components and react on these transformation processes in a SES. For instance, a change in the technical equipment of anglers might increase their catch yield of certain fish species. This might endanger the abundance of fish stocks and requires a reaction by recreational fisheries managers to change used regulations, such as a higher limitation of the allowed number of fish caught. However, it is to bear in mind that various other influencing mechanisms, such as food web structures, nutrient status of waters, and angler's attitudes may compensate the opportunity of higher catch amount and make stronger regulations redundant.

The capacity to solve social-ecological problems lies in the ability of humans to adapt their actions consciously on changes in the environment – in contrary of unconsciously adaptation in the ecological system. The precondition of institutional and behavioural adaptation in the social system is to get information about the impact

[4] Considering these conditions, the framework delineated here can only be restricted as well.

and outcome of human-nature interactions. Knowledge about and understanding of what is going on in the ecological system, what is the amount and abundance of the fish stock, what kind of problems are caused by human impact guided by resource use rules, what is caused by other influences within the ecological system is crucial to be able (and willing) to alter the rules and human activities to eliminate inappropriate resource management and use outcomes.

The core issue in investigating renewable resource management is to find out whether there is an adaptive cycle. Are there monitoring tools and an assessment of management measures and resource traits? Which evaluative criteria are in use? Will the governance structure take in the feedback? Are the agents of the governance structure able and willing to learn from changes in the ecological system and from resource use problems, and are they able to adapt their management system on new situations? Or do they just what they always do in the resource management and do they keep the status quo?

The initial point of adaptive management is on the one hand the monitoring and the assessment of processes in SES and on the other hand the definition of evaluative criteria for the findings of the information gathering process. These criteria can be named as management objectives as well – following the previously defined social, economic or ecological goals.

The need for gathering information about complex SES is obvious and managers of renewable resources require support by social and nature scientists. However, "scientific knowledge of the conditions and trends of ecosystems is far from complete," (Carpenter & Folke 2006: 311). Therefore, a long-term **monitoring** process which includes systematic data gathering and supervision of the processes in SES should be established. This is furthermore the basis for appropriate **assessment** of SES which can be defined as follows: "a structured process for synthesizing technical information in a way that is useful for policy." (Carpenter & Folke 2006: 309)

The results of the monitoring and assessment process need to be comparable with previously defined **evaluative criteria.** This makes it possible to judge whether the outcomes of the resource management and use comply or do not comply with these criteria (Ostrom 2005, Imperial/Yandle 2005). However, there can be manifold criteria (or management objectives) in renewable and fisheries resource and clarifications is often necessary (Pitcher 2000). Studies about this should concentrates on the

evaluative criteria of economic efficiency, social agreement, and maintenance of ecosystem services as the three major components of sustainability.

Efficiency is notionally defined as follows: under a designated set of governance structures, rules, and resource characteristics there is no management improvement possible (Pareto efficiency). The goal is to achieve the highest amount of benefit with the lowest possible amount of costs to gain common societal goals such as averting the exploitation of fish resources or satisfying anglers catch requirements.

However, being aware that fish stock resource themselves and the management of them are characterized by high biological and social complexity, we have to admit our imperfections of measuring all costs and benefits of these social-ecological system arising of use interactions. Thus, it is unlikely to achieve full Pareto-optimality. Also economically feasible management options are highly constraint by limited knowledge and uncontrollable resource variations (Wilson 1982: 417).[5]

Nevertheless, the investigation of **economic efficiency** is possible as so far as to compare incomes and expenditures of the distinct governance structures in East and West Germany carried out in different resource systems. For instance, this includes incomes such as angling permits, membership fees, or other financial sources on one hand and expenditures on the purchase of fishing rights, fish stocking measures, or other management instruments on the other hand. The monetary measure is often quite difficult. Thus, spending time hours or number of engaged people in resource management are important parameters as well. A further crucial point is the evaluation of transaction costs. For instance, it is to figure out how far information costs differ regarding the distinct governance structure, how high enforcement costs differ to monitor the compliance of rules in varying resource characteristics, or how high bargaining and decision costs of self-regulated GRF management differ on different organisational levels. Issues like these can only be measured by interviewing and surveying the perceptions of GRF managers on those issues.

The balance of income and expenditure and the appropriateness of transaction costs support the functioning of GRF management and can be seen as a precondition to achieve the other management objectives. It is assumed that, when management fails in economic issues, then the chances to solve social conflicts and maintain ecosystem services are comparative low.

[5] Therefore, Wilson suggest to understand efficiency “in this kind of environment … much more closely related to the adaptive, learning behaviour of individual economic actors than to the traditional notion of input cost minimization.” (Wilson 1982: 417)

Another evaluative criterion is the **social agreement** about the allocation of fish stock resources. This is to find out whether the distribution follows the maxim of equity (everybody has the same opportunity to use the resource), is there a redistribution process to support poorer people of the society, or is the goal to restrict the number of potential users in general. Furthermore, it is important to clarify whether the management is organized in a way that those who benefit from the resource use should bear the costs as well (and vice versa). For instance, this is crucial in the policy-decision process with other stakeholders of the resource. How do they deal with arising positive or negative externalities of the use of resource systems or units? It is important to achieve a social agreement between the resource users to support the maintenance of the resource. Otherwise, in extreme cases, social conflicts might cause oppositional reactions by anglers and non-compliance with management regulations to save from environmental degradation and economic inefficiency.

The criterion **maintenance of ecosystem services** means that managers should take into account that certain kind of human impact might destroy fish stocks or freshwater habitats which provide services within the ecological system and for the human use as well. This holistic view should be considered in resource management to maintain further functioning and use of ecosystem services.

The challenge for the governance structure is to find optimal solutions in trade-off situations such as on the one hand between the different evaluative criteria, e.g. the calculation of costs for fish stocking measures and the consideration of habitat requirements or on the other hand the opposed objectives of different interest groups regarding inland waters and fish resource use, e.g. water power plants block fish routes and hamper catch possibilities for anglers. The choice between different management alternatives can be facilitated by calculation of opportunity costs. If a GRF manager decides to stock non-endemic species because of limited financial resources and a high demand for fish stocking by anglers, he faces the risk that in the long run these non-endemic species will derogate the ecosystem in general and will cause lower angling satisfaction.

Crucial to get the adaptive cycle of natural resource management closed is to take in the **feedback** loops of the SES. Feedbacks refer to “the result of any behaviour which may reinforce (positive feedback) or modify (negative feedback) subsequent behaviour” (Berkes & Folke 1998: 6). That means managers and users of natural resources should develop the “ability to observe and interpret essential processes

and variables in ecosystem dynamics to develop the social capacity to respond to environmental feedback and change" (Folke et al. 2005: 445). Different authors have identified several feedback mechanism and principles of adaptive management to balance the social-ecological system in a sustainable manner (Folke et al. 2005; Almlöv & Hammer 2006; Lebel et al. 2006). These feedback mechanisms consist of monitoring tools, management evaluation, data collection on the status of fish stocks, knowledge building, learning processes, consideration of anglers' responses to management measures, utilisation of cost-benefit analyses as management tools etc. This social capacity consists of the following major matters: **learning**, meaning, knowledge, and experience of ecosystem dynamics. Considering the complexity and dynamics of SES agents of the governance structures need to realize that not single-species models or managing for control and stability help to sustain ecosystem services but knowledge and understanding of the whole system. This understanding should "be continuously updated and adjusted, and each management action viewed as an opportunity to further learn how to adapt to changing circumstances" (Folke et al. 2005: 447, Carpenter & Gunderson 2001). A rewarding step to attain comprehensive information about changes in SES is to combine local and scientific knowledge. And other research found out that besides gradual changes particularly rapid crises seem to activate learning and knowledge generation (Folke et al. 2005: 446, Olsson & Folke 2001).

Based on these learning processes and knowledge building the next step is the **adaptation** of resource management on the dynamics in SES. Adaptive management means that agents of the governance structure continually adjust rules in use on the unwanted outcome of previously implemented resource management measures. This might include the alignment of property rights or the cross-scale integration of institutions (Carpenter & Folke 2006: 311). Folke et al. (2005: 463-464) characterize this process as follows: "The sharing of management power and responsibility may involve multiple and often polycentric institutional and organizational linkages among user groups or communities, government agencies, and nongovernmental organizations… Adaptive co-management relies on the collaboration of a diverse set of stakeholders, operating at different levels through social networks. This aspect emphasizes the role of multilevel social networks to generate and transfer knowledge and develop social capital as well as legal, political, and financial support to ecosystem management initiatives." This definition makes it

possible to investigate renewable resource management regarding the major traits of adaptive governance.

In this adaptive management approach the concept of **resilience** is intended. Resilience is defined as the capacity of SES to absorb disturbances and to re-organize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks (Gunderson & Hollung 2002). Successful adaptive management is able to avert regime shifts in the social-ecological system, e.g. a change from oligotrophic to eutrophic nutrient content of waters which affects the fish population structure significantly. In respect to the context of this paper, we focus on institutional (or management) resilience which is defined as the degree to which agents of the governance structure, who are able to define and alter institutions of human resource use, can manage a social-ecological system for resilience including the capacity for learning and adaptation to maintain its functioning (Berkes et al. 2003; Carpenter & Folke 2006).

5. Connecting theory & framework – propositions for further studies

To guide upcoming required research about renewable resource management failure using institutional economic theories we provide four propositions on the outcomes of renewable resource management allowing for their dependency on governance structures and resource characteristics. It is assumed that distinct governance structures have different success in achieving economic efficiency, different potential to solve social conflicts and to maintain ecosystem services considering the different resource system characteristics, i.e. simple and complex resource systems. A similar approach is shown in Carpenter & Brock (2004) who point out that 'one-size-fits-all' management regulations erode ecological and social resilience in fisheries.

The following propositions comply with beforehand envisaged four branches of institutional economic theories and are illustrated by some pioneer studies in these areas. One starting point for an evaluation of renewable resource management is the characteristics of the resource. Fish stocks are embedded in rivers and lakes and their detailed formation within the landscape have major influence of success and failure of renewable resource management measures. This can be seen for example with complex water systems (e.g. lake-rich landscape with interlinked canals and river systems). Interconnected lakes and rivers make it easy for fish stocks to migrate. With increasing complexity it gets more difficult to observe angler and fish behaviour and to get information about the whole SES. Complex water systems increase the number of owners and interests groups utilizing the fish or water resources. Rarely a single stakeholder would own an entire river system. The opposite can be assumed for simple resource systems (e.g. ponds scattered widely on the landscape). Fish migration is hardly possible in ponds or lakes. Furthermore, single ownerships are more likely and the observation of anglers or fish stocks or the collection of information is probably much easier. Furthermore, as common pool resources, the use of fish stocks is highly competitive and it is difficult to exclude non-authorized users. These resource characteristics have direct consequences for management measures and (should have) on managers' decisions beforehand. For instance the search and information costs about the resource, the bargaining and decision costs in multiple stakeholder settings, the monitoring, implementation, and enforcement costs of e.g. bag limits and other management tools increase with the broadening of the resource system.

How does affect these resource characteristics local or regional organised governance structures, i.e. managers with fishing rights on local or regional level? The first proposition deals with the allocation of property rights as one fundamental theoretical assumption for success or failure in renewable resource management and use. The definition who is responsible for management, who takes decisions in resource management, and who is allowed to use fish resources in distinct water bodies should be implemented as clearly and powerful as possible. If this is not fulfilled and if property rights mismatches on spatial and temporal scale occur, ambiguity and conflict in resource use can take place (Yandle 2007). However, distinct governance structures might make a major difference in those cases. For example Almlöv & Hammer (2006) investigated diverse patterns of property rights in coastal fisheries management in Sweden and identified a scale-mismatch of both centralized governance structures and local property rights arrangements within the coastal ecosystem.

Proposition 1: property rights

- Governance structures with property rights on local level have a higher capability to manage for sustainability in simple resource systems than governance structures with property rights on regional or states level.
- Governance structures with property rights on regional or states level have a higher capability to manage for sustainability in complex resource systems than governance structures with property rights on local level.

The following graph visualizes this proposed relationship:

> Figure 3 here <

We assume that in governance structures where local managers hold the fishing rights are more sustainable in simple resource systems than governance structures on higher organisational level. Why we suppose this relationship is because of lower transaction costs arising in this scale ratio, a higher amount of social capital, and better capability to adapt on changes in the SES. These three theoretical assumptions are directly connected to the allocation of the property rights and will be explained in more detail in the discussion of the next three propositions.

The second propositions deals with the varying amount of transaction costs depending on governance alternatives in different resource characteristics. In detail we expect that search and information costs about the ecosystem and the resource use, the bargaining and decision costs within a low-level governance structure about management tools, and monitoring and implementation costs of management measures organised by low-level governance structures are lower in simple resource characteristics than in complex resource systems.

Proposition 2: Transaction costs

- Governance structures on local level have less management transactions costs in simple resource systems than governance structures on regional or states level.
- Governance structures on regional or states level have less management transaction costs in complex resource systems than governance structures on local level.

For example angling clubs holding fishing rights at local level might have low monitoring and enforcement costs (e.g. regarding access and use restrictions) in simple resource characteristics because of their proximity to the resource. Representatives and managers have shortest link to anglers and water bodies. Furthermore, simple resource systems are typically small and have usually very few stakeholders. A low quantity of varying interests decreases bargaining and decision costs in resource management. Managers might have to consider only local anglers expectations in this setting. Additionally, enclosed water bodies with small area might have lower search and information costs about fish stocks and other parts of the SES. The local knowledge about the resource might increase as well. In these resource systems the delegation of management responsibility to higher governance structures might be more costly than needed and even downgrade management success.

With increasing complexity of the resource system (e.g. major rivers, interconnected lakes, canal systems etc.) we assume that governance structures on higher level are more appropriate to decrease management transaction costs. Representing a higher number of anglers increase their power and influence in management decision processes, which are likely much challenging in complex resource systems because of manifold interests exist in water and fish stock use such as hydroelectric facilities,

water traffic companies, nature and animal protection projects etc. Furthermore, in complex resource systems the search and information costs about the resource (e.g. fish migration) might be much higher. However, high-level angling associations might be more effective with regards to fish stocking measures because of the large amount of financial resources available (more members who pay for angling licenses and permissions), the consideration of wide ranging ecosystem characteristics and the recruitment of specialists in fish ecology and resource use. For governance structures on higher organisational level it might be much easier to administrate and use that information collected from local entities. Moreover, in complex resource systems the area to monitor resource use and enforce e.g. access regulations is larger as well. Governance structures on higher organisational level might have better facilities to manage in those wider spatial scales than agents of local level governance structures such as angling clubs with local fishing rights. An insightful case study about management transaction costs arising from different organisational levels provide Salmi et al. (2008). However, they came to the result that participation processes between high and low governance levels decrease both bargaining and decision costs, and information and monitoring costs.

The influence of governance structures and resource characteristics on the amount of trust, cooperation, information exchange existing in one SES is assumed as follows: low-level governance structures such as angling clubs draw on higher amounts of social capital in simple resource systems than high-level governance structures.

Proposition 3: Social capital

- Governance structures on local level are more successful in developing social capital in the management of simple resource systems than governance structures on regional or states level.
- Governance structures on regional or states level are more successful in developing social capital in the management of complex resource systems than governance structures on local level.

Angling club managers are closer to the anglers and this might support quantity and quality of communication. This and long-term acquaintance with the anglers community (who most likely elect long-term members as representatives) might

increase trust, and steady information exchange between anglers and managers. Furthermore, this might be directly connected with a high level of shared norms in resource use and cheating on management regulations and other opportunistic behaviour might be less possible. This again might decrease considerably the amount of information, monitoring, and enforcement costs in fish resource management.

In complex resource system the requirements on the governance structures to match wider spatial scales in fish resource management increase. For instance in policy decision process on higher organisational scale about water and fish stock resource use angling clubs might be not involved or overchallenged considering manifold stakeholder interests. This is also assumed for other management measures such as access and use restrictions and fish stocking measures. In complex resource systems it is much less likely to get to know all anglers and all other stakeholders on water and fish resources. Mutual information, steady communication and consequently interpersonal trust might occur less often than in simple resource systems. Angling associations with management responsibility (i.e. agents of the governance structure) might have both stronger influence on high-level policy decision processes and more appropriate management measures on wider spatial scale. As spokesmen of many anglers they might develop easier social capital with representatives of state authorities or other interest groups. Furthermore, they might be more efficient in coordination and cooperation of fish resource management in complex resource systems because of their multiplexed information about wider spatial resource scales collected by local entities. Nagothu (2007) shows an interesting case study in this area. He investigated established norms and rules in respect to bonding social capital in different local fishing groups in Chilika Lake, India. He found out that within the local fishing communities a high amount of social capital keep the fishers together in times of resource scarcity and controlling of rule violations and overall strengthening of community fisheries management. In contrast, top-down management mechanisms from external fishery authorities increased conflicts in this rather delimited resource system.

The fourth proposition condenses the before delineated assumptions into institutional change theory. Institutional change or also here referred to as adaptation to change might have various reasons. Among them there are for example transaction costs, inefficient property rights, technological or market changes. As described on the

earlier pages governance structures and resource systems have probably a major impact on SES management and might cause crucial management failure. Insufficiency in this regard might lead to conscious changes in management regulations and implementation (institutions). However, there is also slightly mutual adaptation between the ecological and economic system and we assume that low-level governance structures, with competent fishing rights on local level, might adapt easier to changes in the SES in simple resource systems than governance structures on regional or states level. In those settings transaction costs are likely reasonable low and are even more reduced through high levels of social capital. Therefore, resource and user monitoring, and information gathering might be much easier and support learning and feedback mechanism in fish stock management and lead to mutual adaptation processes in the SES.

Proposition 4: Institutional change

- Governance structures on local level are more likely to adapt to changes in the SES in simple resource systems than governance structures on regional or states level.
- Governance structures on regional or states level are more likely to adapt to changes in the SES in complex resource systems than governance structures on local level.

On the other hand changes in resource management on wider spatial scale might be easier conducted by high-level governance structures because of their better capability to influence high-level policy decisions with other water and fish resource stakeholders. Crucial in both settings is the match of the level of management with the appropriate spatial resource scale (Carpenter & Brock 2004; Folke et al. 2007).
However, if one is following these assumptions it will be kept in mind that the opposite can take place as well. High-level governance structures in simple resource systems may achieve sustainable management by implementing and using a more local management setting to reduce e.g. information costs. On the other hand, low-level governance structures in complex resource systems may use additional management tools on the higher (regional or states) level to gain more influence in policy-decision processes or for the management requirements of complex resource systems (cp. Salmi et al. 2008).

6. Conclusions

By responding to the widely ascertained endangered functioning of renewable resource systems in general and fish resources in detail we proposed a framework to analyze management malfunction. This framework consists of the major components of social-ecological systems such as the institutional environment, governance structure, resource user, and biophysical world, resource system and resource unit. The interplay between these components is exemplified by recreational fisheries and explained by institutional economic theories. These theories based on property rights, transaction costs, social capital, and institutional change provide reasons for potential renewable resource management failure but also success.

We assume that high-level governance structures (e.g. angling associations with property rights on regional or states' level) are likely more able to establish a sustainable management approach in complex resource settings than low-level governance structures (e.g. local angling clubs with full property rights on local level). However, low-level governance structure might have a better capability to manage for sustainability in simple resource systems. Both proposed relations are based on theories of institutional economics. Their potential to identify reasons for success and failure of possible short- and long term adaptation strategies of the agents of the governance structure are directly associated with the matter of management and resource scale match. Summarizing the last section, delineating the four research propositions, we expect that high-level governance structures match better with complex resource systems on wider spatial scale and low-level governance structures match better with simple resource systems on narrower spatial scale (Folke et al. 2007). Both alternatives might be able to decrease transaction costs, to increase social capital, and to adapt more suitable on changes in the SES in their appropriate spatial scale ratio.

However, as long as insights from institutional economics are not considered to a greater degree in renewable resource management research we just won't know and a powerful tool for evaluating management failure and consequently finding new ways for improving ecosystem health, maintaining further resource use, and solving social problems of resource users is leaved unexploited.

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Table legend

1.	Number of users
2.	Socioeconomic attributes of users
3.	History of use
4.	Location
5.	Leadership/entrepreneurship
6.	Norms/social capital
7.	Knowledge of SES/mental models
8.	Dependence on resource
9.	Technology

Source: Ostrom (2007)

Table 1: Second-tier variables analyzing users in a SES (Ostrom 2007)

1.	Mobility
2.	Growth or replacement rate
3.	Interaction among resource unit
4.	Economic value
5.	Size
6.	Distinctive markings
7.	Spatial & temporal distribution

Source: Ostrom (2007)

Table 2: Second-tier variables for analyzing resource units in a SES (Ostrom 2007)

Figure legend

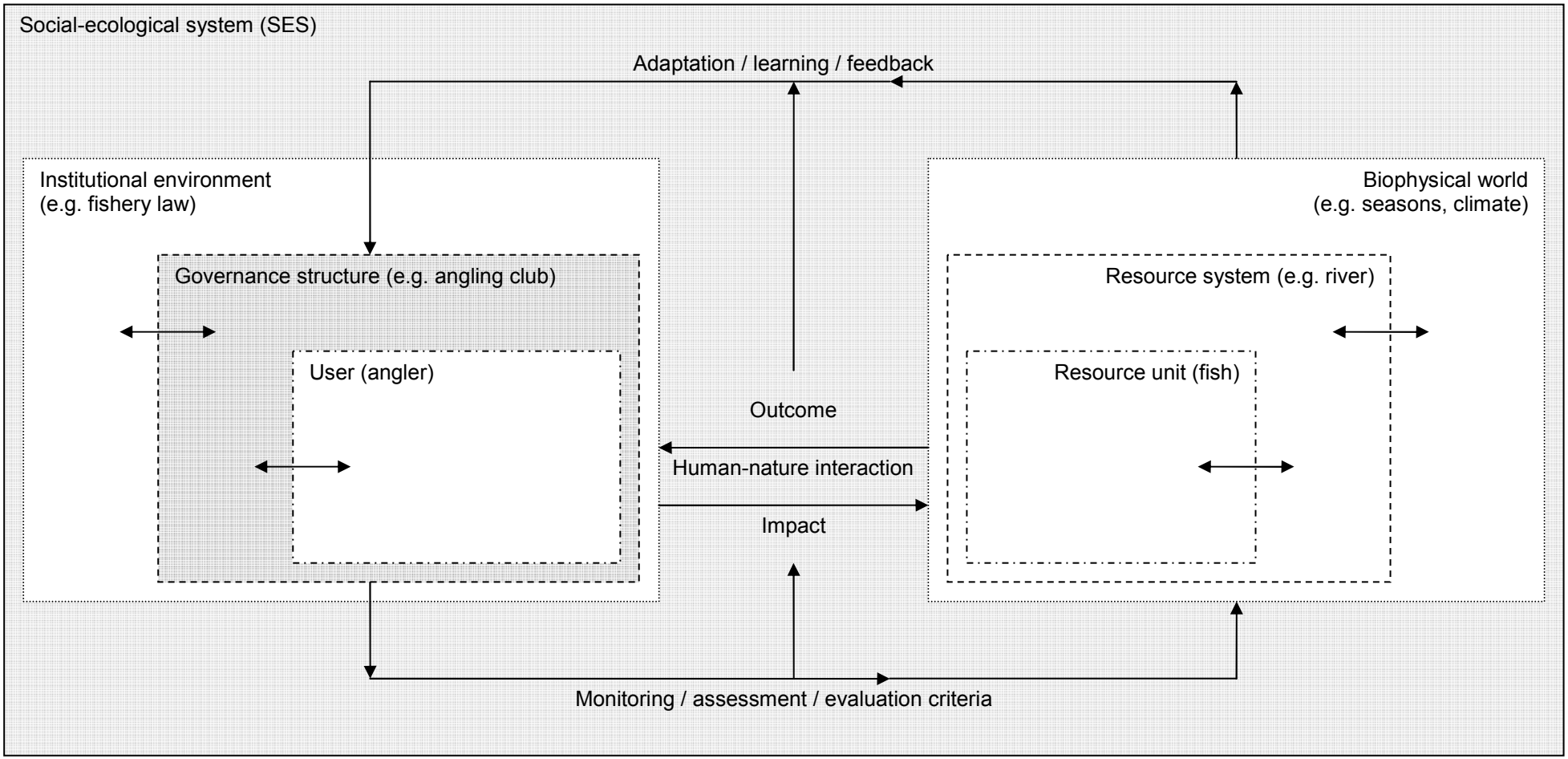

Figure 1: Adaptive management cycle in the recreational fishery social-ecological system (based on Ostrom 2005, 2007)

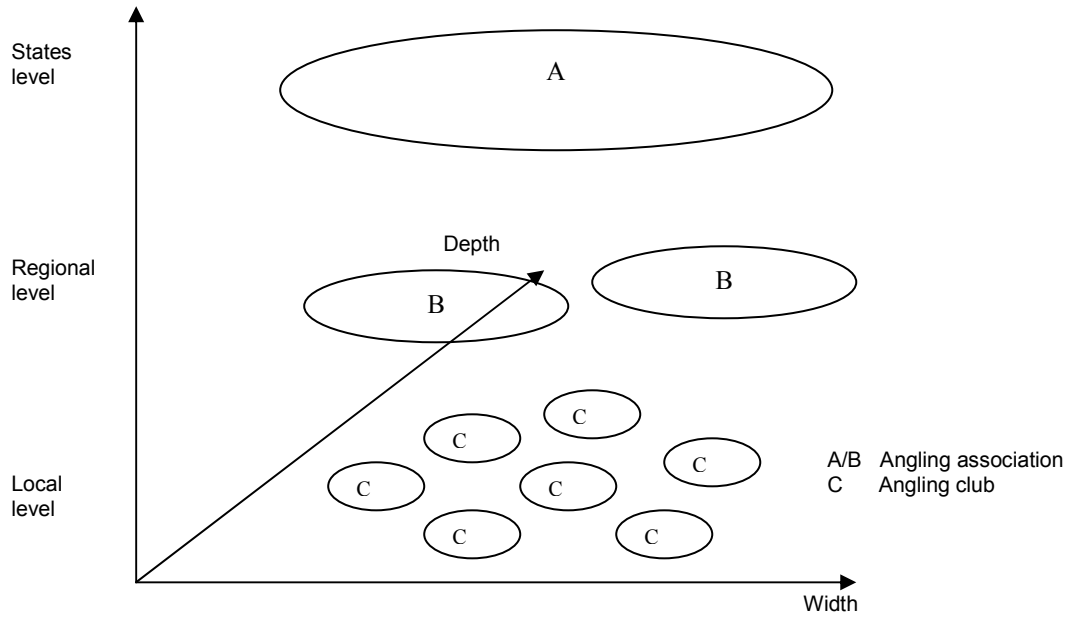

Figure 2: Potential structural alternatives of governing agents in recreational fisheries

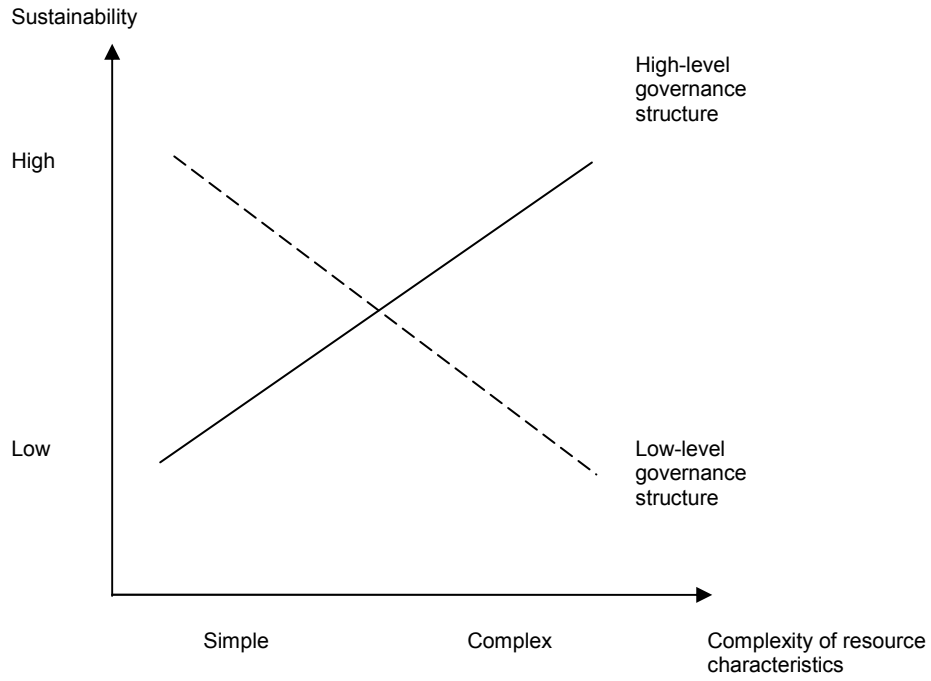

Figure 3: Capacity of distinct governance structures to manage for sustainability in varying resource characteristics