FISHING ACCORDS:
THE POLITICAL ECOLOGY OF FISHING INTENSIFICATION IN THE AMAZON

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This study addresses human responses to environmental change. In particular, it analyzes fishing accords, a recent local fishing management instrument created by the floodplain populations in the Amazon. The dissertation identifies the major factors related to the emergence, maintenance, and performance of the fishing accords in order to examine the incentives to create this local management system, and its potential ecological outcomes. Data were obtained by combining secondary data from local publications, and primary data from community census and extensive fieldwork between 1991 and 1997 including interviews, participant observation, and structured questionnaires on household socioeconomy and fishing production. A regional analysis of the fishing accords in ecological, historical, socioeconomic, and institutional contexts highlights the major factors influencing its emergence and maintenance. Then, a community-based analysis of two cases of fishing accords evaluates the variability of performance between the two communities. Finally, a summary of the theoretical findings is presented that relate fishing accords to floodplain co-management for the Lower Amazon. The findings reveal the importance of human agency in the performance of local management systems. The heterogeneity of ecological opportunities and local social organization present in floodplain communities creates diverse incentives to individuals to participate in this collective endeavor. The study finds that fishing accords can improve the ecological system when the local population is able to control local decisions, can solve internal conflicts, has access to other resources, and when the ecosystem can be managed by local rules. Therefore, fishing accords are not a panacea to improve fishing productivity or provide fish conservation. Rather, formal recognition of those institutions should rely upon an evaluation of the social features of the population as well as of the ecological features of the system to be managed in order to determine the degree of fit.

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AMAZONIAN FISHERIES AND THE THEORY OF COMMON-POOL RESOURCES

1.1. INTRODUCTION

This study focuses on the local management of fishing in the Lower Amazonian floodplain. The theoretical approach is drawn from a vast array of literature dealing with common-pool resources in which the exploitation by a given user directly affects the availability to other users who are difficult to exclude. In recent decades, the theory of common-pool resources (CPRs) has integrated ecological, historical, socioeconomic, and political factors. Such interdisciplinary endeavors have enabled scholars to identify different incentives that individuals face when they decide whether or not to join a collective action to manage CPRs.

The tremendous number of case studies describing how people deal with common-pool resources reveals that outcomes of the CPR dilemma are diverse. Groups of people facing relatively similar external factors influencing their decisions may have distinct responses according to the local structure of the system. Therefore, the analysis of factors at different levels – such as individual, household, community, and regional – helps to answer why there is so much variation in the performance of groups dealing with common-pool resources.

This dissertation explores the ecological and social factors that define the limits and opportunities in the development of local institutions related to resource management. In particular, I focus my analysis on the fishing accords, a type of fishing management that emerged in the late 1960s and has become increasingly pervasive in the

Amazon Basin. Fishing accords imply a commitment of members of floodplain communities to manage lake systems collectively, through informal rules written in a document format. The recent interest of the Brazilian government in recognizing this new management device as a way to build a collaborative management system raises questions about the evolution of fishing accords, and the possible outcomes of this local institution.

The goal of this dissertation is to identify the major factors related to the origin, maintenance, and outcomes of the local management of fishing in order to evaluate its strengths and weaknesses in an integrated co-management system with the national government. The working hypothesis for this analysis is that groups influenced by relatively similar, larger-scale external factors will respond differently according to the ecological and social structures of opportunities and constraints defined at the local level. In other words, the ecological and social heterogeneity of the floodplain system can generate a range of incentives, which affect the establishment, maintenance, and performance of local management arrangements.

This introductory chapter is divided into six sections. The first section presents the social context of the Amazonian floodplain in which the fishing accords have emerged. In the second section, I describe the fishing problems in the Amazon which have resulted from the rapid socioeconomic changes in the floodplain. The third section lays out the evolution of the theory of common-pool resources, focusing on the fish resources. The fourth section discusses the theoretical approaches used in fisheries management. The fifth section presents the theoretical framework used to carry out an integrated analysis of local management fishing in the Lower Amazon. Finally, the chapter closes with a section describing the structure of the dissertation.

1.2. HUMAN POPULATIONS AND THE USE OF NATURAL RESOURCES IN THE AMAZON

Amazonian populations have experienced a number of social changes throughout their history. Since the European colonization process, several economic cycles based on natural resources – such as forest drugs, cocoa, rubber, jute, gold mining, timbering, cattle ranching, and fishing – have taken place in the Amazon Basin. In each cycle, the pattern of resource appropriation emerged according to specific social and ecological contexts in which the production system was established. In this process, external factors such as the international markets, governmental policy, new technologies, and immigration were as influential as local factors such as the ecological distribution and abundance of resources, local knowledge, and household and community organization. In other words, each cycle has been part of a historical process in which a complex set of factors has defined actors, products, and forms of production.

Scholars interested in understanding the relationship between human populations and natural resources use in the Amazon have followed two main approaches, according to the type of human population concerned. On the one hand, cultural ecology has been used to explain how local factors have affected the adaptive process toward sustainable use of natural resources by native populations (e.g. Smith 1981, Hames and Vickers 1983, Posey and Balee 1989; Neves 1991, Redford and Padoch 1992). On the other hand, political economy has been used to explain how external factors have led to the non-adaptive process of unsustainable use of forest by settlers (Mahar 1979, Moran 1981, Bunker 1985, Hecht and Cockburn 1989, Schmink and Wood 1992). This dichotomy reflects the different circumstances in which native population and settlers emerged in the Amazon. Despite their interconnected economic, social, and political bonds, each group faces distinct incentives according to the ecological and social context where they live.

Settlers are immigrant farmers, located on the uplands, who arrived from the southern and northeastern part of Brazil during the twentieth century, mostly after the 1970s. They were attracted by government-sponsored development projects carried out along the roads, such as the BR-153 (Belém-Brasília), BR-230 (Transamazon), and BR-364 (Brasília-Porto Velho) on the uplands (Moran 1983). Resource use in those areas has been mainly influenced by such large-scale incentives as maintenance of national sovereignty, and the alleviation of land conflict in other regions (Schmink and Wood 1987).

Native populations, on the other hand, encompass two main human types — indigenous and *caboclos* — whose strategies of resource use have been strongly influenced by local factors, such as the distribution and abundance of resources and local social organization. The indigenous populations are the most ancient native group and, according to Roosevelt (1989), have occupied the Amazon for about 12,000 years. They suffered from the epidemiological impact during the colonization period, which led a population of approximately 6,000,000 inhabitants distributed in thousands of groups to drop to the current figure of 236,000 inhabitants distributed in 506 communities (CEDI 1991).

The *caboclos* represent the contemporaneous native peasant population who emerged during the colonization process as a result of miscegenation of indigenous with Europeans during the eighteenth and nineteenth centuries, and later with African

Brazilians in the late nineteenth and twentieth centuries (Moran 1974). The *caboclo* populations live mostly along the riverbanks. Their intermediary social position between the "traditional" indigenous population and the "modern-prone" settlers has made them relatively invisible in regard to governmental policies (Parker 1985a).

Despite social invisibility and constant exposure to external and local factors, the *caboclos* have been socially resilient due to three major features: 1) the refined ecological knowledge inherited from their indigenous ancestors, 2) the maintenance of a subsistence production system even during boom periods of intensive commercial activity, and 3) a cohesive social organization based on strong kinship ties among households. Their mixed inheritance has given them conditions to develop flexible strategies of survivorship and to better resist rapid social changes in the Amazon Basin, such as during the rubber boom (Schmink 1985) and during the colonization projects (Moran 1981). Recently, two external factors have strengthened the social resilience of the *caboclo* populations. First, between the 1960s and 1980s, the Catholic Church, through Liberation Theology, provided the local population with information to organize politically and to resist external political forces. Second, environmental movements increased during the 1980s and influenced the development projects to account for local practices of resource use, and to focus on the enhancement of self-reliance and local welfare as a way to achieve conservation (Cernea 1985). As the international media turned to the local population, land conflicts, which had been commonplace in the Amazon since the 1960s, were finally exposed, thus shifting the picture of local populations from forest destroyers to forest stewards (Allegretti 1990, Schmink and Wood 1992, Almeida 1995).

By incorporating conservationist discourse into their speech, the *caboclo* populations found a new form of power, which enabled them to fight against strong political forces (Schmink and Wood 1992). This strategy has been essential to maintaining their access and — at some level — their control over the natural resources. In the uplands, rubber tappers' movement of resistance defeated logging companies and gave the rise to the National Council of Rubber Tappers (Allegretti 1990). In the floodplain, policymakers and scientists started to develop strategies for the establishment of conservation units in which local residents are not only allowed to remain in the area but also invited to participate in the management plan (Mamirauá 1996).

The participatory management projects assume that the integration of a local management system is likely to achieve more compatibility between the ecological and social system. This is the case of the fishing accords, a new type of local management of fishing by the *caboclo* populations that emerged in the 1960s and that has increasingly spread in the floodplain. Fishing accords are written documents formulated by the floodplain communities which define rules regarding fishing and, to a lesser extent, the use of other floodplain resources. Despite basic structural similarities, fishing accords differ in their arrangement and performance. The arrangement may address only fishing carried out by non-resident fishers or may also address problems related to fishing carried out by residents. In regard to performance, the fishing accord may be able to increase the ecological productivity of the lake or simply to exclude non-residents from the lake with no direct ecologically positive outcome.

The differences in arrangement and performance are directly related to factors that define the opportunities and constraints, at both community and regional levels. Therefore, the fishing accords represent a response by the *caboclo* populations that challenges the theoretical explanation of adaptation — or mal-adaptation — based on the dichotomy of local versus external factors. The accords are examples of a complex adaptation process, in which ecological features of the system, ecological knowledge, and local social organization play as important roles as the external market, national policies, and support from international donors. Consequently, the performance of this local institution may vary according to the motives that drive the local population to establish it as well as the congruence of the rules with the local system.

The analysis of fishing depletion in the Amazon has been dominated by the political economy approach which has mainly addressed the importance of external factors constraining a local population's decisions (Smith 1985, Chapman 1989, Freeman 1995). Yet, they have overlooked the variability of responses according to local differences, an issue strongly addressed by cultural ecology. Local populations may suffer similar pressures from external systems, but differences in individual perceptions, ability to organize, and ecological characteristics of the system may trigger different patterns of response regarding the use of resources. The local management of fishing in the floodplain is a case in point. Fishing accords emerged in many parts of the Amazon as part of the regional history of social change, involving long-standing social relationships among different actors. Yet, the heterogeneity of the local ecological and social factors set the stage for the wide variety of incentives for and performances of fishing accords. Therefore, the study of the local management of the fishing activity in the Amazon demands an integrative analysis of both the regional and local context in which fishing accords take place in order to better understand the dynamic behind such a local strategy of resource use. In the next section, I will present the regional context in which fishing accords have emerged in order to raise certain questions about the variability of local responses.

1.3. THE "FISHING PROBLEM" IN THE AMAZONIAN FLOODPLAIN

The *caboclo* populations have drifted back and forth between the upland and floodplain systems over their history, depending on the economic importance of those two systems (Table 1.1). The jute boom in the 1930s attracted the population back to the floodplain by filling the economic hiatus left by the collapse of latex production on the uplands in the early 1900s. Jute production peaked in the mid-1960s, when it started to drop due to its price crash in the international market (Gentil 1988). Meanwhile, the military government launched development projects (Program of National Integration) on the uplands as part of a strategy to promote human occupation in the Amazon. During that period, land titles were allocated to immigrant settlers, with no accountability to the native population (e.g., *caboclos*) (Moran 1981). Similarly, fisheries development programs supported mainly large-scale, high technology, export-oriented ventures (Shoenenberg 1994, Isaac s/d), while native populations were ignored due to their lack of political and economic power.

The increasing demand for fish, and the improvement of fishing-related technology, created conditions for a new economic niche in the floodplain to fulfill the gap left by the jute economic bust. Lake fishing became economically attractive for floodplain residents as well as non-residents, both of whom carried out commercial fishing on a relatively larger scale (McGrath et al. 1993a). By the late 1960s, fishing started to become a major economic activity in the floodplain. Due to its low opportunity cost, fishing was a "labor sponge" which attracted different groups, such as unsuccessful upland smallholders, and jobless people from the urban centers, leading to the encroachment on floodplain lakes (Chapman 1989). The government took over the formal role of fishing regulations in the floodplain, which has been a state property since 1934, through the creation of SUDEPE[1] in 1962. The process of fishing intensification and the change in the fishing policy supported the arrival of new commercial fishers and weakened the former local management system.

Table 1.1. Table 1.1. Major commercial-oriented resources exploited by the native population in the Amazon after European colonization.

Year	Period	Ecological System	Main Resource
1621 - 1757	Missions	Upland	Forest Drugs
1757 - 1799	Dictorate	Upland	Forest Drugs
1799 - 1867	Floodplain Reoccupation	Upland	Forest Drugs
		Floodplain	Cocoa
1867 - 1911	Rubber Boom	Upland	Rubber, Brazil Nut
1930s - 1970s	Jute Boom	Floodplain	Jute
1960 until now	Road Building Projects	Upland	Crops, Timber, Cattle
		Floodplain	Cattle, Fish

The new picture set the stage for constant confrontations between the local residents and non-residents (Goulding 1983, Hartmann 1989, McGrath et al. 1993a, Furtado 1993a). The entrance of motor boats in lakes surrounded by local communities raised hostile feelings from residents toward non-residents, which gave rise to the first cases of fishing conflicts.[2] The first fishing conflicts during this period did not reach the

[1] SUDEPE – Agency for the Development of Fisheries (Superintêndencia de Desenvolvimento da Pesca).

[2] Until the fishing intensification, fishing conflicts were relatively rare and took place in particular circumstances. Only two major regional conflicts were reported in the past in the newspaper. In 1921, floodplain residents in Santarém engaged in a physical conflict over an accusation related to turtle fishing

newspaper until a decade later. In 1973, the "fish war," which took place on Janauacá Lake, in the Middle Amazon, was a confrontation between local residents and non-resident commercial fishers, and led to the destruction of gear and boats, and to the death of a number of people (Salati 1983). Fishing conflicts in the Lower Amazon have similarly been described by Hartmann (1989) who presents the case of Lake Grande in Monte Alegre, located between the cities of Santarém and Monte Alegre. The author explains that the worsening of that conflict, which got to the stage of deadly confrontation between residents and non-resident fishers, was one of the major factors that drove the government to create a decree in 1990, limiting lake access to the residents.

Several local populations adopted the strategy of fishing accords to rescue their control over the lakes. Despite their illegal status, the fishing accords have spread throughout the Amazon Basin and have become a de facto ruling system based on the concept of collective property (McGrath et al. 1993b). The establishment of fishing accords aggravated the tension between residents and non-resident fishers and caught the attention of both governmental and non-governmental agencies in the late 1980s. In addition to the political agenda of alleviating local conflicts, the conservation movements increased the political demand for a fisheries management that was ecologically and socially sound. Several agencies engaged in the endeavor to develop a model of fisheries co-management by integrating the local management of the floodplain into the broader management plan for the whole Basin developed by the government (IBAMA 1995, McGrath 1995).

(A Cidade, 22/10/21). In 1922, a fisher's raid (*Motim dos Pescadores*) took place in Santarém to expel Portuguese fishers from the town (Santos 1984).

Research programs have used the fishing accords as a link to develop a participatory management plan. In the Middle Solimões, the Mamirauá Project is testing a zoning model that recommends the rotation of the use of lakes based on local decisions for a Sustainable Management Reserve (Lima-Ayres 1994). The Várzea Project in the Lower Amazon is developing a program to establish a Lake Reserve, based upon the integrated use of floodplain resources defined at the local level (McGrath 1995). Governmental agencies have shown interest in supporting fishing accords as well. In 1996, the national agency in charge of monitoring the use of natural resources, IBAMA,[3] promoted a series of meetings with researchers and fishing-related organizations in Manaus (Middle Amazon) to discuss strategies for providing legal support to fishing accords in the region. In 1997, the regional chapter of IBAMA in Santarém (Lower Amazon) launched a program of partnership with a group of communities; this move represents the first case of legal support to the fishing accords in the Lower Amazon (Isaac et al. 1997).

Thus, the fishing accords are becoming the basic institutional unit upon which the co-management system is expected to be built (Hartmann 1991, McGrath et al. 1993a, 1994, Isaac et al. 1997). The interest of the government in supporting the fishing accords is a major step forward in regard to natural resource policy in the region for at least three reasons. First, fishing accords have the potential to increase fishing productivity in lakes (Castro 1995). Second, local monitoring systems represent an efficient solution to the current under-monitored condition of the floodplain system, due to the extension and

[3] Brazilian Institute for Renewable Natural Resources and the Environment – Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis.

isolation of the region with understaffed, under-budgeted offices (McGrath et al. 1999). Third, the establishment of local control over the system represents social justice for a population who has historically depended (and still does) upon floodplain resources for their livelihood (McGrath et al. 1993b).

Although fishing accords represent an important local institution, they take place in a heterogeneous ecological system (floodplain) where multiple use of CPRs is carried out by actors with different interests and socioeconomic characteristics. Moreover, fishing accords are embedded in a social structure that involves other forms of local practices which may affect the performance of such an institution. The variability of local conditions has affected the incentives for and outcomes of fishing accords. Therefore, before any attempt is made to extend the fishing accord concept to a co-management system, it is fundamental to identify the ecological and social factors at local and regional levels that affect the origin, maintenance, and outcome of such an institution. In order to identify those factors, an integrative theory to analyze the fishing accord is needed.

Below, I discuss briefly the theory of common-pool resources (CPR) in general and the approaches on fisheries management as a CPR in particular, in order to develop a framework for the analysis of the local management of fishing in the Lower Amazon.

1.4. THE THEORY OF COMMON-POOL RESOURCES

Building a theory of common-pool resources has been an interdisciplinary endeavor due to the ecological and social aspects of the decision-making process regarding the patterns of appropriation of CPRs. The development of CPR theory can be divided into three major phases that I will call henceforth "the tragedy of the commons" approach, the local management approach, and the co-management approach.

The first phase is marked by the acknowledgement of the relationship between resource depletion and the form of appropriation. A seminal discussion on appropriation of CPRs began among fisheries scientists, who introduced the question of the "commons" by discussing the condition of open access to oceans to explain the increasing depletion of maritime fish resources (Gordon 1954, Scott 1955). Hardin (1968) later developed a general model that explains the logic behind resource overexploitation. According to Hardin, the "lack of property" creates incentives for users to race to use up a resource. Users intensify their investment in resource exploitation, since each unit retrieved from the system represents an individual gain to a given user while the exploitation cost is dissipated among all the users. This process leads to what Hardin called "the tragedy of the commons," in which economic (rent dissipation and overcapitalization) and ecological (overexploitation) inefficiencies lead to ecological destruction and social ruin. Hardin's conclusion was that resources could be used at the sustainable level only under state or private property regimes.

Hardin's model was important in explaining the process of ecological destruction under the "lack of property," but it failed to address the social dynamics of users in dealing with the "commons" dilemma. Assumptions regarding the social structure held in the model of "the tragedy of the commons," such as that users are homogeneous and profit maximizers, failed to recognize the individuals' ability to build a social arrangement of resource appropriation (Feeny et al. 1990, 1996). It was not until Cyriacy-Wantrup and Bishop's article on the concept of common property (1975) that the model of "the tragedy of the commons" was consistently contested. The authors argued that human populations were able to engage in collective action to establish collective property regimes. This argument was not only important to recognize other types of property regimes, but also to focus attention on the fact that, in many cases, the so-called "open access" systems were actually held under collective property regimes. Collective property regimes encompass a set of rules defining access and use of a resource or system by an eligible group of individuals. The recognition of this fourth property regime overlooked in Hardin's model was the starting point of the second phase of the "commons" debate.

Social scientists led this phase by examining the relationship between resource use and resource appropriation within a local ecological and social context. Those studies were based on the cultural ecology approach, which tries to explain a regular pattern of behaviors that result from a process of adaptation to cope with ecological factors (Steward 1955). According to this model, the social condition of human beings permits individuals to optimize their behavior in regard to resource use through the rearrangement of social interactions (McCay 1981a). In other words, human beings can respond to ecological factors at different levels – e.g., individual, household and community. The appropriation of natural resources is a case in point.

In general, individuals or populations who co-occupy an ecosystem explore a limited range of resources and conditions (ecological niche). This resource partitioning is part of an evolutionary process in which individuals accommodate their needs by adopting less costly strategies, which help them to avoid competition (Pianka 1983). When resource use greatly overlaps, it can trigger competitive behavior in the parties involved. If the resource is highly ranked by the users, territorial behavior and partitioning may be adopted to avoid competition and ensure access to the resource. Since territorial defense is costly, it tends to take place when the benefit is high enough to provide positive net return (Brown 1964). Thus, the adoption of territorial behavior depends on ecological features of the resource that influence the value of return as well as the ability of the appropriators to defend against competitors.

Human territoriality can take place at the individual or group (population) level. Thus, although there is a fundamental social distinction between individual (private property) and group (communal property) territoriality (Cyriacy-Wantrup and Bishop 1975), both are based on similar ecological mechanisms: the value of the resource and the cost of defense. This pattern was clearly presented in the ground-breaking study by Netting (1976), comparing private and collective properties in the Swiss Alps. The author used the economic defensibility model to show how ecological and economic attributes of the ecosystem influence the cost/benefit balance to define the social organization of human territoriality.

Netting's study was followed by a massive number of empirical studies published in the 1980s, which provided strong ethnographic evidence of collective property systems across different ecological settings and cultural backgrounds (Martin 1989, 1992, Hess 1996). According to those studies, local institutions dealing with CPR dilemmas are mainly built upon local ecological knowledge and local social norms (Ruddle and Akimishi 1984, Ruddle and Johannes 1985, McCay and Acheson 1987a, Berkes 1989).

The "local management" approach to the commons made a shift in the theoretical perspective by annulling three major assumptions in the former model. Contrary to "the tragedy of the commons" model, this new model assumes that users are not isolated individuals, but potentially belong to groups that are able to develop local institutions to control access to and use of resources (McCay and Acheson 1987b, Ostrom 1990). Similarly, it assumes that resource depletion is not an unavoidable outcome path that resource users take. As shown in multiple case studies, local populations are able to construct ecologically sound mechanisms to avoid resource depletion. In fact, in most cases, overexploitation is a consequence of external factors such as market pressure, governmental policies, and loss of local control, which destroy long-standing, efficient local institutions (Berkes 1985, McCay and Acheson 1987a, Bailey and Zerner 1992, Gadgil et al. 1998). Finally, the model clarified the distinction between type of goods and type of property regime. As Ostrom (1998) explains, the misuse of the expression "common property" to refer to both type of goods and open access helped to create a confusion that goods that are difficult to exclude users from are fated to lack a property system (open access). Instead, the term "common-pool resource" has been proposed to replace "common property resource" in order to define a set of resources from which it is costly to exclude potential users (difficulty of excludability), and whose use by one individual affects the availability to other users (subtractability) (Ostrom and Ostrom 1977). Hence, common-pool resources (CPRs) represent a particularly puzzling set of resources in regard to their appropriation, but do not necessarily represent resources under open access regimes.

The proponents of the "local management" approach have not only contributed to the understanding of the relationship between local populations and resource use but also to challenging the dominant state- and private-oriented views used in conservation studies. Key terms such as "community-based management" and "co-management" are now commonplace in development projects, whose goals recognize the need for the devolution of control of resources to local populations in order to achieve both ecological conservation and social justice (Cernea 1991). Although this change has been an accomplishment, it also represents a concern regarding the success of such an enterprise. The efficiency of a local management system should not be taken for granted. It depends on a set of factors that are embedded in the social relationship at the local and regional levels (Roper et al. 1997). The ability of local management to respond efficiently to broader influences and, therefore, to successfully integrate into a broader institutional arrangement has been treated in the co-management approach to the commons in the 1990s.

The volume edited by Pinkerton (1989a) on cooperative management of North Pacific Salmon fisheries represents a benchmark in the co-management approach to the commons. It recognizes that local management systems represent a strong potential to conserve natural resources; yet, it also recognizes that the development of a co-management system involves multiple resource use and participation of different user groups in complex political arenas. Therefore, although it takes into account the role of local management in resource conservation, the co-management approach to the commons also recognizes that collective action requires the provision of certain incentives to the user groups (Ostrom 1990). This approach touches on issues related to policy, such as organizational structure (McCay and Jentoff 1998, Gibson and Koontz 1998), the relationship between the local population and the bureaucratic system (McCay 1988, Ascher 1995), the ability of the local arrangement to cope with external pressures (Ostrom 1999), the process of integration of different actors in the arrangement

(Pinkerton 1992), and the level of collaboration of local institutions (McCay and Jentoft 1996).

The three approaches to the commons mentioned above have been used in fisheries management, whose system has been a major stage for the development of the theory of common-pool resources. The next section describes how policymakers and scientists approach fisheries management systems in light of CPR theory.

1.5. THEORETICAL APPROACHES TO FISHERIES MANAGEMENT

Fishing systems are one of the most puzzling CPRs because fish are highly mobile, have a low degree of visibility, and are strongly influenced by physical characteristics of the aquatic system. Three major approaches to fisheries management vary according to broader theoretical assumptions related to the appropriation of common-pool resources: 1) scientific management, based upon biological attributes of the resource carried out at a large geographical scale; 2) local management, based on an integrated view of the social and ecological system, limited to small geographic areas; and 3) co-management, based on a combination of scientific and local management systems. The different assumptions affect how productivity is measured, how fishing efforts are controlled, and how decisions are made. I discuss below each approach in more detail.

1.5.1. Scientific Management

Scientific management of fisheries is mainly structured by government agencies whose decisions are based on biological information about the resource. This approach emphasizes the difficulty of excluding users from a fisheries system, and policies are focused on the remedies to the "open access condition" of the fish resource. In this regard, scientific management of fisheries aims to control fishing efforts according to the assessment of the fish stock.

Although other models existed earlier, it was Schaefer (1957), based on Gordon (1954) and Scott (1955), who provided the seminal model that opened the path to bioeconomic models (Larkin 1978). Schaefer's model is based on the logistic function that describes the growth rate of a fish population according to the population size (density-dependent model). Considering that, the sustainable yield function describes the curve that represents the amount harvested, which corresponds to the surplus population which affects the population growth rate. Consequently, the Maximum Sustainable Yield (MSY) curve is the set of points which yields the highest catch with the lowest effort. This curve can vary when other variables such as fishing price can affect the fishing effort (MEY - Maximum Economic Yield) (Copes, 1981).

The Schaefer model has become very popular in fisheries agencies because it provides a policy strategy. It tells what should be tracked: the fishing effort. Second, it provides a method for optimization: find the MSY curve (or MEY) in order to determine the optimum fishing effort. Based on the stock assessments, governmental agents define methods to control the fishing effort. The most popular policy measure is the assignment of limited fishing licenses to boats or individuals.

Fisheries management based on the combination of stock assessment and state control has not been able to control the enormous increase in fishing that has taken place in the last decades. A fivefold increase of the world annual fish capture occurred between 1950 (about 20 million tons) and 1990 (about 100 million tons) (World Bank 1992).

resulting in the collapse of several fish stocks, overcapitalization of the fishing sector, and an increase of fishing conflict throughout the world. The realization of the world crisis that the fishing sector has been undergoing in recent decades led policymakers to revise their former policy measures (McGoodwin 1990).

Policymakers have increasingly recognized that the "Leviathan model," delegating total control over the fish resource to the state, has not been an efficient means of regulating the fishing effort (Neher et al. 1988). Alternatively, the unsuccessful measures due to the government's inability to monitor the resource use, have been replaced in some regions by the "invisible hand" model, which foresees an "efficient" market to create incentives for private "fish owners" to invest in a long-term commitment to resource conservation. This model has taken place through the creation of tradable fish quotas owned by individuals or enterprises, based on the establishment of Total Allowable Quotas (TAQs) (Copes 1986).

The efforts to reevaluate the conventional policy measures toward more efficient management strategies have not been able to solve the misspecification problem of the bioeconomic models. The inability to carry out accurate stock assessments upon which MSY or TAQ has been based, proved to be a major flaw of the scientific management approach (Wilson and Kleban 1992). Although fisheries scientists have generated more elaborate models of fish recruitment (Larkin 1978), the focus on stock assessment persists in the fisheries policy. For example, the "adaptive management" proposed by Walters (1986) calls for a complex statistical model based on a yearly fishing stock assessment to back up policy measures.

Data sets on population dynamics of fish stock have not fit into the bioeconomic models, which assume that systems are ordered, balanced, and in dynamic equilibrium (Smith 1990). Unpredictability is one of the main characteristics of such fishing systems (Larkin 1978). Some scholars have recently proposed that the population dynamics of some species of fish better fit models based on the mathematical theory of chaos, which assumes extreme complexity of relationships among variables (Wilson and Kleban 1992, Finlayson 1991), and Acheson and Wilson (1996) argue that marine systems have two main ecological features that are not considered in the scientific management models. First, the systems are very sensitive to "initial conditions," i.e., small changes in the quality of the habitat or other factors affecting the ecological processes – such as reproduction and food chain — can trigger huge transformations in the system. Second, the components of the systems have complex connections, with a large number of nonlinear relationships. In short, the complexity and sensitivity of the system, which leads to multiple equilibrium points, make accurate predictions on fish population dynamics practically impossible. For many species, therefore, due to the lack of information, any prediction of MSY or MEY is artifactual and is unlikely to correspond to actual values.

Another factor that adds to the inconsistency between the model and the real world is the variability of fishing systems in the world. For example, stock-based management has mainly been developed from data on industrial marine fishing in which single-species, single-gear fishing takes place. Therefore, the stock-based models are weak in the evaluation of small-scale fisheries where multi-species, multi-gear fishing usually takes place. This problem is enhanced when applied to the floodplain, where fish abundance is strongly dependent on environmental variables such as flood patterns, which makes it difficult to relate fish depletion with fishing activity (Welcomme 1975). In addition, the multi-species fisheries create barriers to estimating the impact of fishing on particular fish stocks.

Finally, the misspecification problem in the bioeconomic models is not only related to ecological variables but also to the exclusion of important social variables. The assumption of a lack of local institutional arrangements and the homogeneity of fishing groups in terms of technology, perception, and interest add up to the problems related to the dominant scientific management systems (Schlager 1990). The shift from state to private property regimes of fish resources has overemphasized the economic efficiency and overlooked such social components as equity, distribution, and recognition of interest group position (Schlagler 1998). Therefore, the integration of the social factors into the fisheries management is fundamental to understanding the incentives fishers face in the fishing sector. The social aspects of the fishing systems have been addressed in the local management perspective.

1.5.2. Local Management

As pointed out by McGoodwin (1990), "...there can be no fishery without human fishing effort" (p. 65). Perhaps the macro-oriented analysis undertaken by the scientific management of fisheries has been the major cause of hiding local institutions created by fishers and related to fishing activity (Berkes 1985, Charles 1992).

A large number of maritime anthropologists carried out case studies on fishing populations in the 1970s in order to study the "fishing population culture" in contrast to land-oriented cultures. Those studies had two major foci: 1) the fishing activity per se

(Acheson 1981, Pállson and Durrenberger 1983), and 2) the social aspects of the fishing communities (Smith 1977). Those studies helped to reveal that, among several features shared by fishing populations regarding their culture, a major factor affecting the definition of the use of the fish resource is related to the unpredictability of the fishing system (Acheson 1981, McGoodwin 1990).

Unpredictability takes place along ecological, economic, and social dimensions, and is enhanced among small-scale fishing due to the limitation in the capital investment in the activity (McGoodwin 1990). Ecologically, fishers have little control over the prey (fish) because of its mobility, low degree of visibility, and complex ecological interactions with other components of the ecosystem. In addition, some fishing systems (e.g., marine) present very risky weather conditions (Acheson 1981). Economically, fish markets usually operate with low information, a fact which affects the fish price, considering the perishable conditions of the product (McCay 1981b). In addition, fishing activity usually has a low opportunity cost in comparison with other activities available, and attracts a large number of people (McCay 1981b; Smith 1988). Socially, fishers also have to overcome uncertainties regarding their access to the fish resource (Berkes 1985). Fisheries are CPRs, whose high cost of individual exclusion demands solutions through institutional and network arrangements such as local fishing rules (Acheson 1975, 1981; Berkes 1977,1986,1989; Cordell 1989; Dyer and McGoodwin 1994).

Fishers face three main dilemmas when using CPR systems: 1) stock externalities, which are related to resource subtractability; 2) technological externalities, which are related to direct or indirect physical interference among fishers in fishing spots; and 3) assignment problems, which are related to how access to different fishing spots should be determined (Ostrom et al. 1994). Schleger et al. (1994) argue that fishers refrain from addressing stock externalities because of the characteristics of the resource. Fish is a fugitive resource and storage is absent. Since users have limited control over the biological and physical characteristics of the fishing system, it is more feasible to coordinate among the group such strategic variables as fishing technology and access to fishing spots. Therefore, fishers tend to focus upon governing the physical space of their grounds as opposed to managing the flows of fish, i.e., it is more efficient to control how to fish than how much to fish (Schlager 1990, Acheson and Wilson 1996). Social scientists have called the local institutional arrangements that have defined the governance of fishing grounds by local populations as Traditional Use Rights in Fisheries (TURFs) (Christy 1982, Panayatou 1984).

In addressing technology and assignment problems, TURFs rely strongly upon ecological knowledge of local population and upon cultural ethics formed in the group, inside and outside the fishing activity. For example, accurate information about the system can be used to define territories (Cordell 1974) or maintain secrecy (Kottak 1966, Forman 1967, Moerman 1984). Likewise, cultural ethics are used to define individual territories (Acheson 1975) or to define rotation systems in the same fishing spot (Taylor 1987). In some cases, local management is mediated by cultural norms (Smith 1981) such as taboos and customs that eventually increase the productivity of the system. Berkes and Folke (1992) argue that those attributes, referred to as cultural capital, must be taken into account in management strategy since they can lower the transaction cost of monitoring the system. In this regard, the concept of management is broader than the rational-oriented practices toward resource conservation (Dyer and McGoodwin 1994).

A local management system can be a long-enduring institution that has been continuously reshaped along the history of the user group or a recently established institution resulting from a radical social change. In many cases, societies connected to the market and urban centers can develop new institutions in order to cope with external pressures such as cooperatives and grassroots organizations. However, those institutions are more likely to work when they are created from local interests, as illustrated by the special issue of *Anthropological Quarterly* (1980) on marine anthropology, which shows examples of success of fishing cooperatives in EUA and Canada and failure of cooperatives in Mexico and Ecuador. The integration of local management systems with broader institutional arrangements in collaboration with the government has been addressed in the fisheries co-management endeavors. This issue is discussed below.

1.5.3. Co-Management

While maritime anthropology had a major role in the "cultural ecology" agenda of searching for sociocultural similarities across systems influenced by local attributes of ecosystems, the political economy approach has shown how broader social factors impact local management. Local management systems may have the cultural capital to manage the local resource, but do not always have secure control over the system. In many cases, these institutions are not robust enough to resist conditions of rapid change. Even long-enduring local management systems can erode when external influences are too strong, such as in Indonesia (Bailey and Zerner 1992) and in the Solomon Islands (Doulman 1993).

One of the main factors of erosion in local institutions is the loss of community control through the implementation of governmental policies (Berkes 1985). Furthermore, the government usually is not able to monitor the system that it implements, turning the former collective property systems into open access systems, thus leading to fishing conflicts (Charles 1992). However, erosion of local management is not always the outcome. A local management system can be maintained whenever local populations are able to adjust to change and create ways to enforce the local prescriptions (Crawford and Ostrom 1995). In some cases, local fishers have been able to respond to external forces by reshaping their local management system to suit a broader context, despite the lack of legal support. In cases where local management receives some degree of governmental support, the maintenance of local management is more likely to occur. In sum, a minimum of such an institutional structure is needed if local management systems are to be maintained under the constant pressure of external influences (Ostrom 1990).

The support of local management systems has occurred through the establishment of co-management systems, an institutional arrangement in which government and user groups share the responsibilities (Pinkerton 1989a). However, "shared-responsibilities" may take different forms in regard to the level of participation of each group in decisions. Sen and Nielsen (1996) analyzed 22 case studies of co-management from different counties by grouping the variations of co-management into five types: 1) instructive, where the government provides a dialogue with the users, but the process itself tends to consist of the government informing users of the decisions they plan to make; 2) consultative, where there are mechanisms for the government to consult with the users, but the decisions are made by the government; 3) cooperative, where the users and the government are equal partners in decision making; 4) advisory, where the users advise the government of decisions to be made and the government endorses these decisions; and 5) informative, where the government delegates authority to user groups to make the decisions, and the government is only informed. According to the authors, the first two types of co-management were observed in developing countries, whereas the last three were almost exclusively found in developed countries. This analysis reveals that the presence of a more stable institutional structure plays an important role in supporting long-enduring systems of local management and in promoting integration of local management in broader co-management systems.

Therefore, the approach of co-management systems aims to avoid the dichotomy of state and private control of fish resources. Rather, it recognizes the co-involvement of government and users in the fisheries management both in establishing the policy measures and in monitoring the system. In sum, it calls for a systemic approach, which considers the multiple use of the resource/system by a range of different actors (Pinkerton 1992).

1.6. THEORETICAL FRAMEWORK TO STUDY LOCAL MANAGEMENT OF FISHING IN THE AMAZON

The theory of CPRs combines local and external factors in the analysis. The local perspective provides a basis to explore how the immediate environment influences people's decisions regarding collective action toward the use of a common-pool resource. As a contrast, the analysis of external factors enables one to analyze how external incentives faced by individuals can affect local decisions in joining or avoiding collective actions. Recently, a number of theoretical approaches have emerged from the combination of both perspectives in order to address how the structure of ecological and social opportunities and constraints affect people's decisions regarding the use of natural resources. Although each theoretical approach emphasizes different components of the system — such as the historical dimension of environmental change in historical ecology (Crumley 1994; Balee 1994, 1998), the institutional constraints and opportunities in political ecology (Blaikie and Brookfield 1987, Ostrom 1990, Schmink and Wood 1992), and the economic flow of goods and services in the system in ecological economics (Costanza 1991, Folke and Kaberger 1991) — they share two major methodological strategies. First, the ecosystem is used as the unit of analysis, a fact which enhances the ability to analyze human actions under a set of different interconnected arenas of decisions in different scales of analysis. Second, human action is approached in the light of the combination of factors constraining local decisions (structure) and the ability of individuals to search for new opportunities (agency).

By recognizing human agency, those theoretical approaches assume that people not only respond to the structure of constraints imposed on them but also can influence the structure itself. Individuals can actively search for new sources of opportunities to improve their range of options (McCay 1978, Ostrom 1990). Thus, human agency brings about the importance of local factors in generating variability of response to external factors, such as individual perception (Poggie 1980, Gatewood and McCay 1988, Robben 1989, Pállson 1991), household structure (Netting 1993, Stonish 1993), social structure of the user group (Ostrom 1990, Sheridan 1988, McCay and Jentoft 1998, Gibson and Koontz 1998), local ecological knowledge (Berkes and Folke 1998, Grossman 1998, Pállson and Durrenberger 1983), and ecological characteristics of the system (Moran 1981, Chibnik 1994, Schlager et al. 1994). In short, the focus on human agency explores how heterogeneity in the ecological and social dimensions may affect the outcomes regarding the pattern of resource use in the ecosystem carried out by individuals under similar external pressures.

At the very core of the agency approach is the issue of social dynamics in regard to change. Local populations reshape their pattern of resource use in order to cope with environmental pressures. The constant change in the matrix of opportunities and constraints of the system in which resource use takes place triggers the development of new strategies of resource use, which in turn changes the relationship pattern between users and the resource. Thus, the sustainable use of resources depends on how users are able to constantly reshape their pattern of use compatibly with the ecological characteristics of the system. In other words, the sustainability of local management systems should not be an assumption, but an empirical question related to the features of the system.

According to Berkes and Folke (1998), local management systems are regulatory social behavior that can increase the ecosystem resilience due to the close relationship between local social and ecological components of the system. Those institutions are efficient if they can maintain the resource use in a sustainable fashion. Thus, the ability to respond to environmental change in a conservative fashion depends on the conditions of the local group to organize and constantly reshape their patterns of resource use that are compatible with the ecological processes of the system. In this regard, the robustness of such institutions varies tremendously according to the characteristics of the ecological system, local social system, and external constraints (e.g., rules-in-use) (Ostrom 1990).

Evidence from case studies shows that erosion of many local management systems is due to external influences such as technological innovations, population pressure, governmental policies, and market pressure (Berkes 1985, Smith 1985, Ostrom 1990, Bailay and Zerner 1992, Ascher 1995). Although this process has been observed in many parts of world, there are multiple cases, in which local populations have been able to maintain their local management systems.

Local management systems are dynamic institutions that are constantly reshaped according to local and external pressures on the system. Communities relatively isolated are more influenced by internal pressures, such as internal demographic dynamics and system productivity, which influence the change in the pattern of resource use. Erosion of local management in this case is more likely to happen in communities presenting weak social organization or a lack of institutional support. Comparatively, communities that are integrated with the broader society and face rapid change can more promptly erode their local management systems due to the influence of external pressures on their internal organization. However, when the local population has strong internal organization and/or a minimum of institutional support, the users are able to respond to the external pressure by restructuring their local management system or, in more extreme cases, by elaborating a new institutional arrangement.

Based on this model, surviving local management systems can be divided into two major types. First, institutions that have maintained their structure for generations such as in Switzerland (Netting 1981), Canada (Berkes 1977), Iceland (Pallson 1991), and Japan (Ruddle and Akimishi 1989). The second type of remaining local management systems consists of institutions that have recently emerged in response to strong external pressure. Those local-based institutions are likely to rely upon local values when there is little pressure from the government or under well-structured political organization when external pressure is strong, such as in Canada (Pinkerton 1994a) and the U.S.A. (McCay 1988, Acheson 1988).

Although artificial, the distinction between long-enduring and recently established local management systems is useful to evaluate the resilience of ecosystems in a dynamic perspective, considering the relationship between institutional change and resource conservation. Along those lines, as a social system becomes more complex, the survivorship of local management depends on the ability of the users to restructure the institutional design in order to cope with the external pressures. Therefore, the more the prescriptions can appropriately address problems related to external pressures, the more robust the system is likely to be. In other words, the success of a given local management is not only related to how congruent its current design is with the ecological system but also to whether or not its design is robust enough to respond to future changes and external pressures. In this regard, local management systems that have recently emerged represent living experiments of the social resilience process that can reveal the social and ecological dynamics behind this new enterprise and how they affect the ecological resilience of the system.

Due to its integrated ecological and social system, local management has become one of the most appealing strategies to achieve the dual goals of conservation and development. However, the rearrangement of local management systems does not always result in a positive ecological outcome. Local management systems are embedded in a complex social system in which individuals constantly make decisions under a set of different, overlapped arenas defined in different levels of organization such as individual, household, and community (McCay 1978, Netting 1993, Ostrom et al. 1994, Wilk 1996). How those levels of decisions are interrelated is an empirical question that must be carefully analyzed. In this regard, a local management system based on collective property is bound to other local and regional-based social arenas, which may affect (and may be affected by) the whole system. Therefore, although the focus of analysis is given to a production system (i.e., fishing), the analysis of other related activities by the users is essential to understanding the outcomes of individual decisions regarding the strategies of resource use.

The Institutional Analysis and Development (IAD) framework, developed by scholars at Indiana University, represents an appropriate analytical tool, which combines *structure* and *human agency* to study the origin, maintenance and performance of collective actions toward CPRs. The IAD framework defines a given situation of decision making (action arena) which is influenced by three sets of factors in the system: the attributes of the ecosystem, the attributes of the population, and the prescriptions that define what is required, prohibited, and permitted (rules-in-use) in regard to resource use (Ostrom et al. 1994). The attributes of the ecosystem provide the range of ecological opportunities and constraints affecting the production systems. Features of the ecological environment, such as spatial and temporal distribution and abundance of the resource, productivity, and resilience of the system, influence how individuals shape their strategies of resource use. The attributes of the community influence the perceptions and ability of individuals to define their own strategies of resource use. Individuals are organized in different levels (household, community, and region) and are influenced by the different sets of incentives presented at each level. The rules-in-use of the system constrain the range of decision options faced by the actor. Rules-in-use are prescriptions that are actively in work and correspond to what Folbre (1994) call a "structure of constraints" that ". . . limit what people want and how they can go about getting what they want" (p. 54).

Ecological attributes, population attributes, and rules-in-use affect individuals differently according to their personal features, such as preferences, identity, and assets (knowledge, access to information, technology endowment). Therefore, the pattern of behavior generated through those factors is filtered by individual differences, which can lead to different outcomes. According to evaluative criteria, the outcomes affect the ecological, social, and institutional setting where the social arena takes place, leading to a new round of outcomes (Figure 1.1).

The IAD framework accounts for the dialectics between social and ecological systems in which fishing accords have emerged. The fishing accords are an institution that was recently established by the floodplain population as a response to external and local factors. They represent a new institution to control the use of the floodplain system, which takes place in a heterogeneous ecological, social, and institutional environment. The floodplain is a system where the same resources are used by different actors who in turn present a large variety of strategies of survivorship, including the use of many floodplain resources. Consequently, individuals face different incentives in regard to decisions toward collective actions.

This dissertation aims to explain how the fishing accords came into being as a regional phenomenon, how different outcomes affect the level of sustainability of the fish resource, and how this local institution can be integrated into a co-management system. I will analyze the local management of fishing in the Amazonian floodplain by focusing on the use of the fishing resource as the action arena in which decisions related to fishing strategies are influenced by: 1) the characteristics of the floodplain system and, in particular, the fish resource; 2) the characteristics of the floodplain community, and 3) the rules-in-use established at the regional (fishing accords) and community (local norms) levels. In addition, I will compare the outcome of different local management systems according to the local characteristics of the system. The following section describes how the dissertation is organized in order to address the questions stated above.

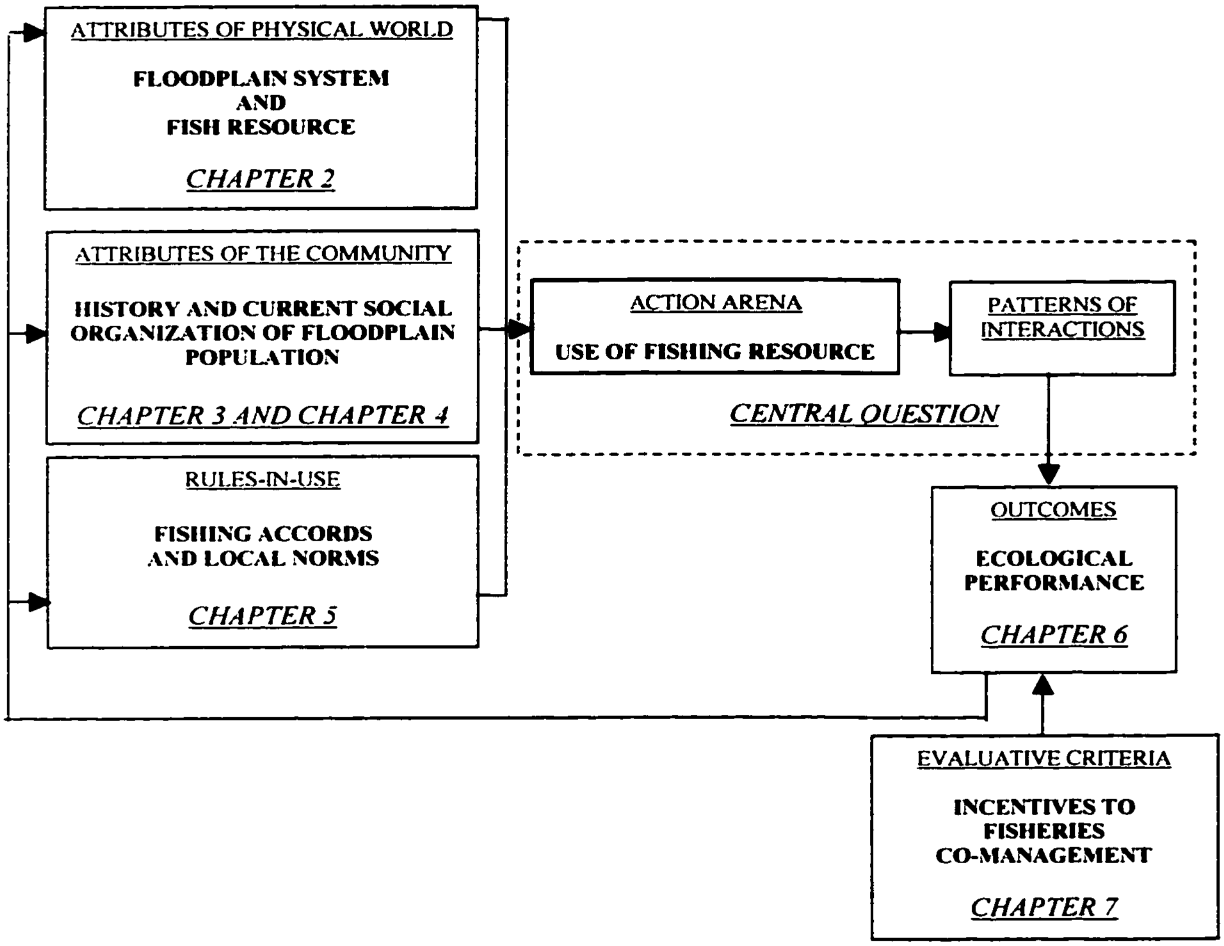

Figure 1.1. Figure 1.1. Analysis of Amazonian fishing based on the Institutional Analysis and Development Framework (adapted from Ostrom et al. 1994).

1.7. ORGANIZATION OF THE DISSERTATION

1.7.1. Analytical Strategy

I analyze the local management of fishing in the Amazonian floodplain by focusing on the structure of opportunities and constraints in ecological and social realms and by evaluating the different outcomes. Such an enterprise demands a complex data set and a methodological design reliant upon analysis on both regional and local scales. In order to accomplish this goal, data used in the study were collected in collaboration with long-term projects, which have databases including information on different aspects on the fishing populations in the Lower Amazon.

The following chapters are based on a mixed methodological strategy, which includes the collaborative effort of myself and several other researchers. Data were obtained by combining secondary source such as local newspapers, books, manuscripts, and archives and primary sources from community census and extensive fieldwork between 1991 and 1997 including interviews, participant observation, structured questionnaires on household socioeconomy, and fishing production.

The analysis of the dissertation follows three major steps. First, as a pervasive regional phenomena, the fishing accords are analyzed by regional-based data in a way which locates local management of fishing in the ecological (Chapter 2), historical (Chapter 3), socioeconomic (Chapter 4) and institutional (Chapter 5) contexts, in order to highlight the major factors that have influenced the origin and maintenance of this local institution in the region. Chapters 2 and 3 are mainly based on literature review addressing the Amazonian system, whereas chapters 4 and 5 are based on empirical regional data from Santarém region. Second, in order to analyze the performance of the institution, I present a comparative analysis carried out at the community level to evaluate the variations along the same dimensions (Chapter 6). Data source were obtained from two communities in the Santarém region presenting different performances of fishing accords. Finally, the summary of the findings gives background to the development of a strategy for the co-management of the floodplain in the Lower Amazon (Chapter 7).

In short, the dissertation tries to balance theoretical and policy questions in order to evaluate the potential of fishing accords to be included in a co-management system of fishing. However, this dissertation is not structured to provide policy recommendations. Rather, it aims to provide guidelines by raising the major factors that should be accounted for in the evaluation of a local management system. Below, I describe the chapters in more detail.

1.7.2. The Chapters

Figure 1.1 shows how the chapters are distributed with respect to the theoretical framework used in this text. The central question addresses the use of fishing resources as the action arena and how it affects — and is affected by — patterns of interactions. The analyses, throughout the chapters, address this issue in regard to the other components of the framework.

Chapter 2 describes the attributes of the ecosystem where fishing takes place – the floodplain – and how it affects the distribution and abundance of fishing resources and, in turn, the fishing activity. It stresses the diversity and interconnectiveness of ecological subsystems and how fishing-related technologies have helped to overcome the decrease in fishing productivity and promoted fishing intensification in the Amazon. In particular, it describes the actual pattern of fishing activity and discusses how the social and ecological consequences of the shift from customary to contemporary fishing has generated a technological externality problem and, in turn, triggered the emergence of local regulations toward outside fishers. The chapter concludes that the floodplain fishing should be analyzed using a systemic approach to account for the interdependence among subsystems for the conservation of the resources and the socioeconomy of the floodplain populations. Moreover, the ecological system is not only a static scenario where socioeconomic processes take place, but a dynamic system which affects and is affected by human actions.

Chapters 3 and 4 address the attributes of the population and the pattern of resource use in the floodplain. Chapter 3 situates the emergence of the user groups and examines how the fishing accords took place. It focuses on the evolution of the pattern of resource use in the floodplain as a continuous social phenomenon that has been changing due to new local and external factors that emerged in different periods of human occupation. The historical analysis reveals that the fishing accord is only one layer of the local management system, a complex institution defined by ecological and social factors.

Chapter 4 describes the population structure and social organization of the floodplain. Based on census data of 172 communities of the Lower Amazon, the chapter focuses on similarities and differences of floodplain communities at different levels (Basin and regional levels). It reveals a heterogeneous socioeconomy within and between communities, which directly affects the pattern of fish resource use. It concludes that the disaggregation of floodplain communities, according to their degree of access to resources, is essential to evaluate the potential success of fishing accords.

Chapter 5 addresses the institutional arrangement that defines the form of appropriation of the floodplain system. It discusses the rules-in-use related to resource use in the floodplain and emphasizes the heterogeneity of appropriation systems (state, fishing accords, and local norms) according to different levels of social interaction. The chapter is divided into two parts. The first part focuses on how the local population describes the resource appropriation in the floodplain according to each floodplain subsystem. Emphasis is given to the fishing accords as the explicit set of rules defining the pattern of fishing activity. The second part discusses 12 local conflicts regarding the appropriation of floodplain subsystems to illustrate the implicit set of rules defining the pattern of resource use at the local level. The chapter analyzes how the social relationship between local actors (residents and farm owners) affects the local management of fishing; it also points out the importance of the local contextualization in the analysis of the appropriation of floodplain resource in order to understand how the fishing accord is a local institution embedded in a combination of property regimes that varies spatially, socially, and temporally. Moreover, it reveals that local management systems can be dominated by powerful local actors who sometimes take over definitions and undermine the major goal of a co-management system regarding devolution of local control of the floodplain resource to residents.

In Chapter 6, the analysis is scaled down to a case study approach in order to address the performance of fishing accords. The chapter is based on an in-depth comparative analysis between two communities presenting different performances in their local management systems. The community-level analysis, which compares two floodplain communities with similar histories of establishing fishing accords, reveals a set of major local factors influencing the outcome of the local management of fishing.

The discussion focuses on several variables affecting the relative ability of the accords to solve external and internal conflicts during their period of establishment and maintenance.

Finally, Chapter 7 summarizes the major theoretical findings on the origin, maintenance, and performance of fishing accords and proposes guidelines regarding how fishing accords could be integrated into a co-management system in the Amazon. The chapter discusses the fact that the floodplain is socially and ecologically complex and cannot be managed unless an integrated management strategy is carried out. It argues that shift of the management goal from the fishing sector to the floodplain system is congruent with the fishing accords and, therefore, the integration of such a local institution is essential for success. Yet, a long-term process, envisaging the local organization at different levels, is essential to ensure that fishing accords do not become merely a way of local population to keep control of the fish resource, but also a local commitment to conserving the resource by which both the local population and the broader society can benefit.

Chapter 2

ECOLOGICAL OPPORTUNITIES AND CONSTRAINTS OF THE *VÁRZEA* SYSTEM

2.1. INTRODUCTION

The Amazon Basin is the largest drainage area in the world, covering 7,000,000 km^2 (Sioli 1984). The main river extends 6,518 km, changes its name three times along its course (Marañon, Solimões, and Amazonas) from the Andes to the Atlantic Ocean, and crosses two different countries (Peru and Brazil). The Amazon River is the largest river in the world in terms of water catchment and encompasses several large tributaries; these in turn receive water from a dense network of small streams whose combined length equals more than 1,000 times that of the main river. The Amazon River's discharge of 175,000 m^3/sec amounts to between 1/5 and 1/6 of all the water released into the seas of the Earth (Sioli 1984, p.128).

The low elevation of the Amazon Basin, of which about 1,000,000 km^2 is within 100 m of sea level, provides a favorable environment for the formation of floodplains (Junk 1984a). Floodplains are defined as systems "...that are periodically inundated by the lateral overflow of rivers or lakes and/or by direct precipitation or groundwater" (Junk et al. 1989). Through the year, the ice melting regime in the Andes and rainfall in the catchment areas lead to a variation of river water level up to 20 m in upstream areas of the Upper Solimões, Peru. Junk (1997a) estimates an area of 307,300 km^2 for the Amazonian floodplain or about 6 percent of the total area of the basin. In particular, the Amazonian floodplain is described as a "flood pulse system" to distinguish it from the traditional limnological concept of closed systems (Junk 1997a). According to the flood pulse system concept, the floodplain has an intermediate position between open and closed systems. Its inundation pattern creates a “pulsing effect” that makes the river and its surrounding lowland an indivisible unit that shares physical and biological aspects (Junk 1997a). Therefore, the interface between the aquatic and terrestrial phases makes the floodplain a dynamic and patchy ecotone with regular change in the landscape affecting the structure of the biological communities throughout the year (Junk 1997b).

Despite the recognition of the major role of continuous physical change on the biological system, human and non-human species are usually treated separately in the studies of ecological adaptation to the flood pulse. For example, the most recent edited volume on adaptation to flood pulse is divided into chapters dealing with different biological groups, with no mention of humans (Junk 1997b). However, human populations have existed in the floodplain long enough to have had an important role in the co-adaptation process in the ecosystem. They have been able to increase fish productivity in poor-nutrient systems (Chernela 1989), have changed vegetation composition in the flooded forest (Brondizio and Siqueira 1997), and have even altered flooding effects by constructing mounds (Roosevelt 1991). The detailed local knowledge among riparian populations is a reflection of their intimate relationship with such a risky environment. Several authors have described how local populations recognize multiple strata that are differently affected by the flood pattern (Denevan 1984, Hiraoka 1986, Frechione et al. 1989, Chibnik 1994, Futemma 1995).

The water-oriented daily life in the floodplain has created a structure of ecological opportunities and constraints that represents a tradeoff to which the occupants are adapted. This chapter does not aim to cover the broad issues regarding human adaptation to the floodplain system. Rather, it focuses on one type of ecological relationship that is relatively conspicuous in the system: fishing. Fishing holds important cultural, economic, and biological meaning for the local population. It is a material resource (i.e. income, protein source) as well as a source for cosmological interpretations (see Chapter 3). At the same time, fishing demonstrates close adaptation to those variations in the floodplain system that influence the structure of the fish populations, such as reproduction, diet, and mobility (Goulding 1980, Junk et al. 1997). Therefore, the analysis of fishing in light of the ecological structure of the floodplain system (landscape and fish behavior) is essential to understanding the patterns of human use of the fish resource. The objective of this chapter is to describe the floodplain system's ecological opportunities for and constraints against human occupation and the use of natural resources in general, and the fish resource in particular.

This chapter is divided into five sections. The first section describes the structure of the Lower Amazonian floodplain with a focus on the ecological and socioeconomic diversity of the floodplain landscapes. The second section deals with ecological features of the community structure of the fish community, according to physical and biological factors of the system. The third section discusses the pattern of fisheries in the Lower Amazon. The fourth section focuses on the major ecological and social implications of the shift from customary to contemporary fishing strategies. Finally, the fifth section presents a general conclusion.

2.2. THE FLOODPLAIN SYSTEM

Sioli (1984) divides Amazonian floodplains into two main types according to differences in the headwater zones of the rivers: *igapó* and *várzea*. *Igapó* is a floodplain washed by rivers that carry a low concentration of suspended material from old geological formation of the Guyana Shield and the Cretaceous sediments of Central Amazon (Irion et al. 1997, p.27). Rivers running from the Guyana Shield are blackish and are called black water rivers, while rivers running from the Central Amazon are bluish and are called clear water rivers (Sioli 1984). Due to the low concentration of suspended sediment, the process of sedimentation has been slow, leading to the formation of unfilled lake-like systems on the rivers' mouths (RIA lakes). The second floodplain type, the *várzea*, has its development associated with two major geological events. First, the rise of the Andes from recent geological formation dammed the rivers, which formerly ran westward. Second, the successive erosion in the rivers' valleys during cold periods (glacial), and filling of fluvial sediments from the Andes in warm periods (inter-glacial) in the Pleistocene. Due to the recent geologic formation, the rivers running from the Andes and pre-Andes zones carry high concentrations of sediment, resulting in turbid and muddy water. These so-called white water rivers have been undergoing a sedimentation process for the last 6,000 years. Consequently, most parts of the area in those rivers – whose width ranges from a few kilometers up to 100 km in the Pleistocene – has turned into a diversified landscape of islands with rich nutrient soil that surrounds lakes interconnected by small streams.

The Lower Amazon stretches from the border between the states of Pará and Amazonas to the mouth of the Xingu River, and covers an area of approximately 18,000 km^2 with an average width of 45 km (Figure 2.1). The *várzea* (white water floodplains) dominates the landscape of the Lower Amazon floodplain. Because of its complex hydrology, the area of the Amazonian *várzea* is not clear; estimates in the literature range between 1 and 3 percent of the Basin. The accuracy of these estimates has increased as new, advanced technologies have become available. The lowest estimates provided by Smith (1981; p.5) and Camargo (1957), of 24,000 km^2 and 64,400 km^2, respectively, were obtained by low-resolution maps. Most recent estimates, which were derived from TM and Radar images, present higher estimates such as 180,360 km^2 (Bayley and Petrere 1989); 154,000 km^2 (Sippel et al. 1992); and 160,000 km^2 (Junk 1997a).

The *várzea* has a relatively unstable landscape system due to the constant erosion caused by the soft Tertiary sediment which has been filling in the valley (Irion et al. 1997). Sternberg (1975) points out three main physical features in the *várzea* change: channel aggradation and channel scour, as long-term non-cyclic change; and annual water fluctuation, as a short-term cyclic change (p.17-28). Channel aggradation has an accumulative effect, in which the amount of sediment annually deposited at the bottom during the flood season gives rise to new portions of land (locally called "grown land"). Channel scour has a subtractive effect on the land banks which cave in (locally called "fallen land") as the river channel narrows with the emergence of "grown lands," thus increasing the speed of the current (Sternberg 1975). These phenomena are more intense upstream, such as in the Upper Solimões (Chibnik 1994) and Middle Amazon (Sternberg 1975). Yet, tremendous landscape transformations can also take place in the Lower Amazon within just a few decades (Junk 1984a); these changes directly affect the pattern of human occupation in the floodplain. For instance, a small island (Ilha do Meio do Tapajós) located near Santarém, the main urban center of the region, emerged about 20 years ago, as a result of land aggradation. The island's area has increased every year, and is currently occupied by ten smallholders and two cattle ranchers. In contrast, several residents of another floodplain community (Arapemã), also located close to Santarém, had to move out in 1995 after a large portion of the levee where the population lived caved in during a flood season.

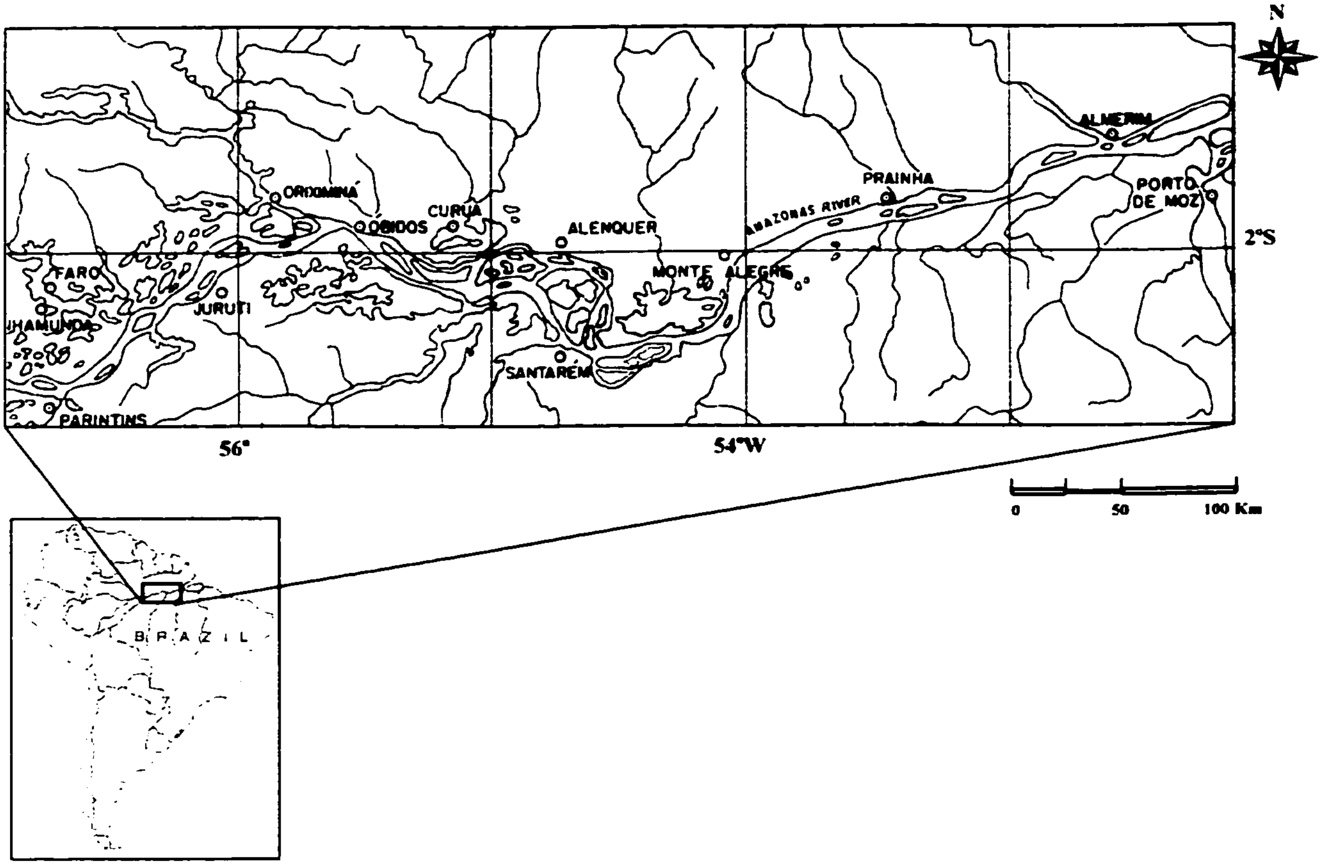

Figure 2.1. Map of the Lower Amazonian floodplain.

Besides non-cyclic changes, the landscape variation in the *várzea* system is affected by the cyclical water level fluctuation. Junk (1997b) discusses four main parameters related to the flooding pattern features: predictability, frequency, amplitude, and source of flooding. The flooding pattern of large rivers in the Lower Amazon is predictable, mono-modal, and of large amplitude (Figure 2.2A). The two major flooding sources — rainfall and ice melting from the Andes — provide a continuum of change in the landscape pattern throughout the year. In contrast, the local population recognizes other parameters that directly affect their decisions. According to the folk classification, the four seasons — dry, rising, flooded, and ebb — may vary according to the height and speed of a flood. Despite its predictability (certainty that flooding will take place), the irregularity of flooding height – low and high – represents a major environmental risk (Figure 2.2B). High floods are not frequent, but have caused major material loss when they happened during the history of the floodplain occupation (O Baixo Amazonas 1953). In addition to the flooding height, the speed of the flooding also increases the environmental risk. When water level increases rapidly, local residents may not be able to harvest their product in time.

A)

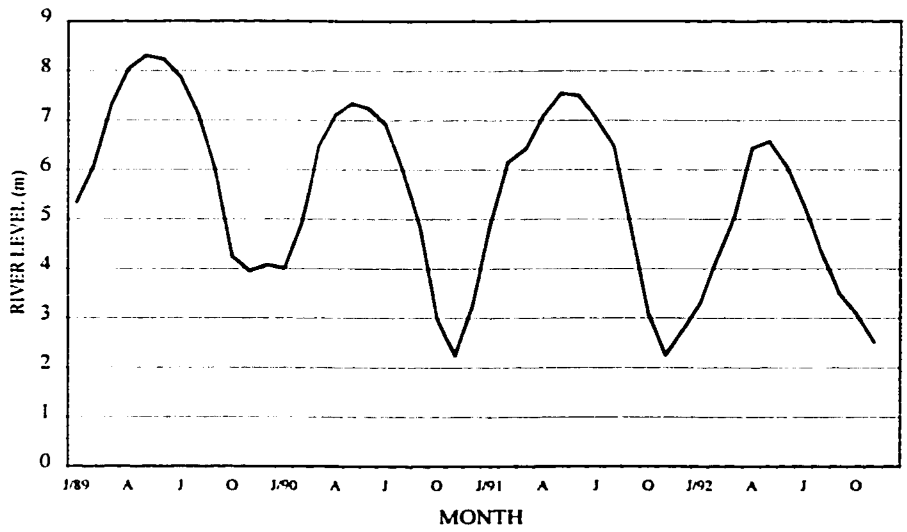

Figure 2.2. Measurement of river level: A) Monthly average river level, 1989-1992 (Source: Capitania dos Portos – Santarém); B) Yearly maximum high river level, 1931-1953 (source: Hydrology Service, Santarém *apud* O Baixo Amazonas 05/13/53).

B)

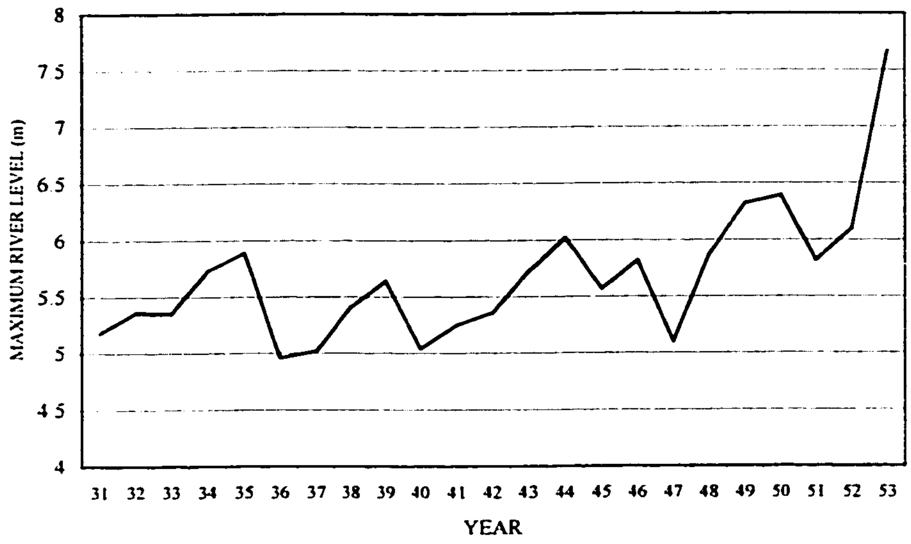

Figure 2.2. (cont.) Measurement of river level: A) Monthly average river level, 1989-1992 (Source: Capitania dos Portos – Santarém); B) Yearly maximum high river level, 1931-1953 (source: Hydrology Service, Santarém *apud* O Baixo Amazonas 05/13/53).

The pattern of annual flooding represents a major environmental factor driving decisions regarding natural resource use. The human activity in the floodplain is based on a diversity of activities that are coordinated according to the environmental changes throughout the year (McGrath et al. 1993a). Due to the flooding pattern, *várzea* agriculture relies upon short-growing products, such as corn, beans, squash, watermelon, and a manioc variety that ripen within six months (Hiraoka 1985, Padoch and Jong 1992, Futemma 1995). The natural grassland for cattle and buffaloes is available only in the dry season, when the lowland is not flooded. During the flooded season, ranchers can build suspended corrals where the herd is kept until the water level goes down, or they can transport the herd to other grazing areas on the upland. The former strategy is mainly taken by small-scale ranchers. It involves the extra monetary cost of labor time in fetching grass to feed the cattle on a daily basis, and watching for eventual hazards to the herd such as water-related diseases and carnivorous fish. Transportation of cattle to the upland is undertaken by medium- and large-scale ranchers. It involves the extra cost of transporting the herd to the upland and of renting or buying pasture in the upland. Thus, the longer the flooding season, the more restrained the agriculture and cattle ranching activities become.

In average years, household members allocate their labor force to distinct activities in order to be able to accomplish all the activities. In years of a fast flooding pattern, the household will not be able to coordinate all the activities in time, and material loss is likely to occur. Likewise, flooding length directly affects agriculture and cattle ranching. Despite the fertile soil in the floodplain, availability of dry land is a major constraint for cultivation. A long dry season can also be a problem if the cultivated fields are distant from the water source, leading to a higher labor force demand to fetch water. Since the flooding is related to the rainfall in the Andes, macroclimate events such as El Niño have strong influences on the pattern of flooding (Richey et al. 1989). The lack of control over such an environmental factor creates constraints to human activity in the floodplain.

The flooding risk becomes more harmful when a combination of constraints occurs simultaneously. For example, constraints related to a high flood can be more difficult to overcome if the flood takes place faster than the ability of the household to rearrange their production system. Likewise, a low flood may be very harmful if its duration is long enough to affect the timing of cultivation. Unfortunately, there are no long-term reliable data to check the relationship between the flooding pattern and system production, and only a few historical registers attest to major losses caused by such events (O Baixo Amazonas 1953).

In summary, sedimentation and water level fluctuations lead to uncertain changes in the landscape that affect the pattern of occupation and natural resource use. The "fallen land" makes the land availability uncertain whereas "grown land" provides new land use opportunities. The opportunity of high nutrient soils provided by the sedimentation process is balanced by the constraint of water level fluctuation, which causes an annual change in land availability. Variations in height and speed in the flood pattern enhance the risk of the floodplain environment in regard to land-oriented activities. Agriculture is limited to short-term crops and is under constant risk of production loss while cattle ranching depends on extra upland terrain or suspended corrals during the flood season. In regard to occupation, water level fluctuation also creates a change in the land boundaries, an issue addressed in more detail in Chapter 5. The next section describes the *várzea* landscape in detail.

2.3. THE *VÁRZEA* LANDSCAPE

The *várzea* system is composed of several microenvironments that the local population can distinguish, in both aquatic and terrestrial systems (Denevan 1984, Hiraoka 1986, Frechione et al. 1989, Futemma 1995). The *várzea* system may differ according to the region. In the Upper Solimões, the sedimentation process has cut off the river meanders and originated several oxbow-shaped lakes (Moran 1993*a*). In the Lower Amazon, such a process has not occurred; rather, the sedimentation process at the mouth of tributaries has formed large extensions of *várzea* islands. For the purpose of this study, the *várzea* system from the Lower Amazon is described in terms of the four main subsystems: streams, natural levees, grasslands, and lakes (Figure 2.3).

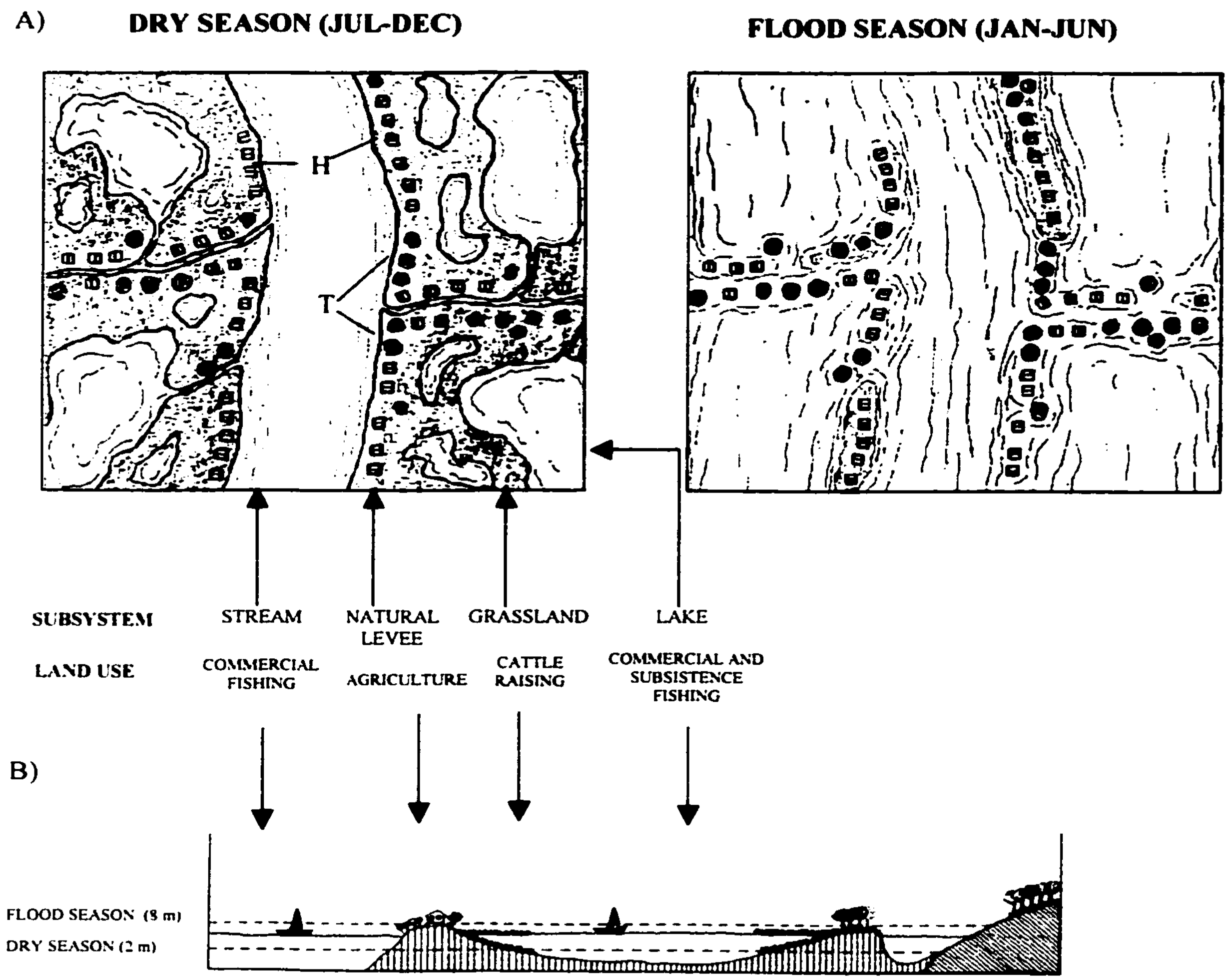

Figure 2.3. Landscape pattern of the Lower Amazonian floodplain during dry and flood seasons. A) overview (H=houses; T=trees) and B) cross-sectional view.

2.3.1. <u>Streams</u>

Streams are the waterways; they have higher currents and pump water into the lakes. The streams can be classified into creeks, river arms, and channels according to the size and type of connections. Creeks (*igarapés*) are small channels that connect lakes with each other or with other larger streams. River arms (*paranás*) are the river's main branches that contour the islands. Finally, the channels are rivers that cross the *várzea* system. The channels have two landscape units that deserve attention for the purpose of this study: 1) main channel, which is the ever-flooded part of the river and is used for transportation and for commercial fisheries; and 2) beaches, which are shallow areas at the river edge that emerge during the dry season and are used for commercial fisheries. The Amazon is the major main river in the Lower Amazon. The channel fisheries are a seasonal activity performed for commercial purposes and rely upon migratory fish species.

2.3.2. Lakes

As discussed above, the *várzea* lakes differ from the traditional limnological concept of a closed, lentic system. The lakes are surrounded by grassland and natural levees, and represent flexible aquatic systems interconnected through small creeks. The lake systems are closely related to the main river and the dynamic flooding pulse pattern changes the lake boundaries throughout the year. During the flood season, the lakes expand and merge with the streams, forming one large unique water body (Figure 2.3). The lake size may vary from a few to hundreds of square kilometers (Sioli 1984). During the dry season, only deeper lakes remain, while a large part of the system dries out.

Várzea lakes have relatively low primary productivity. During the flood season, the high load of sediment from the river obstructs the light that reaches the river and constrains the photosynthetic activity of plankton. Thus, energetic requirements are fulfilled primarily by an allochthonous source, from the natural levees' vegetation (flooded forest). During the dry season, the water level drops and the lakes turn into small closed water bodies with a low oxygen level. Consequently, only fish who have adapted to conditions of low-oxygen concentration stay in the lake while most of the species migrate out to the streams.

Both subsistence and commercial fishing take place in lakes. Fish productivity is higher during the dry season because non-migratory fish species are concentrated in small water bodies. During the flood season, the lake productivity is patchy, being higher close to food sources, such as macrophytes, and flooded forest areas.

2.3.3. Grasslands

Grasslands are the surrounding lowlands exposed during the dry season. One important distinction between the two types of floodplain — *igapó* and *várzea* — is the rich abundance of herbaceous vegetation in the latter (Junk 1986). In particular, the large extension of "floating meadows" — vegetation rugs made of macrophytes such as *Eichhornia cassipes*, *Paspalum repens*, *Salvinia auriculata*, and *Pistia stratiotes* which have fascinated many researchers for a long time (Bates 1892) — grows seasonally during the flood period in the white water river systems. According to Goulding et al. (1996), the floating meadows have an important ecological role in providing shelter to fish to protect against predation, and to provide food substrate during fish growth. The extended rooted herbaceous species in the Lower Amazon lowlands represent a particular difference from the Middle and Upper Amazonian *várzea* system (Moran 1993*a*). The two main grass species that dominate the landscape — *Echinochloa polystachya* (*canarana*) and *Paspalum repens* (*premembeca*) — are important for ranching during the dry season, when the vegetation is available to the cattle.

2.3.4. *Natural Levees*

Natural levees are ridges that emerged as the result of an ancient aggradation process. The woody vegetation, which grows on the levees, plays a major ecological role in creating the interface between the aquatic and terrestrial phases of the floodplain. The biomass produced in the flooded forest that is transferred to the lake during the flood season represents a large amount of energy to maintain ecological processes in the aquatic system (Junk et al. 1997). The Lower Amazon represents one of the less dense flooded forests in the Amazon due to the intensive land use in the past (Goulding et al. 1996).

The natural levees are the areas where local populations settle and grow most of their crops, because these levees represent the highest floodplain subsystem. The higher the levee is where a population settles, the less is the susceptibility of production loss due to floods. Nevertheless, high levees are by no means free of flooding risk. The unexpected high flooding is harmful to anyone regardless of the height of the levee (Futemma et al. in prep).

In addition to the flooding risk, other environmental factors influence the decisions regarding where to settle. In general, a *várzea* island presents a few strips of levees along the system, and residents usually settle on the outermost strip in order to be close to the streams. However, some high levees located at the stream edge have an abrupt relief and, thus, are more vulnerable to caving in. In those cases, households search inward for a more protected levee strip on which to settle. When the inward levee is relatively far from the stream, the effort in daily activities, such as water fetching and transportation of the product, increases during the dry season. Therefore, the safety achieved during the flood season by the distance from the river channel may represent an extra cost in the production system during the dry season. In other words, the decision regarding where to settle is a tradeoff among levee height, risk of caving in, and distance to the water source.

The dynamic change presented by the channel aggradation/scour process may cause major transformations in the landscape, creating new patterns of opportunities and constraints regarding where to settle. It is common to observe households, or even the whole community, moving to a different levee strip during their life span. Such a pattern is more common in the Upper Solimões, due to abrupt changes in the landscape. For example, the average age of settlements in the Mamirauá Reserve — located between the confluence of Japurá and Solimões rivers — is 40 years (Mamirauá 1996). In the Lower Amazon, where the system is relatively more stable, such change happens more sporadically. As discussed earlier, there are cases when the levee completely caves in, obligating the households to move to other areas. More commonly, though, households move to an outward levee strip as the landscape changes (Chapter 6).

2.4. THE FISH RESOURCES

As with many other living groups, the diversity of fish is higher in the Amazon than anywhere else on Earth. More than 2,300 species have been described, twice as many as the Zaire River in Africa, where fish diversity is the second highest in the world (Lowe-McConnell 1989). Bolkhe et al. (1978) estimate that 30 percent of fish species have yet to be discovered in the Amazon, which would raise the total diversity close to 3,000.

Despite such a high diversity, the study of the ecology of commercially important species has only recently begun in the Amazon. Seminal studies on fishing ecology were carried out by Petrere (1978a, 1978b), who analyzed the population structure based on fish landing data in Manaus, by Goulding (1979), who analyzed the autoecology of catfish and scaled fish in the Madeira river, and by Smith (1981) who studied the human ecology of fishing in a small Amazonian town. Despite the information gap regarding fish ecology, research on economically important fish species has increased in the last decade and some basic features that are important to understand the fishing activity can be drawn.

The structure of the fish community is strongly influenced by the type of floodplain. Black water rivers' floodplains (*igapó*) are called "hunger rivers" because of their low content of fish biomass. Nevertheless, such systems present a high diversity of fish whose community structure is dominated by species under 40 mm (Goulding et al. 1988). Larger fish species are dominant in such systems only during the flood season, when they migrate in search of the food available in the flooded forest (Ribeiro and Petrere 1990).

In contrast, *várzea* systems present the highest fish biomass and the most diverse, economically important species in the Amazon Basin (Junk 1984b). Fish productivity and species composition vary in *várzea* subsystems, depending on the water current and on the primary productivity. Fish composition varies spatially and temporally in the streams. The low primary productivity and the high water current create a harsh habitat in the stream channel for most of the species. Thus, fish diversity increases as it gets closer to the stream edge (Lowe-McConnell 1987). Only top predator catfish, which can reach up to 200 pounds, use the river channels for feeding purposes. These species feed on scaled fish that migrate upstream to reproduce. Thus, fish composition in the stream changes during migration periods, when several scaled fish species reach the channels.

Várzea lakes have a slower water current (lentic system) where fish species can find protection against predators, and food is more promptly accessible. The anastomoses of many narrow creeks (*furos*) linking the lakes and the flooding cycle that expands the water to terrestrial settings provide a large range of ecological niches. Like in the streams, the composition of fish in lakes also varies spatially and temporally. During the flooding season, the fish community is more diverse. The species are dispersed throughout the flooded vegetation (floating meadows and flooded forests), and characins, cichlids, and scianids are the most dominant species. During the dry season, the oxygen concentration drops in the water and characins out-migrate, while the other two groups stay in the lake, thanks to physical and behavioral adaptations that enable them to use atmospheric oxygen through modified organs.

The "flooding pulse" in the *várzea* system provides highly diversified, seasonally based habitats, which in turn have led to ecological adaptations to enhance the individual survivorship in such a patchy system. Some of these adaptations are important to understanding the fishing behavior in the *várzea* system. Below, I discuss three important aspects of fish ecology that influence the fishing strategies in the region: pattern of mobility, feeding habit, and reproduction strategies.

2.4.1. *Pattern of Mobility*

The mobility of fish is a major factor underlying fish ecology in the Amazon Basin. Fish behavior can be divided into three main categories according to the pattern of mobility: sedentary species, short-distance migratory species (SDM), and long-distance migratory species (LDM) (Goulding 1981). Sedentary species such as cichlids and scianids, have morphologic and physiologic adaptations to tolerate the low oxygen concentration. They live in lakes during the dry season, when the water level and current are low. Junk et al. (1983) observed that 40 out of 132 species collected in a *várzea* lake had adaptations to live in such environmental conditions. Migratory behavior is another adaptive behavior present among some species in order to cope with the temporal patchiness caused by the flooding cycle. Migration behavior aims to achieve at least one of the following ecological needs: 1) fulfilling the food requirement (food migration); 2) better environmental conditions (lateral migration); and 3) reproduction (reproductive migration). Food migration toward lakes takes place during the flood season, when forest resources are promptly available. Lateral migration from lakes to streams takes place during the early dry season, when oxygen in the lakes reaches a low level. Reproductive migration may take place in different forms, and some species may present very complex patterns (Goulding 1979, 1980; Ribeiro and Petrere 1990; Barthem 1990).

SDM species are mostly characins that seasonally carry out migrations between stream and lake. These migrations can range from small distances between a lake and its adjacent stream to further distances involving other tributaries. LDM species are mostly large catfish that can weigh up to 200 pounds and cover distances of up to 2,000 miles. Those species are top predators that migrate in the main channel in search of food as well as to reproduce.

Migration involves the formation of schools. Such behavior has been suggested to be an adaptive strategy against predation (Goulding 1981). Nevertheless, human predation (fishing) of migratory species is more efficient due to its aggregate and predictable pattern, which help to decrease the uncertainty created by the mobility and "invisibility" of the fish resource (Acheson 1981, Castro and Begossi 1996). Hence, when fish are caught during the reproductive migration, recruitment is strongly affected because of the high mortality of spawners (Ribeiro and Petrere 1990).

2.4.2. Feeding Habits

Diet patterns are highly diversified among Amazonian fish. Only planctivores are rare, since autochthonous primary productivity is low. The distinct fish community structure between *igapó* and *várzea* is also influenced by the availability of food items. In *igapó*, the low productivity limits the range of food habits. For example, the presence of carnivorous species is constrained by the scarcity of insects and zooplankton in the food chain (Goulding 1988). In contrast, the *várzea* presents a more complex food web, with both specialized and diversified diet patterns.

Marlier (1968) proposes a typology based on diet behavior of species that feed on plant or on animal (stenophages) and species that feed on a combination of these two sources (euryphages). Following this classification, the author names carnivores and herbivores as non-specialist stenophages species, while fruit eaters, grass-seed eaters, scale eaters, insectivores, and mud-eaters are classified as specialist stenophages. For euryphages, fish are defined as predominantly carnivorous or predominantly vegetarian.

Marlier's classification is useful to show the diversity of fish diets, but it does not consider that the same species can switch its feeding niche in either long-term (throughout its developmental stage) or short-term (seasonal variation) change. For example, the characin *tambaqui* (*Colossoma macropomum*) feeds on plankton when young, and on fruits when adult (Honda 1974). Likewise, species can switch between specialist and generalist behaviors, depending on the temporal patchiness. For example, a fruit eater species can become euryphages, feeding on insect and plankton during the dry season, when fruit is not available (Honda 1974). Goulding (1980) points out that specialized species can rank food items based on their specialization, but not be necessarily restricted in their feeding adaptations.

Diet pattern is influenced by both migration and the variation of water level. Junk (1985) observes that SDM herbivores present a pronounced seasonality in fat content because they feed intensively during the flood season to build up fat for reproduction, while sedentary herbivores present a weakly developed seasonality in fat. Similarly, flooding affects herbivores and carnivores in different ways. The former is better off during the flood season, due to high food and sheltering availability, while carnivores are better off during the dry season, when prey are more exposed due to the migration pattern and lower availability of sheltering.

Like any other predators, fishers also take advantage of the fish dietary habits in order to choose the best spot to catch a given species. Goulding (1979) observes a high density of carnivorous catfish in a river confluence during the early dry season to forage for SDM species that leave the flooded forest to get into the river channels. During this period, fishers also explore the same environment to catch catfish. Likewise, fishing in the flooded forest is more intensely focused on the frugivores and granivores (Goulding 1979).

2.4.3. Reproductive Strategies

Amazonian fish species can be divided into three groups according to their reproductive strategies: seasonal, equilibrium, and opportunist species (Winemiller 1989, Isaac et al. 1994). Seasonal species respond to variation in water level and rainfall. They present high fecundity, small eggs, and migrate to an appropriate habitat to reproduce. Equilibrium species present sedentary behavior. They lay eggs continually during their life span, and their fecundity is lower than seasonal species. Their reproduction can include more developed behavior, such as a mating system, nest building, and parental care. Opportunist species are smaller fish with a short life span and fast sexual maturation.

Equilibrium and opportunist species correspond to the K/r strategies model derived from the K-selected and r-selected life curve (Pianka 1983). The former group spawns several times throughout their life span while the latter presents a single reproductive period, after which it dies. Seasonal species present an intermediate feature between K and r strategies, with several spawning, medium-sized bodies, and a medium life span.

Fish species with different reproductive strategies have distinct impact from fishing pressure. Equilibrium species are more susceptible to intensive fishing due to their limited reproductive capacity in comparison to seasonal and opportunistic species. In addition, equilibrium species are less resilient to fishing pressure even after spawning season, since parental care is essential to ensure the survivorship of the offspring. Seasonal species are moderately impacted by post-spawning fishing because mature individuals will not have the conditions to reproduce again. Opportunistic species are the least impacted by post-spawning fishing since their reproductive capacity is finished after one spawning season.

Fishing activity has been considered one of the major factors affecting fish recruitment. The following section explores the effect of fishing modernization on the fish resource in the Amazon.

2.5. THE FISHERY

Fishing is a traditional subsistence activity in the floodplain. It became economically important for the first time in the Amazon during the Rubber Boom (1845-1911). The intensive activity of latex extraction attracted a wave of migrants, which increased the demand for salted fish in the adjacent upland areas. Only a few aquatic species were exploited during that period, such as manatee, turtle, caiman, and the large sedentary fish *pirarucu (Arapaima gigas*) (Verissimo 1895). After the crash of the rubber price, fishing returned to its role as a subsistence-oriented activity, and recuperated its commercial importance only after the early 1960s, when fishing was modernized (Isaac s/d, Schoenenberg 1994).

In the last 40 years, fishing has turned into the major economic activity in the floodplain (McGrath et al. 1993a) and one of the major economic activities in the Lower Amazon (Almeida et al. in press). Barthem et al. (1992) estimate an annual economic yield of $200 million generated from the small-scale fishing in the Amazon. Although fishing intensification has been considered one of the major factors impacting fishing productivity, signs of stock depletion have been confirmed for only three species: the LDM catfish *Brachyplatystoma vaillantii* (*piramutaba*), the SDM scaled fish *Colossoma macropomum* (*tambaqui*), and the sedentary scaled fish *Arapaima gigas* (*pirarucu*) (Petrere 1983; Barthem 1990,1995).

Data on fishing stock are limited due to the difficulty in establishing long-term landing statistics in the main landing centers (Barthem s/d). Consequently, a few data scattered throughout the Basin, combined with "educated guesses" by knowledgeable scholars are the main sources of the estimates available on fishing production and potential fishing yield in the Amazon. Bailey and Petrere (1989) compiled scattered data from different regions and carried out a statistical treatment to generate an estimated annual fishing production of 198,650 tons, and an estimated potential fishing yield of 902,000 tons for 1980. The authors argue that those estimates are conservative, since data on potential yield was extrapolated from the African floodplain, which is a less productive system than the Amazonian floodplain. Thus, they concluded at that time that fishing is at an under-exploited level and that the fishing effort could at least be doubled. Yet, the estimates based on highly aggregated data do not account for micro-regional variation in productivity of the small-scale fisheries.

In general, fishing production varies according to ecological and social variables, such as type of environment, distance to the market, and technological endowments. For example, fishing production is far higher in white water rivers (*várzea*) than in black and clear water rivers (*igapó*). Thus, regions with a higher proportion of white water systems are likely to present higher productivity. Likewise, fishing production tends to be lower in areas close to the market due to the more intensive activity of commercial fishing. The analysis of landing data in Manaus shows that fisheries are more specialized toward expensive species as the activity is undertaken further from the urban center (Petrere 1985). Finally, Almeida et al. (in press) observed that fishing efficiency increases according to the size of the boats, which is directly related to technological conditions. Therefore, estimation of fishing production is more appropriate for policy purposes when disaggregated to a level which comprises similar ecological and socioeconomic factors, such as the Santarém region in the Lower Amazon.

Santarém is located in the confluence of a white water river (Amazon River) and a clear water river (Tapajós River) (Figure 2.1). Currently, the city has the fourth largest fishing market in the Middle/Lower Amazon, and represents a picture of an emergent fishing market in the region (Isaac et al. 1996, Almeida et al. in press)[1]. It has three fish processing plants, a contingent of 370 fishing-related boats and about 4,500 commercial fishers who generate about $5.8 million per year (IBAMA 1995, Almeida et al. in press). The fish market is supplied by more than 1,000 motor boats from 14 different cities (Ruffino 1996).

Fish landing in Santarém was 3.7 tons and 4.4 tons in 1992 and 1993, respectively (Isaac and Ruffino in press). These figures are equal to $1.8 and $2.2 million per year, respectively, based on the average fish retail price of $0.50 in Santarém. The catch composition attest that there are more than 60 morpho-species[2] — including approximately 129 biological species (Ferreira et al. 1996) — commercially exploited in

[1] The three major fish markets in the Amazon are Manaus, Belém, and Tabatinga, respectively (Isaac et al. 1996).

[2] Morpho-species refer to popular names of fish, which can encompass more than one biological species.

the region; yet, 10 morpho-species encompasses 76 percent of the total catch (Figure 2.4).

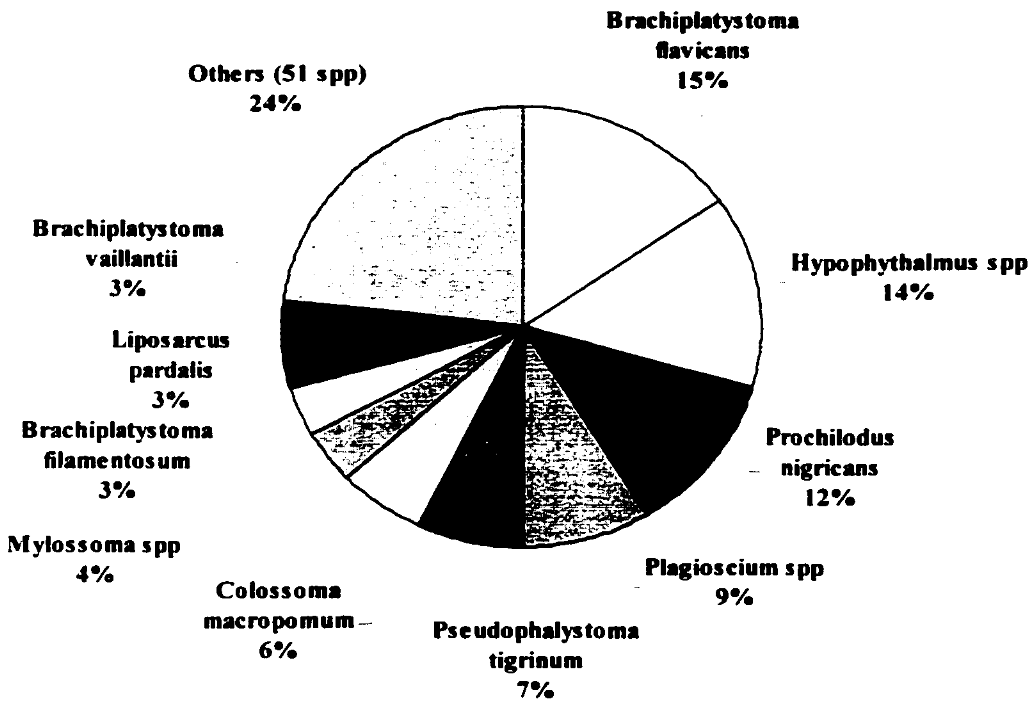

Figure 2.4. Fish composition of the annual catch landed in Santarém in 1992 (Source: Isaac and Ruffino in press).

The most common species caught in Santarém region encompasses the catfish *Brachyplatystoma vaillanti* (*dourada*), a long-distance migratory species that is mainly bought by fish processing plants to export to other regions in Brazil (Ruffino and Isaac 1994). Although it is difficult to draw conclusions about the implications for the fish stock in the region (Ruffino et al. in press), the analysis of the transition of fishing modernization in the Amazon can shed some light on the condition of the fishing system in the region.

2.6. FISHERY TYPOLOGIES IN THE AMAZON

The major driving force in the fishing intensification in the Amazon was the modernization of the activity, through the introduction of new fishing-related technologies and the provision of financing sources to fishing companies as part of a development program launched by the government in the 1960s (Shoenenberg 1994). Yet, small-scale fishing predominates throughout the Basin, except in the estuary, where an industrial fleet operates with metal gauge trawlers, and focuses on the large catfish *Brachiplatystoma vaillanti* (*piramutaba*) and shrimp (*Penaeus subtilis* and *P. brasiliensis*) (Barthem 1990).

The small-scale fisheries are diffuse and involve about 230,000 fishers in the whole Basin who carry out a large range of fishing strategies depending on the aquatic system and on the technological input. Several typologies have been proposed for the small-scale fishing in the Amazon, each of them focusing on part of the fishing structure, thus aiding in the evaluation of the major "human ecological factors" driving the intensification of the fisheries in the Amazon. Five major typologies are presented below in order to analyze how the structural changes of the fishing have affected the process of fishing intensification and, in turn, caused it to become the major economic activity in the floodplain.

2.6.1. Fishing Environment

Fishing can be divided according to the environment where it takes place. There are five major fishing categories: 1) estuarine fisheries, 2) ornamental fish fisheries, 3) reservoir fisheries, 4) stream fisheries, and 5) lake fisheries. Estuarine fisheries are located at the Amazon River mouth, and rely upon both freshwater and maritime species, depending on the season (Barthem 1995). Ornamental fish fisheries are mainly located on black and clear water rivers (*igapó*) and represent an industry that generates more than $2 million per year and employs about 10,000 people (Chao 1993). Reservoir fisheries emerged in the mid-1980s, after the increase in construction of human-made dams. One of the most important reservoir fisheries takes place in Tucuruí dam (Pará State). According to Petrere (1992), this fishery yielded 1,424 tons of fish between October 1987 and September 1988, and the catch composition was dominated by two cichlids (78 percent of the catch).

Stream and lake fishing take place in the white water rivers (*várzea*) and provide the largest proportion of catch in the Basin. In Santarém, both fisheries provide 99 percent of the fish landed for the local markets and have a similar economic importance (49 percent in the streams and 50 percent in the lakes) (Isaac et al. 1996).

Stream fisheries have emerged only recently, since the provision of more efficient fishing technologies. The high current and depth of the main channel constrains this fishing unless specific fishing gear is used. Stream fisheries are seasonal and experience two peaks each year: one, during the higher water month (May), when SDM species are migrating back to the lakes, and one during the driest months (August to October), when characins and catfishes are migrating upstream in the main channel. This pattern leads to two main types of stream fisheries: migratory characins fisheries and river channel catfish fisheries (Goulding 1983). The former focuses on SDM scale species and serves mainly the local and regional market demand. The latter focuses on LDM predatory catfish and serves mainly the fish processing plants.

Lake fisheries represent a customary activity in the floodplain. The seasonal variation in the lake fisheries is not as pronounced as in the stream fisheries. Yet, it peaks during the dry season, when fish are more concentrated and the fishing efficiency increases (McGrath et al. 1998, Ruffino et al. in press). In addition, species composition presents a high seasonal variation. During the dry season, the catch is dominated by sedentary species, and immature migratory species. During the flood season, migratory characins migrate back to the floodplain to feed on the flooded forest products, and the catch becomes more diverse, including both sedentary species and migratory characins.

2.6.2. Target Species

The second classification of fishing is proposed by Isaac et al. (1996), who analyzed the regional commercial fishing in the Lower Amazon. The authors distinguish two major fisheries — scaled fish fishery and catfish fishery — that are directly related to the target market. Catfish fishing is directed toward fish processor plants, which export the fish to other regions in Brazil. Small and medium catfish, such as *Hypophthalmus* spp (*mapará*), *Pseudoplatystoma* spp (*surubim*), and *Liposarcus pardalis* (*acari*), are mainly caught in the lakes during the flood season; large-sized species, such as *Brachiplatystoma flavicans* (*dourada*) and *Brachiplatystoma vaillanti* (*filhote*), are mainly caught in the streams during the dry season. Likewise, scaled fish fishing also takes place in both subsystems. SDM scale fish, such as *Semaprochilodus* spp (*jaraqui*), *Prochilodus nigricans* (*corimatá*), *Myleus* spp, *Metynnis* spp and *Mylossoma* spp, are caught in the stream during the dry season, while the same species and other sedentary species, such as *Plagioscion* spp (*pescada*), *Liposarcus pardalis* (*acari*), and *Oxydoras niger* (*cojuba*), are caught in the lake during the flood season (Isaac et al. 1996).

2.6.3. Fishing Gear

Small-scale fishing is carried out by several different fishing techniques. Detailed descriptions of each type of gear used throughout the Amazon Basin are available in several publications (Petrere 1978b, Smith 1981, Goulding 1981, Furtado 1993a, Freeman 1995, Ruffino et al. in press). Below, I briefly describe the most common gear used in the Lower Amazon, based on structural categories proposed by Smith (1981) and Freeman (1995).

2.6.3.1. Hook Technologies

The use of baited hooks to attract the prey represents customary technologies that were improved with the introduction of metal hooks by the Portuguese fishers in the early colonization period (Goulding 1983). The two most important hook technologies are:

Hook and line: a hook attached to a line (handline) or a pole attached to a hooked handline (fishing pole). This gear is used to catch small fish, from the canoe, from the banks, or from the deck of a house during the flood season. Hooks and lines are widely used by children and women.

Longline: a single hooked multi-filament line hung on vegetation at the edge of the lake (*rapazinho*) or several hooked monofilament lines attached to a wire, approximately 30 cm apart (*espinhél*). The former is used to catch *Arapaima gigas (pirarucu)* during the flood and ebb season, when vegetation is close to the lake edge. The latter is mainly used to catch catfish in the stream during the dry season.

2.6.3.2. Piercing Technology

This technology encompasses a projectile that is thrown toward the target fish. It is used for fishing in lakes and small streams during the ebb and dry season. It is characterized by a "hunting" strategy which relies upon visual skills to seize the prey. Due to the skills involved in the activity, it is carried out mainly by experienced fishers. The gear has been improved with the introduction of iron points by the Portuguese fishers (Goulding 1983). There are three types of piercing technologies:

Harpoon: a wooden shaft (about 3m long) with a sharp metallic point at the end, attached to a multifilament nylon cord. It has strong piercing power, and can be thrown from a relatively long distance. It is mainly used to catch *Arapaima gigas (pirarucu)* during the ebb and dry season.

Gig: a small wooden shaft (about 2m long) with a sharp two- or three-pronged metallic point at the end.

Bow and arrow: a small shaft (about 1.5m long) propelled by means of a bow.

2.6.3.3. Traps

A trap is an apparatus built to capture and entrap the prey. The most common trap is the *matapi*, a cylindrical cage, one-foot long, made of wooden sticks with bait inside to attract the prey. There is a funnel at each end that facilitates entrance of the prey, but complicates its exit. *Matapi* is a customary technology mainly used to catch shrimp.

2.6.3.4. Overkill Technologies

The main feature of overkill technologies is the massive capture through impacting the system. The two main overkill technologies are piscicides and explosives; the former is an indigenous technique whereas the latter was introduced in the early nineteenth century by the Portuguese fishers (Goulding 1983). Both strategies are combined with a net to retrieve the fish affected by the impact.

Piscicides: leaves of wild or domesticated poisonous plants, locally known as "*timbó,*" that are tapped and beaten into the small creeks to release the substance that makes the fish groggy. The most common plant species are *Paullinia pinnata, Hura crepitans, Tephrosia toxicaria, Clibadium sylvestre,* and *Serjania* sp (Smith 1981).

Explosives: homemade bombs that are blasted in small creeks.

2.6.3.5. Net Technologies

Net technologies were rarely used in the past because they were made of natural fiber, which is a perishable material. The advent of synthetic fibers in the 1960s made nets more resistant, and they consequently became the most popular fishing gear among the local population. The nets are made of multi- or mono-filaments interwoven into even-sized meshes. They have different shapes, mesh sizes, and uses. The most common net-like technologies used are:

Small-mesh net (*miqueira*): a mono-filament nylon gillnet, with a mesh size varying from 6 to 13 cm between knots. *Miqueira* is commonly used as a stationary strategy (set up and retrieved), but can also be used as an active strategy (drifting net in the lake "*bubuinha*").

Large-mesh net (*malhadeira*): a multi-filament nylon gillnet, with a mesh size varying from 13 to 25 cm between knots. Like *miqueira*, *malhadeira* can also be used either in stationary (in the lake) or active ("*bubuia*" in the stream) strategies.

Castnet: a funnel-shaped net with lead weights around its opening. It is thrown out from a canoe or riverbank and immediately retrieved.

2.6.4. Actors

Fishing can be classified according to the characteristics of the fisher. Barthem et al. (1992) classify fishers into urban, floodplain, indigenous, sport, and ornamental fishers. Urban fishers live in the urban center, do not have a direct link to land-based productions such as agriculture, livestock, and extractivism, and their income is based in specialized commercial fishing. Floodplain fishers live in the riparian area, and fishing is part of their income (either principal or complementary) along with other land-based activities. Indigenous fishers have characteristics similar to floodplain fishers, but are culturally distinct and more isolated from the market. Sport fishers are usually from the city and carry out fishing for recreational purposes. Finally, ornamental fishers specialize in the commercial fishing of ornamental fish, and suffer little influence from the local market.

The establishment of fishing accords creates another distinction between resident and non-resident fishers, based on their access to the fish resource. Resident fishers live close to the managed lake and are eligible to exploit the lake. Non-resident fishers can be divided into three groups according to their origin and technological endowment: boat fishers, urban fishers, and neighbor fishers. Boat fishers are from other regions and travel long distances to fish in different lakes along their trip. They travel in groups of about 10 fishers in a motor boat with a fish storage capacity between 1 and 5 tons (*geleira*), towing several small paddled canoes. Urban fishers live in the cities nearby and carry out daily fishing trips in small paddled canoes. Neighbor fishers are residents from neighboring communities of managed lake, who also travel in canoes.[3] This classification will be used throughout the dissertation.

2.6.5. Production System

The fifth typology of small-scale fishing, which is provided by Almeida et al. (in press), focuses on the production system. The authors divide commercial fishing into five major categories, according to the storage capacity of the boat, which in turn is correlated with the crew number, technological endowments, and distance and duration of the fishing trip: 1) canoe fishing; 2) motor boat with storage capacity of up to 1 ton; 3) motor-boat with storage capacity between 1 and 4 tons; 4) motor boat with storage capacity between 4 and 8 tons; and 5) motor boat with storage capacity between 8 and 15 tons. The major contribution of this classification is the accountability for quantitative socioeconomic differences of fishers' profiles in each fishing production system. According to Almeida et al. (in press), the larger the fishing boat, the higher the ecological efficiency (CPUE)[4]; but the lower the net return, and the lower the economic return of each fisher. In short, large boats are more ecologically efficient because they can use more advanced fishing gear and reach distant fishing spots, but they are less economically efficient because of the high cost of technological investments. Almeida et

[3] The categories of non-resident fishers are not discrete, i.e., neighbor or urban fishers may work for boat owners and become boat fishers. However, the distinction among those groups is useful for analytical purposes since each category has a different impact on the evolution of fishing accords as will be described later.

[4] CPUE is defined as the unit that better explains the variability in the catch (Gulland 1964), and is used to draw comparisons between fisheries.

al. (in press) demonstrate the importance of combining ecological and economic cost in the unit of effort used for comparative analysis of fishing strategies. Such an issue is discussed in the next section.

2.7. ECOLOGICAL AND SOCIAL HETEROGENEITY IN THE FISHING SYSTEM

The fishing typologies presented in the previous section are useful in describing the structure of the fishing, but they touch only superficially on the fundamental ecological features related to the costs and benefits of the fishing strategies. An ecological typology for fishing is necessary in order to reveal the ecological opportunities and constraints raised by the structural change in the fishing activity from customary to contemporary fishing strategies. For the purpose of this discussion, customary fishing strategies are defined as the set of techniques carried out prior to the recent fishing modernization process characterized by the introduction of gillnets and motor boats. Hook and piercing technologies are the most common customary technologies that are still used in the region, while the contemporary fishing strategies are net-technologies[5].

The customary fishing strategy is mostly carried out in lakes and small streams. It is performed by one or two fishers in a paddled canoe in fishing grounds close to the communities. A set of fishing gear is used and shifted according to the season, the fishing ground, and the target species. Each season is characterized by a different combination of fishing gear, each of them specialized for a small range of species. Thus, the major endowment driving the efficiency of customary fishing is the local ecological knowledge, used to appropriately define the shift of fishing strategies. Contemporary fishing strategy

[5] Castnet is considered customary strategy since it was commonly used before the fishing intensification.

is carried out in lakes, creeks, river arms, and river channels. Although contemporary fishing is also done in canoes with one or two fishers, motor boats are used to tow the canoes, which enable the fishers to reach more distant fishing spots, spend less time fishing, and overcome water current more easily in the stream. Contemporary fishing relies heavily upon a single technology (gillnet) while variations are made by changing fishing grounds or by the way the technology is used (stationary gillnet, drifting net, and seine). Thus, the major endowment driving the efficiency of contemporary fishing is the technological assets[6]. In short, customary fishing strategies rely upon active strategy, low technological input, and a high level of local ecological knowledge, while contemporary strategies are mainly passive, depend upon relatively higher technological input, and require a lesser degree of ecological knowledge. The customary strategy varies techniques throughout the year, but is relatively homogeneous across fishers in terms of production system (McGrath et al. 1998). In contrast, contemporary strategies keep the technique relatively homogeneous throughout the year, but can vary largely in terms of capital investment (Almeida et al. in press).

The comparison of catch per unit of effort (CPUE) between customary and contemporary fisheries reveals a much higher efficiency of contemporary techniques, which explains the dominance of such strategy among commercial fishers (Freeman 1995). Data generated by Petrere (1978b) show that net technologies yield 5-6.5 tons/trip, followed by other technologies with efficiency of 0.2-3.6 tons/trip. The data analyzed from the commercial fishing fleet in Manaus is supported by data collected in

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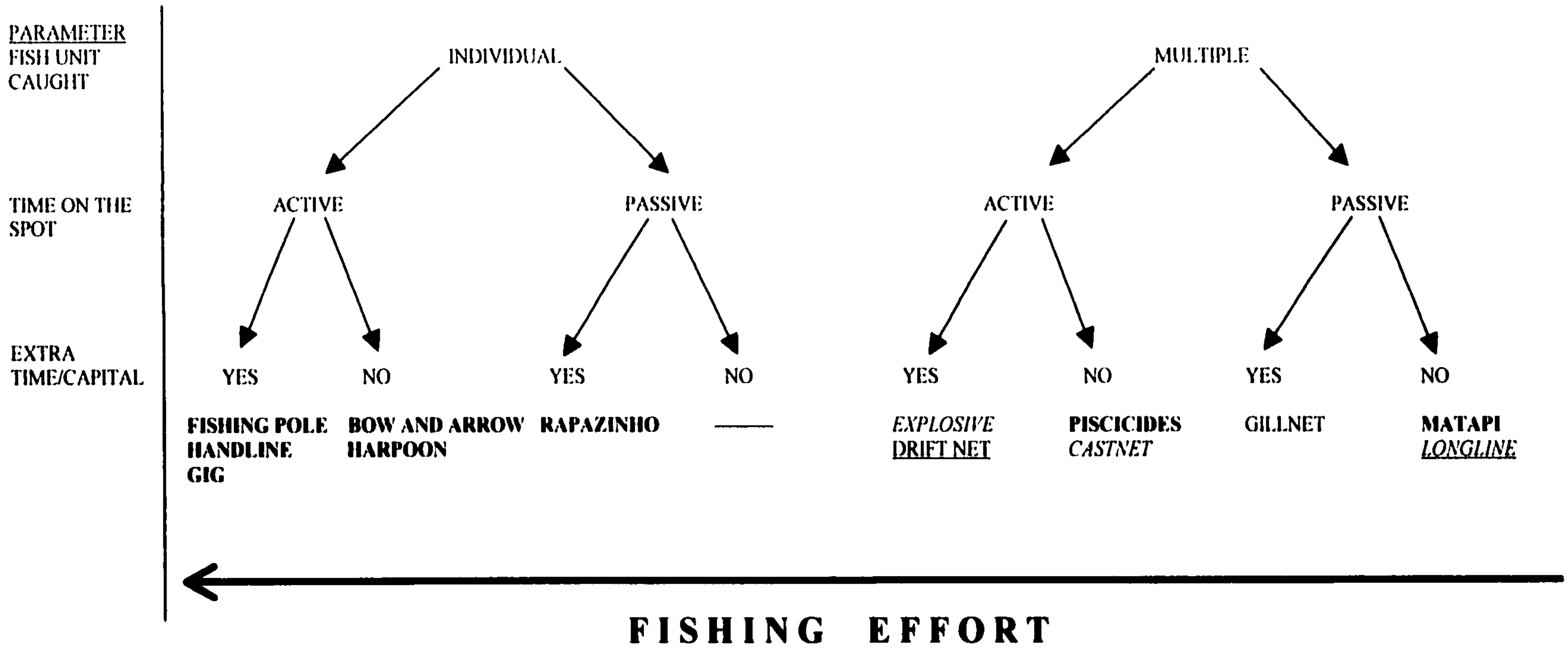
[6] Local ecological knowledge is also important in the process of choosing fishing spots in contemporary fishing strategy. Yet, such information is less complex than those involving variations of fishing techniques in the customary fishing strategy.

smaller-scale fishing in Itaquatiara, where Smith (1981) found that lampara seine and gillnet fishing yield 34.3 kg/man/hour and 10.9 kg/man/hour, respectively, while customary technologies yield 0.7-4.0 kg/man/hour. Therefore, the rapid shift from customary to contemporary fishing was a response to the higher efficiency of gillnets, which yielded high fish production with lower fishing effort. Fish production is a function of fishing effort and the productivity of the system. Such a relationship implies that fish production can be augmented either by increasing the fishing effort or by choosing highly productive fishing spots. It also implies that the decrease of productivity of a fishing spot can be overcome by the increase of the fishing effort.

The tradeoff between production and fishing effort is directly related to four variables in the structure of the fishing strategies. First, *withdrawal capacity* is defined in terms of the number of fish captured per fishing unit. The single-capture strategy is carried out with gear that is able to catch only one fish unit at a time, while the multiple-capture strategy is carried out with gear that can catch several fish units at the same time. Second, *fishing time on the spot* is defined in terms of active and stationary strategies. Active strategies demand the presence of the fisher during the whole fishing activity, whereas stationary strategies demand the presence of the fisher only to set up and to retrieve the gear. Third, *fishing time out of spot* is defined in terms of "out of spot" fishing-related activities that are carried out before or after the actual fishing effort. Fishing strategies that demand less "out of spot" time contrast with strategies that demand "out of spot" activities, such as bait fishing and gear repair. These first three variables are directly related to the labor force invested in the fishing activity. Yet, fishing effort depends not only on labor effort but also on capital effort, since labor demand can be replaced by technological improvement (Almeida et al. in press). Therefore, *capital effort* to purchase (one-shot investment) and maintain (continuous investment) the equipment represents a fourth major variable affecting the fishing production. Strategies of high capital effort are those with relatively higher investment in purchase and repair of the equipment.

Based on the above four variables, a scheme can be drawn to compare basic factors affecting the fishing effort spent between more customary and contemporary fishing strategies. Figure 2.5 shows a gradation in the overall effort demand, from strategies that are highly time-consuming (single-active-extra) to those that are less time-consuming (multiple-passive-non-extra). Three major differences between customary and contemporary fisheries can be drawn from this model. First, contemporary strategies (gillnet and drift net) are all multiple-catch methods, while most of the customary strategies are single-catch methods. Second, customary strategies are carried out in the lakes and small streams only, while contemporary strategies can also be carried out in channels and river arms. Finally, contemporary technologies demand extra time in post-fishing repair, involving both labor and capital effort (to purchase the filament), while most of the customary methods do not. In the customary technologies that do demand extra time — fishing pole and handline — that time is related to pre-fishing activity (bait fishing), which involves only labor effort.



LEGEND

Bold	**– Customary Fishing Technologies**	Non-Underline	– Lake Fisheries
Italic	***– Fishing Technologies Introduced in Early 1900s***	**Underline**	**– Stream and Lake Fisheries**
Normal	**– Contemporary Fishing Technologies (after 1960s)**		

Figure 2.5. Description of fishing technologies used in the Lower Amazon according to their ecological and capital effort.

Thus, customary and contemporary fishing represent two major foraging strategies that have several differences in regard to fishing and capital efforts. First, contemporary fishing has allowed fishers to expand their ecological niche by exploiting other habitats (channels and river arms) and by catching other fish species, such as the LDM catfish, formerly underexploited. In addition, the emergence of contemporary fishing permitted fishers to stretch the fishing pressure on the SDM scaled fish to their migration phase in the river channels. Second, the multiple-passive nature of the gillnet strategy led to the decrease of fishing time "on the spot." Third, the reduced demand for ecological knowledge to manage contemporary techniques (e.g., gillnets) enabled people from other sectors to easily engage in fishing activities. Less-skilled individuals could learn quickly how to fish efficiently. Fourth, the major drawback in the contemporary strategy is the initial large "one shot" capital effort in the purchase of the equipment as well as the continuous capital and labor effort required for gear repair. Gillnets are constantly damaged by the entrapped fish, by carnivorous aquatic animals (e.g., piranhas and river dolphins) who feed on entrapped fish, and by floating debris.

In other words, fishing modernization led to a bifurcation of fishing activity into two major strategies facing different sets of ecological opportunities and constraints, which affected the efficiency of the strategies available. The shift from single-active to multiple-passive strategies was the major breakthrough in allowing the increase of fish production, which is crucial for commercial purposes. However, the investment involved in this shift is a constraint that local fishers had not experienced before. Moreover, the scale of modernization has driven fishers to specialize in commercial fishing by increasing fishing efforts through technological improvement. The major structural difference between contemporary and customary fishing is related to how the fishing effort can be increased. Since customary fishing techniques are primarily active strategies, the increase of fishing effort depends on the addition of fishers or increase of fishing time. Thus, fishing effort is limited by labor force in the household. In contrast, the increase of fishing effort in contemporary fishing takes place through capital effort since it involves passive strategies, depending mainly on technological assets. In this case, the fishing effort is limited by the capital available in the household to invest in technology. Consequently, the heterogeneity in capital assets among fishers leads to different fishing productivity between those two major groups. Consequently, fishers relying upon customary fishing strategies are more sensitive to the drop in the fishing productivity than fishers relying upon contemporary fishing strategies. In other words, customary-oriented fishers tend to feel decrease of the fishing efficiency more promptly than contemporary-oriented fishers.

Although local populations also use contemporary fishing techniques, they maintain a low technological input in comparison to those performing intensive commercial fishing. Consequently, a local decrease of fishing productivity affects these two groups differently. Fishers undertaking contemporary fishing strategy can overcome the problem by travelling further in search of other highly productive fishing grounds or by increasing the number of gillnets. In contrast, fishers undertaking customary fishing strategy have limited technological assets and can rarely purchase another gillnet or move further away from their houses. Thus, the only option is to allocate more time for fishing, since local fishers rely heavily upon active fishing techniques. Considering that the household economy is based on a mixed strategy of subsistence and commercial activities, the allocation of labor force toward fishing is costly. Consequently, the emergence of contemporary-oriented fishing has generated a technological externality toward the customary-oriented fishers.

Technological externality is a type of appropriation problem in which fishers performing more technologically endowed fishing increase the cost for those performing less technologically endowed fishing (Ostrom et al. 1994). In the Amazonian case, such a problem is particularly strong in lake fishing, where both customary and contemporary fishing techniques take place throughout the year. Customary techniques are carried out by the local population who rely upon active strategies, have low technological endowments, and have a mixed production system of fishing, agriculture, and ranching. Due to the high reliance of the local population upon lake fishing, any decrease in the fishing productivity affects the household economy as a whole. The local population has designated gillnets as the major cause of the decrease of fishing productivity due to their strong impact on the fishing production system. Consequently, populations from several local communities have chosen to establish a gillnet ban, regardless of its high short-term efficiency in comparison to customary techniques. Such a response not only trades optimized short-term efficiency for long-term maintenance of local productivity, but also decreases the level of technological heterogeneity among users. In other words, while the production efficiency of a fisher group can be increased by technological improvement, it can decrease the efficiency of another less technologically endowed fisher group. Consequently, in many communities, the improvement in technology has been rejected and replaced by a social institution (fishing rules, including gillnet ban) in order to solve the technological externality.

The creation of fishing rules reveals that local populations not only respond to improving the short-term efficiency in resource procurement but also to decreasing social dilemmas in the long-term access to the resource. The ability to respond effectively depends on several characteristics of the group, which will be addressed in the next chapters.

2.8. CONCLUSION

Fishing in the Amazonian floodplain takes place in a heterogeneous ecological environment. The *várzea* is a complex network of interconnected subsystems upon which fish depend. The flooded forest on the natural levees represents an energy source for several species. Floating meadows are important during the fish growth, for protection against predation and as sources of energy. Streams work as waterways where some species carry out migration. Finally, lakes are the main subsystem where fish grow. Therefore, the analysis of any production system in the floodplain demands a systemic approach in order to understand the impact of a given activity on the whole system and vice versa.

The patchy landscape provides a large range of resources that are used according to the pattern of environmental change. Spatial and temporal change in the landscape usually take place in a predictable fashion; yet, unpredictable features of the change (e.g., flooding and land scouring) may happen as the result of external ecological processes such as the El Niño, causing major impacts on the ecology of the fish resource as well as on the socioeconomy of the floodplain populations. Those physical characteristics of the floodplain strongly influence human access to the resource. In particular, the unpredictability of the system, including local and large-scale environmental change, affects the distribution and abundance of the resources. Thus, the ability of the system to recover from environmental change (resilience) is of major importance in the floodplain.

Local populations have coped with such a risky environment by shifting the strategy of resource use. The distribution of the resource influences the availability of the resource to the human population. Thus, as the system becomes less productive, human populations respond by rearranging their pattern of resource use. A case in point is the recent change in the floodplain economy toward commercial fishing, which has created the bifurcation between customary and contemporary strategies. Fishing productivity has changed with the increase of fishing intensification. Due to technological externality, local fishers have perceived the decrease in fishing productivity more rapidly than commercial fishers who have been able to overcome lower productivity due to their higher withdrawal capacity. In other words, less technologically endowed fishers perceive a decrease in fish productivity more promptly than those fishers carrying out a more capitalized fishing.

In general, the scientific fisheries management systems focus on features of the aquatic system and the fish resource and fish commercialization (Copes 1981). Such a sectorial approach – which has also been applied in the Amazonian *várzea* fisheries – overlooks the interdependence among subsystems to maintain the floodplain productivity, including the fish resource. In additional to the importance of the ecological service of subsystems, fishing is a human activity, which is affected by other activities in the floodplain. Thus, the continuum represented by the *várzea* system demands a conceptual model that assumes its dynamic condition. The focus on ecosystem resilience, which emphasizes the ability of the system to resist disturbances, helps to account for the relationship among subsystems in the conservation of the fish resource.

The next chapter analyzes how social change in the floodplain has affected the ecological system according to the different patterns of resource use throughout the history of the floodplain occupation. Such a historical analysis aims to reveal the dynamics of response to social and ecological change, a major issue related to floodplain resilience.

Chapter 3

EVOLUTION OF LOCAL MANAGEMENT IN THE AMAZONIAN FLOODPLAIN

3.1. INTRODUCTION

Natural resources have long been used by human populations in the floodplain. The distribution and abundance of resources as well as the modification of the landscape units have been strongly influenced by human activities. In some cases, the pattern of resource use led to improvement of ecological productivity, while, in other cases, it led to a decrease in productivity. Therefore, the ecological structure of the floodplain is not only a result of physical and biological processes in the system but also of human actions throughout history.

Human ecologists have contributed to showing that the patterns of resource use by human populations are not randomly defined. Rather, the dialectical process between social aspects of the users and ecological features of the resource/system reflects on the production system through technological development, changes in social arrangements, and the search for new alternative resources. Thus, the shaping of resource use patterns is a dynamic process which continuously changes according to the modification of both ecological and social realms. Such a process leads to an intricate relationship between the changes in the social structure and the changes in the environment, from which local management systems emerge.

Local management systems are shaped from a process of trial and error based on the ecological knowledge accumulated through generations. This information is basic to developing strategies of resource use that, when compatible with the ecological structure, can keep or improve the system productivity (Berkes and Folke 1998). Thus, local management systems have different sources of influence, and are mediated by different mechanisms of control. They differ from scientific management, which is based upon modern Newtonian science, by being diversified according to particular characteristics related to the imediate factors affecting each ecosystem. In this regard, local management systems differ from scientific management systems by not been specifically rational (Dyer and McGoodwin 1994).

Although in western science the notion of the management of a natural resource usually implies a conscious, goal-oriented behavior toward conservation (McInerney 1981), the restriction to rational behavior in management practices limits the understanding of the dynamic process of re-shaping patterns of resource use by human populations when coping with constant social change. The assumption of rational conservationist behavior hides how adaptive practices of resource use that envisage an increase in short-time efficiency can affect the long-term efficiency of resource use through productivity maintenance. Dyer and McGoodwin (1994) argue that to consider management systems as rational behavior toward conservation overlooks the adaptive process of trial and error, which drives certain practices that can gradually be fixed to the cultural realm and become unconsciously maintained. The recognition of unconcious behavior related to resource use as management strategies, such as forms of resource procurement and resource/system avoidance, can help one to understand how different practices are related to each other and how they may affect the system resilience. In other words, it allows one to analyze the local management system as a whole and understand the process of change throughout history.

Perhaps the major confusion in the debate regarding the consciousness of behavior is related to the assumption of a goal of conservation in management practices. The recognition that a local management system encompasses the set of behaviors toward natural resource use implies that individuals can manipulate the environment through their pattern of use in order to increase their efficiency – either short-term or long-term. For example, Hames (1987) argues that procurement methods are selected for the increase of short-term efficiency, but may not necessarily lead to long-term conservation. Likewise, Ruthan (1998) argues that even conscious behavior of management may be related to controlling access, but may have little interest in controlling the resource productivity. Therefore, resource conservation resulting from local management practices should be an empirical question, not an assumption.

The analysis of a set of practices used by the local population in regard to natural resources is especially useful for understanding local management systems as a social arena where individuals' behavior is influenced by a range of factors from different sources. In this regard, it enables one to evaluate how different sets of practices based upon distinct forms of social relationships can affect — either positively or negatively — the productivity of a given resource/system.

In this chapter I discuss the local fishing management in the Amazon through a historical perspective of the patterns of natural resource use in the floodplain system, with a focus on the Santarém region, in the Lower Amazon. The goal of the chapter is twofold: to describe how the evolution of local management systems has taken place during the human occupation in the floodplain, and under what circumstances fishing accords have emerged. The diachronic analysis aims to highlight the factors that have driven the changes in the structure of ecological and social opportunities and constraints in the system. In order to identify the major factors that have affected the structure of the management system, I focus on one aspect of the institutional arrangement of the management system — the prescriptions regulating the resource use. The analysis shows that the diversity of ecological subsystems has enabled local populations to explore a large range of resources in many different ways. Yet, the pattern of resource use has been strongly influenced by local and external factors which in turn have driven local populations to search for new strategies based on social arrangements.

This chapter is divided into four sections. The first section presents the framework in which the local management systems are analyzed. The second section analyzes the process of local management and change in the history of floodplain occupation. The third section discusses how the evolution of local management is related to the social change in the region, and why the ecological models are limited in explaining the patterns of resource use. The fourth section presents a general conclusion.

In order to develop the analysis of the local management, I surveyed the scientific literature and historical documents (newspapers and local publications) from 1911 to 1980 in the Boanerges Senna Library, in Santarém (Table 3.1), and conducted interviews with local residents in order to obtain general contextualization of historical facts.

Table 3.1. Newspapers surveyed, and their respective coverage period (Boanerges Senna Library, Santarém).

Newspaper	Year
Irregular Edition	
Santarém	1911-12
O Commercio	1912
O Farol	1912
O Independente	1913
A Epoca	1914
O 44	1931
O Momento	1934-36
O Tempo	1937
O Sigma	1937
O Mariano	1950-56
O Baixo Amazonas	1952-54
Tribuna Estudantil	1954
O Congresso	1960-74
Hileia Brasileira	1963
Folha do Baixo Amazonas	1966
O Observador	1968
A Foha do Norte	1980-81
Regular Edition	
A Cidade	1917-30
O Jornal de Santarém	1932-35
	1945-47
	1956-59
	1962-73
	1979-81

3.2. INSTITUTIONAL ANALYSIS OF LOCAL MANAGEMENT SYSTEMS

For the purpose of this analysis, I define local management systems as a set of prescriptions that somehow define regular patterns of behavior regarding how a given resource/system should be used or avoided. Such prescriptions define the structure of preferred behavior toward the resource procurement (e.g., foraging behavior) and institutional arrangements that mediate human interactions regarding resource use (i.e., a rule-based system). The former is mainly defined by ecological attributes of the resource/system while the latter is also defined by the social structure of the user group. In other words, I assume that the structure of any strategy of resource use is influenced by the interplay between ecological and social factors (Berkes and Folke 1998).

Stocks (1987) describes three main mechanisms for local management: optimal-foraging, customary, and rational management. Optimal foraging management maximizes short-term efficiency according to the distribution and abundance of the resource. These prescriptions emerge from the outcome of the optimized balance between the benefit of the resource (value) and the cost of obtaining it (effort). In contrast, customary management is designed through "unconscious" social interactions related to resource use. The prescriptions are cultural practices that, regardless of their original purpose, enhance the system productivity. Customary prescriptions are established through cultural norms such as rituals, myths, and taboos embedded in the social realm. Finally, rational management is the closest local arrangement to a scientific management system, which is designed through a "conscious" problem-solving process (Stocks 1987). Rational management systems rely on prescriptions that are explicitly formulated to solve a particular problem and are enforced by an external sanctioning system.

The three types of management systems – foraging, customary, and rational – present a gradation in assignments that reflects the increase in social interaction to control the resource use. The difference in the structure of the prescriptions is a major feature which reflects the social complexity under which natural resource use takes place. Crawford and Ostrom (1995) propose a structural model for institutional arrangements based on the composition of five basic assignments: 1) who is eligible (Attributes); 2) what is permitted, obligated, and forbidden (Deontic); 3) particular actions and outcomes in which deontic is assigned (aIm); 4) the universe in which the assignment is valid (Conditions); and 5) the sanctioning (Or else). According to the model, there are three types of institutional arrangements. *Shared strategies* are those encompassing only three assignments (AIC); *norms* add deontic to the former three assignments (ADIC), and *rules* have all of the above assignments (ADICO). This institutional model is useful for understanding the structure of local management systems. In this regard, optimal foraging management is "norm- or rule-free," based upon individual strategies of procurement and the features of the resource (Gibson et al. 1998). Customary management may encompass shared strategies, where the user groups (Attribute) present particular actions (aIm) related to the universe where the use of natural resources takes place (Condition); norms, which include detailed deontic logic that defines "must" (rituals) and "must not" (taboos), with respect to the natural resource use; or rules, including sanctioning (social reprehension). Finally, rational management includes more structured definitions of assignments regarding permissions, obligations, prohibitions, and sanctioning system.

Local management systems usually present a mixed and dynamic structure of assignments. Therefore, they provide a rich theoretical scenario for testing hypotheses concerning human responses to environmental changes. The emergence of institutions is a costly process, and it is more likely to take place under particular circumstances of resource and social attibutes (Ostrom 1998). Thus, institutional change usually involves an evolutionary process of adjustment of the old structure unless radical social change takes place (North 1990). Therefore, the structural analysis of "management strategies" through time can reveal which environmental factors can affect the emergence and change of management systems (Ostrom 1990, Gibson et al. 1998). In other words, the analysis of prescription changes in the management system can help to understand human behavior on a dialectical basis, in which environmental characteristics (including demographic, social, and ecological) and human behavior affect each other.

Local management in the Amazon has suffered major impacts throughout its history, including cultural change (Parker 1985a), demographic change (Browder 1997), technological innovation (Roosevelt 1989), governmental projects (Moran 1981, Schmink and Wood 1984, Hecht and Cockburn 1989), economic pressures (Santos 1980), and local power struggles (Schmink and Wood 1992, Leroy 1991, Allegretti 1990). The fishing accords indicate a rational management that has recently been created in the floodplain. Yet, although fishing accords represent a dominant management system based on a conscious effort to locally manage the fishing resources, they do not represent the only set of prescriptions in the floodplain. Foraging and customary practices are still used among local populations, including indigenous populations (Stocks 1987; Beckerman 1983; Gragson 1992a, 1992b, 1993) and *caboclos* (Smith 1981, Begossi and Braga 1992, Begossi 1998). The analysis of the process of change in the local management of the floodplain can provide information on what and how factors have affected the pattern of resource use, and how the different sets of prescriptions are related.

3.3. HISTORY OF LOCAL MANAGEMENT

Local management in the Amazonian floodplain can be divided into three historical phases: 1) Indigenous Management, 2) Farm Owner Management, and 3) Smallholder Management. Each phase reflects distinct management systems, related to socioeconomic, cultural, political, and ecological factors.

3.3.1. Indigenous Management (10,000 B.C. - 1757 A.D.)

The indigenous management phase comprises the Pre-Colombian period, when only the indigeneous population used and controlled the Amazonian system. According to Roosevelt (1989), human occupation in the Amazon dates from at least 12,000 years ago, with four stages temporally differentiated by social organization and patterns of resource use: a) nomadic hunter-gatherers after 10,000 B.C.; b) early transitional sedentary groups starting in 8,000 B.C.; c) widespread pottery suggesting a sedentary society of early horticultural villagers subsisting on root crops, fish, and game, starting in 3,000 B.C.; and d) highly dense agricultural chiefdoms supported by intensive seed cropping and supplemented by intensive fishing and hunting until 1,000 A.D.

The combination of ecological opportunities in the floodplain, such as waterways for transportation, fertile soils, and an abundance of protein sources, propelled the development of horticulture after 3,000 B.C. and, later, seed-cropping agricultural societies. As a result, the Amazonian population reached 6,200,000, mostly distributed in the floodplain (Denevan 1992). By the beginning of the century, complex chiefdoms flourished in several different parts of the Amazonian floodplain, such as the Omagua in the Upper Solimões, societies of Middle Orinoco, the Tapajó, the Lower Amazon, and the Marajó at the Amazon's mouth (Meggers 1971; Roosevelt 1980, 1989, 1991; Whitehead 1994).

Technological innovations, such as the domestication of plant species and the shift from animals to plants as major protein sources, allowed the local population to develop a sedentary economy, and to overcome protein source limitations. However, sedentary behavior in combination with population growth demanded new strategies to overcome the depletion of surrounding resources. As Roosevelt (1989) points out, "humans have been living in the Amazon more than enough time to . . . create population pressure on resources." It suggests that mechanisms to conserve natural resources took place during that period.

Local management during the pre-Colombian period was mainly based on optimal foraging and customary management systems. Since archeological data provide limited information on past institutional arrangements, an analysis of resource use by contemporary indigenous societies is helpful to understanding the past management systems. Despite the social discrepancy between ancient and contemporary societies (see Roosevelt 1989 for a criticism on the principle of uniformitarianism), Beckerman (1994) argues that the mechanisms driving current resource procurement should be similar to those presented in the past. Thus, a careful analysis of contemporary strategies of resource use and beliefs related to the natural system sheds some light on how the ancient local populations managed their resources.

Examples of optimum foraging management have been reported mostly from studies related to the "protein debate" in the 1980s, which explored the role of protein availability in the cultural evolution of the Amazonian societies (see Neves 1989 for a review). Because most contemporary indigenous populations are currently located on the interfluvial areas, game has been the main protein item analyzed in foraging studies (Setz 1989, Hames and Vickers 1983), while discussion on the role of other protein sources in the local diet, such as fruit (Beckerman 1979), insects (Dufour 1987), seed crops

(Roosevelt 1980) and fish (Beckerman 1983, Gragson 1992b) is rather rare.

Studies on fishing among indigenous groups show that the fishing strategies are strongly influenced by the distribution and abundance of resources and, thus, conform to major predictions of optimal foraging models. Gragson (1992b) shows that changes in fishing strategies take place according to ecological changes in the system (river water level) in order to maintain fishing productivity. Yet, as Beckerman (1983) argues, fishing activity cannot be analyzed in terms of optimum foraging strategy in systems showing strong seasonality. The availability of other resources in the system demands an analysis of choice among different protein sources in order to evaluate how resource availability in time and space affects the fishing pattern. Such a systemic analysis, which takes into account ecological heterogeneities and interdependence among subsystems, is discussed by Hames (1983).

Customary management systems described in ethnoecological studies can be divided into "altered" and "untouched" systems. The former involves direct human interference in the system such as alteration of the distribution of plant species in fallows ("*apêtes*") to attract game among the Kayapo (Posey 1985), and organic waste dumping in lakes that increases fish productivity among the Cocamilla (Stocks 1987). The latter involves human avoidance of a specific resource (food taboo) or of the system as a whole (sanctuaries). In aquatic systems, taboos mainly apply to carnivores, such as river dolphins and catfish. These species are top predators, which have an important ecological role in controlling the population density of species at lower levels of the food chain (Goulding 1980).

River dolphins are considered enchanted species that turn into human figures to seduce women (Wagley 1953, Galvão 1955). Local populations believe that this species has the power to attract fishers to the river bottom. As a top predator, the river dolphin has an ecological function in regulating the fish community (Stocks 1987). The catfish taboo is related to illness. Catfish are considered "*remoso,*" a folk concept in which the local population assumes that their blood can thicken or health problems can be exacerbated if they eat *remoso* fish (Smith 1981). Explanations for the catfish taboo are multiple. According to Ross (1978a), animal taboos are the result of the high cost of procurement. In fact, the cost to capture several of the catfish species is far higher than other species because they occur mainly in the river channel, which implies several disadvantages in comparison with lake fish. The channel has a higher current, is deeper, and the catfish usually swim in deeper areas of the river. Smith (1981) shows that both lake and channel fish can be considered *remoso* among floodplain residents and argues that this food taboo must be related with other factors such as fat content, and feeding habits of the fish. Begossi (1992a) follows Smith's arguments and defends the hypothesis that the animals with medicinal value tend to be protected through food taboos. In any case, the conservation of some fish species has likely provided a more resilient environment for the fish community in the Amazon.

The second type of customary management among contemporary indigenous societies is the maintenance of "untouched" systems. These sanctuaries are areas avoided due to beliefs or social norms created among the local groups. Chernela (1989) dicusses the customary agriculture practiced by Uanano Tukano in a poor-nutrient floodplain system (*igapó*) which maintains the forest at the river's edge. The author argues that such a strategy enhances the productivity of this poor aquatic system, since fish productivity depends upon allochthonous nutrient sources. Similarly, indigenous peoples establish use restrictions to protect the nutrient-rich and productive marshy areas in the floodplain (*várzea*). In general, such areas are perennial lakes surrounded by dense flooded forest and macrophytes where fries and juvenile fish grow. Stocks (1987), for example, describes how the Cocamilla avoid the "dying lakes," which are isolated "oxbow" lakes closed by aquatic vegetation and suffering from deoxygenation. Mythical beliefs in supernatural creatures have been of particular importance in mantaining sanctuaries. Smith (1992, 1996) discusses the role of *Tapirê-iauara,* a tapir nymph that patrols the flooded forest, to keep fishers away from some areas that are densely covered by flooded forest. Likewise, the myth of "the giant Anaconda" that lives in marshy areas is shared by fishers throughout the Amazon floodplain and also has an important role in restricting the access of fishers to productive aquatic systems (Smith 1981). Finally, the Godess Iara, the mother of the river, is an entity who lives in the water and protects the fish by ensuring the fishers' appropriate behavior.

Sanctuaries are directly related to habitat protection and interdependency among ecological subsystems. By protecting the habitat, not only is the resource conserved but also ecological services, such as biodiversity in sacred groves in India (Gadgil et al. 1998), water capture in cloud forests in Ecuador (Becker 1998), and watershed in Europe (Folke 1991). This systemic perspective of sanctuaries is appropriate in an aquatic system because it is more likely to ensure biological processes of reproduction and growth of individuals in complex systems (Acheson and Wilson 1996). In particular, the diet of several fish species in the Amazonian floodplain relies upon allochthonous sources from the flooded forest such as fruit and insects (Chapter 2). Therefore, this type of customary management system strongly influences the maintenance of floodplain productivity.

It is important to note that optimum foraging strategies mostly define "how to use the resource" while customary management mostly defines "what should and should not be used." Foraging strategies define ways of choosing patches, searching, pursuing, and catching the prey, while customary management usually constrains options by defining permissions and prohibitions. Both systems present incipient rules in which sanctions are internalized and self-controlled. In the optimum foraging system, the sanction is self-determined by the low efficiency of the capture if the expected strategy of foraging activity is violated. In regard to the customary management, sanctions are defined in terms of fear, self-respect, and shame.

The combination of both management systems in the indigenous management phase was sufficient to ensure the maintenance of productivity of the system. Only when the social structure underlying the resource use changed did a new model of local management emerge.

3.3.2. Farm Owners Management (1757 A.D. - 1960 A.D.)

Ironically, the ecological opportunities of the floodplain ultimately played against indigenous interests, since the rivers provided access to colonizers during the European conquest. Colonizers arrived in the seventeenth century in the Amazon and, over the next hundred years, annihilated the riverine indigenous population through war, disease, and capture into slavery. Survivors left the floodplain to occupy interfluvial areas more distant from slave chasers. Catholic missions had relative success in protecting the indigenous populations from external pressure until 1757, when the Jesuits were expelled and the Colony created incentives for intermarriage between Indians and Europeans during the Dictorate period (1757-1799). This process led to the formation of a new ethnic group — the *caboclos*. This non-indigenous native group re-occupied the riverine systems in the Amazon in the latter part of the eithteenth century.

The *caboclos* differed from indigenous societies in many ways. First, they were socially organized in families living in separate houses linked by a strong kinship system (Parker 1985b, Lima 1992). Second, they integrated knowledge and values from both indigenous and European cultures (Wagley 1953, Galvão 1956, Moran 1974). Third, they became closely involved with the regional market (Lima 1992). These particular characteristics of the *caboclo* society enabled them to retain part of the ancient management systems, such as optimal foraging strategies which relied upon folk knowledge and customary management systems based on inherited indigenous cosmology. Nevertheless, the local management system suffered major changes during the process of the floodplain re-occupation that created different opportunities and constraints on natural resource utilization.

Caboclos slowly re-occupied the floodplain until Independence, in 1822, when two major factors intruded upon the local social structure. First, a popular revolutionary movement — the *Cabanagem* — killed a large *caboclo* population in the mid-1830s. Second, the Brazilian Emperor donated land (*sesmarias*) to immigrant farmers for cultivation. The Constitution of 1891 reafirmed the privatization of the floodplain through establishment of large monocrop farms, creating institutional constraints to *caboclo* smallholders who formerly occupied the area (Benatti 1996).

Farm owners and *caboclo* smallholders carried out different strategies. Large-scale farmers established cocoa plantations, which were well adapted to the forest-shadowed levees and to the fertile soil in the floodplain. In addition, they carried out nascent cattle ranching activity on the natural grassland during the dry season. In contrast to farm owners, the *caboclo* smallholders practiced a mixed subsistence activity of agriculture, fishing, extractivism, and small livestock raising, e.g., chickens and ducks. Smallholders were flexible and adapted to the different economic alternatives that emerged in the region; they worked for farm owners, collected logs for steam boats, and sold fish during the Rubber Boom (1840 to 1911), when an estimated 500,000 immigrants arrived in the Amazonian upland from the Northeast region (Santos 1980). During this short period, increased fish demand encouraged commercial fishing of a few aquatic species, such as the fish *pirarucu (Arapaima gigas),* turtle, caiman, and manatee (Verissimo 1895). At that time, commercial fishing involved both the farm owners, who provided access to private lakes and the infrastructure to catch and process fish, and the smallholders, who provided labor (Furtado 1984). Despite the cooperative nature of this arrangement, the contractual activity, called *feitoria*, is historical evidence that farm owners controlled the lake use during that period.

After the "Rubber Bust" in 1911, the floodplain experienced an economic hiatus for more than 20 years. During this period, smallholders relied upon activities of low economic return such as wood collection for steam boats, and sporadic contractual work. The constrained access to resources by farm owners triggered repeated land conflicts with smallholders (Table 5.1 — Chapter 5). This picture did not change until the 1930s, when jute (*Corchorus capsularis*) was introduced in the floodplain by Japanese immigrants. Smallholders rapidly assimilated the jute cultivation, thus triggering a major transformation in the social structure and pattern of natural resource use in the floodplain. Jute cultivation absorbed local labor, had market demand, required low technological input, and was adapted to the flooding cycle (Zimmerman 1987, Gentil 1988).

In the Constitution of 1934, the property regime of the floodplain changed to state property with toleration of smallholders' use, except in cases of public interest conflict (Vieira 1992). Despite state ownership, farm owners maintained control over local resources, and both farm owners and smallholders continued to make transactions of floodplain properties, a fact which is revealed by the advertisements in local newspapers. During this period, farm owners and smallholders engaged in a patronage relationship (*aviamento*) in which farm owners provided land and financial aid to smallholders, who paid them back with part of the production (sharecropping). This dependency-based relationship increased the local power of farm owners, who controlled decisions at the local level while smallholders obeyed them in order to ensure their access to the resources needed to cultivate jute. The patronage relationship developed along with two other social strings between the parties. First, the engagement of smallholders in cattle activity was facilitated by a system of informal cattle partnerships with farm owners[1]. The cattle partnership is still practiced today and consists of an informal agreement in which a smallholder takes care of a herd for a farm owner and receives half of the calves in return. A second social relationship between smallholders and farm owners transcended their economic bonds for a sociocultural system of co-parenthood, which consists of a social commitment of respect and trust between the parties involved (Wagley 1953, Lima 1992,

[1] Existence of cattle partnership is reported at least since 1935 (Jornal de Santarém, Anno II, # 127, 27/04/35).

Futemma 1995).[2] Thus, farm owners and smallholders became closely integrated in the two main economic activities of the floodplain, cattle ranching and jute cultivation, reconciling the former land conflict between them.

In short, the farm owner management phase was characterized by the establishment of a private tenure system of the floodplain (which was informally maintained even after the state took over ownership), by the emergence of two major actors (smallholders and farm owners), and by an economic change (jute boom) that affected the social relationship between the two actors. The low impact of external actors on the local system enabled the development of a local management based upon customary norms controlled by farm owners through sociopolitical power.

The farm owners management system prevailed until strong external influences came into being in the region and a new form of local management, mainly led by smallholders, emerged: the fishing accords.

3.3.3. Smallholder Management (1960 - present)

Although natural levees and grasslands were extensively used for jute cultivation and cattle ranching, respectively, lakes did not become economically important until the 1960s. The advent of synthetic fiber affected the price of natural fiber in the world market and triggered the decline of jute production (Gentil 1988). In turn, it influenced another

[2] Co-parenthood involves a social relationship between two families in which a child of one party is offered to the other party to support the child in situations of need. Co-parenthood is established through the Catholic rite of baptism and reinforces the social relations between the two families by creating an extended system of relations between the child and the co-parents (godchild (*afilhado*) and godparents (*padrinhos*)) and between the child's parents and the co-parents (co-mother (*comadre*) and co-father (*compadre*)).

social transformation. The introduction of synthetic fiber in the fishing sector contributed to the intensification of commercial fishing due to improved efficiency of manufactured gillnets. Fishing efficiency also increased due to technological innovations in transportation (engine-propelled boats) and fish preservation by use of ice and Styrofoam boxes (McGrath et al. 1993a). In addition, road-building projects launched by the government in the uplands propelled a new immigration wave, leading to rapid urbanization (Goulding 1983, Smith 1985). Santarém is the third-largest urban center in the north region of Brazil (Browder and Godfrey 1997), with a threefold population growth between 1960 and 1991, from 91,456 to 277,091 (Anonymous1995). The increase of the population, mostly in the urban area, has affected the fish demand and opened a new economic niche for commercial fishing to fill the gap left by the decline of jute production. As a result, fishing has become the main economic activity among smallholders (Chapman 1989, McGrath et al. 1993a) while farm owners have intensified cattle ranching activity, becoming large-scale ranchers.

Despite such innovations, fishing in the Lower Amazon has remained artisanal. Local management of fishing has also been backed up by optimum foraging and customary management systems. Smith (1981) describes adaptive foraging strategies as well as mythical entities present in the contemporary fishing activity among floodplain smallholders in the Lower Amazon. However, the fishing intensification led to the emergence of a new user group — the non-resident fishers — which triggered fishing conflicts in the Amazon (Goulding 1983, Hartmann 1989) and gave rise to the fishing accords.

Fishing accords differ from the former management systems in that they represent a rule-based, conservation-oriented, rational management system. The fishing accords present a set of hand- or type-written prescriptions in document format, established at community meetings. The document encompasses three main parts: 1) a paragraph describing the place and date of the meeting, names of the communities involved, names of the lakes to be managed, and the reason for the fishing accord; 2) rules listing prohibitions and the sanctions; and 3) a list of signatories, indicating the signature of the participants who support the accord. The document is sent to regional offices (Fisher's Union or IBAMA) and announced on the radio. The accords rely upon a local monitoring system using armed patrols, and sanctioning involves physical confrontation, retaliation, and destruction of fishing devices (see Chapter 5).

The fishing accords have evolved according to the emergence of distinct actors and the enpowerment of smallholders. This process can be divided into three main phases that I will call: 1) local organization, 2) regional organization, and 3) participatory organization.

The local organization phase comprises the period between the mid-1960s and mid-1980s, when conflicts between smallholders and motor boat fishers became more frequent. During this period, smallholders were strongly supported by the Catholic Church (Lima 1999) and by farm owners. The Catholic Church helped by providing a supporting social structure for political actions. The Church organized the scattered rural household units into community-based institutions in order to facilitate their religious work. A community encompasses a group of kin-related households settled in a contiguous area along a stream, with collective facilities such as church, common shelter, and school (see Chapter 4). The Church provided the communities with educational work (Basic Education Program) and political background, which led to a "collective identity" through the formation of "common interests" and "group strength." In the 1970s, other church-based organizations — FASE (Organization for Social and Educational Assistance) and the Pastoral Land Comission — provided the rural area with an information network (radio station, bulletins, and regional meetings). This network played a major role in developing rural leadership to struggle against external political forces at the regional level (Chapter 4). Farm owners, who were engaged in cattle ranching, also supported the fishing accord due to their concern about property poaching and cattle piracy by non-residents, an old problem that became pervasive in the 1960s (Jornal de Santarém 22/09/34). Thus, despite their lack of interest in the fish resource, farm owners were able to expel potential cattle poachers by supporting the fishing accords. Therefore, the local organization phase of the fishing accords was marked by the conflict between smallholders and motor boat fishers, the organization of smallholders in community-based decisions, and the support from farm owners for the fishing accords.

Organized support for fishing accords at the regional level started in the mid-1980s, with the participation of a grassroots organization — the Fishers' Union. The increased involvement of local populations (from both urban and floodplain areas) in commercial fishing expanded fishing conflicts between residents and fishers from urban areas and neighboring communities. The conflict among these actors magnified the need for a regional-based organization to mediate the conflicts. Meanwhile, the Fishers' Union, which was under the power of motor boat owners, was taken over by small-scale fishers during a church-supported peasant movement that started in the early 1970s (Leroy 1988, 1991). Since then, the Fishers' Union has represented the local communities in the governmental offices and has tried to solve conflicts at the regional level. A historical marker of this phase is the *Obidos Statement ("Carta de Obidos")*, a document prepared by representatives of several Fishers' Unions in the region during the first Meeting of the Artisanal Fishers from the Middle Amazon in Obidos in 1984. The document, which was submitted to the government, raised five main topics: 1) social conflicts related to fishing activity; 2) commercialization and credit lines for fisheries; 3) the role of the Fishers' Unions in artisanal fishing; 4) conservation of the ecological system; and 5) health and education issues (Furtado 1993b). As a result of this document and other claims, the government launched a research program through IBAMA, the office in charge of monitoring the use of renewable natural resources.

This process gave rise to the "participatory" phase of the fishing accords in the early 1990s, which marked the formal involvement of local communities, grassroots organizations, governmental offices (IBAMA), and NGOs. Such a process emerged from a serious fishing conflict that had existed in the region since the mid-1960s in the Lago Grande de Monte Alegre (Monte Alegre Lake). The confict led to the establishment of a decree in 1990 that prohibited commercial fishing in part of the lake (Hartmann 1991). In the following year, the Brazilian and German governments lauched a bilateral research program (IARA Project) in order to ". . . subsidize the policy measures regarding the exploitation of fish resources in the Middle (Lower) Amazon. The program aimed at sustainable use, compatible with the interests and needs of the local population and the society as a whole, as well as the regional and national economy" (authors' translation) (IBAMA 1995). The IARA Project was the government's first attempt to explicitly consider local social factors in Amazonian fisheries policy. The collaborative work between the regional Fishers' Unions and the IARA Project has resulted in several accomplishments. First, it changed some formal rules that regulate fishing in the region. In 1993, policymakers, supported by suggestions from researchers and representatives of the Fishers' Union groups of the region, re-evaluated a few decrees regarding the minimum size of fish and closure of the fishing season (*defeso*). In 1996, IBAMA released a new fishing policy, which aims to descentralize the normative system at the regional level. Such a process has strenghtened the Union's voice at the regional level. In addition, through a collaborative work between the IARA Project and the Fishers' Union, fishers claimed their eligibility to collect unemployment compensation during the off-season. Based on the Constitution of 1989, employees deprived of work should receive social security during their inactivity. An eligibility criterion enabled unionized fishers to have access to this insurance. Consequently, the participation in the Fishers' Union increased severalfold across the region.

Finally, the most recent collaborative enterprise has been the creation of a reserve in the Maicá Lake, close to Santarém. The Maicá Reserve represents the first attempt to design a collaborative fishing management system with local participation in the design and monitoring of the system. NGOs have also become involved in the participatory process through research programs supported by international development agencies such as Overseas Development Agency (ODA) and World Wildlife Fund (WWF). These projects focus on the design of local management systems by strengthening social organization and by developing economic alternatives at the community level (McGrath 1994, Mamirauá 1996). In summary, the participatory phase has focused on the creation of a more representative system that includes both local actors and the broader society.

Isaac et al. (1997) use the model formulated by Sen and Nielsen (1996) to describe the evolution of the fishing management in the Lower Amazon. The authors explain that before the IARA project, the fishing management was "instructive." The government simply informed users about their decision making. When the IARA project was launched, fishing management assumed a "consultative structure," in which the government began consulting fishers about policy measures. Recently, the creation of Fishing Committees, which includes representatives of different actors related to a given fishing region, has been an important step toward decentralized decision making. Despite the imperfect nature of representation, the Fishing Committees represent a breakthrough in the fishing co-management process — by shifting from the former top-down, Amazonia-wide management system run by the government to a bottom-up, regional system run in collaboration with the resource users.

3.4. LOCAL MANAGEMENT, INSTITUTIONAL DEVELOPMENT, AND CONSERVATION

The pattern of resource use in the Amazon has changed throughout its 12,000 years of human occupation according to alterations in the ecological and social structure of opportunities and constraints at local and external levels. The historical analysis of management systems in the Amazonian floodplain reveals an increase in the level of coercion as the social system became more complex (Figure 3.1).

MANAGEMENT PHASE	INDIGENOUS	FARM OWNER			SMALLHOLDER		
	10,000BC	1750	1840	1910 1940	1960	1980	1998
					Local	Regional	Participative
ACTORS	Indigenous		Residents Farm Owners		Residents Farm Owners Catholic Church	Residents Farm Owners Catholic Church Fishers' Union Boat Fishers	Residents Farm Owners Fishers' Union Boat Fishers Urban Fishers Neighbor Fishers GOs NGOs
MAIN RESOURCE	Mixed	Cocoa	Rubber	Jute	Fish Cattle Timber	Fish Cattle Timber	Fish Cattle Timber
ECONOMIC PURPOSE	Subsistence Exchange		Commercial		Commercial Subsistence	Commercial Subsistence	Commercial Subsistence
MAJOR PRESCRIPTION	Foraging strategies Cultural norms		Political norms Cultural norms Foraging strategies		Explicit rules Political norms Cultural norms Foraging strat.	Explicit rules Political norms Cultural norms Foraging strat.	Explicit rules Political norms Cultural norms Foraging strat.
PACE OF CHANGE	Slow		Medium			Rapid	

Figure 3.1. Time line of the local management in the Lower Amazonian floodplain, according to the social characteristics of the system.

The indigenous management phase was driven by physical and biological characteristics of the resources, such as soil fertility and protein availability (Neves 1989). Despite the high social complexity of pre-Colombian chiefdoms, the characteristics of the system, such as high reliance on natural resources, close social ties, and relative isolation from external factors, enabled foraging methods and cultural norms (taboos, myths, and social pressure) to be sufficent to control the resource use.

Less coercive systems are more likely to develop when the populations have ecological, social, and temporal conditions to build their pattern of use into their cultural values. As Pinkerton (1994b) points out, "folk management systems were probably developed through trial and error in situations where the resource was fairly forgiving, that is, mistakes could be made that were nonfatal to species" (p. 319). Hence, the close relationship with the local environment and the resilience of the ecological system were probably the major factors in providing ancient societies with conditions to shape their management systems into culturally constructed systems of trust and common understanding. No less important is the time frame in which the process of change took place. The slow pace of the development of indigenous management systems enabled the compatibility between short-term efficiency in resource foraging and long-term efficiency in resource conservation. In other words, the indigenous management phase achieved biological conservation by ensuring the dynamic co-adaptive process between resource exploitation and resource recovery through constant, slow ecological and social change.

The long-standing indigenous management phase contrasts with the other two management phases, which followed the faster pace of the colonization process. The farm owner management phase emerged as a result of a radical change in the social structure.

The importance of the attributes of the resource in defining its use was overlayed by new institutional constraints, which filtered the forms of access to the resource, and in turn affected the foraging strategies. Thus, resource use by smallholders was defined by only one segment of floodplain occupants (farm owners) who enjoyed higher local political and economic power.

While foraging strategies were also present in the farm owner management, they were overlayed by other local norms, which differed enormously from those prescribed during the indigenous management phase. Unlike the indigenous management phase, when local norms originated through a cultural process, the local norms during the farm owner management phase originated through political and economic processes defined by the state policy (change in property rights) and external market pressure (economic boom). The prescriptions guiding farm owner management were based upon a combination of economic coercion at both the local (patronage) and the external (global market) level. The dependency generated by the patronage relationship (*aviamento*) gave farm owners power to dictate the resource use according to their economic interests. Thus, economic revenue became the major "optimizing" input and, therefore, exploitation was less likely to be compatible with the ecological integrity. For example, a cocoa plantation was compatible with the ecosystem because it grew under the forest shade, ensuring the maintenance of the flooded forest. On the other hand, jute plantations, which were operated in cooperation with farm owners, led to extensive deforestation of flooded forest (Goulding et al. 1996). Similarly, cattle ranching can be an activity compatible with the renewable natural grassland on the floodplain; yet, the intensification of cattle and buffalo ranching may cause strong impact on the productivity of the floodplain system (Goulding et al. 1996). The process of ecological change that took place in the floodplain during the farm owner management phase suggests that major activities were less "conservative" than during the former period. Despite the "private" tenure of the system, the pattern of resource use seemed less prone to conservation than those held under the "collective property" regime during the Indigenous management phase.

Despite the change in the mangement system of the floodplain, aquatic resources were not strongly affected because of the low economic importance of fish during this phase. Fishing was carried out mainly for subsistence purposes and remained a locally-based activity, driven by foraging and customary prescriptions (taboos and sanctuaries). The only exception was during the Rubber Boom, when commercial fishing gained relative importance in the region. During this period, commercial fishing was controlled by farm owners who optimized their economic return while smallholders optimized their return in capture. The *feitorias* in the late 1800s are examples of such an arrangement, in which commercial *pirarucu* fishing relied on detailed local ecological knowledge of the species (Verissimo 1895), but was controlled by the farm owners who appropriated the lake. Thus, market pressure and lack of control by smallholders were the main factors driving the overexploitation of some aquatic species during this period, such as turtles, caiman, manatees, and the large fish *pirarucu*.

The farm owner management phase gave way to a new management arrangement only when a new wave of external and internal factors affected the local social structure and economic patterns in the floodplain. The development projects launched by the Brazilian government marked a phase with another set of opportunities and constraints that affected the pattern of natural resource use. Fishing became a major economic activity in the region with the emergence of new fisher groups and fishing devices. The local population rapidly felt the decrease of fishing productivity due to the technological externalities created by commercial fishing and the threat to local norms that defined lake appropriation, thus raising the transaction cost among the local population. Meanwhile, the smallholders gained political power by getting support from the Catholic Church and from the new ideological shift toward conservation. The new political environment created a channel in which smallholders were able to develop a system of management based upon written rules. The emergence of external coercion, which involves moral (humiliation), economic (gear burning), and physical (body injury) retaliations was, therefore, a response not only to the decrease of fishing productivity, but to the increased technological and social heterogeneities between resident and non-resident fishers.

The major outcome of this rational management system has been the control over lakes by smallholders. Fishing accords claim the right of local populations (smallholders and farm owners) to control access to lakes based on the premise that lakes are the "collective property" of residents living in the sorrounding area. However, this claim holds different meanings for the two local groups. To farm owners, who are mainly cattle ranchers, it represents the maintenance of their control and security against cattle piracy. To smallholders, who live in the local villages, it represents an "increase in efficiency" by restricting the fishing effort, and an attempt to gain participation in the control over the lakes. Therefore, for both local actors, the fishing accord presents two goals: 1) an explicit agenda of conservation; and 2) a hidden agenda of property claim.

The acknowledgement of the potential value of local management for conservation has given local populations a chance to articulate their power by including the concept of conservation in their discourse (Schmink and Wood 1992, Alegretti 1990). The conservationist discourse embedded in the fishing accords is also a strategy by local populations to enhance their bargaining power at the political level in order to maintain their access to the local system. Therefore, the dominance of fishing accords in the smallholder management system represents a response to new opportunities in the political realm obtained by both local and external factors.

The implications of this dual agenda of the fishing accords raise a question about the potential of such local institutions in the conservation of fish resources, which will be discussed in Chapter 6. Regardless of the role of the fishing accord for biological conservation, as it is now, the structure of the smallholders management system also includes foraging strategies, cultural norms, and rational rules. This system is part of a dynamic process of institutional formation that has long been taking place in the Amazonian floodplain. It holds important social capital accumulated from local knowledge, cultural values, social organization, and the skills to develop "formal" management systems.

3.5. THEORETICAL APPROACHES TO LOCAL MANAGEMENT

The history of the local management systems in the Lower Amazon is an example of a complex system, where, over time, an ecological system has been exploited under a series of different management systems according to the distinct social structure of each period. This historical analysis reveals a dual mechanism of adaptation to the ecological and social systems directly related to the pace of the changes. Indigenous management systems were guided by a slow process of optimization of resource use backed up by a cultural repertoire of norms (myths, taboos, and sanctuaries). In contrast, the farm owner and smallholder management systems were driven by a faster process of optimization of resource control backed up by a sociopolitical repertoire of norms and rules.

The optimum foraging theory defines human beings as predators who shape their behaviour regarding resource use according to ecological factors. The decision-making process is analyzed in four major contexts: diet choice, space to cover, time allocation, and group size (Schoener 1971). It focuses on the characteristics of the resource by measuring ecological parameters such as spatial and temporal distribution and abundance of the resource. Political economy defines human beings as social actors who can engage in collective action to use the natural resource. Decision making is analyzed in terms of the structure of the group, such as power, trust, reputation, communication, and information (Ostrom 1998). Thus, political economy emphasizes how interpersonal relationships mediate the pattern of resource use. Thus, although both theoretical approaches assume optimization of behavior in the resource use, optimum foraging theory and political economy present a major analytical distinction regarding what stage of the decision-making process is emphasized – the former on the "action level," and the latter on the "meta-action level."

The analytical power of the optimum foraging theory to explain the pattern of resource use during the Indigenous management phase is related to the intimate relationship between the users and the resource, the slow pace of environmental change, the relative isolation from external factors, and ecological resilience, which are essential conditions for the development of the foraging practices congruent with the ecological system. Yet, the shift in focus from the characteristics of the resource to the characteristics of the users is the limitation of ecological models to explain institutional structures related to resource use. The more complex the institutional arrangement, the more limited the optimum foraging theory is in revealing the factors driving a pattern of resource use. The structure of power and the market forces that emerge when local societies are integrated to a broader society are not included in the ecological models. Hence, while optimum foraging theory studies usually search for "ecological" missing variables when suboptimum behavior is detected (Begossi 1992b), the political economy approach broadens the analysis by searching for "contextual" factors that affect "meta-action" decisions (McCay 1981a). In short, the optimum foraging theory is useful in understanding the human adaptation process toward resource use under conditions of relative isolation, stability, and slow environmental change; but it is limited in explaining adaptation in those systems which are under rapid change and strongly influenced by external factors. In this sense, the combination of the optimum foraging theory and political economy is a useful analytical strategy to account for a dual adaptation process influenced by ecological and social factors. Instead of focusing on the question of whether or not optimization took place during the different local management phases, a fundamental question regarding resource use is how and why the "meta-action" behavior (institutional arrangements) has occurred throughout the history of local management in the Amazon.

The Amazonian case reveals two major reasons for "claiming control of access" during the smallholder phase: 1) ecological — increase in the efficiency of capture; and 2) social — increase of decision-making power. It represents a short-term adaptation that cannot necessarily be conservative in the long run. Ecologically, short-term efficiency in foraging strategies is not always compatible with the long-term maintenance of resource productivity (Hames 1987). Socially, an "increase of decision-making power" is an adaptive behavior in complex systems to lower transaction costs when high heterogeneity and low common understanding take place.

The social resilience of *caboclo* populations stems from their ability to maintain their access to resources, and fishing accords emerged as one strategy for achieving that goal. In conditions of a complex environment, the ability to cope with rapid change is possible only when control of resources is ensured. Claiming control of access has been one of the major socioecological factors observed in local management systems (McCay 1978, Steins 1997, Ruttan 1998). In fact, some degree of local autonomy is one of the basic conditions for a local management system to work (Schlager 1994, Ostrom 1990). Nonetheless, claiming control of access is not enough to ensure the conservation of a resource at the local level, if the institutional and ecological systems are not compatible. If claim of control is related to other economic or political revenues, it may not achieve conservation unless the structure of incentives is changed.

Conservation is usually an epiphenomenon of customary techniques regarding resource use (Ruttan 1998). The relationship between local management and resource conservation is more likely to take place among populations that have co-existed for generations, have a close relation to the local environment, and are relatively isolated from external forces. In contrast, neo-traditional populations,[3] who have experienced

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[3] ". . . populations with both traditional knowledge and a body of new knowledge coming from outside the population" (Begossi 1998, p. 133). Along the same lines, neo-traditional management systems are defined as those ". . . which do not have historical continuity, but which are based on observations, experience and local knowledge of resource users" (Berkes and Folke 1998, p.5).

closer integration into the broader society, are more likely to suffer from incentives to develop local management systems that are less ecologically sound. This distinction is essential to recognizing the potential weaknesses and strengths of local management systems. "Increase of power" is a valuable social capital; yet it has no direct avenue to conservation outcomes.

There are two possibilities in which increase of control may not turn into a conservative practice. First, control of the system may be used as a means to achieve other purposes. For example, Steins (1997) discusses a case where local control of fisheries in one Irish fishing community was used as a means to expel fish farmers from the region. The local population used their legal rights to create local cooperatives but once their goal of expelling potential fish farmers was achieved, they gave up their organization, which is now poorly structured. In the Amazonian floodplain, farm owners had similar incentives to participate in the first stage of fishing accords, whose major interest was not related to fish conservation but to avoiding potential cattle piracy. In this case, the lack of direct commitment to conservation increases the threat to resource sustainability. A second possibility in which claiming control of access may not turn into a conservative practice is when the local management is not able to control the activity by the user group (Ruttan 1998, Gibson and Koontz 1998).

In this regard, fishing accords address a sensitive issue of self-enforcement. They differ from the former management systems in that they are more coercive, even among smallholders. In general, fishing accords have been more successful in expelling non-residents than in actually controlling local fishing. A major factor affecting the efficiency of self-enforcement is the close relationships among local families (Taylor 1987, Sheridan 1988). The overlapping social spheres of the accordants sometimes create a barrier against accusations of each other, since individuals carry out multiple tasks together and a minimization of conflict is usually prioritized. In contrast, sanctioning among local actors may stem from other historical conflicts among families (Araujo 1994). Individuals involved in conflicts originating from other social arenas may use the fishing accords as a way to achieve revenge, thus enhancing conflicts instead of regulating the fishing activity. Hence, the analysis of the interpersonal relationships among users is essential in tackling "meta-action" adaptations, which in turn reflect in the foraging strategies. In doing so, "action" adaptations described by the optimum foraging studies can be contextualized in the social realm in which resource use takes place.

3.6. CONCLUSION

The Amazonian case shows that local management systems comprise a multi-layered set of prescriptions, created from distinct source of pressures, and arranged in order to define the relationship between users and the resource/system and among users in regard to resource exploitation. Despite the different arrangement of prescriptions, each management system throughout history presented foraging strategies, local norms, and explicit rules. While foraging strategies function mainly at the action level, norms and rules function at the meta-action level. Therefore, only the analysis of each set of prescriptions can provide a thourough explanation of the factors operating in the process of change.

Like anywhere in the Amazon, the floodplain has suffered constant changes in the structure of opportunities and constraints that affect the pattern of natural resource use.

The combination of local ecological knowledge with the diversified production systems gave native populations the ability to respond quickly to new economic alternatives. In addition, the social structure of *caboclo* populations, combining household and community-based organizations, has played a major role in enhancing their social resilience vis-à-vis the several economic changes that have taken place throughout Amazonian history. Over time, *caboclos* have developed multiple strategies of social organization, such as seasonal migration between floodplain and upland systems (Futemma *et. al.* in prep), urban migration (Mougeot 1981), extended family networks (Futemma 1995), engagement in patron-client relationships (Lima 1992, Gentil 1988), and community organization (Furtado 1993a, Lima 1999). As a result, while non-native populations have always enjoyed access to resources due to external support — private property (*sesmarias*) in the eighteenth century, economic power during the rubber boom and the jute boom in the nineteenth and mid-twentieth centuries, and recent land titles during road projects — the *caboclo* populations have been relatively successful in maintaining their access to resources mostly due their local social organization and ecological knowledge.

Foraging strategies and cultural norms were efficient when the user group was encompassed by kin-related, subsistence-based, relatively isolated groups, which facilitated common understanding based upon "internal sanctions." Norms were less costly than rules because enforcement was based on internalized values (Posner and Rasmusen 1997). The social homogeneity and slow pace of change enabled local populations to adapt their strategies of resource use to the ecological characteristics of the system. They were able to internalize stable "norms" into the cultural background and, therefore, made the creation of more elaborate sanction systems less necessary. As the system became more integrated into the broader society, resources became accessible to other user groups, and a more coercive system emerged in order to lower the transaction cost among users.

The constant experience of economic and political change increased the social resilience of this population and enhanced their ability to search for new opportunities under the threat of losing control. New strategies of social organization, including linkages with other external actors in the region, have been fundamental to ensuring the maintenance of their social resilience. Actors such as the Catholic Church, farm owners, and NGOs have helped to strenghten the ability of the *caboclos* population to organize their collective action toward controlling the use of natural resources. Regardless of the incentives that drove those actors to support the local organizations — facilitation of religious work for the Catholic Church, decrease in cattle poaching for farm owners, political reasons for the government — floodplain populations have used their discursive power to search for new opportunities that will ensure their access to the floodplain resources.

In addition, political actions have played a major role in the process of change in the local management systems. The analysis of this process of change reveals the dialectics between social organization and resource use in the floodplain. Thus, despite the conservationist discourse embedded in the current rational management of fishing, it should not be assumed to have conservation as an exclusive primary goal. Even in such a rational local management system, which is driven by conscious decisions toward resource conservation, other factors, such as the increase of economic return and political power, can play a more important role in the decisions. Therefore, the fishing accords should not be analyzed as a conscious long-term resource conservation practice. Rather, they result from a combination of social and ecological factors based on the historical background of the group, its ability to organize, and the level of perception of resource scarcity. In regard to historical background, *caboclo* populations have been exposed to multiple economic booms, a fact which has affected their ability to respond to social changes. In addition, their ability to organize has been enhanced by other actors as well as by internal incentives resulting from the perceived threat of losing access and control of a very valuable resource.

In short, it is difficult to distinguish between the ecological (conservation) and social (property claim) goals of the fishing accords. Whether or not a smallholder management system can play an important role in the conservation of natural resource in the floodplain is a matter of how well the fishing accords can operate within the local social structure and within the ecology of the fish resource. The next chapter describes the current social structure of the floodplain population and how the patterns of resource use are related to access to floodplain subsystems.

Chapter 4

THE STRUCTURE OF FLOODPLAIN POPULATIONS AND THEIR USE OF NATURAL RESOURCES IN THE LOWER AMAZON

4.1. INTRODUCTION

In Chapter 2, I discussed the fact that the floodplain system varies spatially and temporally, and, in Chapter 3, I discussed how the contemporary riparian population has emerged from a combination of social and ecological factors in the floodplain system. In this chapter, I discuss how the contemporary floodplain population is distributed in this patchy environment. The analysis aims to show that although floodplain populations share similar characteristics, the differences in their relative access to resources affect their patterns of resource use.

Studies on human use of natural resources in the Amazon focus mainly on two ecological systems (upland and floodplain) and three human groups (indigenous, settlers, and *caboclos*). Despite the theoretical importance of these categories, recent studies have proved that finer ecological and social disaggregation is essential to understanding patterns of resource use (Moran 1995).

Non-indigenous native populations (*caboclos*), who are mainly located in the floodplain systems, have been the least studied human group in the Amazon (Parker 1985). Consequently, the contemporary pattern of resource use by human populations in the floodplain is still poorly understood. *Caboclos* have only recently come to the attention of scholars due to emergent socioecological issues, such as social justice (Allegretti 1995), cultural diversity (Neves 1995), the role of local knowledge in conservation (Anderson 1990, Hiraoka 1992, Brondizio 1996), and their ability to adapt to the external pressures (Schmink 1985, Parker 1989, Chibnik 1994).

These recent studies on the *caboclos*' social systems reveal that although those populations share a similar history throughout the Amazon (Moran 1974), they have faced different ecological and social pressures, which in turn have led to the development of a range of life strategies. The *caboclos*' economy varies from a focus on Brazil nuts in the eastern upland (Allegretti 1990) to agriculture in the Middle Solimões (Lima 1992), fishing in the Lower Amazon (McGrath et al. 1993a), or palm fruits in the estuary (Brondízio and Siqueira 1997). Similar to the *ribereños* in Peru (Chibnik 1991), the term *caboclo* implies an identity constructed by outsiders, while local groups identify themselves by local social factors, such as kinship, community membership, religion, and economic activity (Lima 1992).

The floodplain system has been the target of pressures on multiple geographic scales that have affected local populations differently. A focus on the economic strategy represents an empirical way to disaggregate *caboclo* populations because it relates to two important features regarding the use of natural resources. First, it links ecological diversity with cultural diversity by exploring the role of the ecological system in defining new human categories. In this regard, the floodplain system represents an environment with a limited range of resources, with which the populations can engage, and which in turn may shape their social and economic life. Another advantage in focusing on the economic strategy is the ability to disaggregate the *caboclo* populations according to the level of detail demanded by a particular empirical question. Like *ribereños* (Padoch and DeJong 1992), *caboclos* develop a mixed production system which can vary extremely among households in the same community or even in the same household during different years.

Furtado (1993a) has proposed a categorization of *varjeiros* (from "*várzea*" = floodplain) for *caboclos* living in the Lower Amazon floodplain. The author argues that such a definition implies the importance of the ecological system in defining the mixed production strategy that is based on the floodplain. The category *varjeiro* represents an improvement in the *caboclo* disaggregation in that it makes a distinction between the set of ecological opportunities and constraints faced by this group and those faced by upland populations such as rubber tappers (Alegretti 1995). Yet, the category does not separate out those major ecological distinctions in the floodplain system throughout the Basin that play a major role in the access to natural resources, such as environmental risk, soil productivity, and vegetation distribution (Moran 1990). As discussed in Chapter 2, the patchiness of the floodplain system creates a distinct distribution of resources. The use of aquatic (fishing) and terrestrial systems (agriculture and cattle ranching) depends upon several features, such as access to landscape units, access to credit lines, and household structure (Chibnik 1994, Padoch and Jong 1992, Futemma et al. 1998). In addition, floodplain populations have a different level of access to the upland system where private areas are more common (Futemma et al. 1998). Due to the interdependency among subsystems, any constraint upon the access to a given resource represents a displacement of human use effort to other resources. Therefore, the provision of finer disaggregation of the *varjeiro* category based upon access to and use of resources can help to reveal the local factors that influence the pattern of natural resource use in the Lower Amazon.

The goal of this chapter is to describe similarities and differences among the *varjeiro* populations of the Lower Amazon. The chapter is divided into five sections. First, I present the methodology. Second, I describe the concept of floodplain community in the Amazon. Third, I describe the structure of the floodplain population and patterns of resource use. Fourth, I discuss the differences among the floodplain communities in regard to their access to resource. Finally, I draw general conclusions.

4.2. METHODOLOGY

Data were collected from 1993 to 1997, using the Community Census Statistics Methodology (Censo Estatístico Comunitário - CEC). CEC is a participatory method that was developed by the IARA Project (IBAMA 1995) in order to overcome the lack of data on the target group, among other goals (Isaac et al. 1999).

The CEC is carried out by a multidisciplinary team including educators, social scientists, and ecologists. CEC meetings varied according to the local context. Meetings were three to four hours long, and usually took place in collective spaces such as schools, community shelters or outdoors. The number of participants ranged from a few individuals to the whole community.

Usually, a CEC meeting started with a general presentation on the project. It was followed by community mapping and data collection on community and household levels. Community mapping was carried out with the help of the community members who drew the houses and community buildings. Data at the community level were obtained through questions related to the infrastructure of the community, history, and social life. In general, mutual discussion among the participants helped to achieve reliable information. Finally, data collection at the household level, such as demography and socioeconomic activities, was followed by dividing the community map into sectors and assigning groups who lived in the sectors to provide information about every household in each specific area. The census carried out at the group level is the main novelty of CEC methodology, since it overcomes the time constraint of the door-to-door methodology. The help of local residents in a one-shot collective meeting enables faster data collection with relative accuracy, since basic information about absentees can be provided by their neighbors who usually share a close social relationship (Isaac et al.1999).[1]

The CEC methodology was carried out in all 198 communities where the economic activity of the residents relied at least partially upon the floodplain system. It covered an area of approximately 4,500 km^2, encompassing four municipalities (Santarém, Monte Alegre, Alenquer, and Obidos) (Figure 4.1). The present analysis encompasses 172 of the total number of communties. As questionnaires were not consistently filled out, the results presented were based on different sample sizes, which are appropriately referred to in the text.

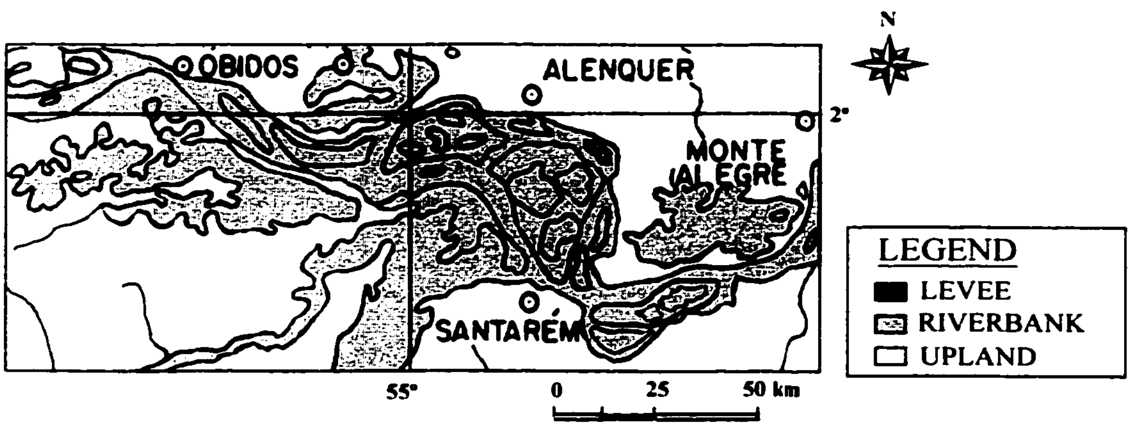

Figure 4.1. Floodplain of Santarém region showing the three ecological locations where the communities are settled (levee includes islands and water, riverbank, and upland).

[1] No local norms that could constrain the provision of information were observed. Data on both present and absent community members were easily provided with no sign of embarrassment or gossip.

4.3. THE CONCEPT OF COMMUNITY

The term "community" has been broadly used in the literature to address issues on local management. Human ecologists define "community-based management" as local institutions including a group of individuals who fulfill some criteria of eligibility. Although a community does not necessarily represent a group of people living in the same physical space, residency has been one of the most common criteria of eligibility in those local institutions (Schlager 1994). Residency is an important social factor which bonds people in collective endeavors. Neighbors tend to share closer social relationships in settings where residents do not enjoy external support for developing their daily activities. In the Amazon, residency is defined according to the "community," a term that implies particular historical, sociocultural, and political contexts (Lima 1992).

Community is a recent concept that emerged from internal and external factors. As described in detail in Chapter 3, the contemporary occupation of the floodplain started in the late eighteenth century, but its pace increased only after the erosion of the upland-oriented production of rubber (Table 1.1). Local populations searched for new economic alternatives in the floodplain when they abandoned the latex production in the upland. Small clusters of kin-related houses, called "locations" (*lugares*), settled in increasing numbers along the riverbank. Until the 1930s, the subsistence-oriented activities of fishing and agriculture were complemented by the production of firewood for steam boats or by contractual jobs such as cowboys for the large farms that had been established a few decades earlier.

During this period, decisions on resource use were mostly taken at the household level, whereas the social relationship among the households of the location was informally structured through kinship links. The main inter-household activity was collective work based on labor force exchange, locally called "*puxirum*" in the Santarém region. The *puxirum* is an informal contract among households in the community; it implies a reciprocal exchange of labor force to develop tasks that demand a higher labor input than is available in each single household. Despite the collective work, the *puxirum* did not imply a collective outcome, since the households held the benefits of their harvest separately. However, it represented a social system in which households exercised interpersonal relationships in the locations. The most important collective structure in a location was the chapel, which was usually built by the local patrons. It usually housed a sculpture of a saint who represented the spiritual protector of the location (Wagley 1953, Galvão 1955).

During the jute boom, between the 1930s and the 1960s, the locations experienced population growth. As elderly people in the floodplain communities often mention, ". . . there were a few houses scattered in the region when I was a kid." Local decisions regarding resource use were mainly defined by the patrons who had control over the residents' cash crop system (Chapter 3). When the Catholic Church launched a catechism program in the 1960s, it found locations with relatively weak sociopolitical organization; this represented a barrier against achieving their religious goals. In order to facilitate their work, the Church carried out an educational program called the Movement for Grassroots Education (MEB),[2] which advanced both the individual and collective skills necessary to develop a socio-political organization at the local level. The action of the MEB program caused enormous change in a location's social structure. The term "location" was replaced by the term "community" as a proposal from the Church in order to stimulate the emergence of a collective identity among the local residents. The new concept of community brought along several group-based organizations, leading to the construction of collective buildings such as communal shelters, schools, and clubs. The two major organizations that represented this change were the catechist group and the community leadership.

The catechist group encompassed a small number of residents who were in charge of religious tasks in the community, such as guiding the Bible study group, conducting the catechism courses, or even performing periodical religious rites. The Church promoted regular regional meetings (i.e., Catechist Meetings), when all catechists in the region exchanged information and developed skills "to bring the word of God" to their followers (Almeida and Gomes 1993). The catechist groups worked, and continue to work as a way for the Church to maintain its influence on the social organization from a distance. The community leadership was another organization that strongly affected the social structure of the settlements. It represented a structured collective institution that defined representation of common interests of the residents. The leadership was formerly based on a committee consisting of a president, secretary, and treasurer that represented the community as a whole. The leadership representes the first explicit "community-based" political institution. It affected the locations internally by defining social boundaries for decisions, creating a political identity, and leading to the rationalization of common problems; it also affected them externally by representing the community regionally (Lima 1999). The leadership system also gave residents the opportunity to

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[2] Movimento Educacional de Base.

make decisions on a collective basis through regular meetings and a voting system.

In this regard, the community organization in the Amazon represents a valuable social capital that has developed at the local level. However, it is by no means a harmonious and homogeneous unit. The concept of community imposed an artificial geographic-based boundary to the flexible kinship-based boundary of location. In addition, the community concept limited the permeability of the social boundaries among locations which had resulted from the frequent movement of the population. Related families from different locations enjoyed free access to resources in their relatives' communities. Thus, the outcome of the community concept varied according to the degree of congruence of the boundaries between community and locations. In this regard, a community may include more than one location, or represent only part of a larger, dispersed location. Therefore, when the geographical and social boundaries overlap, successful collective decisions are more easily achieved.

In addition to social differences, communities usually vary in regard to socioeconomic aspects. Households face different opportunities to exploit the resources available in a given community according to ecological features of the system. This source of heterogeneity is a major issue as far as community-based management is concerned. Individuals with different access to resources face different incentives to join a collective action. Therefore, it is important to understand the degree of social and ecological heterogeneity in order to evaluate the potential for conflict and cooperation at the local level.

4.4. FLOODPLAIN POPULATION IN THE SANTARÉM REGION

The term "community" is currently used by both residents and non-residents. In general, a floodplain community encompasses a set of houses from a few kindred households that are linearly distributed along a water channel. Most of the households are related to at least one of the kinship groups that founded the settlement. The 172 floodplain communities analyzed in the Santarém region include the 8,561 families living in the floodplain, comprising a total of 46,555 inhabitants; this number represents approximately 11 percent of the total population living in the region (IBGE 2000).[3] While the population size of each community ranges from a few houses up to more than 150 houses, 74 percent of the communities have between 20 and 60 households (Figure 4.2).

A)

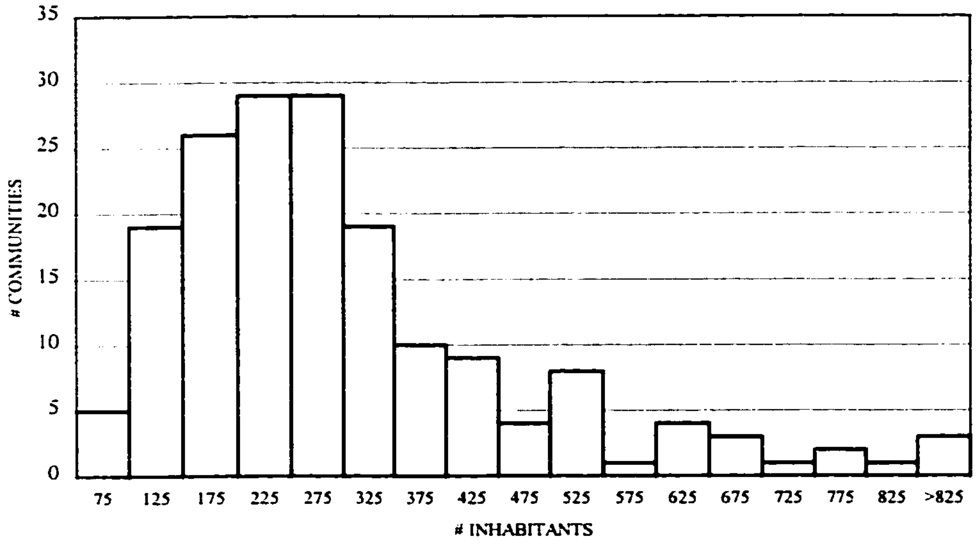

Figure 4.2. Floodplain population in the Santarém region. A) Number of inhabitants per community; B) Number of households per community (number of communities=172).

[3] According to the national census undertaken in 1996, the population of the four municipalities within the floodplain community is 380,084 inhabitants (Santarém = 263,468; Monte Alegre = 49,602; Óbidos = 44,326; Alenquer = 51,419).

B)

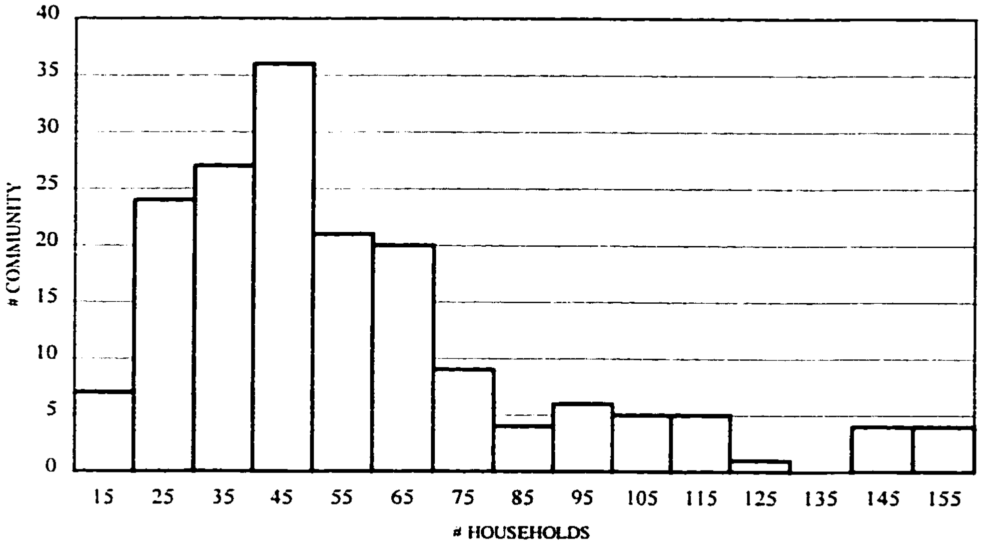

Figure 4.2. (cont.) Floodplain population in the Santarém region. A) Number of inhabitants per community; B) Number of households per community (number of communities=172).

The communities are distributed throughout nine main geographic sectors (Table 4.1).[4] The estimated population density in the floodplain area is 10.3 inhabitants per km^2, but it varies among the sectors. The floodplain population encompasses two main types of actors: the farm owners, who occupy the community surroundings, and community residents. The following sections will present a general description of the farms and a detailed characterization of the communities.

[4] The sectors are informal political divisions with geographical and historical common features, used by the Fishers' Union to develop organizational work.

Table 4.1. Demographic characteristics of the floodplain communities in the Santarém region divided by geographic sector.

SECTOR	SUB-REGION	COMMUNITY #	HOUSEHOLD #	INDIVIDUALS	HH/COMM	IND/HH
1	LAGO DOS BOTOS	48	2453	13830	51	5.6
2	LAGO GRANDE DE FRANCA	32	2048	11202	64	5.5
3	LAGO DE MONTE ALEGRE	36	1613	8269	45	5.1
4	ITUQUI	18	891	4805	50	5.4
5	TAPARA	10	484	2845	48	5.9
6	ARAPIXUNA	12	526	2783	44	5.3
7	ARITAPERA	7	246	1207	35	4.9
8	ATUMA	6	185	1075	31	5.8
9	URUCURITUBA	3	115	539	38	4.7
	$\sum$	172	8561	46555		

4.4.1. Community Surroundings

As discussed in Chapter 3, floodplain communties originated from large farms. Communities occupy only a small portion of the floodplain whereas floodplain farms dominate the region. Among the 74 communities analyzed, 96 percent were surrounded by farms, equaling a total of 224 land properties mainly used for cattle and buffalo ranching.[5] Farms may encompass up to 70 percent of the floodplain system, as observed by Câmara (1995) on Ituqui Island. If this is true for the whole region, land access for community residents is much more restricted than the actual floodplain area, and consequently would raise the population density aproximately to 34.5 inhabitants per km^2.

The recognition of farms in the floodplain is essential not only because of the scale of land occupation, but also because of the social relationship involving farm owners and residents. Farm owners usually live outside the community, but they may

[5] The number of farms can be overestimated because a single farm could have been cited more than once when it shares a boundary with more than one community.

play an important role in the community organization. A farm owner can be considered a member of the community depending upon the relationships s/he has with the residents.

Farm owners and residents have long been engaged in a patronage relationship, and currently their interaction swings between cooperation and conflict due to recent economic and political changes (Chapter 5). Notwithstanding the growing economic independence of residents, the dominance of farm owners over a large portion of the natural resources may directly affect communities' decisions regarding the use of those natural resources.

4.4.2. Population Structure

Floodplain residents in the Lower Amazon live in houses with an average size of 5.4 individuals (Figure 4.3). The size of the household is particularly small when compared to other floodplain communities, such as in the Upper and Middle Solimões (Chibnik 1994, Padoch and DeJong 1992, Mamirauá 1996) where the average household size is around seven. Due to methodological limitations, the household size, as presented in this paper, considers the number of residents living in the same house (co-residents), but does not account for the out-migrant members (either temporary or permanent).

Out-migration from rural areas to urban centers in the Middle Solimões has increased in recent decades due to the attraction of better education, medical services, and job opportunities (Lima 1992). A similar pattern is found in the Upper Solimões, where Chibnik (1994) discovered a higher rate of out-migration to the urban centers among teenagers, suggesting the search for education and jobs. Likewise, a pilot study carried out in Santarém revealed that a number of families migrated to the city in order to provide better education to their children (Sara Motta, pers. comm.). A possible explanation for the lower number of co-resident members in the Lower Amazon is a higher out-migration rate, considering the large attraction to Santarém, the largest urban center of the region. However, such a hypothesis still needs to be tested.

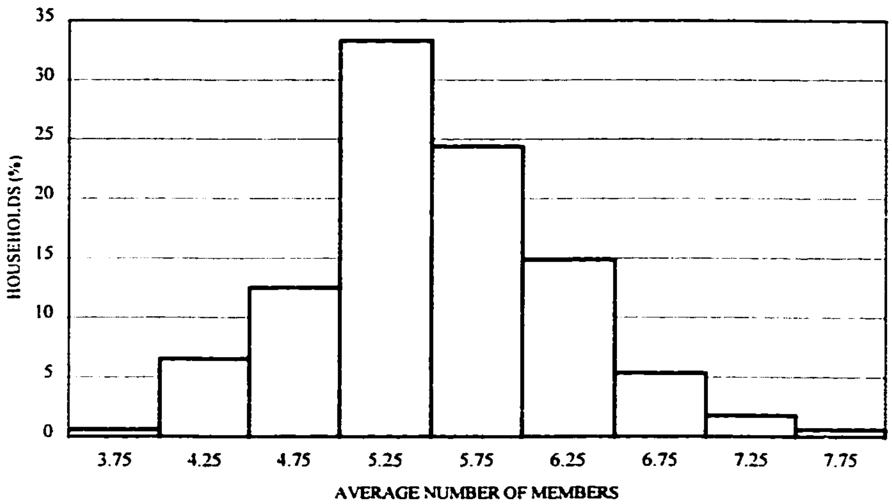

Figure 4.3. Average household size by floodplain community in the Santarém region (number of communities=168).

The age structure of the population is not available for the Lower Amazonian floodplain. Yet, general patterns can be drawn indirectly from aggregated data of three age classes — children (up to 12 years old), adults (between 13 and 60 years old), and retirees (above 60 years old), when data is aggregated at the community level. A total of 36 percent of the dependents was counted, 31 percent of which were children and 5 percent retirees.

Households may have more than ten children, but most have between one and four. Children are not present in 18 percent of the households (n=6,225) (10 percent of which are elderly couples, while the remaining are likely to be young couples).

Examining the total adult population, males (29.5 percent) make up a higher percentage than females (25.5 percent) (n=6,203 households). This disparity can be related to differences in the pattern of migration. Since the crash of jute prices, female labor has been in less demand in the floodplain due to the dominance of male-oriented activities such as fishing and cattle raising. Consequently, women have been more able to attend school and more likely to continue their studies in the city, since only the primary school is usually available in the communities (see next section). Futemma (1995) provides an example of a floodplain community where agricultural activity is greatly constrained by the extremely low height of the levee. The author discusses the high number of women who become teachers is related to their lack of economic alternatives in the area. The opportunity to become a maid is another factor that has attracted women to the city. Men, on the other hand, usually out-migrate for a limited period of their life in order to get to know places, to acquire new skills, and to make money. Therefore, while men usually migrate back to their original community to settle down, women are more likely to get married and stay in the city.

4.4.3. Community Structure

Communities are composed of infrastructure, social organizations, and political organizations. Broadcasting (radio and television), education (school), transportation (ferry boat), and stores are the main infrastructures in the communities (Table 4.2).

Table 4.2. Relative frequency of attributes related to infrastructure, social organization and political organization of the floodplain communities in the Santarém region.

INFRASTRUCTURE	% (n)	SOCIAL ORGANIZATION	% (n)	POLITICAL ORGANIZATION	% (n)
RADIO	100(112)	SOCCER TEAM	99 (112)	LEADERSHIP	85 (95)
SCHOOL	97 (110)	CHURCH	95 (107)	FISHERS' UNION	61 (100)
TV	97 (102)	CATECHIST GROUP	90 (110)	ASSOCIATION	42 (102)
FERRY BOAT	90 (104)	YOUTH GROUP	36 (107)	RWU	37 (103)
STORE	89 (106)	MOTHERS' GROUP	27 (106)	PARTY AFFILIATION	24 (101)
COMMUNITY SHELTER	71 (105)				
ELETRIC POWER	53 (109)				
HEALTH CENTER	39 (109)				

Radio is present in all of the 172 communities for which data are available and has represented the major communication system since 1964, when the Rural Radio Station was inaugurated. The educational program carried out by the Catholic Church (MEB) was broadcast on the radio in order to overcome distance constraints (Almeida and Gomes 1993). Radio is no longer used for educational purposes but still plays a major role in overcoming the constraints that distance places on communication. A show broadcast twice per day provides air time free of charge for messages sent to/from communities in regard to any subject. The messages can be about delays in return trips, to place orders to purchase specific items, or to provide news about the illness or deaths of relatives. This service is also used for collective matters, such as notices of regional meetings or of community decisions. Fishing accords, for instance, are usually divulged to non-residents on these radio shows. The shows are very popular, and the messages usually reach the receiving parties. While radio has an immediate role in the communities' daily life in that it solves problems of communication, television is mostly related to entertainment. Due to power constraints, television is on only for a short time (2-3 h) in the evening to watch soap operas and soccer games. Although television is present in almost all communities, only a few residents own television sets and they usually invite their neighbors over to watch the shows.

Education has been the basis of community since the establishment of the MEB program. In 104 communities, there are 89 primary schools (grades 1-4), 15 of which include junior high (grades 5-8). A contingent of 265 teachers serves 8,537 students. Despite the proportion of students above twelve years old (and thus not considered children in this analysis), school attendance seems relatively high, since a proportion of the 10,123 children is expected to be under school age. School not only represents a part of the social life for kids but also a source of meals, which are served on a daily basis. The high attendance is also helped by the fact that the class schedule is from August to March, the drier months. Another factor that may lead to such a high attendance rate in the Lower Amazon is related to the low farming activity, in which demand for child labor is limited. A different pattern is found in the Upper Solimões, where the low school attendance (42 percent of school-age children) is attributed to the fact that the school schedule does not correspond with the seasonal variation (Mamirauá 1996). Perhaps the greater importance of farming activity in that region may exacerbate this problem. The residents in that region also mention that the low teaching quality is a major reason preventing the parents from putting their children in schools. Nevertheless, low quality in education is also a problem in the Lower Amazon, where the low salary attracts only lay teachers who have received just a basic formal education (elementary school). Consequently, the students spend several years in school but barely learn how to read and write. Those interested in having a better education have to move to the cities.

Transportation is provided by regional ferry boats with regular schedules and routes. Usually, a ferry boat is owned by a community member who serves a group of neighboring communities as their link to the urban centers. A single community may be served by several ferry boats during the week. Considering the fact that most of the residents do not have motor boats, the ferry boats have a major role in facilitating the flow of products to the regional markets. Ferry boats charge fees for passengers and goods separately. In addition, the boat owner can take orders when the person cannot go to the town. The length of the trip varies according to the location of the community, the season, the boat size, and the route taken. Thus, the trips can take several hours and represent a social arena where residents from different communities interact.

Several communities have small stores, where basic supplies such as sugar, salt, kerosene, soap, and oil are sold. The owner may keep a small room to display the products or simply a small space to store the items. Stores are usually owned by wealthier members of the community. A community shelter is an open-air structure that residents use for social encounters such as meetings and parties. The shelter is usually part of the soccer club and present in 71 percent of the communities. Eletric power is generated by diesel motors and is present in half of the communities. However, 50 percent may be an overestimation, since a motor may not serve a whole community, and, in several cases, the motors are frequently out of order. The health centers are poorly served in the communities and are often out of basic medicines.

The social structure of the community is dominated by sports (soccer) and religious organizations. The importance of soccer in the floodplain communities is expressed by the high number of soccer teams —169 male teams and 32 female teams in 112 communities. Soccer teams represent part of the community identity. Usually each team has its own soccer field and shelter. They host opponent teams from neighboring communities, and the games are often followed by a party. Games take place on Sundays during the dry season. Although soccer is dominated by males, women can participate by either playing or cheering. Thus, soccer games are social arenas in which local and regional encounters take place. They may also be opportunities for carrying out revenge for other conflicts. As soccer clubs represent one of the most vital and exciting institutions, they have been the focus of participatory research on conservation of natural resources (Mitlewsky 1997).

Religious life is based upon two major religions — the Catholic and Protestant churches — which are present in 95 percent and 58 percent of the communities, respectively. The Catholic Church is the most ancient religious congregation in the communities and still maintains its dominance through the catechist groups present in 90 percent of the communities. The Protestant Churches encompass about nine related religions (Assembly of God and Church of Peace are the most common) which have proliferated in the last decades and have challenged the hegemony of the Catholic Church. The emergence of new religious segments has created another identity layer based upon "brotherhood in faith" among Protestants. In some cases, it has affected the "community identity" by triggering internal conflicts between followers of different religions. It is not clear how such a trend can affect community-based actions such as fishing accords. However, two social implications can be considered. First, followers of each religion have conflictual perceptions in regard to resource use. On the one hand, Catholics are more emphatic about conservation issues, defending their rights to access and control their resources, while Protestants tend to believe that the resource supply is protected by a divine force. On the other hand, Catholics are more flexible on their duties, including their commitment to collective action, which can threaten the covenant, while Protestants adhere more closely to their personal commitment to their "brothers and sisters" (Schoenerberg 1994). However, a more detailed study on this aspect should be carried out in order to evaluate the potential for cooperation and conflict among these religious groups within the communities.

The political sphere in each community is dominated by the leadership system, present in 85 percent of the 95 communities analyzed (Table 4.2). The leadership organization may take different forms, such as committee (52 percent), individual leader (38 percent), or formal association (10 percent). The latter organizations have emerged recently and may not be related to the leadership system. Rather, they can be an effort to create a basis for gaining financial support from the government in order to strengthen their production systems, or to ensure the local collective control of resources. Among 109 communities analyzed, 45 have formal associations that provide legal support to claim a collective right of use of common-pool resources.

Local communities are linked with the regional political system through residents who are affiliated with Unions (Fishers' Union and Rural Workers' Union) and, to a lesser extent, to political parties. The stronger participation of residents in the Fishers' Union reflects the importance of commercial fishing in the floodplain communities. Since the mid-1980s, the Fishers' Union has been developing a closer relationship with the floodplain communities through a system of local representation (*capatazia*). The Union in Santarém is currently represented in 52 communites[6] (*capatazia*), and has 4,190 affiliated members, including 620 women and approximately one thousand urban fishers.

The smaller number of residents affiliated with the Rural Workers' Union is related to a strategic division of work between the Fishers' Union and the Rural Worker's Union set in the late 1980s. According to this strategy, the former organization focused their work on the floodplain populations and the latter on the upland populations. Although the division aimed to better serve each group, this strategy reduced the representation of floodplain populations in land use issues, which was carried out mainly by the RWU. Moreover, the label "fisher" that was imprinted upon the floodplain population enhanced the biased dichotomy of floodplain-fishing/upland-agriculture, thus reducing governmental agencies' interest in creating incentives for agriculture in the floodplain.

4.4.4. Production System

The economic strategies of floodplain populations combine five major activities: subsistence fishing (S), commercial fishing (F), agriculture (A), ranching (R) and wage-based activities (W) (Figure 4.4).[7,8]

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[6] This figure includes representatives in six urban neighborhoods, and nine upland communities.

[7] Subsistence and commercial fishing are inclusive categories, i.e., all commercial fishers were counted as subsistence fishers as well.

[8] Forest extractivism is carried out by "*varjeiros*" but has not been included in this analysis due to lack of data.

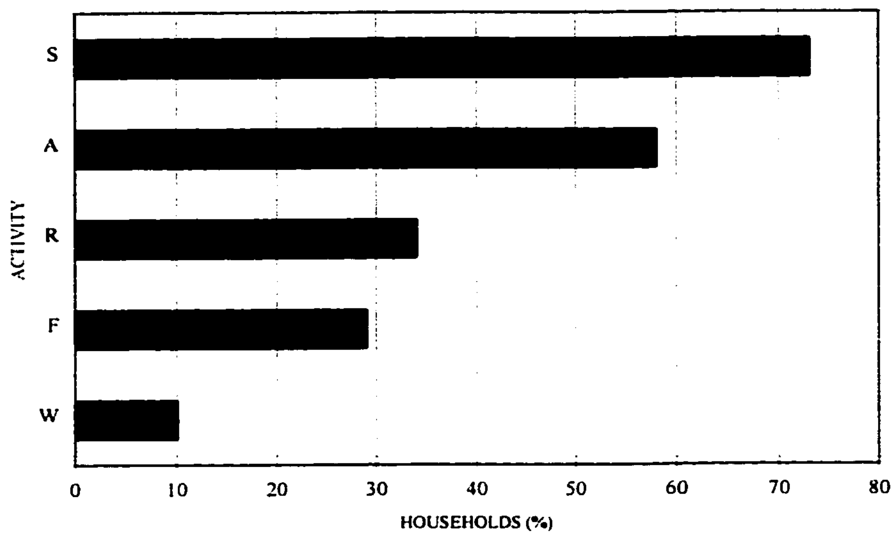

Figure 4.4. Relative frequency of the major economic activities performed by floodplain households in the Santarém region (S=subsistence fishing; A=agriculture; R=ranching; F=commercial fishing; W=wage labor/pension) (number of households=8570).

Each activity has a distinct pattern throughout the year, involves different members of the household, and has its own specific purpose for the household economy. Fishing represents the major commercial activity, while agriculture is mostly subsistence-oriented, and cattle raising represents a capitalization system.

Fishing is currently the main activity in the floodplain; 73 percent of the households engage in it for either subsistence or commercial purposes. The importance of subsistence fishing reflects the local population's reliance upon fish as a main protein source. The Amazonian floodplain has one of the highest rates of fish consumption in the world. Shrimpton and Giugliano (1979) show that the average fish consumption per capita in Manaus, the largest city in the Amazon Basin, is seven times higher than in several developed countries.

Fish consumption varies according to multiple factors. In general, larger cities present a lower average fish consumption per capita. For example, Manaus has 1,200,000 inhabitants and has a relatively low fish consumption rate of 122 g/person/day[9] (Shrimpton and Giugliano 1979), in contrast to Itacoatiara, a town with 30,000 inhabitants in 1980, located 250 km downstream which has a fish consumption rate of 194 g/person/day (Smith 1981). Within the same town, fish consumption varies according to economic status, being of more importance to the lower class population (Amoroso 1981). Shrimpton and Giugliano (1979) found that the average per capita consumption of fish in Manaus was 105g, 139g, and 150g, for high-, medium- and low-income class households, respectively. Finally, in the same county, rural floodplain areas present a higher consumption level than their urban counterparts. Such a pattern is clearly observed in the Santarém region. Fish consumption by the urban population can be estimated by fish landing data, which was an average of 4,056 tons for 1992 and 1993 (Chapter 2). Half of the production was directed to the local market and half processed and exported (Ruffino and Isaac1994). Considering that the estimated urban population is 169,665 inhabitants (IBGE 1991), urban Santarém has an estimated fish consumption rate of 33g/person/day. This figure is far below the estimated average consumption of fish of 379g/person/day, found among 17 floodplain communities in the same region (Cerdeira et al. 1997). Despite the possible biased value for the urban area due to omissions in the reporting of fish landing, this comparison shows that rural populations in the Lower Amazon are far more reliant on fish for consumption than anywhere else in the Amazon where fish consumption data are available.

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[9] The consumption figures are based on whole fish. Net consumption is an average of 40 percent less due to non-edible weigh related to bones and skin (Smith 1981).

The relatively low percentage of households involved in commercial fisheries (29 percent) does not reflect the current picture of fishing intensification in the floodplain. Rather, in this case it reflects the unclear boundaries between commercial and subsistence fishing. Pure subsistence fishing is rarely found, since fish production is commercialized whenever possible. In addition, the degree of fish commercialization can vary throughout the year and between years in the same household. Thus, fishing commercialization may vary accoring to season in several households, some of which may have reported themselves as subsistence fishers. Therefore, the figure can be cautiously interpreted as to the proportion of households that are engaged in a more intensified commercial fishing.

Agriculture is the second-most common activity in the floodplain, and is carried out by about 60 percent of the households. Like fishing, the data reported on a yes/no basis do not provide information on the intensity of farming activity, limiting the evaluation of the importance of this activity in the household economy. However, the data can reveal the pattern of farming activity undertaken in the region. The prevalence of annual crops among the small variety of products cultivated by the households is due to flooding constraints (Figure 4.5). Perennial crops are mainly cultivated in communities with access to uplands (see next section).

Bitter manioc, maize, and beans are the three most common crops in the floodplain, each one cultivated for a different purpose. Bitter manioc is cultivated mainly for subsistence, and the surplus is eventually sold. The fast-growing variety can be harvested after six months, thus making possible its cultivation in seasonally flooded terrain. Upland varieties are cultivated only when non-flooding soil is available. Bitter manioc is processed into flour, and used as a staple food consumed with fish. Maize is cultivated mainly to feed small livestock. Maize can be stored for months and used during the flood season. Beans have become the main cash crop in the floodplain since the mid-1980s. Among their several advantages, beans grow fast (about three months to ripen), are suitable for well-drained lowland soils, can be stored, and have a relatively high market price. However, access to lowland soils is constrained by competition with cattle ranchers who use the same biotope for pasture (see Chapter 5).

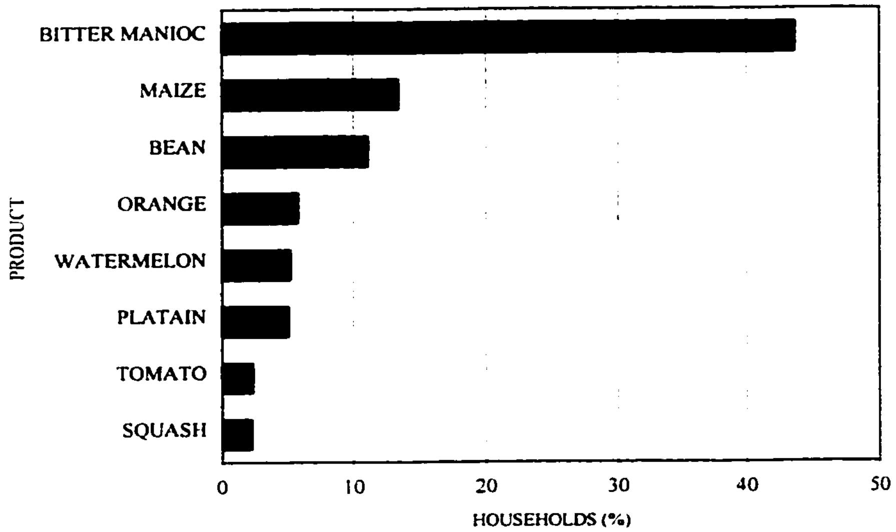


Figure 4.5. Agricultural products cultivated by more than 2 percent of the floodplain households in the Santarém region (number of households=7429).

Both small and large livestock are raised in the floodplain. Chicken and duck are the most common small livestock, raised by 35 percent and 15 percent of the households, respectively. Small livestock are important for ensuring protein availability during fish scarcity, or for raising some money during times of emergency. Small livestock raising is an important activity because it has a low labor demand and can be performed by any member of the household, such as children, elderly people, and women, while performing other household tasks. Small livestock can involve an extra effort if the risk of flooding is high, thus demanding maize cultivation for use as a ration during the flooding season.

Cattle is the major large livestock in the floodplain, raised by 27 percent of the households, followed by water buffaloes on a smaller scale (2 percent). Cattle raising is a traditional activity among farm owners in the floodplain since the nineteenth century. Yet, the community residents did not begin to raise cattle untin the mid-twentieth century, and the activity spread among them only in the last 20 years (Chapter 3). Cattle have a particular importance to residents because it represents a promising "savings account." The price of meat, which follows (or surpasses) the inflation rate, high liquidity, and access to grassland have driven residents to invest their surplus income into cattle raising.

This trend can be observed in the distribution of cattle herds among the 27 percent of the households who own cattle in the region. According to the number of heads, ranchers can be divided into small-scale ranchers (16 percent), with up to 10 heads; medium-scale ranchers (8 percent), with between 11 and 50 heads; and large-scale ranchers (3 percent), with more than 50 heads.[10] Figure 4.6 shows that the majority of ranchers (60 percent) are small-scale, and own only 10 percent of the area's total cattle herd, while large-scale ranchers are farm owners and present opposite values (10 percent of the households owning 62 percent of the cattle population). Middle-scale ranchers represent an emergent social stratum among residents who were successful in accumulating capital during the jute boom and currently own relatively larger properties

[10] Large-scale ranchers are probably misreported in the census for two main reasons: 1) local population may not have considered some farms as part of their community; or 2) farms with borders in more than one community may have been counted multiple times.

and power. They play a particularly important role in the local social arenas because of their intermediary social position as "local patrons."

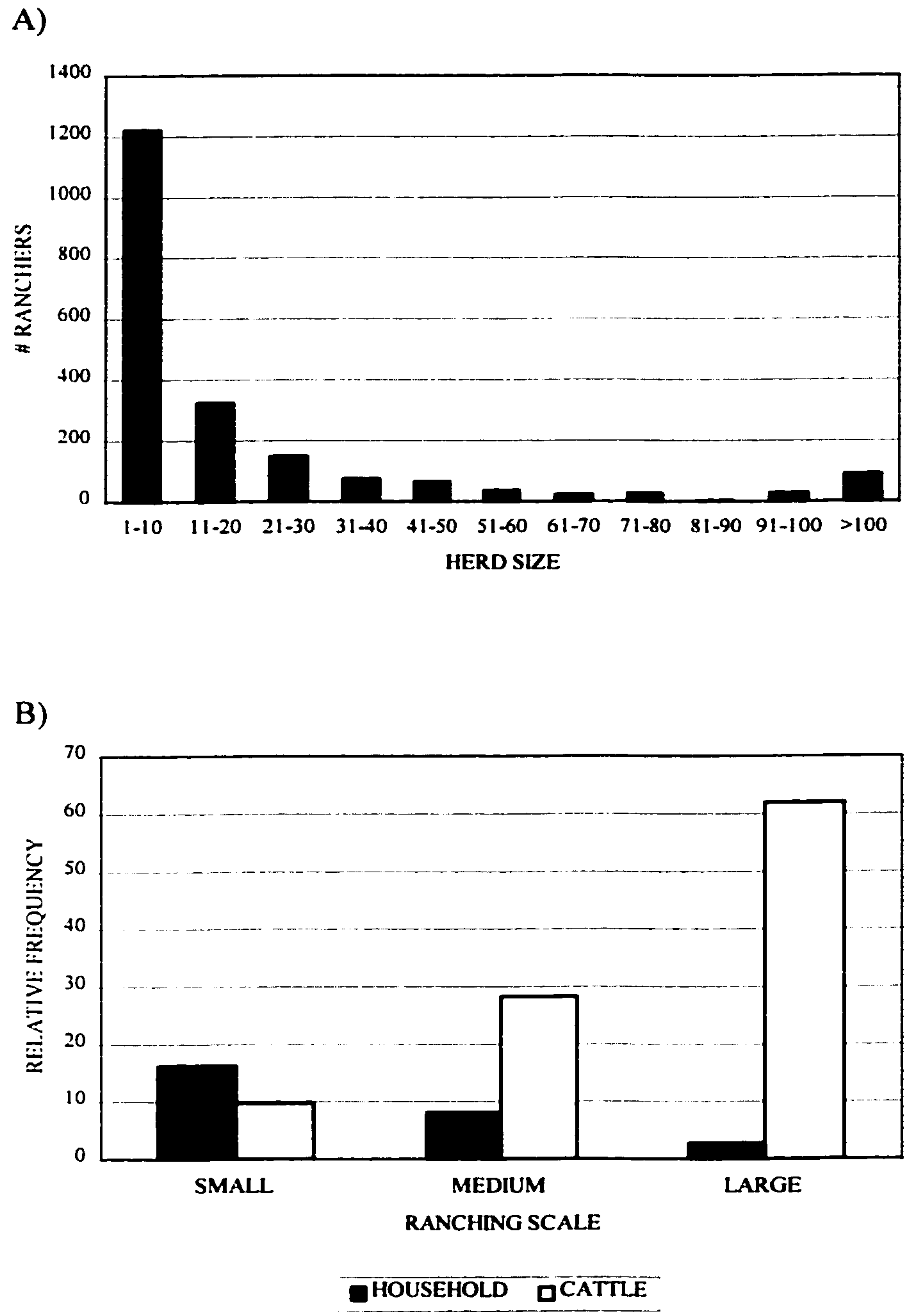


Figure 4.6. Cattle ranching in the Santarém region's floodplain. A) Distribution of herd size by floodplain ranchers; B) Rancher typology according to herd size class (number of ranchers=2029).

Water buffaloes are another important large livestock in the region. Buffalo raising was introduced later and has been promoted by the governmental agencies, based on the assumption that this animal is more ecologically adapted to floods than cattle (Lourenço Jr. 1983). Despite such an effort, residents have strongly reacted against raising water bufalloes, arguing that they are more likely to cause damage due to their strength and ability to reach remote areas. Destruction of fences and crop fields, and soil compactation (which affects grass regeneration) are the major forms of impact mentioned by residents. Local expressions such as "nothing grows where a buffalo steps" and "there's no barrier for buffalo" illustrate the residents' rejection of buffaloes. The inclusion of rules regarding buffalo raising in recent fishing accords reveals the increasing conflict involved in this activity (Chapter 5). Consequently, buffaloes have been raised mainly by farm owners who have power to fight against local decisions.

Finally, wage-based activities include mostly teachers, carpenters, cowboys, and retirees. Wage-based sources have been increasingly incorporated into the household economy. The major incentive for such activities is the security of the money generated by the household regardless of the environmental constraints. In this regard, wage-based income represents a strategic way to overcome environmental risks and to increase the ability to capitalize. A retirement salary represents a particularly important source of money among households with elderly members. Monthly retirement salaries (US$120.00) are available to unionized rural workers — women above 60 years old and men above 65 years old. The 2,342 individuals receiving retirement salaries are present in 29 percent of the households (n=7,066) and tend to live as members of extended families. While 30 percent of retirees live in households with one or two people, which are likely to be old couples or widows/widowers, the remaining 70 percent are part of larger households. Thus, retirement salary has redefined the role of elderly people in the household, from an extra burden to a new economic opportunity, affecting the degree of local investment in a floodplain community (Futemma et al. 1998).

4.4.5. *Economic Strategies of Households*

The economic strategy of a household varies in terms of the number of activities performed, from specialized (40 percent) to diversified into two (32 percent), three (26 percent), and four activities (2 percent) (Figure 4.7). The importance of each activity in the household economic repertoire varies, leading to heterogeneous patterns within and among communities. The variation in strategy depends, among other factors, upon the economic purpose of the activity, the household structure, and the access to resources. A subsistence-oriented economy exists in 61 percent of the households, while 39 percent have cash-oriented strategies based on commercial fishing and wage-based sources. Commercial fishing is the major cash activity and is carried out by 31 percent of the households while the wage-based source is part of the economy in 8 percent of the households (Figure 4.8). Specialization is more common for fishing (23 percent), followed by agriculture (5 percent) and ranching (2 percent).[11,12] The dual function of fishing (consumption and cash income) allows this activity to prevail among the floodplain population. As discussed before, the category "commercial fishing" may represent only part of the actual commercial fishing activity since the category

[11] The dominance of subsistence activities does not mean that those families do not trade their products. As discussed before, the subsistence/commercial activities define only the dominance of the strategy.

[12] Specialization ranching is likely to be associated with farm owners who undertake large-scale ranching.

"subsistence fishing" may also involve fish commercialization to a lesser degree.

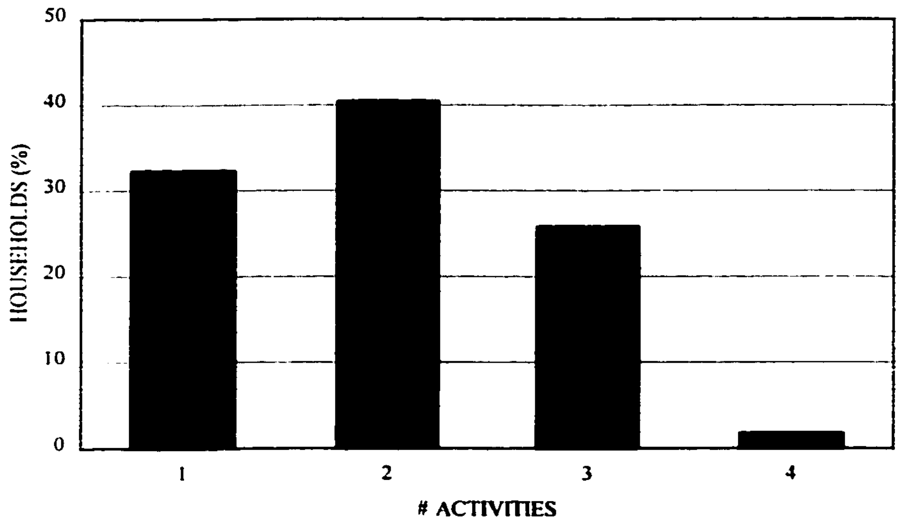


Figure 4.7. Average number of economic activities performed by the floodplain households in the Santarém region (number of households=7770).

The level of diversification of activities depends on the level of commercial fishing in the household. The more the fishing activity is oriented toward commercialization, the higher the tendency is toward economic specialization in the household. This pattern can be observed in Figure 4.8 which shows that commercial fishing (F) is more common as a specialized activity (11 percent of the households) than as part of a mixed economic strategy — 9 percent in combination with agriculture only, and 8 percent in combination with agriculture and livestock. In contrast, subsistence fishing (S) is more common as part of a mixed economic strategy — 19 percent in combination with agriculture only and 15 percent in combination with agriculture and livestock — than as a specialized activity (13 percent).

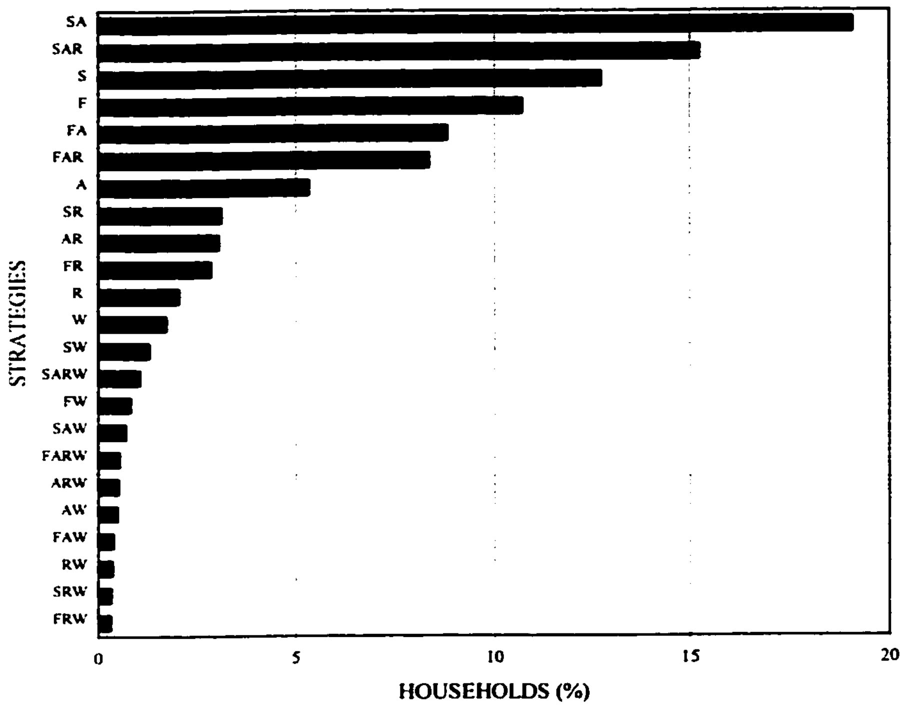


Figure 4.8. Economic strategies performed by the floodplain households in the Santarém region (S=subsistence fishing; A=agriculture; R=ranching; F=commercial fishing; W=wage labor/pension) (number of households=7614).

Furtado's (1993a) definition of *varjeiro* populations implies access to floodplain resources, multiple activity (polivalent), and subsistence-oriented household economies. In this regard, the *varjeiro* population is distinguished from two other population groups — urban fishers and motor boat fishers — who specialize in commercial fishing (univalent). According to Furtado's model, urban fishers are individuals who migrated from the floodplain communities to the urban centers and changed their production system into a univalent strategy of commercial fishing, whereas motor boat fishers are fishers who associate with boat owners to carry out commercial fishing. The analysis of the economic activity in the floodplain suggests that the *varjeiro* population is not always polivalent. About 32 percent of the *varjeiro* households carry out only one activity and 11 percent have specialized in commercial fishing. Those who specialize in commercial fishing are likely to be among the fishers who associate with boat owners. They are of special interest because they represent incipient specialized commercial fishers who have the potential to become urban fishers. In other words, these data reveal a dynamic process of specialization in commercial fishing among urban populations from diversified economic strategy of *varjeiro* populations.

Despite the different degrees of economic engagement with the fisheries market, the distinctions between univalent and polivalent may prove to be artificial in circumstances where boundaries between urban and floodplain populations are unclear. In many cases, floodplain residents migrate back and forth between the floodplain and the town according to the economic opportunities. Therefore, specialization in fishing is part of a dynamic economic strategy that may change according to economic incentives that eventually take place in the system.

The most common combination of two activities in the floodplain populations is fishing (either commercial or subsistence) with agriculture (28 percent). This is an expected pattern since agriculture also has both subsistence and commercial purposes. A combination of fishing, agriculture, and livestock, which is considered the typical mixed economy of *varjeiro*, is carried out by only 24 percent of the households (Figure 4.8). These households probably have more assets since cattle is mostly related to capital accumulation.

Besides their economic purpose, the number of activities carried out by a household seems to depend on the household composition as well. Households tend to add more activities to their economic repertoire as the number of adult members increases. Likewise, the intensity of cattle raising activity tends to increase as the number of adult males and retirees increase in the household. A similar result was observed by Futemma et al. (1998) who found cattle raising to be determined by the amount of male labor in the household. The authors argue that cattle ranching requires marginal effort, such as seasonal migration from the floodplain to the upland, construction of stilt-raised corrals, and eventual pasture cultivation. In regard to retirees, elderly members provide money from the retirement salary that can be invested in the cattle ranching activity.

Finally, another factor that affects the definition of activities carried out by a household is its access to resources. Floodplain communities can provide different levels of ecological access to resources according to their geographic locations, which can be divided into three types: levee, riverbank, and upland communities. Levee communities are located on the floodplain islands with no direct access to upland soils. Riverbank communities are located between the floodplain and upland soils and thus enjoy direct access to both systems. Upland communities are located on upland areas, close to the floodplain system (Figure 4.1). Among 114 communities analyzed, levee, riverbank, and upland communities are represented by 28 percent, 60 percent, and 12 percent, respectively. Those communities present distinct proportions of activities among them. Commercial fishing is far more important in levee communities — where about 60 percent of the households are involved — than in the other two areas (about 20 percent in riverbank communities and about 10 percent in upland communities) (Figure 4.9).

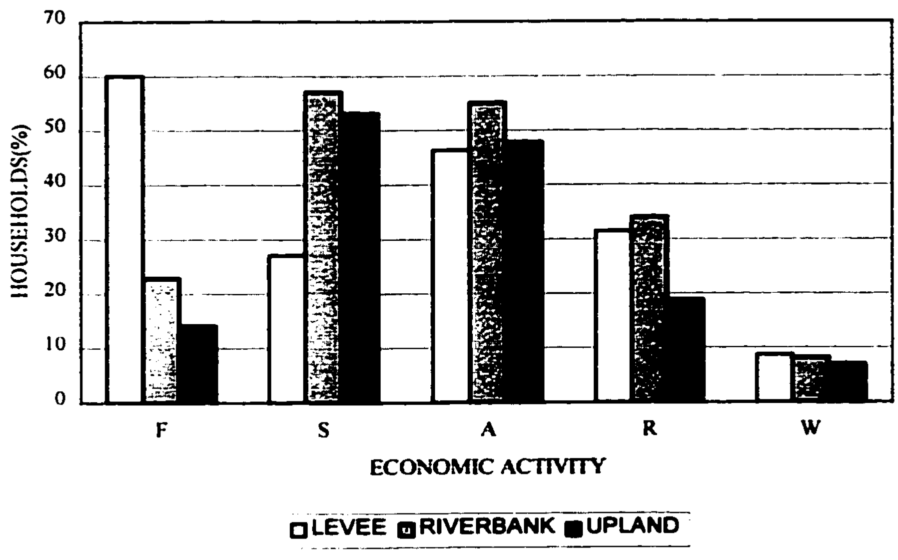


Figure 4.9. Relative frequency of household involvement in the major economic activities according to their ecological location (F=commercial fishing; S=subsistence fishing; A=agriculture; R=ranching;; W=wage labor/pension) (number of households=5883).

Figure 4.10 shows the frequency of households engaged in different economic strategies for levee, riverbank, and upland communities. The proportion of households involved in agriculture and ranching activities is similar in levee and riverbank communities. Yet, riverbank communities grow a larger variety of products (36 items) than do levee and upland communities (16 and 18 items, respectively). There are particular distinctions among the three community types with regard to the economic strategy of specialization and diversification of activities. Levee communities present the largest proportion of households engaged in specialized commercial fishing (22 percent), in comparison with riverbank (8 percent) and upland (10 percent) communities (Figure 4.10). Beans are more important in the levee communities where lowland is well distributed. In addition, while the major combination of activities includes commercial fishing in levee communities, subsistence fishing dominates the diversified strategies in riverbank and upland communities (Figure 4.10). In opposition to fishing, specialized agriculture is higher among upland communities (13 percent), than in the other two regions (3 percent in each). Finally, specialized ranching shows a similar pattern in all three regions (1-2 percent) and probably represents large-scale ranchers only.

A)

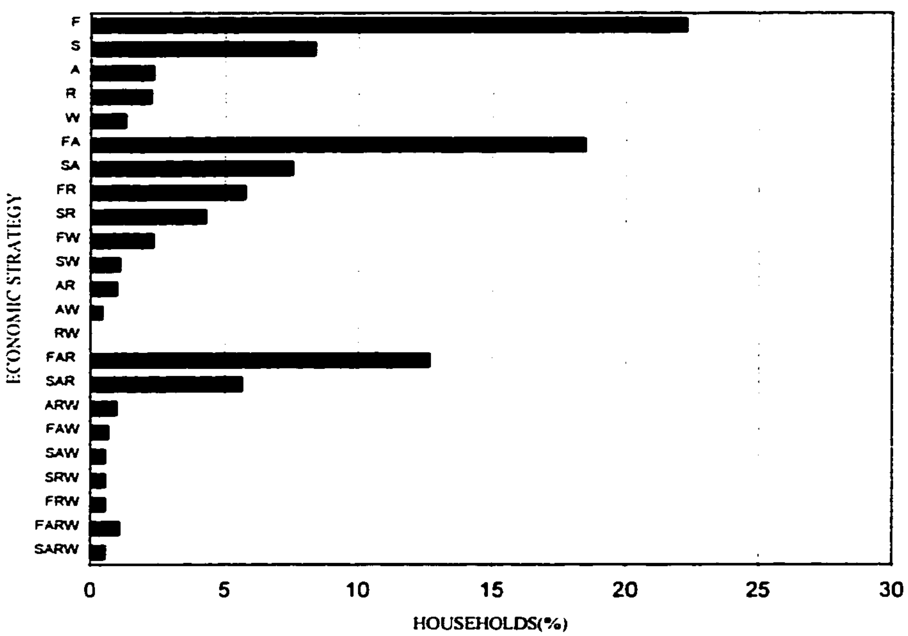
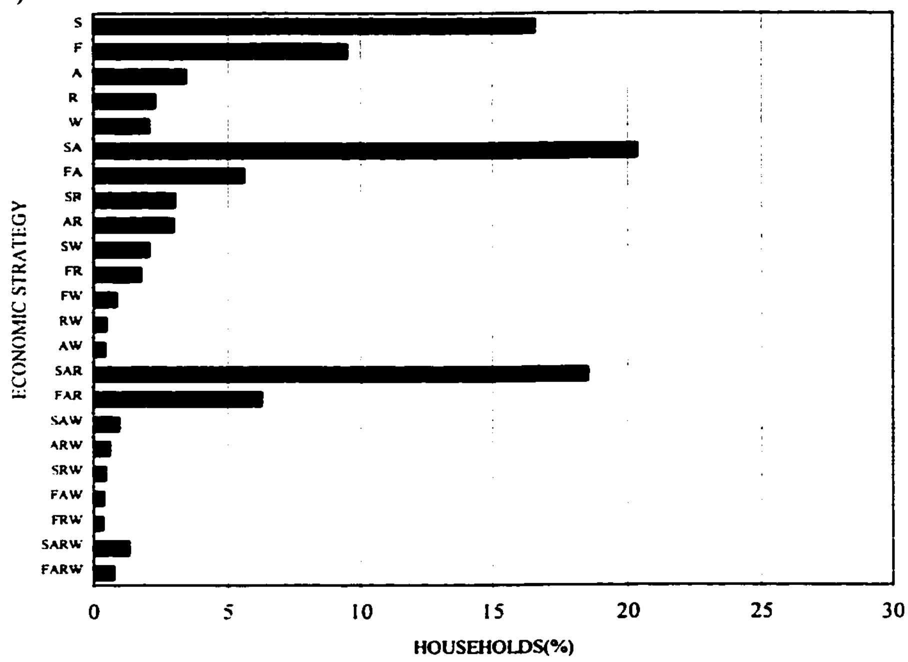


Figure 4.10. Economic strategies performed by the floodplain households in the Santarém region, according to their location: A) Levee, B) Riverbank, and C) Upland (S=subsistence fishing; F=commercial fishing; A=agriculture; R=ranching; W=wage/pension).

B)



C)

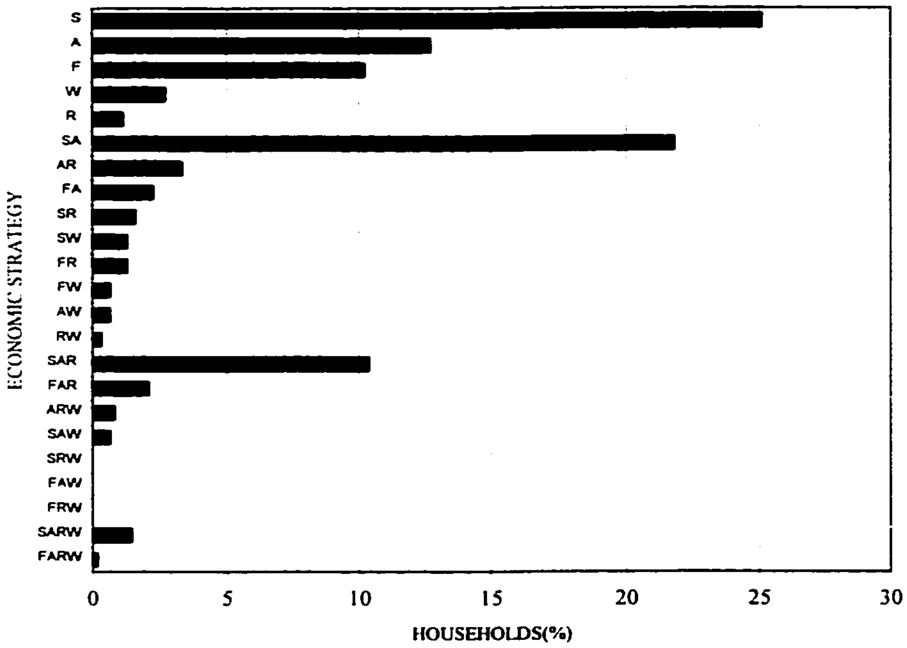


Figure 4.10 (cont.). Economic strategies performed by the floodplain households in the Santarém region, according to their location: A) Levee, B) Riverbank, and C) Upland (S=subsistence fishing; F=commercial fishing; A=agriculture; R=ranching; W=wage/pension).

4.5. HETEROGENEITY IN FLOODPLAIN COMMUNITIES TOWARD RESOURCE ACCESS

Although community-based management has been claimed in many cases to be an appropriate conservation strategy, the discussion regarding local management of lakes in the Amazon has failed to address to what extent the structure of the communities is favorable for establishing an efficient resource management system. Local populations are dynamic units; they respond to both local and external factors by changing household structure, the social relations among households in the settlement, and the pattern of use of natural resources.

The floodplain populations have enough similarities to represent a type of *caboclo* throughout the Amazon Basin. They share the same sociopolitical structure, concept of community, and range of economic activities. Nevertheless, the pattern of household economy varies across regions, across communities in the same region, and across households in the same community. Thus, the aggregation of floodplain populations hides factors affecting the dynamics of the household economy.

Ecological and institutional factors can also affect the diversity of patterns in resource use at the local level. The category *varjeiro* implies homogeneity of the floodplain population in regard to use of natural resources. However, the disaggregation of *varjeiro* into levee, riverbank, and upland populations is useful for bringing about the ecological and institutional distinctions that affect the pattern of resource use. In particular, the comparison between levee and riverbank communities can yield an insightful analysis, since both types of communities have prompt access to the floodplain system but present particular distinctions in the pattern of resource use. Levee populations are surrounded by flooding terrain while riverbank populations are located between floodplain and upland systems. Such an ecological distinction plays a major role in the level of access to upland resources and, in turn, strongly affects the definition of socioeconomic activities.

The contemporary occupation of the floodplain started on the riverbanks, where access to both upland and floodplain systems enabled residents to use the highly productive soils in the floodplain during the dry season and the less risky upland system throughout the year. In addition, the access to non-flooded terrain gave them the opportunity to build their houses and establish their gardens in a more stable system. Thus, riverbank populations were especially gifted with a diversified landscape distribution in which integrated, mixed household economy was possible. Recently, they have been engaged in the three economic trends in the Amazon: commercial fishing, logging, and cattle ranching. Commecial fishing is an extractive activity that provides prompt cash income. Logging represents a new income source when forest resources are available. Besides the income from the timber trade, the local population also enjoys the marginal benefits of roads opened by the companies to reach the logging sites. These roads facilitate the establishment of new gardens due to the easier transportation of the harvest (Futemma et al. 1998). Cattle ranching is particularly advantageous in riverbank communities, because it enjoys access to the cost-free and high quality natural grassland on the floodplain and the continuous access to non-flooding terrain where they can keep their herds during the flood season. In short, the riverbank populations are granted opportunities to carry out upland activities (perennial and semi-perennial crops, forest extractivism), floodplain activities (fishing, fast-growth crops), and an activity which is better conducted under integrated use of both systems (cattle ranching).

In contrast, levee populations developed during the jute boom (after the 1930s), when the floodplain system became economically attractive (Chapter 3). However, the advantage of available areas to cultivate jute was contrasted with the limited opportunity to develop other economic activities. Despite the high nutrient soils, farming is limited to the dry season. In addition, the seasonal variation of the water level creates a troublesome residence condition during the flooding season. Therefore, the ecological advantages of the floodplain system are offset by particular ecological constraints found in the levee systems. Consequently, after jute prices crashed in the 1960s, the levee populations were left with few economic alternatives. The production system was limited to annual crops, fishing, and small livestock. In contrast to riverbank populations, levee populations have been able to engage in two of the three emergent economic activities in the Lower Amazon: commercial fishing and cattle raising. However, cattle raising implies an extra cost in the levee communities due to the lack of an upland location to keep the cattle during the flood season. Alternatively, cattle raisers must build a stilt-raised corral, where the herd is maintained during the flooding season, or send the cattle to the uplands, which involves cost of transportation and pasture rental (Futemma et al. n/d). Consequently, commercial fishing becomes the major economic alternative among the levee populations.

Besides ecological factors, access to resources is also influenced by institutional opportunities and constraints, such as land tenure and credit lines. Land tenure of both floodplain and upland systems was traditionally controlled by farm owners who gave free access to residents to carry out their subsistence activities (Chapter 3). This land tenure system has changed with the introduction of government-based projects to the riverbank areas.

Since the upland system was the major target of the road-construction projects along the Amazon, the government did not recognize the presence of local residents and allocated the upland and its contiguous riverbank strip to large companies.[13] Thus, despite ecological access to upland resources, its use by the riverbank populations was constrained due to external institutional changes. This threat triggered a local organization to fight back in order to guarantee access to the upland resource. For example, the riverbank population from the Ituqui area in the Lower Amazon engaged in a successful 10-year battle against a cattle company to keep their access to the upland resources (Leroy 1991, Futemma et al. 1998). The status of land-holders that was awarded to the residents ensured their access to the upland area and opened access to a new resource, the credit line, which has provided the opportunity to develop other economic activities.

Therefore, riverbank populations have suffered directly from the government projects but have overcome institutional constraints and consequently opened new opportunities such as land tenure security and credit lines. Levee populations, on the other hand, were indirectly impacted through fishing intensification (Chapter 2). Failure of the projects has driven settlers to urban centers at the river's edge (Browder and Godfrey 1997). The lack of job opportunities in the urban centers combined with few

[13] In general, riverbank populations located on the left side of the river did not suffer the same pressure because of the absence of large-scale projects.

economic alternatives in the rural areas has attracted both rural and urban populations to the commercial fisheries (Chapman 1989, Smith 1985). The increased exploitation of floodplain lakes by non-floodplain populations has threatened levee populations who have started to lose control over the fish resource, leading to several fishing conflicts in the region (Hartmann 1989; C.P.T. 1992a, b; McGrath et al. 1993b; Ruffino and Isaac 1994; Furtado 1993a). The levee populations have been squeezed in by farm owners, who have increasingly used the floodplain system to raise cattle, and commercial fishers, who have used the lake systems. Unlike the situation of the riverbank populations, the lack of institutional support (land title and credit lines) and ecological access to upland resources (forest products and upland terrain for farming and pasture) has left levee populations with few economic alternatives besides commercial fishing, creating a dilemma between exploiting the resource for short-term needs or establishing institutions to ensure the long-term maintenance of the fishing resources.

4.6. CONCLUSION

This chapter shows that floodplain populations are heterogeneous and that a finer disaggregation is necessary to analyze the population in terms of constraints faced to create and maintain a local fishing management. Disaggregation of the *varjeiro* in the Santarém region reveals ecological and institutional distinctions which directly reflect in the pattern of resource use. The difference in access to natural resources is the major distinction, which directly affects the ability of populations to organize local management systems. Floodplain populations may rely upon floodplain and upland resources. Keeping other variables constant, populations with a broader range of resource access have a greater ability to restrain the use of a particular resource or subsystem.

The disaggregation of floodplain communities is essential for both theoretical and policy purposes. Theoretically, it represents an analytical strategy for recognizing human responses to local environmental factors. The household economy varies in floodplain communities from specialized to diversified strategies according to the access to resources and household composition. Populations facing limitations of institutional and ecological access to resources have a tendency to specialize in one activity, which in turn decreases the ability to cope with environmental pressures by rearranging their production systems.

The definition of strategies is directly related to the ecological distribution of the resources. Floodplain resources come from two major ecological realms – water and land – and levee, riverbank, and upland communities represent a gradient in access to them. Riverbank communities have access to both water and land systems, which enables populations to diversify their economic strategy, in contrast to the levee populations, who tend to specialize in commercial fishing due to a lack of similar opportunities.

For policy matters, these distinctions in access to resources can play a major role in the outcome of the fishing accords. The opportunity to diversify activities allows a population to rely less upon commercial fishing as their major economic activity. In other words, the more viable the mixed strategy is, the more likely it is that the local management of fishing will succeed. The emergence of institutional constraints to commercial fishing has increased due to the establishment of fishing accords. However, when economic alternatives to commercial fishing are less viable, successful accords are unlikely to take place. In this regard, riverbank communities have a more resilient status concerning the potential to develop local management systems due to their opportunity to diversify the use of resources. Therefore, any management strategy should take into account local factors that can eventually affect the populations in different ways according to their characteristics. In particular, the local management of lakes is directly related to the main economic resource in the region (fish), and, thus, access to other economic alternatives becomes a major issue in the success of fishing accords. In this regard, the analysis of differences among floodplain communities represents an information guide to future policies regarding the management of natural resources in the region. Therefore, fishing accords should be congruent with the socioeconomic characteristics of the community. In the next chapter I discuss the major prescriptions that define the resource use in the floodplain in order to examine how congruent they are with the ecological and social features of the system.

Chapter 5

PATTERNS OF APPROPRIATION OF NATURAL RESOURCES IN THE FLOODPLAIN

5.1. INTRODUCTION

As discussed in Chapter 3, the local management of fishing in the Amazon is regulated by a set of prescriptions defined at different levels of interactions which increase short-term productivity and the power to control local decisions. In this chapter, I describe how the appropriation pattern of floodplain resources defined by the local populations affects the fishing management system. I aim to analyze how individuals try to achieve their goal of local management and how the prescriptions regulating the use of resources affect local decisions in the floodplain.

Appropriation of resources by human populations takes place through the establishment of prescriptions that define property rights over a resource or ecosystem. Those prescriptions can be defined formally by laws or informally by local norms and rules. The Amazonian floodplain has been a state property since the Constitution of 1934, which delegates to the federal government the right to regulate the use of this system. According to the Water Code, Article 11 (§ 2°, Dec. 24.643/34), the government can assign right-of-use to individuals to occupy the floodplain whenever the use does not threaten the public interest (Vieira 1992). After the Constitution of 1988, the use of the floodplain system became more restricted due to the establishment of Law #7803, which states that the use of the flooded forest (along with other vegetation) must be undertaken in a way that ensures the integrity of the ecosystem (Vieira 1997a). Despite state control, only recently was Decree #1567 of 02.14.97 created by the Secretary of Union Patrimony to regulate the human occupation in the floodplain (Vieira 1997b).

While the state has neglected the appropriation of the floodplain, local occupants have developed a de facto property system on which the pattern of resource use is based. As discussed in Chapter 3, despite the formal status of state property, the private property regime informally persisted in the floodplain until the mid-1960s, when local populations created the fishing accords which assume that part of the floodplain (e.g., the lake system) is collectively held by the local populations.

The history of appropriation of the floodplain has led to a complex de facto tenure system based on a combination of the ecological and social characteristics of the system. In general, local populations — including floodplain residents and farm owners — describe the property regime in the floodplain as multistructured property rights according to each subsystem – open access for streams, collective property for grasslands and lakes, and private property for natural levees (Figure 5.1). The fishing accords are institutions based upon this de facto property system which recognizes the lake system as a collective property of the landholders living in the surrounding levee.

Besides ecological influence, the defining of the de facto property system is influenced by individual power at the local level. This factor is evidenced by the contradiction between discourse and practice of local populations who violate their own de facto property system. Local incidents over appropriation of natural resources reflect this contradiction and reveal another layer of prescription regulating resource use embedded in the fishing accords.

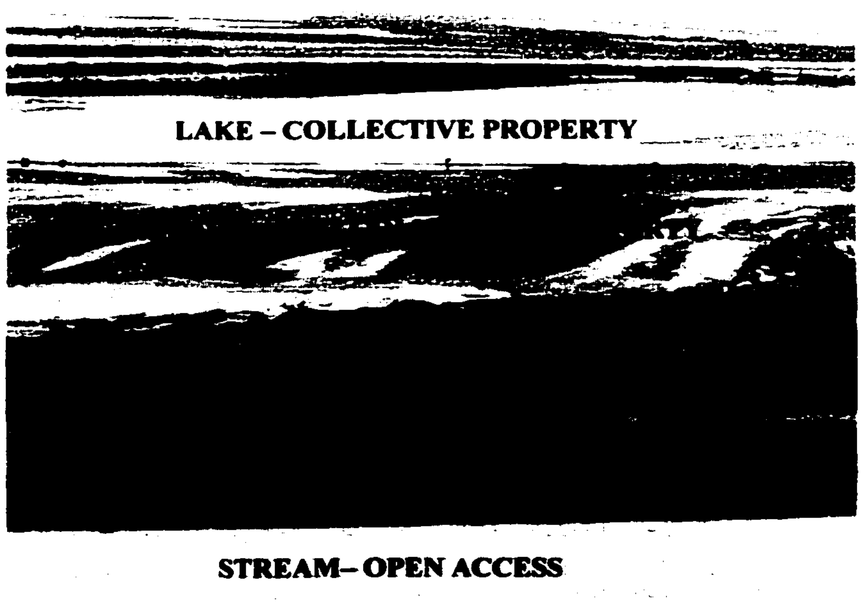


Figure 5.1. Overview picture of the floodplain system showing the property regimes for each subsystem, defined by the explicit ruling system.

The ecological and social variability of the floodplain system sets the stage for potential local incidents over appropriation of floodplain resources. However, the close social relationship between individuals – including kinship ties, reciprocity in production, and economic dependency – makes the engagement in explicit conflicts costly to the parties who depend on each other to carry out collective decisions in economic and political realms. Consequently, local populations manage potential conflicts through a negotiation process that is not obvious to outsiders. Only when those local incidents that violate the explicit ruling system described by the local residents emerge, is it possible to identify the distinct perceptions of local residents as well as the factors that influence decisions about resource appropriation. Therefore, the analysis of those incidents represents an efficient strategy for uncovering "implicit" social interactions at the local level.

The goal of this chapter is to describe the layers of property rights related to floodplain resources. I describe the fishing accords in order to discuss the explicit ruling system and the local incidents that reveal violation of the explicit ruling system in order to discuss the implicit ruling system. The fishing accord is a recent ruling system that addresses problems related mainly to non-residents (although it is supposed to address residents as well), while local norms are part of an older ruling system that is based on a negotiation process mostly between residents and farm owners.

The existence of two sets of local prescriptions demands an analysis of the degree of compatibility between those systems and their potential outcomes. In this regard, I aim to contextualize the collective action of fishing accords within the local social relationship between residents and farm owners in order to illustrate the local perception on the appropriation of resource use and how the local populations respond to the institutional constraints.

The chapter is divided into five sections. First, I briefly describe the methodology. Second, I discuss the structure of fishing accords as the "recognized" informal system of appropriation of the floodplain. Third, I discuss several incidents that reveal another layer of informal tenure systems hidden in the local discourse. In the fourth section, I discuss the implications of the multilayered pattern of appropriation for the conservation of the natural resources of the floodplain. Finally, I present a brief conclusion.

5.2. METHODOLOGY

Data were drawn from two major sources: documents of fishing accords and descriptions of local incidents.[1] I retrieved 69 documents of fishing accords written between 1981 and 1995 from archives at the Fishers' Union and at the governmental office (IBAMA). In addition, I participated in 15 community meetings where issues related to fishing accords were discussed.

Information on 12 local incidents involving the local population (residents and farm owners) was obtained from different communities in the Lower Amazon during several fieldwork trips undertaken between 1992 and 1997. I interviewed individuals involved in the incident and observed activities related to the incidents during my stay in the field. In each incident, I tried to identify the parties involved, the resource/subsystem where it took place, the major causes, and outcomes (when incidents had been settled).

5.3. EXPLICIT PROPERTY RIGHTS: THE FISHING ACCORDS

Fishing accords are the local management devices developed by local populations who claim the collective property regime of lakes in order to maintain the system's productivity for their descendants. The fishing accords encompass three main parts, each revealing a distinct aspect of the institution. The *statement* is related to social (users) and physical (lakes) boundaries of the accords; the *rules* are related to definitions of resource use and sanctions; and the *signature list* is related to representation of the accord.

[1] The lack of information on the actual number of fishing accords and local incidents limits the ability to draw conclusions based on frequency of occurrence. Likewise, lack of data on the ecological outcomes of the fishing accords constrains the ability to draw conclusions regarding the performance of the ruling systems.

5.3.1. Statement

The statement is a short paragraph that defines the area managed (names of the lakes) and the communities involved in the accord. Although there is a consensus among the appropriators regarding the preservation-oriented purpose of the fishing accord, only a few documents clearly mention their mission.

Due to the high interconnectiveness of lakes in the floodplain (see Chapter 2), the accord may focus on only a part of the system (a particular lake) or on the whole system (a set of lakes). The varying geographic scale of the lake system is reflected in multiple, overlapping fishing accords by a single community. For example, residents of a community may establish an accord to regulate the use of a particular lake located next to their community while participating in other regional-based accords involving neighboring communities to regulate the whole lake system. This variation in arrangements creates a complex network of fishing accords that can be, sometimes, incompatible.

Of the 69 fishing accords analyzed — which refer to approximately 100 lakes in the region — there were 137 communities involved, of which 54 were involved in more than one accord, either for different lakes, or for the same lakes in a different year. Approximately half of the accords involve only one community and a particular lake next to the community, while only 32 percent involve more than two communities (Figure 5.2). This dominance of fishing accords based on a small number of communities suggests the local populations face limitations to creating more complex institutional arrangements. Rather, accords involving multiple communities are more frequent when the accord focuses on a set of lakes. Even though the data presented are not a representative sample, fishing accords do seem to have been broadly established in the region. According to informants, this increase has been particularly intense in the 1990s (Figure 5.3).

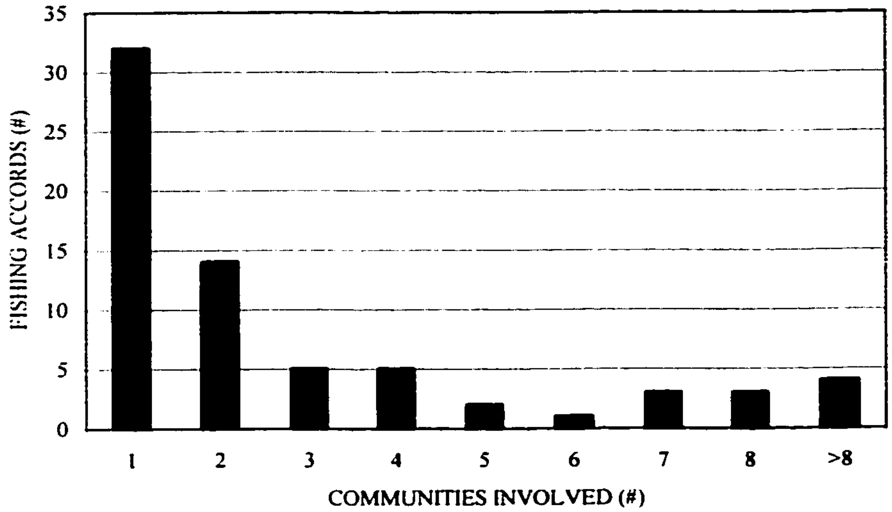


Figure 5.2. Number of communities sharing fishing accords.

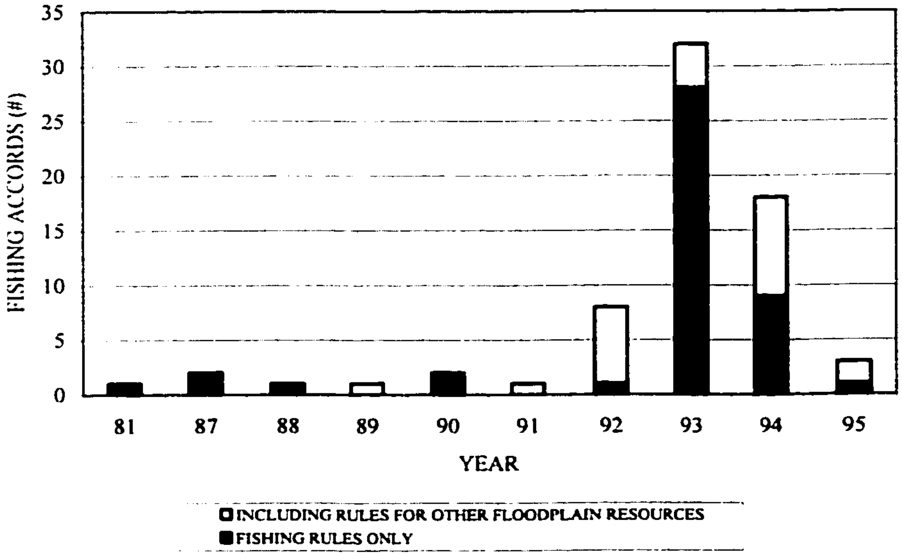


Figure 5.3. Establishment of fishing accords, 1981-1995.

5.3.2. Rules

The rules described in the fishing accords can be grouped into two main types: rules of activity and rules of enforcement. Rules of activity define who is allowed to use the resource (rules of access) and how the resource can be used (rules of use). Rules of enforcement define the sanctions against violations (rules of sanction) and how activity rules are monitored (rules of monitoring).

5.3.2.1. Rules of Activity

Rules of activity focus on the action of resource use, i.e., they define what is prohibited and permitted in regard to membership (rule of access) and exploitation (rule of use). The rule of access is clearly defined by residence criterion. There is a common understanding throughout the region that eligibility is limited to the landholders from the surrounding managed system, which includes both community residents and farm owners. The definition of the user group is facilitated by the relatively well-defined community boundaries (Chapter 4), from which user group boundaries are derived. The use of resources by those individuals enjoying regular access to the lake should be restrained by the rules of use.

Despite the focus on the fishing resource, the rules of use may be related to other resources, which is the case in 35 percent of the accords analyzed. The non-fishing rules address mainly regulations for hunting, the use of grassland, logging, ranching activity, and property rights. The frequency of non-fishing rules has increased since 1992, revealing an evolution from a focus on the fishing sector to a focus on the floodplain system (Figure 5.3), an ecologically appropriate tendency, given the close interdependence of subsystems (Chapter 2).

Fishing rules can be sorted into nine categories, in which restrictions of fishing season (75 percent), gillnet bans (59 percent), and commercial fishing bans (56 percent) are the most common (Figure 5.4). These rules try to tackle components that local populations consider to be the major threats to the maintenance of their fishing productivity: 1) the increased efficiency of fishing caused by the introduction of the gillnet; and 2) the increased fishing effort (time fishing and number of fishers) due to market pressure.

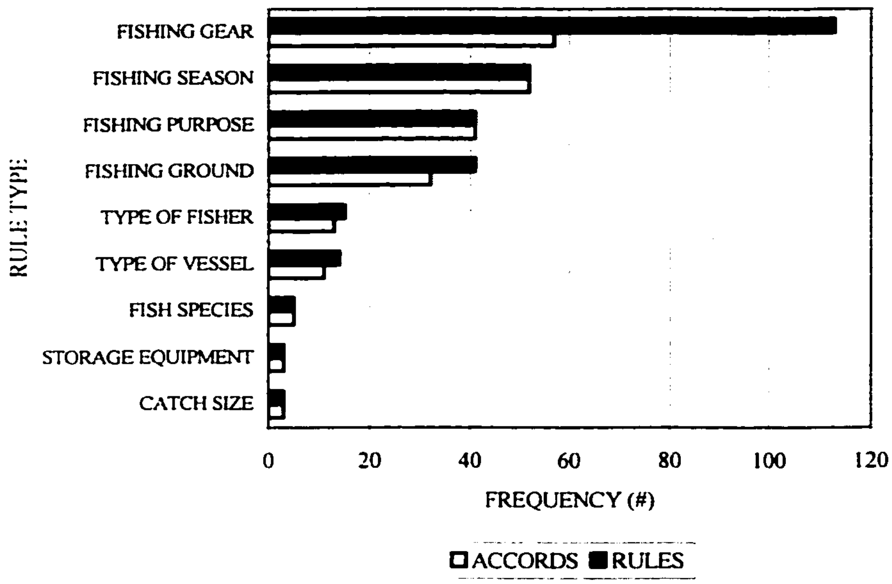


Figure 5.4. Frequency of fishing rules in the sample of fishing accords (n=69).

When fishing accords regulate the fishing season, the period defined lies mostly between September and February — which correspond to the drier months — when the lake fishing is more productive and fishing conflicts are more intense (Figure 5.5). The gillnet ban is an icon of the fishing accords, because residents relate the decrease of fishing productivity to the introduction of synthetic fiber gillnet in the region. The characteristics of the gillnet, combined with the socioeconomic differences among fishers generates a technological externality in which residents are usually at a disadvantage (Chapter 2). The option of monitoring the intensity of gillnet fishing is costly because gillnet fishing is a passive fishing strategy, which implies that a single fisher can set several gillnet units in the same fishing trip. It is difficult to monitor gillnets once they are set up. Therefore, residents prefer to give up this relatively efficient fishing method in order to avoid incentives for cheating and monitoring cost. The commercial fishing ban is another icon of fishing accords; its goal is to limit the catch per individual and to indirectly limit the incentives for non-resident fishers to enter the lakes.

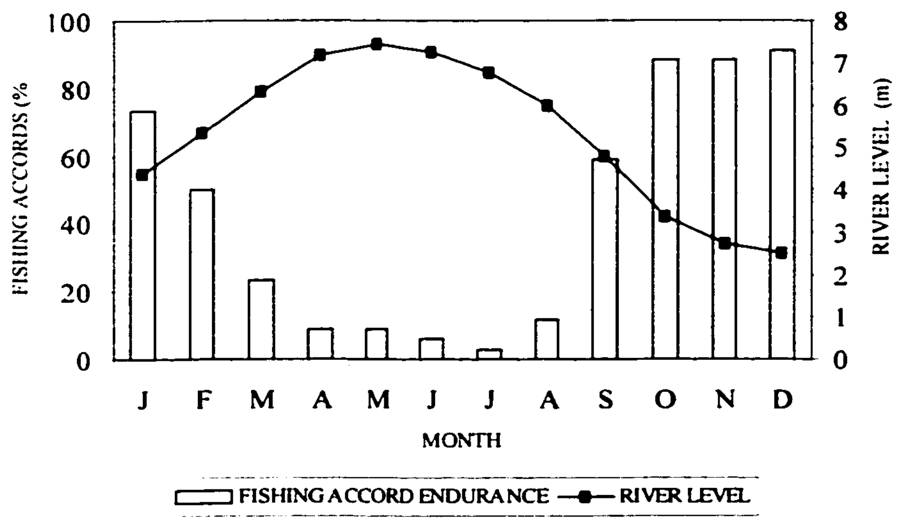


Figure 5.5. Relative frequency of fishing accord endurance.

5.3.2.2. Rules of Enforcement

Rules of enforcement aim to ensure the efficiency and maintenance of the rules of activity. They are divided into sanctioning and monitoring rules. Sanctioning rules are mentioned in 45 percent of the accords. The temporary apprehension of fishing gear (87 percent) is the most cited rule in the accords, followed by accusation in the governmental offices (29 percent), and a verbal warning (19 percent). In about half of those accords (n=14), the three rules are combined into a graduated sanction form of verbal warning, to gear apprehension, to accusation, for the first, second, and third infraction, respectively. This graduated system helps to solve problems of information sharing. The warning system gives a chance to those who do not know about the local management system to be aware of the possible consequences of their infraction. In addition, it reveals an attempt to solve conflicts at the local level, since a third party (e.g., officers) is brought in only after the occurrence of a few flagrant cases. Gillnet apprehension is carried out by the members of a fishing accord. The temporary apprehension is particularly effective because it can halt fishing activity of some non-resident fishers (e.g., neighbor and urban fishers), who have little capital with which to replace the gear. Yet, gillnet apprehension is often followed by the destruction of gillnets, although this sanction is explicitly stated in only a few accords. Both apprehension and destruction of gillnets have been a major source of conflict between residents and non-residents because the latter is economically and morally affected.

If sanctioning rules are poorly spelled out in the fishing accords, the monitoring rules are even weaker. Only five of the 69 accords present a clear strategy of monitoring by local members. Monitoring is a major component in any management system where external rules are established. The lack of commitment to controlling the accord lowers the incentives for participants to follow the prescriptions and raises the incentives for opportunistic behavior. As a result, a monitoring system is usually efficient toward non-residents, since a common interest in expelling non-residents creates incentives for residents to patrol the lakes consistently. On the other hand, the lack of a structured monitoring system strongly affects the control of the fishing activity among residents. For example, a violator who enjoys relative power in the community may receive milder sanctions than less powerful individuals. Therefore, the lack of a structured enforcement structure gives room for unbalanced sanctioning.

5.3.3. Signatories

One of the major problems in collective actions is to guarantee that decisions are made with participation of the group. The fishing accords account for participation through the personal signature, which is a major component in the document, representing both acknowledgement and moral commitment to supporting local management. Despite the moral importance of the signature, the levels of direct participation and substitute representation in the fishing accord is somehow unclear. Among the 34 accords in which the list of signatures was available, one half were signed by residents while the other half was signed by representatives. As expected, the former was the case more often in accords including a single community, whereas the latter was more common for those cases including more than one community.

When the accords are signed by residents, all community members are invited to the meeting and those who show up participate in an open voting system. The establishment of the fishing accord and its list of rules are defined by the majority at the meeting. Despite its "democratic" model, the voting system has at least three major flaws. First, decisions are made by the majority; but voting is run whenever the participants consider it appropriate, and absentees are considered abstention voters. Sometimes absentees send their "vote" through a relative or they sign it later. Yet, absentees do not sign the document when they do not agree upon the rules. Consequently, they do not consider themselves morally committed to the fishing accord and, thus, do not follow the regulations. The rule violation by an individual may trigger perverse incentives for those who signed the accord to break their commitment. This snowball process can rapidly take place, increasing the monitoring cost, and consequently leading to the failure of the agreement reached by part of the community. In short, the "rule of the majority" approach undertaken in the establishment of the fishing accord does not account for the moral value of the signatures on the document. On the other hand, if the decision process is undertaken through consensus, preceded by intensive discussion, the fishing accord is more likely to be successful.

The second problem of the voting system is the unclear unit of commitment. Accords are usually signed by every single meeting participant. However, sometimes only a representative of the household is required. This ambiguity may raise misunderstandings when there is conflict of interest among multiple fishers within a household. For example, one member of the family signs the accord while another member may break the rule. Hence, the moral component of the signature demands that every fisher should sign the accord in order to create social pressure based on moral values. Residents emphasize the importance of getting every household involved in the fishing accord through their signatures. Likewise, they stress the lack of moral values of those who "break their word" when they break the rules to which they had agreed. Thus, a clear definition of unit of commitment, based on moral values, is essential to ensure the strength of the commitment.

Finally, the open voting system is important to help the group to reach a consensus, but also may represent a threat to the expression of the voters' will. In such a close social arena, where norms of reciprocity are embedded in both cultural and economic practice, a voter may not feel comfortable expressing his/her will because of eventual retaliation that s/he can suffer in the future. Consequently, a verbal consensus on a fishing accord may not necessarily reflect an actual common interest of the user group; rather it may be only a result of the social pressure of a more powerful group over the rest of the voters. Therefore, open voting cannot be efficient unless freedom of expression by the individual is ensured.

The problems presented in individual-based participation are incrased when the accords are established by representatives. Similarly, the problem of "rule by the majority" is increased when regional fishing accords are established by community representatives, because the absence of one individual may represent the absence of a whole community. Such a case was observed in two of the fishing accords analyzed. A second problem involving decisions by representatives is related to unclear choices of criteria. Although representatives help to solve the problem of participation in regional decisions, they can enhance the inequities at the local level when internal conflicts and power relationships are exacerbated in the communities. When representatives are involved in local incidents or enjoy relatively powerful positions in the community, decisions may not correspond to the interest of the group.

Representation suffers a second-level problem when the fishing accord is analyzed in terms of a broad strategy for conservation. A collective action is more likely to succeed when there is common interest among individuals engaged in the endeavor (Olson 1965), and if there is a commitment by the members to avoid opportunistic behavior (Ostrom 1990). Currently, fishing accords are established primarily by community residents. If they are to be integrated into a regional management strategy, two other inequalities in representation should be addressed: first, among the other actors in the fishing sector, e.g., urban fishers; second, among the other actors living in the managed system, e.g., farm owners. As discussed earlier, fishing accords are established according to the perception that the lake managed is a collective property of the floodplain occupants. As a result, fishing accords are established as an agreement among the "owners" of the system who are eligible to make decisions regarding the management, while non-resident fishers are not invited to the meetings either to discuss or to vote. Despite the increasing involvement of the Fishers' Union in such meetings in order to partially fill this gap, the lack of participation of other potential fishers in defining rules of activity has been the main cause of conflicts between residents and non-residents. In particular, urban fishers are the most prejudiced actors since they do not have a "community lake" to manage. This asymmetry in access to lakes combined with the lack of participation in local decisions create incentives for non-residents to violate the rules established by the communities and increase the fishing conflicts.

In addition, a lake is part of the larger floodplain system and is used for other purposes besides fishing. Although fishing accords are defined mainly by residents, farm owners are also occupants eligible to use the lake. However, farm owners usually live in the urban centers, while cowboys take care of the cattle; therefore, they rarely exploit lakes economically. They rarely participate in the meetings, and only eventually sign the accords. The active participation of farm owners in fishing accords has decreased as the local populations have gained local power. Yet, the participation of farm owners in the fishing accord is crucial for at least three reasons. First, the multiple use of resources in the floodplain, combined with the interdependence of the subsystems, demand an integrated management of the system. Fishing accords are evolving into a systemic approach to regulating other resources besides fish. If farm owners do not participate in the local decisions, future incidents regarding the rules are more likely to arise. Second, the complex social relationship between these two local actors demands close cooperation in order to achieve the multiple goals of the fishing accords. Third, before fishing accords emerged, residents and farm owners had another de facto appropriation system which is now embedded in the explicit ruling system. Therefore, in order to ensure compatibility between the fishing accords and old local norms, both actors must be closely integrated in the local decisions regarding the establishment of the rules. The next section discusses these local norms as an implicit property system held between residents and farm owners.

5.4. IMPLICIT PROPERTY RIGHTS: LOCAL NORMS

Although fishing accords are present in the discourse of the local population throughout the region, this local property system is overlaid by another local institutional arrangement that has persisted from the farm owner management phase, and can be observed only when confrontation over appropriation of natural resources takes place among local actors.

Incidents between residents and farm owners are not new. Since the floodplain became a more economically attractive environment, both actors have disputed their claim over the floodplain's resources. Local incidents were more intensive between the end of the Rubber Boom (1911) and the beginning of the Jute Boom (mid-1930s), when the social relationship between these two groups was relatively loose (Table 5.1). During that period, farm owners held the status of private proprietors while residents were squatters. After the Constitution of 1934, neither farm owners nor residents held formal private ownership of the floodplain. Yet, the patronage relationship that was installed during the Jute Boom reaffirmed the de facto private property held by farm owners and lowered the conflicts over property rights after the 1930s. Recently, due to changes in the social structure in the floodplain, conflicts over resource appropriation between residents and farm owners began to arise again. The little attention paid to the current social relationship between residents and farm owners is due to the fact that conflicts between those actors are hidden in their discourse. The close social relationship that these groups still hold makes engagement in an open conflict costly since it would affect the long-term cultural, economic, and political commitment between them. Consequently, while conflicts with outsiders often stand out due to verbal and physical confrontations, negotiations between residents and farm owners are rather subtle and usually cannot be easily depicted in the local discourse.

Only when the incidents emerge is it possible to evaluate how local populations perceive the appropriation system at the local level. Below I discuss 12 incidents regarding appropriation of the floodplain system in which residents or farm owners violated the explicit rules described in the local discourse. I do not intend to present an ethnographic description of the incidents. Rather, the incidents are briefly described in order to highlight the actors involved, the nature of the incident, and the outcomes.

Table 5.1. Local conflicts on floodplain appropriation in the Lower Amazon. (F= farm owner, R= resident, — = unclear definition)

YEAR	PLACE	CONFLICT TYPE	ACTORS
1912	Tapara	—	F, R
1913	Aritapera	—	F, R
1913	Urucurituba	—	F, R
1927	Ituqui	Property claim	F, R
1927	Ituqui	Property claim	F, R
1927	Costa do Amazonas	Resource access	F, R
1927	Maica	Resource access	F, R
1928	Tapajos	—	F, R
1928	S. Jose	—	F, F
1929	Aritapera	Cattle	F, R
1929	Lago Grande de Franca	Property claim	—
1929	Ituqui	Property claim	F, F
1930	Ituqui	Property claim	F, R
1930	Tapajos	—	F, F
1930	Ituqui	—	F, R
1934	Ituqui	Property claim	F, F

5.4.1. Incidents

5.4.1.1. Streams[2]

Usually, fishers have free access to the main channels, and no incident was observed in this environment. The appropriation of main channels is difficult because

[2] As described in Chapter 2, streams are divided into creeks, river arms, and large channels. Creeks are small waterways which connect lakes and will be discussed as part of the lake system. In this section I focus on the large channels.

they must be accessible for transportation, which makes exclusibility troublesome. While activity in the main channel has conformed to the explicit ruling system of an open access regime, one incident of a claim for a collective property regime over a beach was observed.

INCIDENT 1

An urban fisher was fishing on the Amazon River at a beach in front of the Arapema community, located close to the city (Santarém). The residents asked him to leave, arguing that the area was a collective property of the residents. As the fisher refused to leave, the residents took his gillnets and destroyed them. The incident was brought to the police department but no further procedures were taken. Therefore, the community residents violated the free access to streams dictated in their explicit ruling system.

5.4.1.2. Natural Levees

Natural levees are the subsystem where the residents build their houses and grow their crops (Chapter 2). According to the explicit ruling system, levee property is defined in terms of the extension of the façade along the riverbank, whereas the length inward is rather confusing due to the boundary permeability throughout the year. It can be informally sold, rented, and inherited. Sale transactions are carried out by using informal receipts on which the name of the owner, property size, and sale price are written. The private system of natural levees is facilitated by its relatively clear definition of boundaries based upon elevation, i.e., the area with the least probability of flooding (Figure 5.1).

When the property is on a lower levee, it is considered a misfortune for the owner. Likewise, "fallen land" is considered a private loss. In both cases, the owners do not claim their loss, and no incident has been observed in regard to those issues. Despite the relatively clear private-based arrangement, the natural levees may have a collective component in particular situations, as illustrated in the following incidents.

INCIDENT 2

A piece of land was put up for sale in Ilha de São Miguel and an untrustworthy resident from another community expressed his interest in buying it. The community warned the proprietor not to sell to him. Later on, a community resident decided to buy the land, and the proprietor promptly accepted his offer. Consequently, all the residents were more comfortable with the decision because they were worried that the non-resident could ruin their local management system. Therefore, the pressure of other residents on the landholder violated the alienation right in the private system of natural levess.

INCIDENT 3

Usually, cattle are set free in the floodplain while private cultivators fence their gardens in order to avoid cattle damage. However, cattle can easily break the fences, reach the gardens in the private levees, and damage the crops. These events are commonplace and residents try to solve this problem by setting a rule that says that the cattle owner should pay for eventual damages caused by the animal in private crops. However, it is often hard to prove whose cattle invaded the garden, and the damage remains unpaid. As a result, residents are doubly affected by having to fence their garden and bear the risk of crop damage, while farm owners usually do not cultivate and have the largest herds. Therefore, farm owners violate the exclusibility right of residents over their private gardens on the levees.

5.4.1.3. Grasslands

Grasslands are located between the natural levee and the aquatic system (e.g., lake) which emerges only during the dry season when the water recedes. This seasonal landscape is exposed across the residents' and farm owners' properties in the floodplain system. Grassland may be traditionally used lowland or newly emergent lowland. The former is lowland that emerged a long time ago and has continuously been used by residents and farm owners. The latter is lowland that has recently emerged from the process of sedimentation (Chapter 2). The "grown land" has potential economic value, due to the highly fertilized soil. The "grown land" is a source of conflict between farm owners, who see it as potential grassland to feed cattle, and residents, who see it as good soil to cultivate fast-growing crops, such as beans and watermelons.

The collective property system over grassland, which is described by the explicit ruling system, may shift to a private property system in some cases. Because grassland is the main biotope exploited by farm owners, their power over residents is clearly revealed when an incident arises. For analytical reasons, I present separately the two incidents observed over the traditionally used grassland and the three incidents observed on the newly emergent grassland.

Traditionally Used Grasslands

INCIDENT 4

Grass is scarce on the upland during the dry season, and upland ranchers pay the floodplain population a monthly rent per head to take care of their cattle and feed them on the floodplain grassland. The grassland rental business gradually became a source of income in Ilha de Sao Miguel for a few residents and farm owners who raise cattle. Although cattle are fenced in on the caretaker's land during the night, they are set free in the "collective grassland" during the day to graze. Farm owners started to feel signs of overgrazing and proposed a rule, in which the number of cattle that each occupant (residents and farm owners) could take care of should be proportional to his/her owned grassland. The residents accepted the rule, which led the grassland rental to be restricted to farm owners who are the only local group with large landholds. In other words, grassland was considered privately owned, violating the equal distribution of a collective property system.

INCIDENT 5

Water buffaloes are adapted to wetlands. They were introduced in the Amazon estuary more than 200 years ago, and to the Lower Amazon only a few decades ago. Although better adapted to the floodplain environment in comparison to cattle, buffaloes have caused major environmental damage. Among the many problems cited by residents, the water buffaloes destroy grassland area, the floating meadows where fish grow, and gardens (more often than cattle because they are better at destroying fences). Several communities have experienced conflict regarding buffalo-related damages. Efforts made to prohibit buffalo raising have been effective among residents, while farm owners continue to raise buffaloes with no social constraint. Therefore, farm owners violate the management right of the collective property system of grassland in the explicit ruling system.

Newly Emergent Grasslands

INCIDENT 6

Agriculture is not practiced in Igarapé do Costa due to its location on a very low levee, which constrains the cultivation of annual crops. Thus, fishing is the major commercial activity practiced by most of the residents. About 20 years ago, an island emerged close to the community; it was promptly occupied by a resident, a middle-scale rancher, to keep his cattle. A friendly relationship between the rancher and the other residents was maintained in regard to the island use; the former exploited the grassland, while the latter exploited the lake within the island. The rancher died a few years ago, and his son who took over the island ownership prohibited the residents from using the lake. Supported by the Fishers' Union, the residents claimed their right to use the land, arguing that they did not have any other place to grow their crops. In court, the residents won the collective legal use-right of the island and the rancher had to leave. Therefore, the middle-scale rancher unsuccessfully tried to violate the access right in the collective ownership of grassland, but the other residents were able to maintain their access to the area with the support of the Union.

INCIDENT 7

An island emerged in front of Aracampina, and a resident who was a middle-scale rancher occupied the island to keep his cattle. He obtained the individual legal use-right to the area of 20,000 m^2, defined in a document written by the Secretary of Union Patrimony in 1959. As time went by, the island area grew due to the sedimentation process, and other Aracampina residents peacefully occupied part of the "grown land" to cultivate beans and watermelons. Several years later, the rancher died and his son decided to sell the land. However, the heir claimed ownership of the whole island in 1994, now with 2,500,000 m^2, including the area occupied by the other residents. Supported by the Fishers' Union, the Aracampina residents advocated that the proprietor held a document which described a limited area of the island, and they claimed their share of the island. The residents won their collective legal use-right in court, and the rancher sold informally only the area described in the document. Therefore, the middle-scale rancher tried to violate the access right to the collective grassland in the area with no legal private rights, but the other residents were able to maintain their access to the area with the support of the Union.

INCIDENT 8

An island emerged in front of the Ilha de São Miguel community 30 years ago, and one resident who was a middle-scale rancher took an individual piece of land, while 15 other families took the remaining area collectively to cultivate beans. Ten years later, the rancher applied to the Secretary of the Union Patrimony for the legal use-right of the whole area. His claim triggered a conflict with the other residents who were using the area collectively. However, since the rancher was a patron in the community, most of the residents withdrew from the area in respect for him. Two residents, who were local leaders, stayed on, sought support from the Rural Workers Union, and won their use-right in court two years later. The land was divided into three equal pieces upon which each claimant was given individual use-right. Therefore, the middle-scale rancher tried to violate the access right to the collective grassland but other residents were able to maintain their access to the area with the support of the Union.

5.4.1.4. Lakes

The most frequent incidents in the floodplain are those involving the use of lakes. These incidents between resident and non-resident fishers regarding property rights stem from the claim for collective property of lakes through fishing accords, in which the local population — including residents and farm owners — are the only eligible users. While conflict resolution at the regional level is explicit, conflict resolution at the local level is rather unclear. Unlike grassland, lakes can be a perennial system with flexible boundaries. During the flooding season, the lake becomes an open system which trespasses the boundaries of farm owners' and residents' properties. Yet, during the dry season, the lake recedes and becomes a semi-closed system, with access provided only by small creeks (*igarapés*). When lakes remain within farm owners' properties during the dry season, incidents between the farm owners and residents may emerge.

INCIDENT 9

Farm owners from Ilha de São Miguel usually bring friends to fish in the lakes. Although visitors fish for recreation purposes only, they are supposed to follow the local fishing rules, even though they fish in the lakes surrounded by the host's land. A farm owner allowed his guests to use a gillnet in a lake where a gillnet ban was in effect. The residents confiscated the gillnet and expelled the visitor; this triggered a conflict between the residents and the farm owner. The incident ended at the police department. The two parties reached an agreement and the farm owner agreed to warn his visitors about the local rules in the future. Therefore, the farm owner violated the collective right to manage the lake but the residents were able to enforce their rule on the farm owner.

INCIDENT 10

A gillnet ban was established in Ilha de São Miguel, but a farm owner claimed the right to use gillnets in "his water," arguing that he was not a commercial fisher and would not have the skill to fish otherwise. The community allowed the farm owner to fish with a gillnet for subsistence purposes only. The farm owner agreed, and his fishing is monitored due to the easy visibility of the fishing ground. Therefore, the farm owner violated the management rule of the gillnet ban, which is the icon of the fishing accord, with the consent of the community residents.

INCIDENT 11

Residents from Ilha de São Miguel set fishing rules that successfully increased the lake productivity, and provided a higher income by the commercialization of a high-priced fish species (*pirarucu*). Recently, a farm owner who owns the land contiguous to a highly productive fishing ground claimed the right to buy all the fish caught in that spot. The residents accepted the farm owner's claim since that was his condition to support the collective fishing rules. Therefore, the farm owner violated the management right of the residents by taking their right to commercialize the product freely.

INCIDENT 12

When a fishing accord including a gillnet ban was first established in Ilha de São Miguel in the late 1970s, three families did not agree to it. The residents restricted the gillnet fishing by those families to "their water," i.e., in the area of the lake projected from the imaginary boundaries defined from their property on the natural levee. Among other factors, the limitation of access to the lake led the families to accept the fishing accords a few years later. Therefore, some residents violated the right of the community to decide collectively how to manage the lake, and the majority of the residents responded by assigning restrictions which implied private ownership to lakes.

5.4.2. Patterns of Resource Appropriation at the Local Level

The implicit ruling system of floodplain appropriation reveals a distinct structure of control over decisions in the floodplain subsystems (Table 5.2). While the explicit ruling system considers streams and levees to be open access and private systems, respectively, the implicit ruling system allows collective-based decisions regarding those subsystems in some cases. Collective decisions regarding streams are related to the increasing importance of the commercial fisheries. Main channels remain open access, since easy — and necessary — access to the streams makes the monitoring very costly vis-à-vis the return in the channel fisheries. However, incidents related to the collective property of a beach on the stream's edge, reveal a potential trend that may increase in the future, since beaches are located near the communities and can be easily monitored. In regard to natural levees, the collective decisions regarding that privately owned subsystem stem from the relationship between levee ownership and eligibility to use the collective systems — lakes and grassland. In general, the fishing accords assume that "residents" are individuals who hold property on the levee.

CASE	COMMUNITY	PARTIES	RESOURCE	PROBLEM	OUTCOME
1	ARAPEMÃ	R/ UF	BEACH	USE OF GILLNET	UF EXPELLED, GILLNET BURNED
2	ILHA DE SÃO MIGUEL	R/R	LEVEE	UNTRUSTWORTHY OUTSIDER INTERESTED IN BUYING LAND	PROPRIETOR WARNED BY THE RESIDENTS - LAND BOUGHT BY A RESIDENT
3	SEVERAL COMMUNITIES	R/FO	LEVEE	CROP DAMAGE BY CATTLE	CROP FENCED BY CULTIVATOR, AND CROP DAMAGES UNPAID
4	ILHA DE SÃO MIGUEL	R/FO	GRASSLAND	OVERGRAZING DUE TO GRASSLAND RENTAL TO UPLAND FARM OWNERS	RENTAL PERMITTED ONLY FOR THOSE INDIVIDUALS OWNING ENOUGH GRASSLAND TO SHARE.
5	SEVERAL COMMUNITIES	R/FO	FLOODPLAIN	FLOODPLAIN ENVIRONMENT DAMAGED BY BUFFALO	PROHIBITION TO RAISE BUFFALO - ONLY RESIDENTS FOLLOW THE RULE
6	IGARAPE DO COSTA	R/FO	GRASSLAND	RESIDENTS DEPRIVED USE OF AN ISLAND BY MIDDLE-SCALE RANCHER	RESIDENTS WON THE USE-RIGHT TO THE LAND IN COURT - RANCHER HAD TO LEAVE
7	ARACAMPINA	R/FO	GRASSLAND	RESIDENTS WERE DEPRIVED USE OF THE ISLAND BY MIDDLE-SCALE RANCHER	RESIDENTS WON THE USE-RIGHT TO A LAND SHARE IN COURT - RANCHER HELD THE OTHER SHARE
8	ILHA DE SÃO MIGUEL	R/FO	GRASSLAND	RESIDENT WAS DEPRIVED USE OF THE ISLAND	RESIDENT WON IN COURT THE USE-RIGHT TO A LAND SHARE - FARM OWNER HELD THE OTHER SHARE
9	ILHA DE SÃO MIGUEL	R/FO	LAKE	VIOLATION OF GILLNET BAN BY FARM OWNER	GILLNET CONFISCATED AND FARM OWNER AGREED NOT TO BREAK THE RULE AGAIN
10	ILHA DE SÃO MIGUEL	R/FO	LAKE	VIOLATION OF GILLNET BAN BY FARM OWNER	FARM OWNER IS PERMITTED TO USE GILLNET FOR SUBSISTENCE PURPOSE ONLY
11	ILHA DE SÃO MIGUEL	R/FO	LAKE	FARM OWNER CLAIMS HER RIGHT TO TRADE THE FISH CAUGHT IN AREA LOCATED ON HER FARM	FARM OWNER GAINED THE RIGHT TO COMMERCIALIZE THE FISH
12	ILHA DE SÃO MIGUEL	R/R	LAKE	FAMILIES DO NOT SUPPORT THE FISHING ACCORD	RESIDENTS LIMITED THEIR LAKE ACCESS - LATER, FAMILIES ACCEPTED THE FISHING ACCORD.

Table 5.2. Summary of the incident cases, including where each took place, the parties involved (R= resident; UF = urban fisher; FO = farm owner), the resource disputed, a brief description of the problem, and its outcomes.

Therefore, newcomers fulfill the residency criteria and, thus, gain full rights to participate in collective decisions on local management of resources. The concern about who will be living in the community is related to the concern about with whom the residents will share the collective property. Therefore, the collective control over who can move in is a strategy to lower the risk of sharing the collective structure of resource appropriation with an untrustworthy resident.[3] In this regard, residents are expected to consult other community members before putting up their landholds for sale. According to local norms, priority is given in the following order: 1) to the neighbors; 2) to any other community resident; and 3) to a non-resident. This norm is clearly understood in several communities, and may even be written down in documents, observed in some fishing accords as "property rules."

Incidents over streams and levees seem to be rare. In particular, the clear definition of private property on natural levees stems from the relative facility to define boundaries and the economic importance of this subsystem, where the households keep their houses and their gardens. As a result, residents tend to succeed in the disputes over control of decisions related to those subsystems, unless farm owners are involved in the incidents, such as illustrated in Incident 3. Cattle invasion is both an economic and political issue in the communities where the cost for fencing cattle and the power of farm owners over residents defines the advantage of cattle ranching over agriculture in the floodplain. Incidents over resource appropriation are more frequent between residents and ranchers (farm owners or middle-scale ranchers) regarding the so-called communal

[3] Lima (1992) argues that "community membership" may also be related to kinship and land use. Notwithstanding, the fishing accord as an institution has been clearly defined in terms of residency.

subsystems — grassland and lakes — whose economic value has increased in the last decades.

Incidents over grasslands reveal a pattern. Those concerning traditionally used grasslands are a matter of defining control of decisions, whereas incidents concerning newly emergent grasslands are a matter of defining access to the land. Property rights over traditionally used grasslands were well-defined in the past, when farm owners enjoyed private ownership of the floodplain. Like in the past, residents enjoy access, but decisions are controlled by the farm owners. Incident 3 shows that although grassland is communally used, farm owners control the decisions over its use. Incident 4 shows that the incompatibility between farm owners' and residents' production systems is not taken into account by the former group. Therefore, grassland is used communally but a private system is called upon by farm owners whenever their production system is affected. In contrast, the newly emergent grasslands emerge in a different social context which demands the definition of clear boundaries in order to avoid further incidents. Today, the floodplain system presents a distinct power structure as well as land use patterns. Residents may own relatively large cattle herds and compete for grassland to feed their cattle (Chapter 4). Consequently, the newly emergent grasslands are first occupied by middle-scale ranchers who are residents enjoying relatively high power in the community. Residents who use the area for cultivation or fishing do not claim their formal use-right to newly emergent grassland until their informal access is threatened by the rancher. When a grassroots organization is supportive, residents are able to strengthen their power, and their claim for collective use-rights is more likely to succeed.

Like in the upland (Hecht and Cockburn 1989, Alegretti 1990, Leroy 1991), land conflict in the floodplain has triggered the development of local organizations. When external support is lacking, collective action is more difficult, and the local power structure prevails unless local organization is strong enough to face the rancher's power. For example, in Incident 8, the collective occupation that formerly took place in the grassland shifted to a private-based occupation because the middle-scale rancher influenced other residents to withdraw the conflict.

Concerning lakes, the incidents reveal a gradient of negotiation between farm owners and residents regarding lake use according to the economic value of the resource. In Incident 9, where fishing is for recreational purposes, the farm owners completely ceded to collective decision. In Incident 10, where fishing is for subsistence, there was a negotiation in which the farm owner accepted some collective control, but gained the privilege to use prohibited gear. In Incident 11, where fish have a high commercial value, the farm owner imposed control over the resource commercialization and the community had to accept it. Therefore, the negotiation process between residents and farm owners seems to be mediated by their balance between the cost and benefit of facing a conflict.

Interesting enough is the perception of "my water," slipped into the discourse of both residents and farm owners; this perception underlies the discourse of collective property rights over lakes held by the explicit ruling system. Although the inward limits of the landholds are unclear, both residents and farm owners (incidents 4,10, 11 and 12) seem to share the perception of lakes and grasslands as part of a landholder's private property. When residents were asked to draw the farms' boundaries on a picture taken during the flood season they drew a line in the middle of the lake. The informants explained that the imaginary boundaries represent the dry season, when the surrounding grassland is exposed. Therefore, definition of property boundaries seems to be mainly based upon the dry season landscape. Hence, while ecological factors define the pattern of access rights to the subsystem (held collectively), political factors define control over decisions (held privately). Therefore, the incidents based on boundary permeability may be related to access (such as in the incidents of newly emergent grassland, where access is threatened) or simply to the control of decisions (such as traditionally used grassland and lakes, where access is not threatened). This trend is a result of recent changes in the local socioeconomy and politics in the floodplain, which are reflected in the alteration in the bundles of rights to the floodplain subsystem. The more economically important the resource becomes, the more the power relationship among farm owners, middle-scale ranchers, and other residents is exposed, and the more likely it is that private-oriented rather than collective-oriented control will take place.

5.5. HUMAN TERRITORIALITY AND LEVEL OF APPROPRIATION

While the de jure state property of floodplain has not been efficiently monitored, de facto property systems regulating resource use have been developed by local actors. The customary appropriation system of the floodplain is two-layered: the *explicitly ruled property system* and the *implicitly ruled property system*. Both layers consider the floodplain a patchy system, but each one takes place in a different level of social interaction and is defined based upon a different set of factors. The *explicitly ruled property* layer takes place between the local population and non-residents, and defines property rights in the floodplain mainly in terms of ecological attributes of the system. Landscape diversity directly affects the pattern of appropriation, leading to a range of responses according to the feature of each subsystem (Table 5.3).

Table 5.3. Property regimes for each floodplain subsystem, according to the level of social interaction. Residents' and ranchers' domains are related to the subsystem where each actor has dominated the local decisions to define forms of appropriation.

	RESIDENTS' DOMAIN		RANCHERS' DOMAIN		
PROPERTY REGIME	STREAM	LEVEE	GRASSLAND	LAKE	LEVEL OF INTERACTION
GOVERNMENT (FORMAL LAWS)	STATE	STATE	STATE	STATE	CITIZENS
EXPLICIT RULES (FISHING ACCORD)	OPEN ACCESS	PRIVATE	COLLECTIVE	COLLECTIVE	RESIDENTS AND NON-RESIDENTS
IMPLICIT RULES (LOCAL NORMS)	COLLECTIVE	COLLECTIVE	PRIVATE	PRIVATE	RESIDENTS

The ecological approach to resource appropriation conforms with the economic defensibility model which assumes that territoriality takes place when the benefits overcome the cost of the territory protection (Brown 1964). In general, the ecological heterogeneity of floodplain systems makes the definition of property rights variable, both spatially and temporally. Thomas (1996) analyzed the tenure pattern of a floodplain system in Nigeria and found distinct appropriation systems that were related to the ecological characteristics of each floodplain subsystem. In general, concentrated, predictable, and stationary resources tend to be private in contrast to random, diffuse, and fugitive resources which tend to be either collectively held or under open access. Similarly, seasonal variation of the floodplain environment may also affect the appropriation regime throughout the year, as described by Vondal (1987) in the swampland in Borneo. The author observed that the same physical area was collectively shared during the flood season, and privately owned during the dry season, and concluded that collective appropriation was appropriate during the flood season due to the difficulty in drawing boundaries. Therefore, the boundaries' permeability and property rights may create difficulties in regard to a clear and stable structure of resource appropriation.

Thus, the "flood pulse system," which leads to continuous expansion and retraction of the floodplain system throughout the year, affects the stability of the territory boundaries between two strongly overlapping subsystems, lake and grassland, each of which is a classic example of a system where individual control is costly due to the changing landscape and features of highly dispersed (grassland) and fugitive (fish) resources. In this regard, the explicit ruling system represents a consistent cultural-ecological explanation for the pattern of floodplain appropriation in the Lower Amazon. It is explained as a result of a long-term shaping process influenced by the distribution and abundance of resources. In other words, it is an adaptation to a patchy ecosystem that provides a range of biological zones with distinct ecological attributes. Such a "cultural ecology" approach to the "commons" is not only supported by etic analysis, but also by emic evidence expressed by the local population in their daily discourse and through their current local management system (e.g., fishing accord documents).

Nevertheless, the history of floodplain occupation shows that the floodplain was privately held by farm owners according to their economic importance. Until the late 1960s, when natural levees were the main economically important subsystem in the floodplain for jute cultivation, farm owners exercised their private rights over the levees to engage in a patron/client relationship with residents. During this period, those actors enjoyed free access to grassland and lakes, and conflicts were limited by the economic resource partitioning of the system; farm owners exploited grassland during the dry season, whereas residents exploited the lakes for commercial fishing. As grassland became more important to residents (for farming and cattle ranching purposes) and the lakes became a potential economic source for farm owners (to associate in sharefishing with commercial fishers), both actors strongly overlapped in the use of those two subsystems. Consequently, the control of decisions over grassland and lakes by farm owners started to be exposed. The analysis of incidents between the two local actors reveals the implicit ruling system as a tenure layer embedded in the explicit ruling system with redefined property regimes at the local level for each subsystem. This underlying tenure system is asymmetrically exercised by the local population according to their degree of empowerment. In some incidents, residents have been able to influence the decisions collectively toward use of streams and natural levees, while farm owners have been able to influence the decisions individually toward use of grassland and lakes (Table 5.3).

The major driving force of this tenure layer is the economic importance of the resource. The recent claim for collective property of beaches by residents has emerged due the increasing economic importance of fish. Likewise, the local population has acted collectively in controlling the sale of levee landholds despite the private status of this subsystem. The claim of private rights on grassland and lakes by farm owners is also a result of the increasing economic importance of the resources of the system (pasture and fish). Therefore, the human territoriality in the Amazonian floodplain is multilayered and has been shaped through a dual process of ecological and social adaptation.

5.6. LOCAL POLITICS AND DISCURSIVE STRATEGIES

The two-layered property system of the floodplain reveals a pattern of resource appropriation that acts on different levels. The explicit ruling system is used by residents to claim local control of the system. Residents have strengthened their claims to governing local natural resources due to recent internal and external social transformations, such as local organization and conservation ideology (Chapter 3). Consequently, residents have not only been affected by new trends in conservation issues but have also affected them, by embracing a conservationist discourse to gain more political power and keep their access (and sometimes control) over the local resources (Allegretti 1990, Schmink and Wood 1992).

While the explicit ruling system is present in the local discourse and has been assumed to be the only de facto appropriation system in the floodplain, the recognition of the private status of grasslands and lakes by local populations is observed only when an incident emerges. As discussed earlier, both residents and farm owners recognize "their water" and the boundaries of farms in the middle of the lakes. The "invisibility" of the implicit ruling system to policymakers and researchers is mainly due to the lack of contextualization of the local management in the social relationships among the local population. While access to "collective" resources (lakes and grasslands) is maintained among them, farm owners try to maintain their control over decisions regarding their use. This subtle difference in the structure of control of the floodplain between explicit and implicit ruling systems can be better observed when property rights are broken into five components that define different levels of control — access, withdrawal, management, exclusion, and alienation (Schlager and Ostrom 1992). Table 5.4 shows that the implicit ruling system does not permit residents to make decisions on the management of the "collective system," such as grasslands and lakes.

Table 5.4. Components of property rights in the explicitly ruled property system and the implicitly ruled property system for each subsystem (adapted from Schlager and Ostrom 1992).

EXPLICIT-FISHING ACCORD	STREAM	LEVEE	LAKE	GRASSLAND
ACCESS	✓	✓	✓	✓
WITHDRAWAL	✓	✓	✓	✓
MANAGEMENT		✓	✓	✓
EXCLUSION		✓	✓	✓
ALIENATION		✓		

IMPLICIT-LOCAL NORMS	STREAM	LEVEE	LAKE	GRASSLAND
ACCESS	✓	✓	✓	✓
WITHDRAWAL	✓	✓	✓	✓
MANAGEMENT	✓	✓		
EXCLUSION		✓	✓	✓
ALIENATION				

Although residents are able to manage the local resources in relation to non-residents and to themselves, they are not able to manage the resources in relation to farm owners. Consequently, when the implicit ruling system is exercised at the local level, the maintenance of collective actions based on an explicit ruling system, such as the fishing accord, becomes strongly dependent upon farm owners who hold the management rights at the local level. On the other hand, if implicit and explicit ruling systems are congruent, i.e., both residents and farm owners share similar perceptions regarding lake management, the fishing accord is more likely to succeed.

The dependence of residents upon farm owners helps the latter to maintain control over the floodplain at a low cost, since there are few confrontations. Yet, as residents have gained external political support through the fishing accords, they have been able to confront and, sometimes, to defeat farm owners. Incidents 6 and 7 are examples of how collective action combined with the support of grassroots organizations can lead to a victory over more economically powerful actors. On the other hand, the floodplain is dominated by farm owners' land and, therefore, their support remains essential to facilitating the monitoring of access to lakes. Moreover, in many incidents, farm owners and residents still maintain close social bonds either economically (as a source of financial aid) or culturally (through kinship or co-parenthood). Therefore, the harmonious relationship between residents and farm owners is fundamental to the success of fishing accords. Both actors share a delicate arena in which the negotiation process is embedded in a complex social relationship that swings between cooperation when fighting against non-residents (in the form of fishing accords) and competition at the local level.

5.7. CONCLUSION

This chapter shows that patterns of resource use in the floodplain are determined by a combination of institutional arrangement structured in three layers of property systems – one legal state property system, and two de facto property systems (explicit ruling and implicit ruling). Each property system works on different levels of interaction and affects different social scales. The explicit ruling system is defined based upon ecological attributes of the floodplain system. It is the basis of the fishing accord in which rules to regulate lake use are formulated collectively by the residents. The implicit ruling system of appropriation is defined based upon social attributes of the population and may emerge according to the economic importance of the resource and the power relationships at the local level.

The ecological attributes of the system are important in defining forms of appropriation but may not be sufficient to explain the patterns of tenure. Rather, they may hide internal aspects of social relationships that are essential to understanding how appropriation takes place. The analysis of incidents between farm owners, middle-scale ranchers, and other residents reveals a complex social relationship based upon cultural, ecological, and socioeconomic factors that leads to asymmetric control over decisions concerning resource use in the floodplain. The historically close social links between farm owners and residents in regard to natural resource use has recently been disclosed due to internal and external economic and political changes. The new social structure may help to improve the success of local management as far as pressure on the resources by non-residents is concerned; yet it may enhance local conflicts that can undermine the collective action at the local level. The exercise of the implicit ruling property system by farm owners threatens the social justice goal of the local management, which is the recognition of the right of the local population to control the use of the floodplain system in a collectively and equally distributed power basis. Therefore, any attempt to incorporate fishing accords into a co-management system should consider a detailed analysis of the relationships among residents and farm owners, and support a negotiation process between these groups in order to achieve a common interest in regard to the local management of the floodplain.

The success of a local management systems depends on the degree of compatibility between these three layers of property rights and on whether or not the local population is able to solve local incidents in order to make the explicit and implicit property rights compatible. Therefore, it should not be assumed that fishing accords will work promptly once recognition of local control and economic incentives are provided. Rather, a local contextualization of the social structure is crucial to reveal potential barriers to the development of a participatory and democratic system of fishing accords. The next chapter discusses how the compatibility of both appropriation systems can enhance the ability of local populations to achieve a successful fishing accord.

Chapter 6

SUCCESS AND FAILURE OF FISHING ACCORDS IN THE AMAZON

6.1. INTRODUCTION

The previous chapters addressed the factors that have facilitated the emergence of the fishing accords in the Amazon. I have argued that external factors such as the decline of jute prices, changes in fishing technology, support from the Catholic Church, and the conservation ideology in the media have influenced local populations to adopt a new local management system for fishing in the Amazon Basin. This chapter shows that although fishing accords are a pervasive response to external factors, the outcome of this local institution varies depending on the ecological and social endowments of each population affected.

Fishing accords represent a "new" local management system, which has emerged as a response to external pressures generated from the intensification of commercial fishing, with two major goals — control of access and increase of lake productivity (Chapter 3). Interestingly enough, this local institution has spread throughout the Lower Amazon, regardless of governmental support or the increasing economic importance of fish. Despite similar external pressures, the institutional arrangement of the fishing accords varies across communities in term of representativeness, rules of activity, and structure of the monitoring system (Chapter 5). In addition, similar rules can have a different impact on communities facing distinct ecological opportunities and constraints (Chapter 4). Therefore, while several communities have succeeded in accomplishing the goal of control of access, the ability to increase lake productivity through regulations of the local fishing remains to be tested.

The analysis of the outcome of the fishing accords demands an evaluation of lake productivity vis-à-vis the institutional arrangement of the fishing accords. Since the communities lack historical data on fishing production to compare the lake productivity over time, an alternative analytical strategy is to compare across communities. In this regard, the comparison of fishing accords that have been considered successful with those that have been considered unsuccessful can shed some light on the local factors that influence the outcome of the fishing accords. In this chapter, I compare two levee communities,[1] who created fishing accords in the mid-1980s, driven by similar reasons (decrease of fish productivity), were similarly successful in expelling non-resident fishers, but have achieved different levels of success in controlling local fishing. This analytical strategy demands in-depth contextualization of the institution in the local historical, social, and ecological dimensions in which the collective action took place, in order to relate its social organization with the ecological performance.

The measure of the ecological performance of the fishing accords demands an evaluative criterion. Despite the increased attention to the ecological potential of local management systems, little effort has been made to evaluate if and how such institutions can improve ecosystem productivity.[2] Recent studies have pointed out the importance of local management to maintaining system resilience, instead of focusing on a single

[1] Levee communities are settlements located on the floodplain islands. Those communities tend to have a higher reliance on fish as an economic source and similar patterns of resource access (Chapter 4). I chose both communities of the same type in order to lower the ecological variance between the two communities (no prompt access to the upland) and analyze the factors which influence the success and failure of the fishing accords in communities presenting high reliance upon fishing.

[2] See examples in forests (Gibson et al. 1998), irrigation systems (Ostrom 1992a, Tang 1992); and aquatic animals (Acheson 1975, Smith and Berkes 1991, Ruttan 1998).

resource (Acheson and Wilson 1996, Berkes and Folke 1998). In this regard, the performance of local management systems should be evaluated by analysis of institutional arrangements and the ecological system in a dynamic fashion, envisaging the pressure of rapid environmental change. The fishing accord is a case in point; its social boundaries are the floodplain community, and its ecological boundaries are the lake system. The goal of this chapter is to evaluate the performance of the fishing accord in light of fish conservation.

The chapter is divided into four sections. The first section describes the methodology. The second section follows a similar analytical structure to analyze the origin and maintenance of fishing accords in the Lower Amazon region presented in chapters 2-5. For each community, I describe the history of the emergence of the community, the current structure of the population, the ecological setting, and the fishing accord in order to understand the main factors in the origin and maintenance of the fishing accord in that community. In the third section, I explore the ecological outcomes of the fishing accords by comparing data on the fish production in both communities. Finally, the last section deals with a general discussion on the sustainability of the fish resource within the local social and ecological context.

6.2. METHODOLOGY

Data collection took place in several intensive fieldwork trips during 1992-1997, and was based on a combination of methods, including a socioeconomic survey, interviews, direct observation, remote sensing analysis, and fish landing statistics.
A household socioeconomic survey was carried out to generate the data on the strategies

of resource use in the communities. Four major economic sources — fishing, agriculture, cattle raising, and wage-based sources (i.e., contract work, middleman, small business, retirement salary) — were ranked at five levels of economic importance (Table 6.1). With a focus on the fishing activity, the households were classified into five major categories of economic strategies — intensified fishing, fishing-cattle, fishing-agriculture, fishing-other, and diversified fishing (including more than two activities). The categories were the basis for a stratified sample of 25 households in each community, randomly chosen, whose fishing production was monitored for seven consecutive days each month in 1992. Fish production data were collected in structured questionnaires containing information on fishing trip (place, gear, crew, time) and catch composition (species and quantity), carried out by trained local residents and monitored by me. Fish production data were used to derive ecological comparative measures such as capture per unit of effort (CPUE), catch diversity, and fish body size, in order to check the extent to which the institutional change may have affected the ecological system.

I conducted non-structured interviews with focal groups (community leaders, fishers, and elderly residents) in order to get information on the history of the community, the fishing accord, and fishing activity. In addition, throughout the year I observed different fishing strategies in fifteen fishing trips in which I participated in order to observe the variability of fishing techniques and the decisions at the fishing spot.[3]

I carried out a classification of a TM Landsat image of the communities taken during the ebb season (July 1997) in order to observe the spatial distribution of the floodplain land cover. I used Software MultiSpec 6.93 for MacIntosh (Landgrebe and

[3] See Chapter 2 for a detailed description of the fishing strategies.

Biehl 1997). The unsupervised classification was based on cluster analysis using the ISODATA technique, improved by integrating my personal knowledge of the area of study, while classification accuracy was tested by applying a separability test.

Table 6.1. Ranking of economic activities undertaken by households.

RANK	FISHING	AGRICULTURE	CATTLE RAISING	OTHERS*
0	No fishing	No agriculture	No cattle	No other activity
1	Subsistence fishing	Small "canteiro"	1 to 5 heads	One other activity
2	Extensive commercial fishing	Mainly subsistence garden	6 to 15 heads	Two other activities
3	Fishing as main economic activity	Extensive cash cropping	16 to 50 heads	Three other activities
4	Intensive fishing activity	Intensive cash cropping	51 to 200 heads	Four other activities

* Others - Each of the following activities represents a unit –contract work (teacher, cowboy), small business owner (tavern), middleman, retirement salary.

6.3. <u>FISHING ACCORD CONTEXT</u>

6.3.1. <u>Socioeconomic History</u>

6.3.1.1. Ilha de São Miguel

Ilha de São Miguel (ISM) is located on the island with the same name, between the towns Santarém (40 km) and Alenquer (20 km) (Figure 6.1). According to the residents, the island emerged about 150 years ago as a small mound which has steadily grown ever since. They estimate that the occupation of the island started more than 100 years ago by three *caboclo* families who made their living from subsistence activities and from small-scale commercial extractivism of wood for steam boats. Two farm owners who arrived to establish cocoa and sugar cane fields employed the local families.

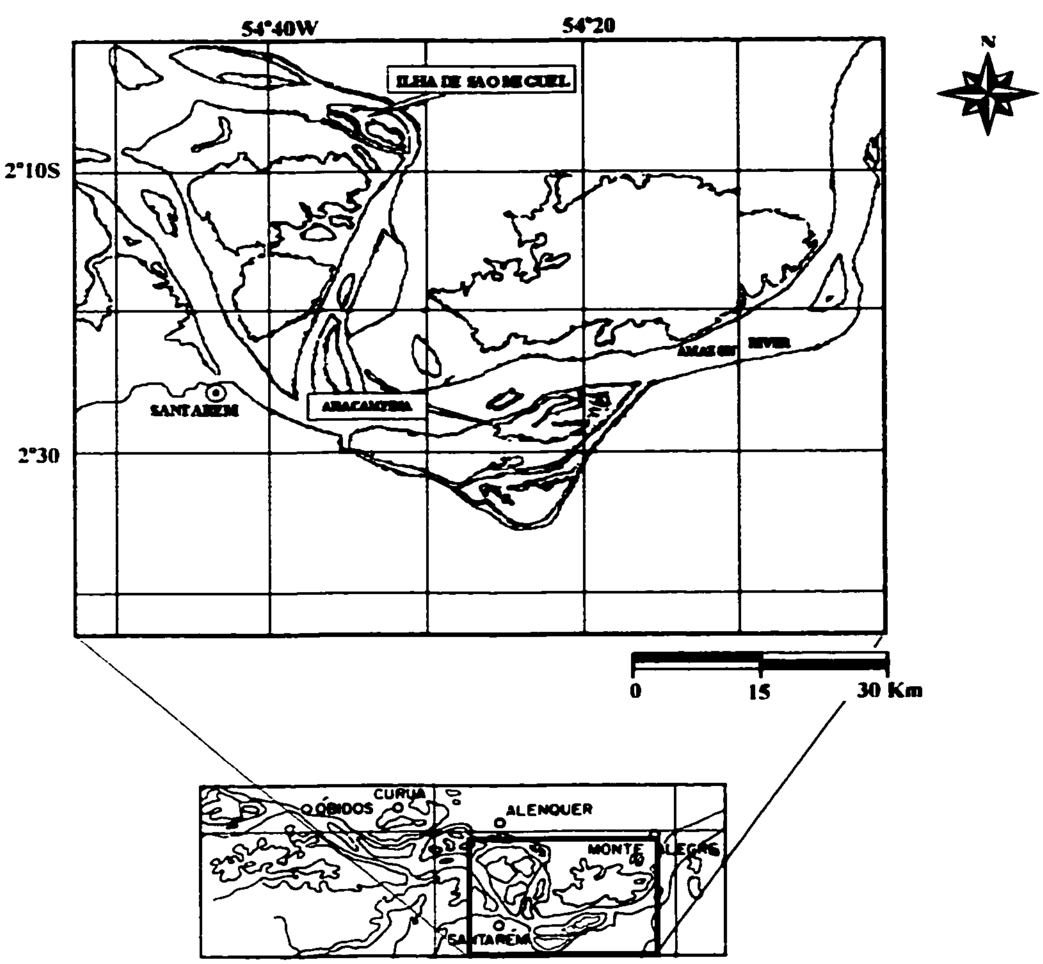


Figure 6.1. Map of the floodplain in the Santarém region showing the locations of the case studies.

The socioeconomic history of the population is marked by two major events: the jute boom and the intensification of commercial fishing. During the jute boom, between the 1930s and 1960s, large extensions of flooded forest and cocoa plantations were cut down on the levees to make room for the jute plantations. Some areas were protected from deforestation because farm owners did not permit the cutting of the flooded forest. In addition, the social relationship between the local population and the farm owners switched from employees to sharecroppers under a patron/client system. Finally, cattle ranching, which was introduced to the island by the farm owners in the early 1920s, became the major investment of the income generated from jute production. Consequently, economic stratification among residents took place when some residents were able to accumulate more capital and became part of a rural "middle" class represented by the middle-scale ranchers.

The intensification of commercial fishing took place in the 1960s, during the decline of jute production. Farm owners resisted the introduction of gillnets in ISM; they prohibited their use within the farms' boundaries because they believed that gillnets scared fish away. Yet, it was not long before gillnet use was widespread in the region, and ISM residents adopted it on the island with no regard for the farm owners. Commercial fishing rapidly became the most economically important activity in the community, and by the early 1970s, residents started to feel the first signs of the decline in fish production, as illustrated by one resident's comment:

> In the beginning, we went fishing with one gillnet and returned with the canoe full of fish; later we went fishing with the canoe full of gillnets and returned with a few fish. (my translation)

Meanwhile, bean cultivation started to be an economically important activity in the floodplain. Beans were included in the economic repertoire of some floodplain households due to their relatively good market price and suitability to the floodplain system (Chapter 3). During the 1970s, a large area of newly emergent grassland was intensively used for bean cultivation by about 15 households. This area was the stage for internal conflicts regarding appropriation (Chapter 5, Incident 8) and conflicts with non-residents regarding turtle and turtle egg poaching. The residents cultivated beans next to the beach which three turtle species used as a nesting site during the dry season —

Podocnemis unifilis (pitiú), *Podocnemis sextuberculata (tracajá)*, and, to a lesser degree, *Podocnemis expansa (tartaruga)*. The poachers acted during the evening, when the turtles came out from the water to lay their eggs on the beach, or at dawn to hunt the eggs laid the evening before. Since the turtle nests were close to the bean fields, poachers often affected the crop productivity. Residents complained about the intrusion and decided to create a reserve to protect the animals. They initially established a turtle nesting reserve without any external support. The reserve was maintained by two families who cultivate beans and enjoy private right of use in the area (see Incident 8 in Chapter 5). The turtle reserve succeeded. A decade later, the reserve was finally recognized by the governmental agency SUDEPE, who gave institutional support to the maintenance of the nesting reserve (*tabuleiro*). Today, the number of nests increases steadily each year; 36 percent for *Podocnemis sextuberculata*; 78 percent for *Podocnemis expansa*; and 220 percent for *Podocnemis unifilis,* between 1991 and 1994. It is not clear whether the original purpose of the turtle nesting reserve was to protect the turtle population or the bean fields, or both. Whatever the motivation, the turtle reserve has created a sense of conservation among the residents. Considering that turtle eggs represent a delicacy in their diet, the establishment of the turtle nesting reserve is a cause of discontent to some residents (mainly young members) who cannot hunt eggs in the area. Nevertheless, in general, the residents proudly recognize their accomplishment and have developed an attitude in favor of conservation both among themselves and toward non-residents.

A similar local compromise for the sake of conservation is present in the fishing accord, which was created in the late 1970s, when several communities in different regions of the Lower Amazon were facing a decrease in fishing productivity (see Chapter

3). The proposal to create the fishing accord came from two major commercial fishers who were community leaders and perceived the decrease in fishing productivity when "only piranhas were caught." They proposed to the rest of the community to quit commercial fishing and establish a gillnet ban in the community lakes. The agreement to establish those local rules was sealed by a symbolic burning of all gillnets in the community.

The period between the time the first fishing rules were proposed and the time when a consensual agreement among residents was reached consisted of about 10 years of intense negotiation, among the residents themselves and between them and non-residents. Among themselves, three families (large- and middle-scale ranchers) resisted signing the fishing accord. Residents had several meetings and put pressure on those who were not supporting the accord by restricting their access to the fishing grounds (Chapter 5, Incident 12). The internal conflict ended only when all community residents and three farm owners signed the accord, revealing the moral importance of the signatures in the accord (Chapter 5).

Today, internal conflicts still exist in ISM. Negotiations with farm owners are constantly exercised (Chapter 5, Incidents 9-11). Two farm owners have given support to the accord only verbally, but have not yet signed the document. Likewise, violation cases by residents also occur, although not often. While the fishing accord lessened the number of internal conflicts, it has exacerbated conflicts with non-residents. The relatively isolated location of the island off from the main channel protected the community from potential entrance of motor boat fishers. Nonetheless, ISM residents faced constant "invasions" of fishers from neighboring communities. Residents also had to face the resistance of the Fishers' Union, which was run by commercial fishers and did not support initiatives for banning gillnet and commercial fishing.

Due to the lack of formal support from the government (SUDEPE) or grassroots organizations (Fishers' Union), ISM residents relied upon individuals with political influence in the city to help them to solve external conflicts. Those supporters, including farm owners and former residents who migrated to the city, were morally committed to the community. They played a particularly important role in helping to resolve conflicts that took place in the early stages of the fishing accord. They helped to find legal support to defend ISM patrols when they were called to the police department to respond to accusations of violence against non-resident fishers. They also contributed with information to create a local association that provides a legal avenue to claim for collective right of use of the floodplain system. The Association of Natives and Residents of Ilha de São Miguel (Associação dos Nativos e Residentes da Ilha de São Miguel) was created in 1989, when, with exception of two farm owners, all residents signed the accord, and the by-laws where finally formalized in 1995.[4] The major feature of the Association is the involvement of residents, non-resident natives, and farm owners in its creation; this feature is reflected in their inclusion of all three groups in the current committee.

Apparently, the fishing accord had a rapid positive outcome regarding fish productivity, as illustrated by a comment from a resident:

> Right before the establishment of the fishing accord, three partners and I took one week to catch about 60 kg of fish; one year later, I went fishing alone and caught about the same amount in a single day. (my translation)

[4] Residents still look forward to the signing of the accord by the two remaining farm owners.

The increase of lake productivity is also recognized by residents from other communities in the region who regard ISM as a community of selfish people who do not share the highly productive lake with their neighbors. ISM residents, on the other hand, defend themselves by accusing non-residents of turning to other communities' resources after overusing their own resource. As one ISM resident points out:

> They have their own lakes to fish. Their lakes are out of fish because they did so. We have been in the same situation before, but we did something. They should be doing the same instead of accusing us. (my translation)

In sum, it is difficult to pinpoint when the fishing accord was first established. The implementation of the fishing accord is better understood as a dynamic process than a single moment. During a period of about 15 years, the residents have worked to solve internal conflicts regarding different interests and to achieve consensus while trying to address problems related to external conflicts. The next sections explore the ecological and social aspects which have played a role at the community level in the performance of this institution during the decade that followed the implementation of the accord.

6.3.1.2. Aracampina

Aracampina (ARA) is located on the Ituqui Island, on the Amazon River, about 40 km downstream from Santarém (Câmara 1996). The community occupies 10 percent of the estimated area of the island. ARA has experienced major changes in its local organization due to a development project that was launched in 1994. Since the analysis of fishing accord performance in the two communities is based on data collected before this date, I will emphasize the characteristics of the community before the interference of external projects, unless otherwise noted.

The Ituqui island has a longer history of occupation than ISM. The presence of archeological remains on the island suggests that it was probably occupied before the European colonization. During the colonization period, Ituqui Island was one of the first islands occupied in the region due to its proximity to the urban center (Santarém) (Figure 6.1). The presence of farm owners dates back to 1808, when their ownership notifications are cited in the local newspaper (A Cidade, 05/11/27, XI, # 542). ARA residents have experienced a history of resource use and social organization similar to that of the residents of ISM. Farm owners in Ituqui island have also followed the regional economic cycles (cocoa, jute, and, more recently, cattle). Likewise, both local communities started to develop within this century.

During the intensification of fishing, the population rapidly engaged in commercial fishing, and agriculture (e.g., bean cultivation) did not support the implementation of the fishing accord in the region. Residents initially rejected the gillnets in the early stage of fishing intensification, mainly because they could not afford them; however, they rapidly assimilated that new technology, and commercial fishing dominated the household economy. However, unlike ISM, where intruders were mainly residents from neighboring communities, the ARA residents suffered strong impact from boat fishers due to the easy access from the channels. By the late 1970s, ARA residents had faced several incidents with non-resident fishers, culminating in a social movement to expel boat fishers from Ituqui Island.

Their first attempts to close lake access to motor boat fishers was a joint effort of residents of the four communities located on the island with support from a few neighboring communities. After constant failures, local residents sought support from external organizations. At that time, the grassroots Fishers' Union and the governmental agency SUDEPE (former IBAMA) did not support community-based organizations; therefore, residents found support from the Navy Department, the national office in charge of regulating tenure in aquatic systems. In 1984, the Navy Department implemented a policy that prohibited the entrance of motor boats into the lake. Although the lake remained legally accessible to anyone, boat fishers were constrained to fishing on the island because they were not allowed to enter the lake by boat. Thus, this rule of activity (prohibition of motor boat) was an indirect strategy to achieve a rule of access (entrance of non-residents) without subverting the constitutional law of equal access to state properties for all citizens. The establishment of this measure was followed by several conflicts in which residents were able to win, thanks to the legal support from the Navy Department. Since then, the pressure of lake fishing by boat fishers has been alleviated on the Ituqui Island.

While conflicts with boat fishers were successfully solved due to the common interest among residents and the legal support from the Navy Department, internal conflicts over commercial fishing have not achieved the same degree of success. Socioeconomic differences, based on different access to resources, and the imbalance of power in political arenas at the community level limit the ability of residents to reach a common interest and to develop a collective action toward the use of natural resources among themselves.

6.3.2. <u>Ecological System</u>

6.3.2.1. Ilha de São Miguel

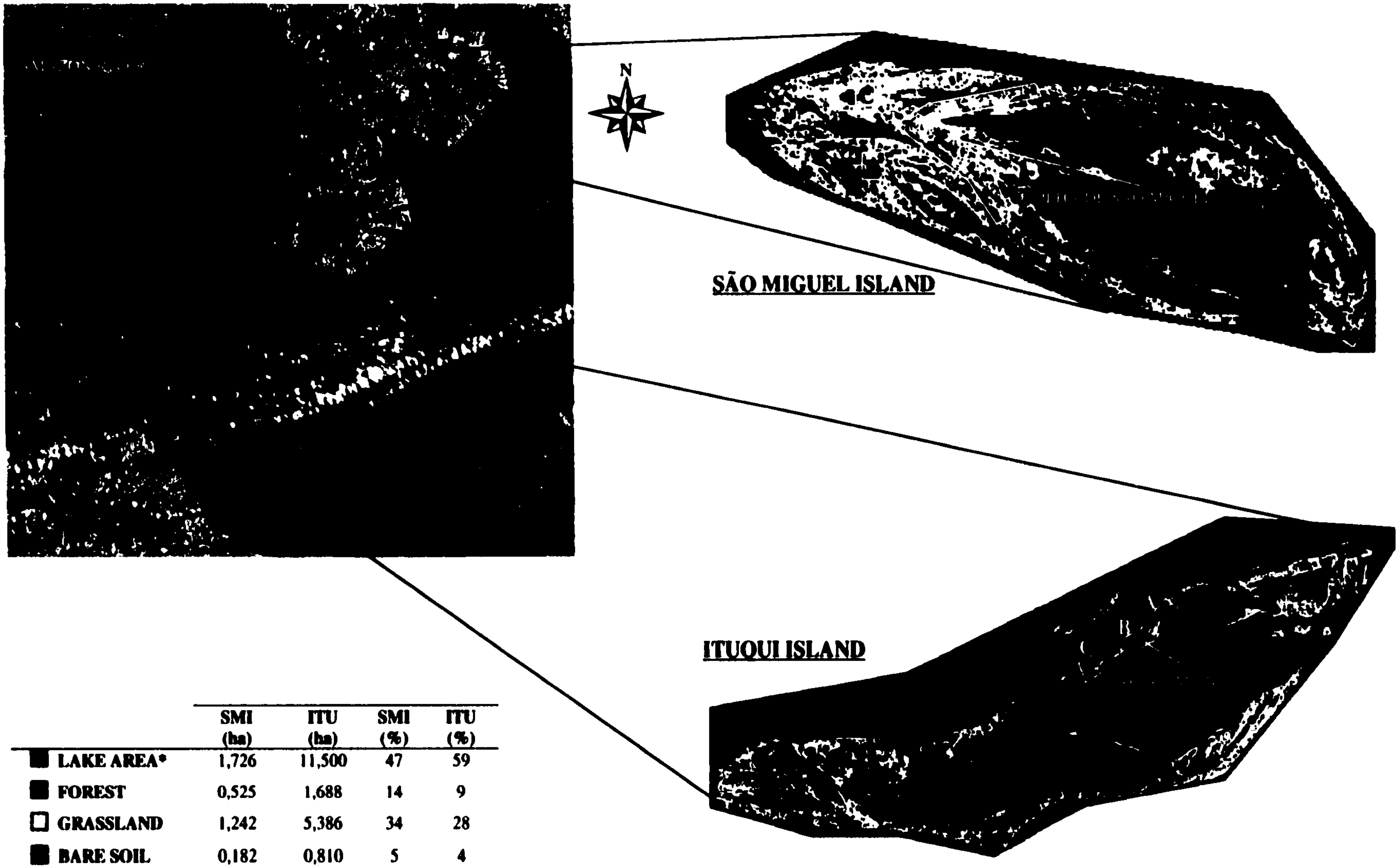
The community is located on an island of 3,675 ha, distributed over several landscape units. The island is divided into three major parts according to its age: 1) the east side is the oldest part, at about 150 years (portion A); the southwest side, which emerged about 60 years ago (portion B); and the northwest side, which emerged about 30 years ago (portion C) (Figure 6.2).

The dynamic pattern of landscape change has influenced the process of occupation of the island. The emergence of the new portion of the island (portion B) protected the western side of the old portion (portion A) from the risk of levees being carved in by strong current. About 20 years ago, in order to stay closer to the water source, several residents moved their houses forward to the outer levee on the western side of portion A.

Portion A is the area exploited by most of the local population.[5] The residents occupy an area of relatively high levee, on which a large extension of their property is only 1 m below the maximum river level. The large extension of high natural levee provides the residents a lower risk of crop loss due to floods (Figure 6.3).

The distribution of land cover during the ebb season — water, grass, bare soil, and flooded forest — is presented in Figure 6.2. Grass and bare soil are on grassland or on deforested natural levee while water and flooded forest represent lake and forested natural levees, respectively. Lake, represented by the class "water" encompasses the largest land cover of the island (47 percent, followed by grassland (34 percent), flooded forest (14 percent) and bare soil (5 percent) of the island.

[5] The lower part of the new portion is a farm that is not involved in the fishing accord. Therefore, the lakes in this area are not regulated by the fishing accord and the farm owner is not allowed to exploit the community lake. Yet, the area as well as the household are considered part of the community.



	SMI (ha)	ITU (ha)	SMI (%)	ITU (%)
■ LAKE AREA*	1,726	11,500	47	59
■ FOREST	0,525	1,688	14	9
□ GRASSLAND	1,242	5,386	34	28
■ BARE SOIL	0,182	0,810	5	4
ISLAND AREA	3,676	19,384	100	100

*Calculated from total "water class" minus the water outside the lake.

Figure 6.2. Landsat TM classification of land cover (July 1997) on São Miguel Island (SMI) and Ituqui Island (ITU), Santarém, Brazil (see scale in Figure 6.1).

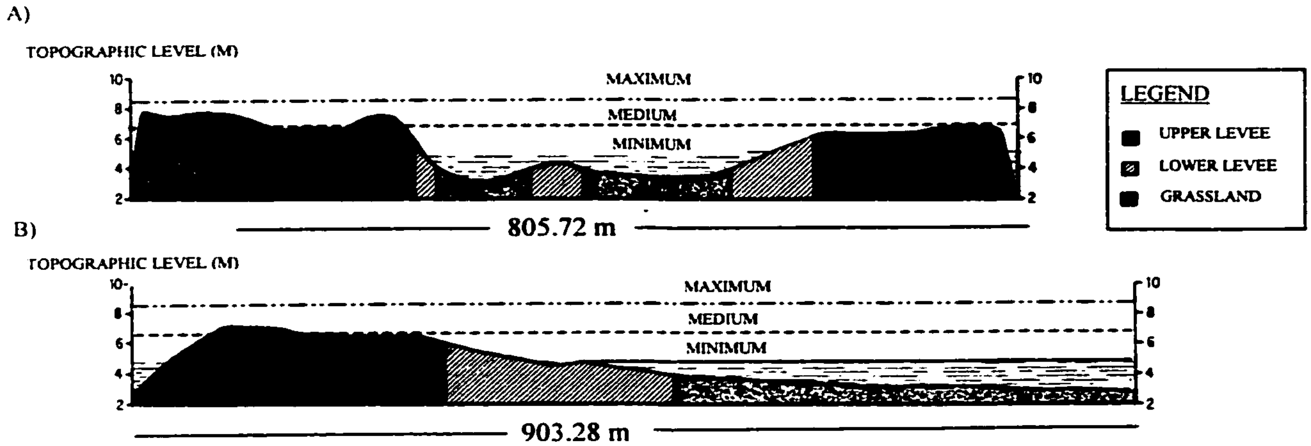


Figure 6.3. Cross-section of the levees in A) Ilha de São Miguel and B) Aracampina, showing flooding according to the average river levels from 1974 to 1985 (modified from Futemma et al. submitted).

In the newly emerged grassland, such as parts B and C, the dominance of grass and bare soil are likely to represent grassland; yet, deforestation in part C makes it difficult to estimate the grassland based on the land cover classes "grass" and "bare soil". In addition, the overlap of lake and grassland throughout the year makes any estimation of both subsystems only applicable to a particular period of the year. Therefore, the flooded forest represents the only class that is possible to measure all year long in the floodplain. In ISM, the flooded forest encompasses 14 percent of the entire island, mostly distributed around the largest lake on the north side of the oldest part of the island (part A) (Figure 6.2).

6.3.2.2. Aracampina

The Ituqui island has approximately 19,384 ha. The island has suffered major transformation in its landscape, mainly on the north side where strong stream currents influence the pattern of land scour and land aggradation (Chapter 2). ARA is the only community located on the north side of the island, and thus is susceptible to peculiar ecological opportunities and constraints.

In regard to ecological opportunities, the process of land aggradation has given rise to a small island in front of the community. It has rapidly grown northeastward in the last 50 years, and has been the source of local conflict (Chapter 5, Incident 7). The island represents a source of resources to ARA residents. Encompassing mainly grassland and a lake, the island attracts residents to raise cattle, cultivate beans, and fish. In addition, the prompt access to the channel gives ARA residents the opportunity to carry out the seasonal fishing of long-distance migratory catfish by drifting gillnets on small sailing canoes. This activity takes place during the dry season and complements the cash crop activity, which is limited by the scarcity of land.

In regard to ecological constraints, the location facing the main channel of the Amazon River makes ARA susceptible to stream currents. The increased risk of landscape change is reflected in the several cases of land scour reported by the residents. In addition, levees exposed to the channel are washed out by water currents; consequently, the levees of ARA are relatively lower and narrower than in ISM. Futemma (1995) found that a 200-meter transect crossing the community levee encompasses about 40 percent of high natural levee, 50 percent of low natural levee, and 10 percent of grassland (Figure 6.2). The author argues that since the high natural levee is about 2 m below the maximum river level, and the low natural levee is between 3 and 5 m below, ARA is located in a very risky area for agriculture, both in terms of the regular flooding pattern and of the influence of the strong current from the main channel.

Figure 6.2 shows the land cover classification of ARA. As with ISM, the lake system occupies approximately 50 percent of the island area during the ebb season. During the dry season, the lake breaks into several small, deep lakes. ARA is far from the deep lakes where fishing is carried out during the dry season. Although Ituqui island has an old formation, it presents a low amount of flooded forest. This pattern seems to be related mainly to the land use pattern, dominated by cattle ranching. Part of the grass and bare soil are natural levees that have been deforested by the ranchers for grazing. Therefore, the dominance of cattle ranchers on Ituqui island has strongly affected the distribution of flooded forests surrounding the lake system. Flooded forests are more common on the east side of the island, while the area surrounding the lake is dominated by grass and bare soil. This pattern differs from ISM, where forest is abundant around the lake.

6.3.3. Population Structure and Social Organization

6.3.3.1. Ilha de São Miguel

ISM has approximately 164 inhabitants distributed throughout 40 households.[6] Most of the local population is related to three major families, who have intermarried through generations (Table 6.2). The residents occupy a small portion of the island, whereas the remaining is occupied by middle, and large-scale ranchers.

The community has one Catholic and one Pentecostal church. The attendance of the latter has increased in the last decade. The conflicts based on religious beliefs rarely affect the collective tasks undertaken by the residents, such as cleaning of the road and the floating meadows that obstruct the traffic of motor boats in the stream during the dry

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[6] Population size was estimated from the socioeconomic questionnaires answered by 75 percent of the community members who were present during the period in which the survey was conducted.

season, eventual building of community infrastructure, and lake patrolling. The collective activities are organized by a leadership system, structured by a committee that is elected every two years.

The leadership structure in the community reveals the participation of members from different family groups, including those in the fishing accord (Table 6.2). The strong participation in the leadership system is illustrated by an incident when a grassroots organization invited one community representative to discuss their fishing accord system in a regional meeting of a peasant organization. The residents had difficulty choosing a community representative for the meeting because several individuals who had activist roles in the process claimed their right to discuss the fishing accord; these individuals included the fishing accord coordinator at that time, the community leader, the two residents who had proposed the fishing accord, and two people who helped in the formalization of the association (one farm owner, and one ex-resident). After several discussions, in and out of meetings, the community finally decided to withdraw their participation in the meeting to avoid internal conflict. In this sense, ISM can be considered a "community of leaders," in that it has ensured the participation of most of the households in the community, as well as the continuity of the collective sense throughout its history.

As in any other floodplain community, ISM's economy relies on a combination of fishing, agriculture, livestock, and salary jobs. Nonetheless, distinct from most of the levee communities, where fishing plays the major role in the household economy (Chapter 4), 62 percent of the residents who undertake commercial fishing specifically see out the *pirarucu* (see section 6.4.4), while agriculture is the dominant commercial activity (89 percent) (Figure 6.4). About 65 percent of the population raise cattle, of which 40 percent raise less than 15 heads while the remaining are middle- and large-scale ranchers.

Table 6.2. List of last names (represented by letters) of residents in the Ilha de São Miguel (ISM) and Aracampina (ARA), showing the percentage of households (n=51) and the number of leaders. Individuals with more than one last name were counted for each name.

ILHA DE SÃO MIGUEL

LAST NAME	HOUSEHOLD (%)	# LEADERS*
A	28	2
B	22	4
C	16	3
D	7	1
E	5	2
F	4	1
G	4	
H	3	
I	3	
J	3	
K	1	
L	1	
M	1	
N	1	1
O	1	

ARACAMPINA

LAST NAME	HOUSEHOLD (%)	# LEADERS*
A	21	5
B	17	1
C	14	
D	8	
E	8	
F	6	
G	6	
H	4	
I	2	
J	2	
K	2	
L	2	
M	2	
N	2	
O	2	
P	2	

Despite the pattern of "agriculture-oriented" economy in the community, household economies vary across the community and within the household throughout the year. The household economy ranges from an intensified to a diversified strategy that includes the four major economic activities (Figure 6.5). Agriculture is present in most of the economic strategies, followed by fishing and cattle ranching (Figure 6.6). However, during the winter, the households quit agriculture and concentrate their activity on cattle and fishing. Since the levee population does not have easy access to the upland, some households that raise cattle migrate to the upland during the flooding season to feed their herds.

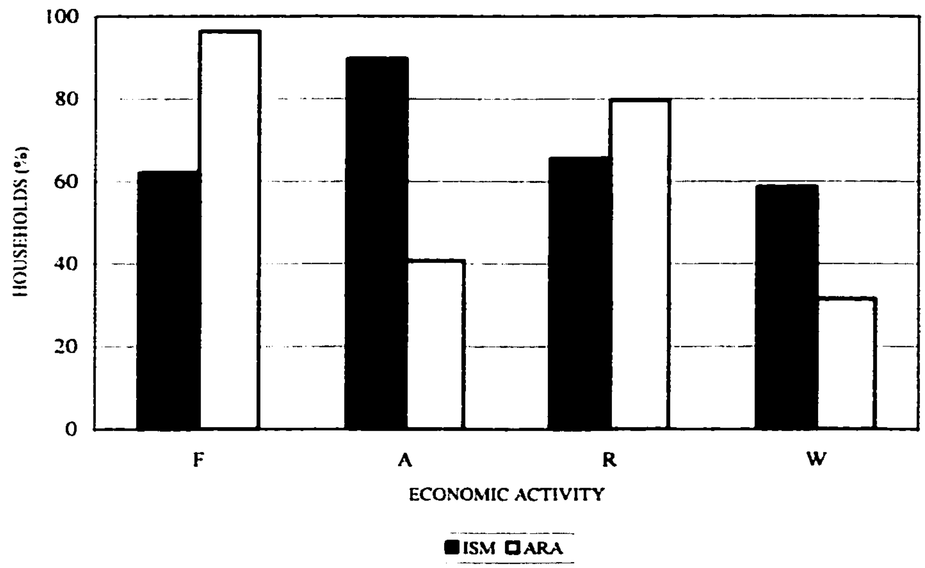

Figure 6.4. Relative frequency of the major economic activities in the floodplain by household in Ilha de São Miguel (ISM) and Aracampina (ARA) (F=commercial fishing; A=agriculture; R=ranching; W=wage labor/pension).

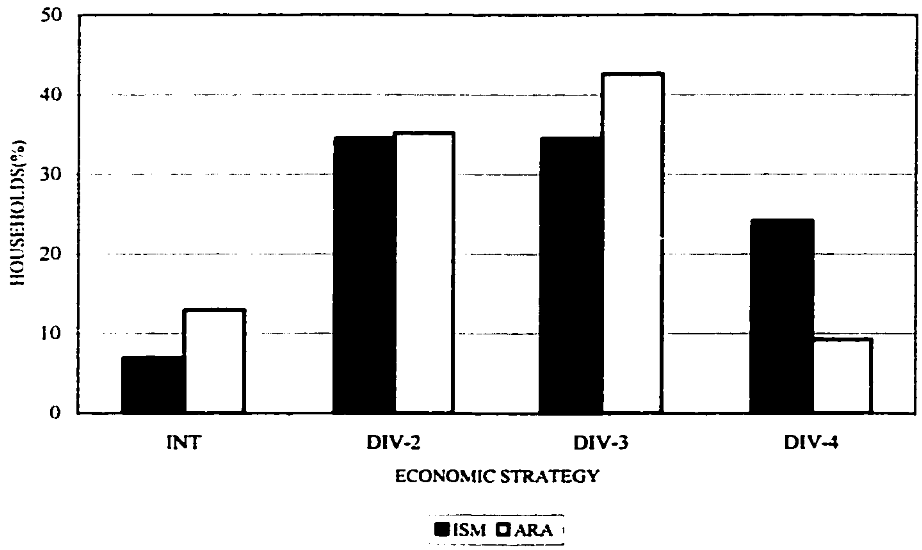

Figure 6.5. Relative frequency of the number of activities performed in households from Ilha de São Miguel (ISM) and Aracampina (ARA) (INT= intensified in one activity; DIV-2= diversified into two activities; DIV-3=diversified into three activities; DIV-4= diversified into four activities).

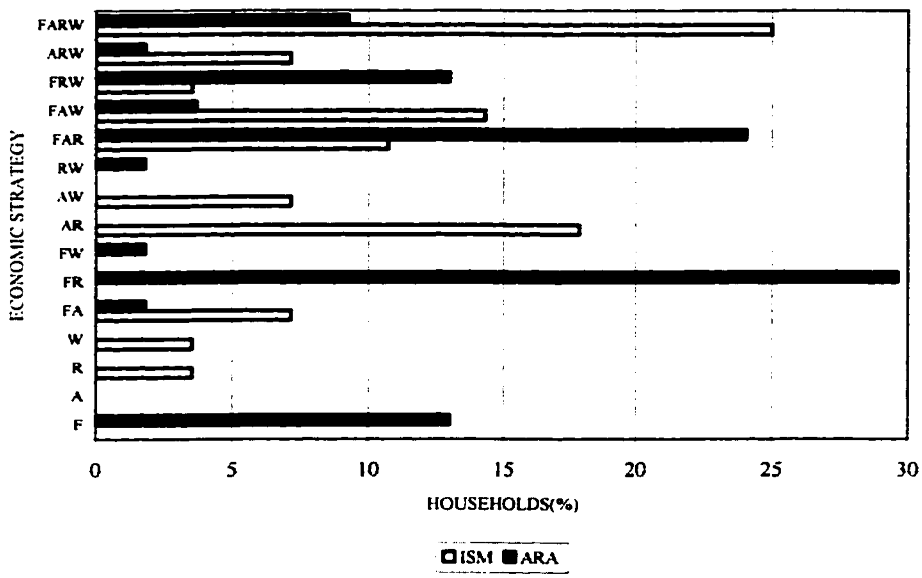

Figure 6.6. Relative frequency of the combination of activities performed in households from Ilha de São Miguel (ISM) and Aracampina (ARA) (F=commercial fishing; A=agriculture; R=ranching; W=wage labor/pension).

6.3.3.2. Aracampina

ARA is a comparatively large community in the region, with an estimated population of 550 inhabitants distributed in 64 families. ARA encompasses three major family groups geographically distributed in different parts of the community; each family group differs in its social and economic activities. As shown in Figure 6.2., the households settled on the downstream side (portion A) are the local religious leaders, and represent the households interested in developing agricultural activity in the community. The family group settled in the middle of the community (portion B) occupies a narrow section of the island. Due to the land scarcity, those households focus their economy on small business, middlemen, and commercial fishing. Finally, the households settled on the upstream side (portion C) are mainly commercial fishers and farm employees. The socioeconomic heterogeneity enhances the conflicts among family groups, which in turn affects the outcome of collective actions in the community. Leadership is dominated by individuals from the family group on the downstream section, a fact which has discouraged several households from other community sections from participating (Table 6.2).

The lack of a clear leadership system in the community has affected the ability of residents to achieve consensus in collective decisions. The community leadership is run by the catechetical group that has been strong throughout the history of the community.[7] ARA is one of the few communities in the region that does not have a Pentecostal Church, due to the resistance of the catechists, who smothered several attempts by pastors to start religious study groups in the community. The enduring dominance of members of one family in the catechetical group — and in turn the community leadership — has deterred other ARA residents from supporting collective decisions. In short, the inability to solve internal conflicts among family groups makes ARA a community of three "sub-communities" with little commitment to a common mission.

At the island level, ARA also differs from ISM in that it shares the lake system with seven other communities and thirty-two farm owners with whom it maintains a relatively distant social relationship. Other communities that share access to the floodplain system include three located on the other side of Ituqui island (in-island communities) and four located in the surrounding area (out-island communities), totaling more than one thousand people distributed in approximately two hundred households (Câmara 1996). Residents from out-island communities use the system for fishing and cattle raising while only the in-island population also uses the system for agriculture. In

[7] The catechetical group is a Catholic-related organization in charge of religious work in the community; it is not chosen through election (Chapter 4).

regard to fishing, there is a partitioning system among the users. Based on interviews with local fishers, Câmara (1996) registered 51 fishing spots, clustered in three major fishing zones that are visited by different fishing groups. In general, fishers from ARA share a fishing zone with three communities. Yet, ARA is particularly distant from fishing spots during the summer, when the lakes which surround the community dry out (Figure 6.2). The in-island communities occupy only 24 percent of the floodplain; the remainder is occupied by farm owners. The large number of cattle ranchers scattered across the island — with whom the residents lacks social bonds, such as co-parenthood, help in emergencies, and participation in community meetings — creates a harsh social environment for interaction and the carrying out of collective decisions.

The household economy in ARA is very different from that in ISM. Cash crops are poorly cultivated due to the high risks of flooding and cattle-related damages (Futemma et al. submitted). The households involved in crop cultivation have experienced several cases of production loss due to unanticipated patterns of flooding (Futemma 1995). Consequently, ARA presents a typical economic strategy of a levee community; fishing is the major economic activity, undertaken by more than 90 percent of the households. The local population has been strongly engaged in cattle ranching, which is also undertaken by 80 percent of the households. In contrast, cash crops are cultivated by only 40 percent of households (Figure 6.4). Like ISM, households usually combine two or three economic activities (Figure 6.5). However, unlike ISM, ARA residents tend to combine cattle ranching with commercial fishing. In addition, ARA residents tend to engage more in specialized activities (e.g., commercial fishing) in comparison to ISM residents (Figure 6.6). As discussed in Chapter 4, the specialization of activity may affect the resilience of the household economy in the long run. In this regard, ARA residents are more economically constrained to give up the commercial fishing activity than ISM residents.

6.3.4. Fishing Accords

6.3.4.1. Ilha de São Miguel

The fishing accord in Ilha de São Miguel is based upon one rule of access and two rules of use. The rule of access prohibits the entrance of non-residents on the lake. The rule of use prohibits permanently the use of gillnets and restricts commercial fishing in lakes to *pirarucu* (*Arapaima gigas*) and catfish during a specific period (06/01 to 11/30) (Table 6.3).

Table 6.3. Rules in the fishing accords in Ilha de São Miguel (ISM) and Aracampina (ARA).

RULE TYPE	ISM	ARA
FISHING GEAR	. Permanent gillnet ban . Limitation of 25 hooks/person to fish *pirarucu*	. Restriction on use of gillnet . Permanent prohibition of "predatory techniques"
FISHING SEASON	. Seasonal commercial fishing	. Seasonal gillnet ban
FISHING PURPOSE	. Restriction on commercial fishing	. Seasonal prohibition of commercial fishing
TYPE OF FISHER	. Access limited to resident fisher	. Access limited to resident fishers
TYPE OF VESSEL	———	. Prohibition of motor boats
FISH SPECIES	. Commercial fishing of *pirarucu*/catfish	———
STORAGE EQUIPMENT	———	. Prohibition of styrofoam boxes

A graduated sanctioning system is based on the number of offenses. The first flagrant violation leads to a warning from residents, and, after the second offense, violators have their gillnets confiscated and burned. As the fishing accord is broadly known, violations usually involve people who are aware of the accord and thus are treated as second offender.

The monitoring system is maintained through patrols organized by a fishing accord coordinator, who is in charge of convoking the residents. The coordinator decides when lake patrols will happen, based on advice from other residents. All adult male residents are convoked the same day the patrol will take place, and those individuals available gather in late afternoon to go to the lake.[8] The team encompasses around a dozen people who spend the night on the lake. The patrols are more frequent during the flooded season, when the lake is more accessible, or in periods of evidence of invasions. Invaders are mainly individuals from neighboring communities who enter the lake with paddle canoes.

The fishing accord is re-checked whenever major problems are identified. Three main adjustments have taken place since the fishing accord was first established. First, lake access was prohibited to non-residents even for subsistence fishing. Rule of access did not happen until non-residents constantly broke the rules of use. Second, single-hooked longlines (*rapazinho*) for *pirarucu* fishing were limited to 25 per person. This rule aimed to limit the intensive *pirarucu* fishing with *rapazinho*, which has an impact on immature *pirarucu*. Third, the households that do not provide labor for the lake patrolling must pay 30 percent of their fish production to the fishing accord committee. This rule is aimed to enforce participation in the patrolling system.

The fishing accord in ISM seems to have reached a stable arrangement with strong local commitment. The rules are constantly checked in meetings with a high level of participation. Notwithstanding, the fishing accord faces some challenges. Fishing pressure on immature *pirarucu*, turtle poaching, and rule-breaking by young residents are the major concerns of community leaders. In addition, ISM residents was relatively

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[8] Elderly people are waived from the patrol. Not all household representatives need to participate in each patrol.

isolated from regional institutions, and, only recently, have the Fishers' Union begun approaching the residents to establish a collaboration to improve the community's political strength. ISM is one of a few communities which have no local representatives from the Fishers' Union. A few residents who were unionized quit their membership several years ago. Membership in the Fishers' Union provides social support, such as work compensation during the fishing closure seasons (*defeso*), medical assistance, and a retirement salary. Despite such benefits, the residents were initially resistant to the Union support due to former conflict with the organization, whose association with commercial fishers could affect their local management system. Only after a community meeting with a Fishers' Union representative in 1998, did residents decide to accept such external support. This shows the concern of ISM residents to maintain their independence, and the influence of external pressure in affecting their internal organization.

6.3.4.2. Aracampina

In Aracampina, the fishing accord relies upon one rule of access and two rules of use.[9] The rule of access prohibits the entrance of any people who are not members of the eight communities involved.[10] The rules of use prohibit gillnet fishing and fish commercialization during the dry season (10/01-01/31) (Table 6.3).

The sanctioning system foresees two types of sanctions according to the frequency of violation. For the first offense, the violator is deprived of his fishing gear, which is kept in the Fishers' Union headquarters and returned only after the end of the

[9] This section is related to the fishing accord established in 1992, which followed the same rules of the former fishing accords. Other recent fishing accords established with support from development projects are not considered in this analysis.

[10] Four in-island communities and four out-island communities.

gillnet ban season. For the second offense, the fishing gear is sent to the governmental agency's office. Despite the relatively clear sanctioning system, the fishing accord in ARA lacks an organized monitoring system. No patrol system is present in the community and enforcement rules are casual. The major problems faced by residents in designing a monitoring system are related to the internal conflicts in the community and, to a lesser degree, the geographic constraints against maintaining communication with other communities involved in the accord.[11]

6.4. ECOLOGICAL OUTCOMES

Considering the history described by local informants, lake productivity in both communities was similarly low when the fishing accord was first implemented. Therefore, the current fishing production in both communities can yield a comparative analysis of the performance in order to reveal the relative improvement in the managed lakes. Below, I discuss how the fishing strategies and composition of catch reflect the influence of the institutional arrangements governing the resource use. Next, an analysis of fishing efficiency as a way to indirectly measure lake productivity in both areas. Finally, an analysis of the *pirarucu* fishing is presented to discuss the importance of commercial fishing in the fishing accord.

6.4.1. Fishing Strategy

ISM residents rely upon the lake system for both subsistence and commercial

[11] Recently, a development project carried out in the region has focused on the creation of a "fishing committee" that includes five representatives of all eight communities involved in the local management of the lake. However, the mission for designing a monitoring system for the fishing accord was still missing in 1998.

fishing while ARA residents also exploit the channels seasonally (Figure 6.7). Channel fishing is undertaken adjacent to the community with sailed canoes and drift nets to catch mostly *dourada* (*Brachyplatystoma flavicans*) during its seasonal upstream migration (Figure 6.1). This long-distance migratory species encompasses about 10 percent of the total catch in ARA and is primary for commercial purposes. Lake fishing is regulated by the fishing accord and is carried out for both subsistence and commercial purposes.

Different regulations regarding the use of gillnets have major implications for the various strategies of lake fishing in ISM and ARA. While gillnet fishing was responsible for 69 percent of the fish caught in ARA and dominated throughout the year,[12] the permanent gillnet ban in ISM leads to a larger range of customary fishing techniques, which varies throughout the year (Figure 6.8). Gillnet fishing is a flexible strategy because the net can be set in any fishing spot to capture any species. Customary technologies, on the other hand, are more efficient in the particular environments and periods of the year that are related to a restricted group of fish species. Consequently, the fishing pattern in ISM is marked by the shifts to different types of fishing gear throughout the year. Cast net fishing dominates in the dry season when *acari* (*Liposarcus pardalis*) is caught at the edges of streams. Hook and line are mainly used during April and June to capture *tucunaré* (*Cichla* sp) and *cara-açu* (*Geophagus* sp) at the edges of lakes and creeks, and to capture frugivores species such as *tambaqui* (*Colossoma macropomum*) and *pirapitinga* (*Piaractus brachypomus*) in the flooded forest. The harpoon is used in the flood season to capture a large range of species, and during the dry season particularly to catch the *pirarucu* (*Arapaima gigas*) (Figure 6.8). In short, ISM maintains a customary

[12] The drop in gillnet use between October and December reflected a new attempt to establish a seasonal gillnet ban in the community, which failed in the following year.

fishing strategy which is more compatible to the ecological system and affects the efficiency of each fishing technique. Consequently, fishers distribute the fishing effort among different species by using specialized active technologies in well-defined periods of the year. This pattern demands detailed knowledge of the ecological system as well as skill to handle several fishing techniques. ARA fishers, on the other hand, rely mostly upon one technology — gillnet — which is versatile enough to be productive throughout the year. Thus, while ISM fishers diversify their fishing strategies by using specialized techniques, ARA fishers expand their fishing niche by varying fishing spots or mesh size of gillnets.

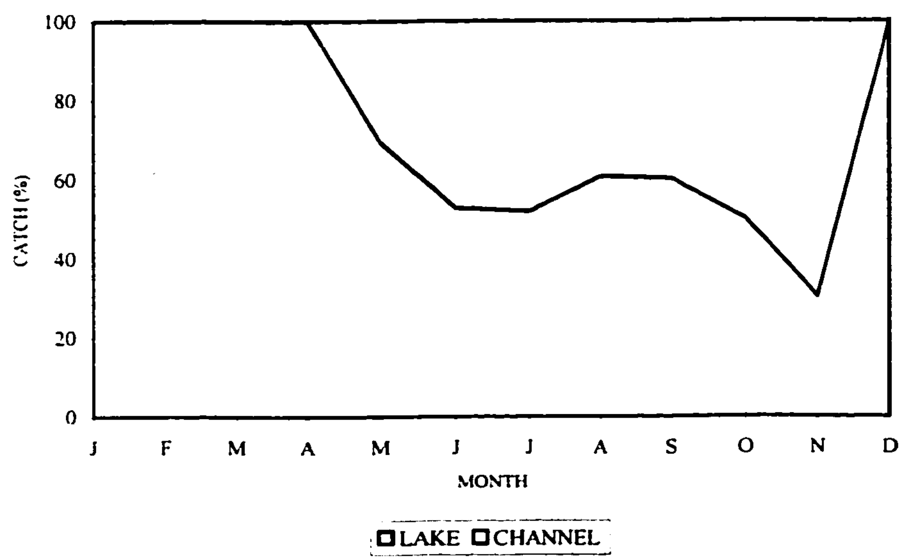
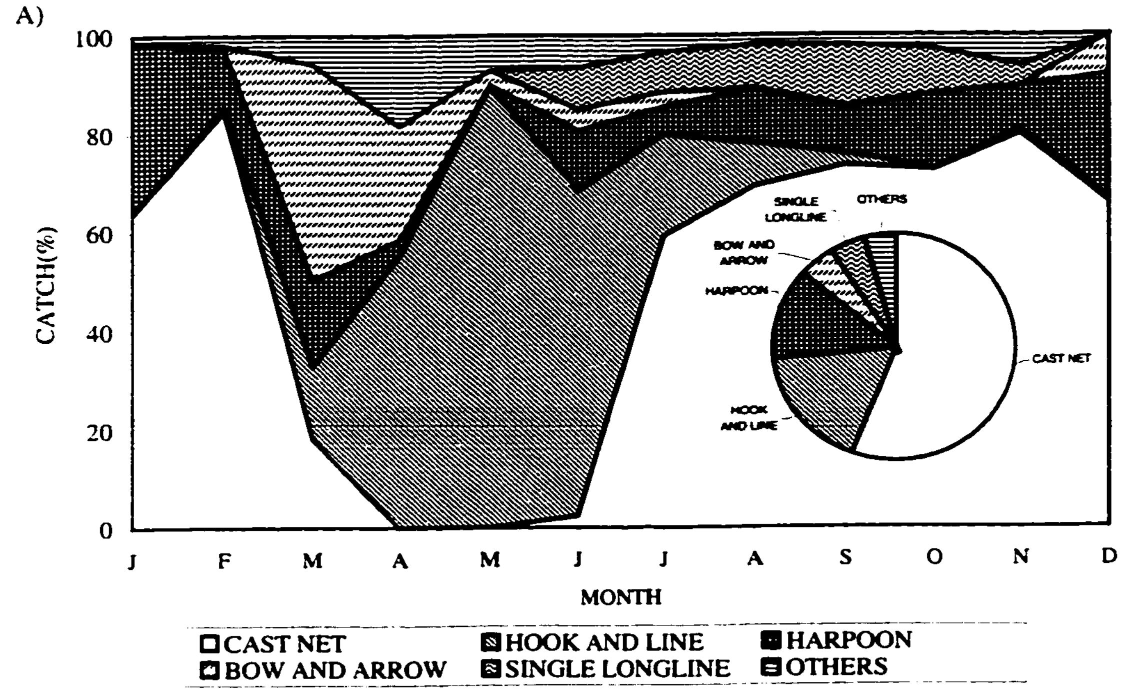


Figure 6.7. Monthly proportional catch of lake and channel fisheries in Aracampina (ARA).



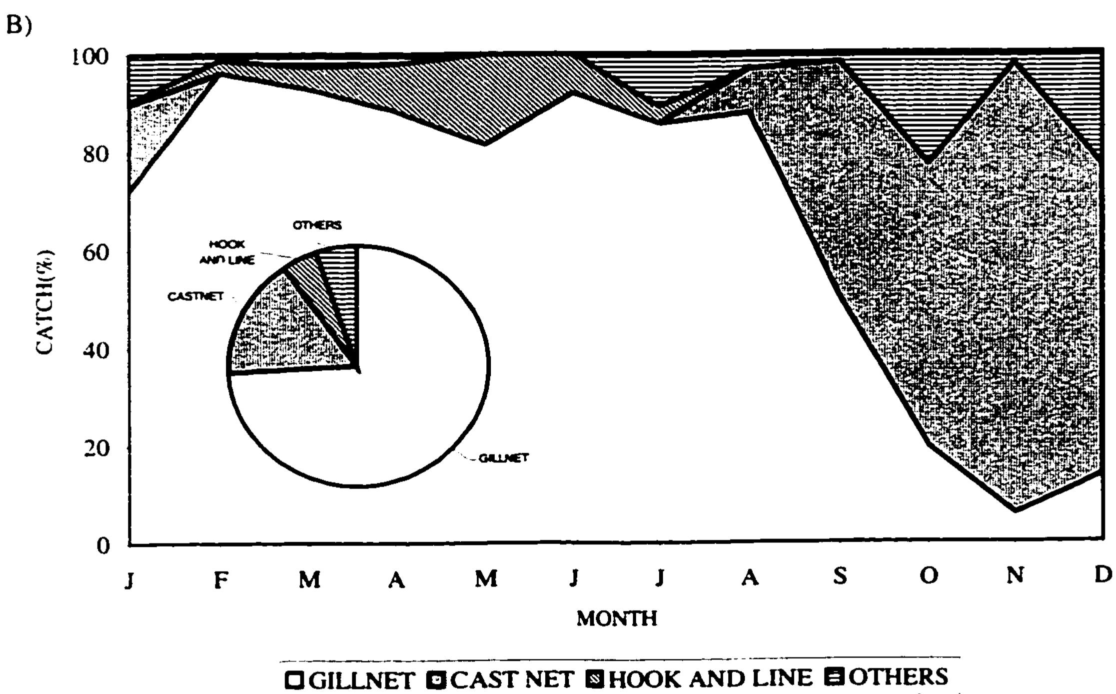


Figure 6.8. Monthly catch by major fishing gear in A) Ilha de São Miguel and B) Aracampina.

Fishing strategies in ARA vary widely from year to year. Based on methodology simiiar to that used in this study and carried out between July 1995 and June 1996, McGrath et al. (1998) observed that 38 percent of the fish production in ARA was caught by gillnet, 22 percent by hook and line, 16 percent by castnet, 11 percent by bow and arrow, 6 percent by harpoon, and 7 percent by three other types of gear. The contrasting difference between the fishing patterns in 1992 and 1995-96 must be related to the pattern of the flooding season. The relatively short and low flood season in 1992 (Figure 2.2) made the customary techniques less appropriate to systems with a low amount of flooded forest. Therefore, despite the maintenance of customary practices (McGrath et al. 1998), ARA residents tend to intensify the use of gillnet to overcome the lake productivity. This difference in the fishing patterns has two major ecological implications. First, it affects the catch composition in the two communities. Second, it affects the fishing efficiency in both the short and long run. Both implications are discussed in more detail in the following sections.

6.4.2. Catch Composition

In general, ISM and ARA caught similar species throughout the year. However, the catch structure from lake fisheries in both communities differed in many aspects. First, the proportion of each species to the total catch was different in both communities (Table 6.4). ISM presented a higher fish diversity in their catch due to the use of different selective strategies during the year, which permitted the fishers to spread the fishing pressure among different species. On the other hand, the catch composition of ARA fishers reflected the large abundance of one species (*tambaqui*), which was particularly high during the data collection period. The data generated by Silva et al. (s/d) for the same community in different years (1995-6) show that catch composition is very distinct from the data collected in 1992. Although similar data are not available for ISM, the local residents state that the lake fishing is relatively predictable and stable. The high variability in catch composition in ARA may be related to the ecological features of the lake system, where the limited amount of flooded forest and the rapid sedimentation process may affect the ability of the system to maintain a stable fish community. As a result, although fishers are able to select species according to their local ecological knowledge (Silva et al. s/d), ARA fishers are constrained by the ecological processes in the lake system which affect the range of species available in the system while ISM residents seem to have more options in their activity of fish procurement.

In addition to the higher diversity, in general, catch composition in ISM encompassed large body size specimens (Table 6.4). The catch of large body size fish in ISM is evidence of the lower fishing pressure on immature fish, which increases the survivorship rate for reproduction. In addition, there is an economic implication when the species has different prices according to its body size. For example, *tambaqui* up to approximately 1 kg had an average price of US$0.44/kg, while larger specimens were sold for US0.60/kg. Oversized *tambaqui* were 70 percent and 23 percent to ISM and ARA, respectively.

Finally, ISM fishing relied primary upon sedentary species (63 percent) in contrast to ARA, where sedentary species were 25 percent of the total catch. The low percentage of sedentary species in the ARA catch is evidence of strong pressure on those species. The abundance of sedentary species is strongly influenced by local aspects of the systems, such as the lake ecology and local fishing pressure, since the recruitment of these species does not rely upon migration of fish from other areas. Therefore, the low abundance of sedentary species in ARA can be interpreted as the result of unregulated local fishing in an ecosystem of relatively low resiliency. The outcome of fishing patterns on the lake productivity can be indirectly evaluated by comparing efficiency of similar fishing techniques in the lakes with different management systems. In the next sections, I will compare the catch per unit of effort (CPUE) of fishing techniques in both communities and the production of a commercially important sedentary species – *pirarucu*.

Table 6.4. Relative catch and average fish body weight in regard to the most common fish species landed in 1992 in Ilha de São Miguel (ISM) and Aracampina (ARA) (fish body weight was measured by dividing total catch per number of specimens in each fishing trip (n)). SED = sedentary; SDM = small-distance migrant; LDM = large-distance migrant.

	PRODUCTION		AVERAGE BODY WEIGHT (g)		
FISH NAME	ISM (%)	ARA (%)	ISM (n)	ARA (n)	FISH MOBILITY
Liposarcus pardalis	31.5	6.6	63 (284)	47 (150)	SED
Colossoma macropomum	19.5	41.5	206 (317)	79 (422)	SDM
Arapaima gigas	10.3	4.0	—	—	SED
Astronotus crassipinis	7.7	3.3	50 (215)	45 (89)	SED
Prochilodus nigricans	7.1	8.3	100 (203)	98 (195)	SDM
Hoplosterum littorale	3.8	6.6	—	—	SED
Osteoglossum bicirrhosum	3.6	1.0	86 (129)	100 (30)	SED
Pseudophalystoma spp	3.5	6.0	231 (78)	401 (74)	SDM
Pseudora niger	3.1	6.2	118 (69)	181(162)	SDM
Cichla monoculus	2.7	2.7	112(119)	84(104)	SED
Piraractus brachypomus	2.7	2.3	145 (70)	107 (36)	SED
Plagioscium spp	2	3.6	97 (41)	57(100)	SED
Brachiplatystoma flavicans	—	10.0	—	—	LDM
OTHERS	2.5	9.0	—	—	—

6.4.3. Fishing Efficiency

The different fishing strategies in both communities were not only reflected in the catch composition but also in the fishing efficiency of the two communities. Due to their lower emphasis on commercial fishing, ISM fishers presented a lower average catch of 4.6 kg of lake fish per day, in comparison to 6.3 kg in ARA.[13] Despite the higher average catch in ARA, ISM presented higher stability of fishing production, revealed by the low standard variation of fish production (0.95 in ISM in contrast to 2.5 in ARA) (Figure 6.9). In particular, when only subsistence fishing was carried out in the lake, ARA households presented a comparatively low catch per day. This analysis is possible by comparing the catches from October to December, when a new fishing accord, which prohibited commercial fishing, was established in ARA. The individual catch per day dropped to 2.7 kg in ARA, a value lower than the 4.41 kg in ISM for the same period.

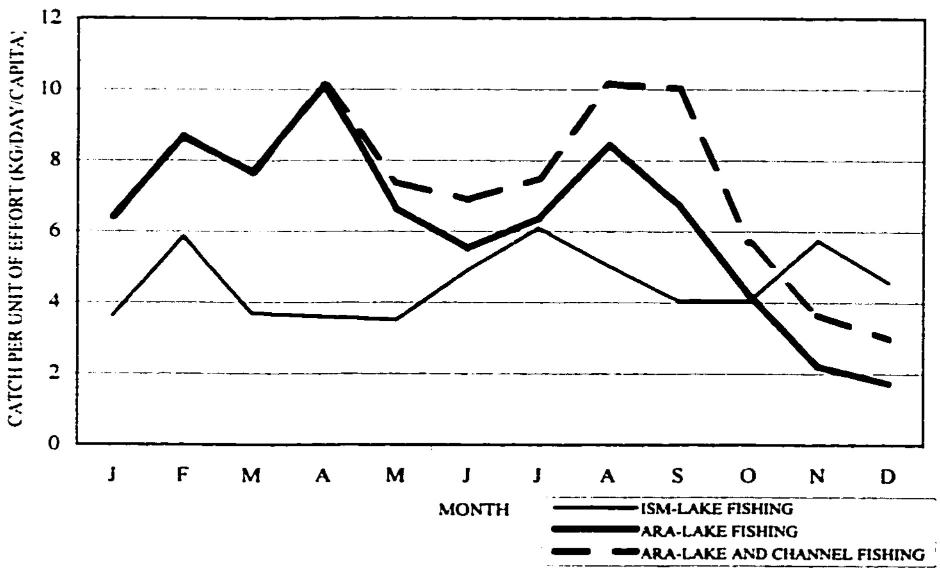


Figure 6.9. Monthly catch per unit of effort (CPUE) for fishing in the Ilha de São Miguel lake (ISM-Lake fishing) and for fishing in Aracampina considering lake only (ARA-Lake fishing) and considering lake and surrounding channels (ARA-Lake and Channel fishing).

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[13] Average catch in ARA is 7.3 kg/day if channel fishery is considered.

Households in each community carried out an average of three fishing trips per week in the lake. Yet, ARA households made extra fishing trips to the main channel during the dry season. In addition, the length of time and the fish production were significantly different. While the average fishing trip in ARA was 67 percent longer than in ISM — 4h34' and 2h42', respectively — monthly household fish production was only 36 percent higher in ARA than in ISM — 175 kg and 128 kg, respectively. Therefore, despite a higher technological level in ARA, fishing was more efficient in ISM. Such results suggest that the lower productivity of the lake may be the major factor leading to lower fishing efficiency in ARA.

Lake productivity can be indirectly measured by comparing CPUE (catch per unit of effort). Assuming that fishers in both communities share similar ecological knowledge, comparison of catch per individual per hour using the same fishing techniques may provide a comparative estimate of lake productivity. Table 6.5 shows the fishing efficiency according to comparative data on production by gear. Data on hook and line and cast nets show that the productivity of the lake was about twice as high in ISM, revealing a higher productivity in the lake of ISM.

ARA residents try to overcome the lower productivity of their lake by fishing with gillnets. However, in periods with high abundance of *piranha*, gillnet fishing has low efficiency because this carnivorous fish feeds on trapped fish and destroys gillnets.[14] As a result, despite its passive nature, the cost of gillnet fishing increases with time spent in periodic gear-checking in order to avoid piranha damage, time spent in repairing gillnets, and money spent in buying new units (Figure 2.5). The high abundance of

[14] Piranhas are voraciously carnivorous fish species of Familiae Serrassalmidae.

piranhas was confirmed by experimental fishing carried out in the lake system of ARA, where *piranhas* amounted to 41 percent of the total catch (Silva et al. s/d). Thus, although the gillnet is the most economically efficient technology in ARA, it is less efficient than cast net fishing in ISM when time spent in checking and repairing the gear is considered. In sum, the gillnet is the most efficient technology among all the gear used in lake fishing. However, under low lake productivity, not only does the efficiency of gillnet fishery drop but it also directly affects the ability to use artisanal gear. Consequently, fishers are forced into a downspin in which use of the gillnet increases and leads to the decrease of fishing efficiency.

Table 6.5. Fishing efficiency of major fishing methods used in Ilha de São Miguel (ISM) and Aracampina (ARA).

	CATCH (%)		EFFICIENCY (KG/HR PER CAPITA)	
GEAR	ISM	ARA	ISM	ARA
GILLNET	—	74	—	3.08
CAST NET	47	9	2.90	1.50
HOOK AND LINE	18	4	1.44	0.78
OTHERS	35	13	—	—

6.4.4. Pirarucu Fishing

Pirarucu is one of the largest fish species of the Amazon Basin; it can reach up to 200 pounds. It is a sedentary species that has an adaptive respiratory system which helps it resist the low oxygen concentration in the lakes during the dry season. By physical and behavioral adaptations, the fish can extract oxygen from the atmosphere by periodically swimming to the water surface to breathe. *Pirarucu* has an equilibrium reproductive strategy, which includes multiple spawning throughout its life span and a developed behavior of parental care (Chapter 2). During the initial phase of spawning, the adults carry the offspring inside their mouth until the larvae can protect themselves against predation.

As discussed in Chapter 2, equilibrium species are more susceptible to fishing pressure because of their relatively low fertility. *Pirarucu* has been commercially exploited since the early stage of the Colonization period and it suffered strong pressure in the in late nineteenth century, during the Rubber Boom (Verissimo 1892).

In the past, *pirarucu* fishing was carried out mainly with harpoon. The harpoon fisher watches the fish movements and, when the fish swims up to the surface to breathe, the fisher throws the harpoon toward the fish. This customary technique relies strongly upon local knowledge to realize the pattern of the fish movement. After the advent of gillnets, *pirarucu* fishing began to incorporate that type of gear as well. The long history of exploitation and its relative vulnerability to fishing pressure have led *pirarucu* to be one of the few species considered overfished in the Amazon Basin (Barthem 1994). The major reason *pirarucu* has been overfished is because of its vulnerability to fishing pressure during its reproductive period, when the capture of the adult indirectly increases the mortality rate of the offspring by predation. The parental care behavior of *pirarucu* leads the fish to swim slower and stay longer in the same spot. Consequently, fishers have incentives to fish *pirarucu* during its reproductive period, when it is easier spot the fish.

In Santarém, *pirarucu* reached an annual average price of $1.00/kg in 1992, an economic value twice as high as the other scaled fish in the Lower Amazon. This relatively high value attracts fishers to undertake *pirarucu* fishing. However, the low abundance of this species increases the incentives for fishers to seek out *pirarucu* during their reproductive period, leading to an unsustainable fishing pressure. In order to regulate the *pirarucu* fishing, IBAMA created a decree in 1991 that prohibits the fishing of *pirarucu* during its reproductive period, defined between December and May (Isaac et al. 1993). Inefficiency of the government in monitoring *pirarucu* fishing has had a poor effect on the behavior of fishers, who maintain the activity during the fishing closure season. On the other hand, if *pirarucu* fishing is appropriately regulated, the sendentary behavior of this species and its high commercial value may represent a reliable economic source to the household. The comparative analysis of the *pirarucu* exploitation in ARA and ISM reveals the contrasting outcome of the unsustainable and sustainable strategies of this fishing.

Commercial *pirarucu* fishing was developed in both communities, but based on different strategies. In ARA, the fishing was carried out mainly by gillnet during the whole year, while in ISM, the *pirarucu* fishing was regulated by the fishing accord. The local rule followed the formal law of a fishing season of six months; in addition it limits the techniques to customary gear such as harpoon and single-hooked longline (*rapazinho*) (Table 6.3). As a result, 68 percent of *pirarucu* production was caught during the reproductive period, while ISM residents opened the *pirarucu* fishing only when parental care behavior was completed (June through November) (Figure 6.10). Despite the shorter fishing season, and the fact that the fishing took place during the "less productive period," annual production of *pirarucu* in ISM was twice as high as that in ARA. Considering monthly fishing production, the average catch per household was fourfold higher in ISM (324 kg). In addition, the low variance of the *pirarucu* fishery reveals that this fishery represents an economic activity of low risk for ISM households.

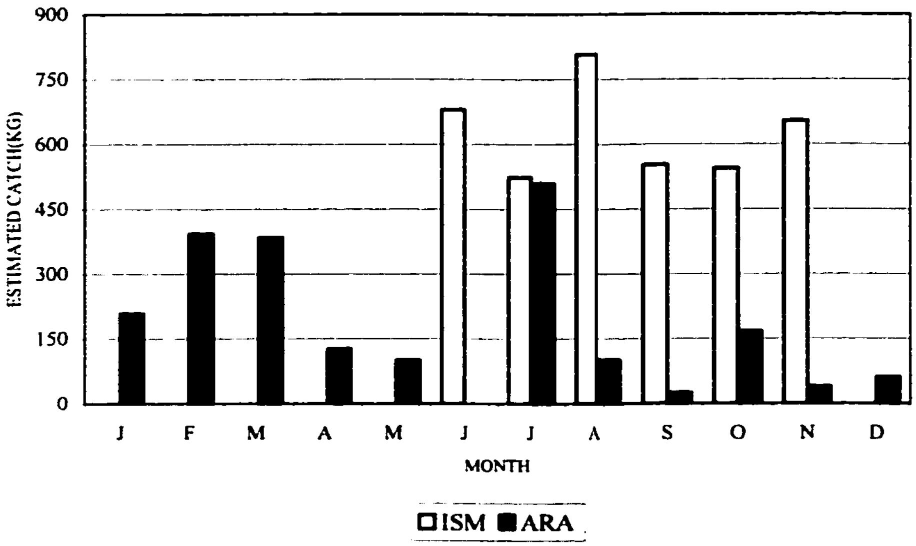

Figure 6.10. Estimated monthly production of *pirarucu* fishing in Ilha de São Miguel (ISM) and Aracampina (ARA).

Therefore, ISM seems to be able to maintain regular intensive commercial *pirarucu* fishing without threatening the productivity level of this species The *pirarucu* fishing in ISM is an example of intensive commercial fishing congruent with the ecological system, which encompasses 10 percent of the total catch in the community. In addition, the *pirarucu* fishing shows that when local rule is supported by a congruent formal rule, the sustainable use of the resource is more likely to be achieved.

While this species is currently considered overfished in the Basin, ISM residents have enjoyed steady increase in the production of *pirarucu* fishing over the last 10 years. Therefore, the management of the *pirarucu* fishing represents a stable source of revenue to the household. Furthermore, it represents an economic incentive to the local population to maintain the local management system.

6.5. SUCCESS AND FAILURE

Like several other communities in the region, ISM and ARA followed similar paths during the fishing intensification process. They initially rejected gillnets, but soon adopted the gear to undertake fishing as their major commercial activity. A decade later, frequency of "invasions" in the community lake by non-residents increased, and the residents felt the first signs of a decrease in fishing productivity. Consequently, residents searched for external support to maintain their local control over the lake system. From this point on, ISM and ARA followed different paths and achieved different outcomes. ISM has been able to control local fishing and to improve the fishing productivity while ARA has been facing organizational problems and has not been as successful in improving fishing productivity.

The comparative analysis of the fishing accords between communities with successful and unsuccessful ecological outcomes raises two major questions regarding the human ability to respond to environmental change. First, the analysis of the successful case (ISM) shows that low productivity can be overcome by social rearrangement among the users instead of merely improving the technological endowment. On the other hand, the analysis of the unsuccessful case (ARA) reveals that the social rearrangement to overcome low productivity depends on several local factors which influence how users organize the local management during its emergence, and how they maintain it. I discuss these two aspects in more detail below.

6.5.1. Ecological Resilience through Social Reorganization

Fishing production is a function of aquatic productivity and catch efficiency.

Thus, individuals seek to improve their catch efficiency as the system productivity drops if the production level is to be maintained. In general, new technologies are developed or introduced to enhance catch efficiency. Technological improvement can affect the local production system positively, but can also have negative effects if it does not account for the local structure of resource use. Technology increases the efficiency of the production system in the beginning, but nonconformity with the ecological and social systems can eventually lead to unsustainable use of the resource as well as social conflicts. On the other hand, the so-called "backlash" production systems carried out by local populations may represent congruent ways to overcome environmental constraints without harming the system in the long run (Ostrom 1990, Netting 1993, Dyer and McGoodwin 1994, Acheson and Wilson 1996, Berkes and Folke 1998).

Thus, technological change is an important strategy for increasing efficiency in resource use (Boserup 1965), but not the only path which peasants have taken to overcome low productivity. Rearrangement of the social structure may strongly influence the outcome of resource use as well. Netting (1993), for example, discusses that peasants facing land scarcity (smallholders) and strong internal (population growth) or external (market demand) pressures may respond by intensifying their production system through the endogenous process of household reorganization. The author argues that land tenure is a fundamental aspect in the process of change. Private property at the household level influences the household members to engage in an implicit contract that lowers the transaction cost, strengthening the long-term commitment among the members. The difficulty of holding CPRs at the household level demands the development of a similar process of "implicit contract" at the community level. In other words, CPR systems demand a reorganization of the production system at the community level, in which the limits of tenure can be more appropriately defined. In this case, the ability of appropriators to craft a long-term commitment is a major condition to the success of collective management systems (Ostrom 1990).

The analysis of the success of the fishing accord in ISM reveals that two main economic factors have supported the fishing accord in different stages of the process. First, the provision of alternative economic activity through bean cultivation in the early stage of the fishing accord. Such a factor was essential to fill the gap created when the main source of income (fish) is suddenly cut off in the household economy. Second, the provision of "seasonal commercial fishing" of a highly valued fish species (e.g., *pirarucu*) based upon local ecological knowledge that enables fish recruitment. The *pirarucu* fishing rule represents the immediate recuperation of fish production after many years of year-round commercial fishing. The local population experienced the return of fish productivity after their social reorganization. At the same time, they also observed that intensification of commercial fishing in a restricted and controllable fashion can generate profit with little threat to either subsistence or commercial fishing. Nonetheless, the challenge to ISM residents is not over. Even if residents can maintain their fishing accord, they will always face the task of controlling the *pirarucu* fishing at a sustainable level as well as the use of the floodplain system as a whole in order to maintain its ecological resilience. Therefore, despite the congruence of the present system in ISM, the robustness of the local institution, which accounts for a constant check and balance system carried out on a consensual basis, is one major feature of this successful fishing accord.

In sum, the ISM case shows that community members were able to increase their productivity through a combination of intensification of one resource (*pirarucu*) and the restrained use of other resources (scaled fish). The intensification of one resource has not threatened the sustainability of the fishing system. Rather, the productivity of the system has steadily increased, creating incentives to the members to invest in their commitment to the local management system. In particular, the ecological characteristics of the system, which are likely to have influenced the rapid recovery of the system, seem to have played a major role in creating incentives to residents to be committed to the collective action. The abundance of flooded forest surrounding the lake has aided in the rapid recovery of the fish population by providing productive ecological niches for sedentary and short-distance migratory fish species (Goulding 1980). As a result, the perception of productivity improvement led to the development of an implicit contract among ISM residents, based on the social organization held by the community and on the structure of the fishing accord.

6.5.2. Major Factors Affecting the Fishing Accord Performance

While ISM residents were relatively successful in designing their fishing accord, ARA residents faced a set of constraints that have limited the efficiency of their local institution. By comparing both communities, it is possible to shed light on the major factors that have affected the performance of the fishing accord in the region. Ostrom (1990) proposes a set of conditions that influences the emergence and maintenance of collective actions. These conditions, which Ostrom calls "design principles," represent a powerful analytical tool for evaluating the major factors that have influenced the outcome of institutions (see Ostrom 1992a, Pomeroy 1994) (Table 6.6). In this section I discuss comparatively the application of the design principles to the fishing accords in ISM and ARA.

Table 6.6. Design principles affecting the maintenance of common-pool resource institutions (source: Ostrom 1990).

•Design Principle 1 – Defined Boundaries *Individuals or households who have rights to withdraw resource units from the CPR must be clearly defined, as must the boundaries of the CPR itself.*
•Design Principle 2 - Congruence between Appropriation and Provision Rules and Local Conditions *Appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions and to provision rules requiring labor, materials, and/or money.*
•Design Principle 3 - Collective Choice Arrangement *Most individuals affected by the operational rules can participate in modifying the operational rules.*
•Design Principle 4 - Monitoring *Monitors who actively audit CPR conditions and appropriators' behavior, are accountable to the appropriators or are the appropriators*
•Design Principle 5 - Graduated Sanctioning *Appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and context of the offense) by other appropriators, by officials accountable to these appropriators, or by both.*
•Design Principle 6 - Conflict Resolution Mechanisms *Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials.*
•Design Principle 7 - Minimum Recognition and Right to Organize *The rights of appropriators to devise their own institutions are not challenged by external governmental authorities.*
•Design Principle 8 - Nested Enterprises *Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.*

6.5.2.1. Design Principle 1 - Defined Boundaries

The fishing accords have clear social (user group) and physical (lake system) boundaries. In general, rules of access have been relatively efficient in excluding non-residents from the managed system (Chapter 5). In both communities, the definition of boundaries is also clearly defined and divulged in the region. Interestingly enough, the definition of boundaries in ARA was clearer than in ISM during the early stages of the fishing accord. ARA limited the lake access to the local population (including the eight communities) due to the intense pressure of non-residents. In contrast, in ISM, non-resident fishers included mostly residents from neighboring communities, who were primarily allowed to fish in the lake for subsistence purposes, but had their access to the lake cut short due to their continuous rule violations.

Despite the clear definition of rules of access in both communities, rules of activity, which directly affect the local fishing, present a distinct outcome. ARA's fishing accord is a case in point.

6.5.2.2. Design Principle 2 - Congruence between Appropriation and Provision Rules and Local Conditions

Despite the ability to expel non-residents, the appropriators should be able to implement rules that are congruent with the socioeconomic and ecological characteristics of the system. In addition, economic factors affect the outcome of implementation and maintenance of the fishing accord differently. During the implementation phase, fishing ban rules are easy to accomplish when the household income does not strongly rely upon the fishing activity, but difficult to accomplish when the members face few economic alternatives. In regard to the ecological congruence, the ability of the managed system to recuperate plays a major role in the local perception of the improvement of productivity, which creates positive feedback from the local participants toward the management.

Both communities implemented fishing ban rules, including the restraint of commercial fishing and gillnet fishing. Yet, those rules were less appropriate in ARA where economic alternatives were not as available as in ISM. During the implementation of the fishing accord, ISM residents relied upon bean cultivation as an alternative economic activity to fill the gap created when the main source of income (fish) was suddenly absent from the household economy. ARA residents, on the other hand, had fewer opportunities to replace fish in their economy due the limited amount of land suitable for cultivating beans. In addition, the fishing accord in ISM regulated the commercial fishing of highly valued fish species (*pirarucu*), based on the ecological knowledge of the local fishers.

Another aspect related to the success of fishing accords in ISM is the relatively rapid recovery of fishing productivity which is related to the ecological condition of the abundance of flooded forest surrounding the lake. Therefore, the relatively fast pace of ecosystem recovery after the rules of activity were set up enabled the local population to perceive the positive outcome of their actions within a period of time short enough to decrease the chance of cheating. The higher environmental risks due to the low height of levees have limited the ability of ARA residents to undertake agricultural activity. In addition, the lower amount of flooded forest surrounding the lake is likely to have affected the length of time necessary for the lake to recuperate its productivity. Consequently, the lengthy period of "waiting for an increase of productivity" raised the cost for the management system, which in turn increased the chance for cheating.

In short, similar fishing rules established in both communities proved to have achieved different levels of congruency with the local socioeconomy and ecological features in each community. The development of rules congruent with the local system in ISM strengthened the incentive for the local population to support the provision rules by participating in the monitoring system. In contrast, ARA members have never achieved a structured monitoring system due to the lack of incentives for individuals to provide labor. Consequently, provision rules were supported by a low number of appropriators who never achieved a legitimate monitoring system.

6.5.2.3. Design Principle 3 - Collective Choice Arrangement

The success of a fishing accord depends on how the decisions regarding the ruling system are organized. The structure of the ISM and ARA accords at the collective choice level is similar to that of most fishing accords. In general, rules are discussed and defined at community meetings with all participants, where all members have the right to speak up. During the meetings, all appropriators have the right to propose alterations, and to vote for the proposals (Chapter 5). Despite their similar structures, the process implementation differs in many aspects between the communities.

First, in ISM, the fishing accord has been based on consensus through a long process of negotiation, which has ensured the actual intention of participation of those who were formerly against the accord. In ARA, on the other hand, decisions have been based on voters' majority. In addition to the failures of the ARA system to legitimize the fishing accords (see Chapter 5), violators have often skipped the meetings, which in turn has created the major threat against the validation of the voting system.

Second, the fishing accord in ISM was proposed by commercial fishers. In order to seal their agreement, the appropriators undertook a symbolic gillnet burning which represented an economic investment in their commitment to the fishing accord based on the abandonment of gillnet fishing. Oppositely, in ARA, the fishing accord was led by cultivators who did not rely as strongly on the fish resource in their economy.

Finally, the process of implementation of the fishing accord in ISM demanded a set of leaders whose personal time investment to designing, reshaping, and solving logistic tasks was fundamental to the accord's success. Furthermore, ISM leaders represented all segments of the community – including all family groups and the farm owners. Regardless of the different interests involved in the participation of those actors, the development of a common interest, mediated by a system of checks and balances coordinated by a legitimate group of leaders, strengthened the ability of residents to achieve consensual agreement. In ARA, the conflict among family groups, between residents and farm owners, and between residents from ARA and those from other communities have made the development of a legitimate leadership and collective decisions more difficult to achieve.

6.5.2.4. Design Principle 4 - Monitoring

One of the major challenges in ruling systems is how to control violations. As discussed in Chapter 3, cultural norms are less costly to monitor due to the internalized values that mediate peoples' incentives. When users are more heterogeneous in respect to resource use, internalized sanctions tend to weaken, and a structured external monitoring system might be necessary to keep the incentives for cheating low and to ensure the maintenance of a covenant among the users. The fishing accords are an attempt to achieve that goal at both regional and local levels. Yet, while rules of access to address non-residents' fishing activity are strongly monitored, the poor monitoring system of rules of use to address residents' fishing activities is one of the major causes of failure in many fishing accords. In the last decade, ARA has enjoyed a relatively peaceful condition in regard to fish exploitation by non-residents, while ISM residents have faced frequent invasions of the lakes by non-residents. However, while residents in ISM have succeeded in controlling local fishing through a regular patrolling and sanctioning system, ARA residents have not been able to structure a similar monitoring system that is legitimate.

In particular, the cost of monitoring local fishing in ISM is low because of the strong social pressure on violators. The identity of ISM as a conservationist community is related to their history of appropriation of the floodplain system, such as the turtle nesting reserve (*tabuleiro*) and the lake management. The recognition of their local management by other communities in the region has enabled the residents to strengthen their bargaining power vis-à-vis governmental agencies and grassroots organizations. Therefore, those positive outcomes have increased the feeling of pride in the residents, who respect their management system. Consequently, conflicts from self-monitoring, which are delicate matters when applied to people with close social relationships, are not an issue in the community (Chapter 3).

Finally, the ISM residents monitor their own patrolling system by sanctioning the appropriators who do not cooperate in the patrol activities. Thus, the chance for free-riding over the fishing accord is minimized.

6.5.2.5. Design Principle 5 - Graduated Sanctioning

Sanctions are a major problem in the fishing accords. Most of the documents present a clear sanctioning system according to the number of offenses. This system is useful for warning violators about local rules and the implications of violation before turning to strong punishments (Chapter 5). Nonetheless, violent sanctioning, such as gillnet destruction, shooting, and verbal harassment usually occurs, creating constant conflict between residents and non-residents. Residents argue that "there is no learning if there is no punishing." While rules are strongly enforced toward non-residents, monitoring among residents is the most difficult task in the communities. Both ISM and ARA have shown little evidence of punishment of local violators. Nevertheless, while rule violation by residents in ARA is common because of the low representativeness of the fishing accord, the consensus among ISM residents and the social pressure toward conservation attitude lower the chance for rule violation. However, the few cases of violations by residents in ISM were promptly responded to with social condemnations.

6.5.2.6. Design Principle 6 - Conflict Resolution Mechanisms

Like any other institution, the fishing accord is not static. It is affected by constant local and external factors, which may lead to conflicts based on the increase in the cost of information and on the increase in the unpredictability of outcomes from appropriators' actions. In particular, the environmental risk of the floodplain system adds to the range of factors influencing the effect of the rules. Therefore, the ability to solve conflicts through low-cost arenas is essential to the maintenance of a fishing accord. In general, fishing accords do not have clear strategies for solving conflict resolution (Chapter 5). However, ISM residents have been able to solve conflicts through peaceful negotiations, during both the implementation and the maintenance phases of fishing accords (see Chapter 5, Incidents 2, 4, 8, 9, 10, 11, and 12). Interestingly enough, conflicts in ISM related to land use were not as peacefully managed as those in regard to the lake use. Ranchers are more influential in land use conflicts, where they tend to have more interest. This pattern shows that conflict between parties with different power relationships makes conflict resolution a more difficult task to manage. This seems to be one cause of conflict in the local management of ARA.

In addition, ISM presents a more homogeneous social structure than ARA. ISM is a relatively small community and does not share the lake with any other community. Likewise, the ISM residents are more homogeneous is respect to socioeconomy and access to resources, which directly affects the level of internal conflicts (either among residents or between residents and farm owners). On the other hand, ARA residents have failed to monitor their rules of activity, as part of their commitment to the fish conservation, due to different interests among users based on an imbalance in the access to resources faced by each subgroup. The social heterogeneity among families in ARA creates a barrier to finding a common interest regarding the use of the fish resource. Usually, cultivator households are the most interested in the fishing accord, since their cost in decreasing the fishing effort is low compared to commercial fishers' households. In addition to the internal variation among the residents, ARA faces a lack of support from farm owners whose properties surround most of the lake system in the island. Finally, ARA residents share the lake management with seven other communities — three located on the island and four located off of the island — each with a different pattern of resource use. Out-island communities that are located on the riverbank have less commitment to the lake management since they have other economic alternatives and access to other fishing grounds. Consequently, consensus regarding rules of use has been difficult to achieve.

In sum, the social characteristics of ISM helped residents to tailor their rules more congruently to the group's interest. They developed a system of checks and balances to evaluate and refine the arrangement according to local demands. In ARA, the lack of a legitimate leadership system in the community creates ambiguity in "community decisions," which are usually made under low participation and fail to represent all the sectors of the community.

6.5.2.7. Design Principle 7 - Minimum Recognition and Right to Organize

Both ARA and ISM have enjoyed partial recognition from other agencies during the implementation of their fishing accords, a fact which helped them to structure their collective choice arrangement. The fishing accord in ISM is supported by the governmental agency in charge of the management of natural resources (IBAMA) on the "*pirarucu*" fishing rule, which coincides with the formal decree. Similarly, ARA enjoyed even stronger institutional support from the Navy Department, which provided them with the right to prohibit the entrance of motor boats in the lake. Therefore, while ARA received major support for their rule of access, ISM received major support for one of their rules of use.

While both communities had support in creating their rules of use – seasonal prohibition of *pirarucu* fishing in ISM and prohibition of the entrance of motor boats in ARA – explicit rules of access to expel non-residents remain illegal. This limitation has been the cause of conflicts but has affected neither community. ARA residents have enjoyed the limited entry of motor boat fishers while ISM residents have been able to regulate the entrance of neighbor fishers.

6.5.2.8. Design Principle 8 - Nested Enterprises

The more complex the system where a given local management is inserted, the more necessary it is for the local institution to be linked to broader-level organizations. ISM has been resistant to the Fishers' Union, which is the grassroots organization responsible for mediating regional decisions and representing fishers in negotiations with governmental and non-governmental institutions. Until now, this role has been accomplished by personal contacts. Such a social avenue can be more efficient if the individual interest is congruent with the community interest, since it relies on personal will to invest time (and sometimes money) in this enterprise. However, such a structure is less likely to ensure institutional sustainability based on participation since the dependence upon particular individuals creates an imbalance in power and low social resiliency. In this regard, the involvement of grassroots organizations is fundamental to providing the link between local and regional institutions. However, a legitimate collaboration between residents and the Union depends on representativeness. ARA has relatively strong connection with the Fishers' Union, upon which they have recently relied to develop the fishing accord. However, the lack of internal agreement on how to proceed with the fishing accord constrains ARA residents from taking advantage of the institutional support from those organizations. Recently, the interference of development projects by NGOs and GOs has improved the structure of representativeness. Yet, these projects have failed to address the social factors related to internal conflicts based on power relationships and different access to resources.

6.6. CONCLUSION

Although fishing accords represent a rational local management system with a clear conservation goal of increasing lake productivity, the process of establishment and local factors that influence the outcome of such institutions may differ across communities in the region. In some communities, the establishment may not represent a democratic decision-making process; instead, it may represent the interests of individuals (such as farm owners) or small groups (such as family groups) (Chapter 3). Furthermore, the establishment of fishing accords may not represent a commitment to fish conservation, but only a way to expel non-residents while internal control over fishing activity is overlooked. Therefore, the motivations regarding the establishment of a fishing accord as well as the incentives that drive (or restrain) individuals to (from) joining a fishing accord are leading forces in the success or failure of this collective action. In this regard, the success of local management systems depends on the ability of residents to overcome three major dilemmas in the process: first, to achieve minimum representation to implement the fishing accord; second, to obtain external support to help solve conflicts with non-residents; and third, to develop a stable structure for solving local conflicts (Figure 6.11). Although these dilemmas overlap, they play a major role in different phases of the establishment of the fishing accord. Below I discuss each of these dilemmas in the process of establishing the fishing accord.

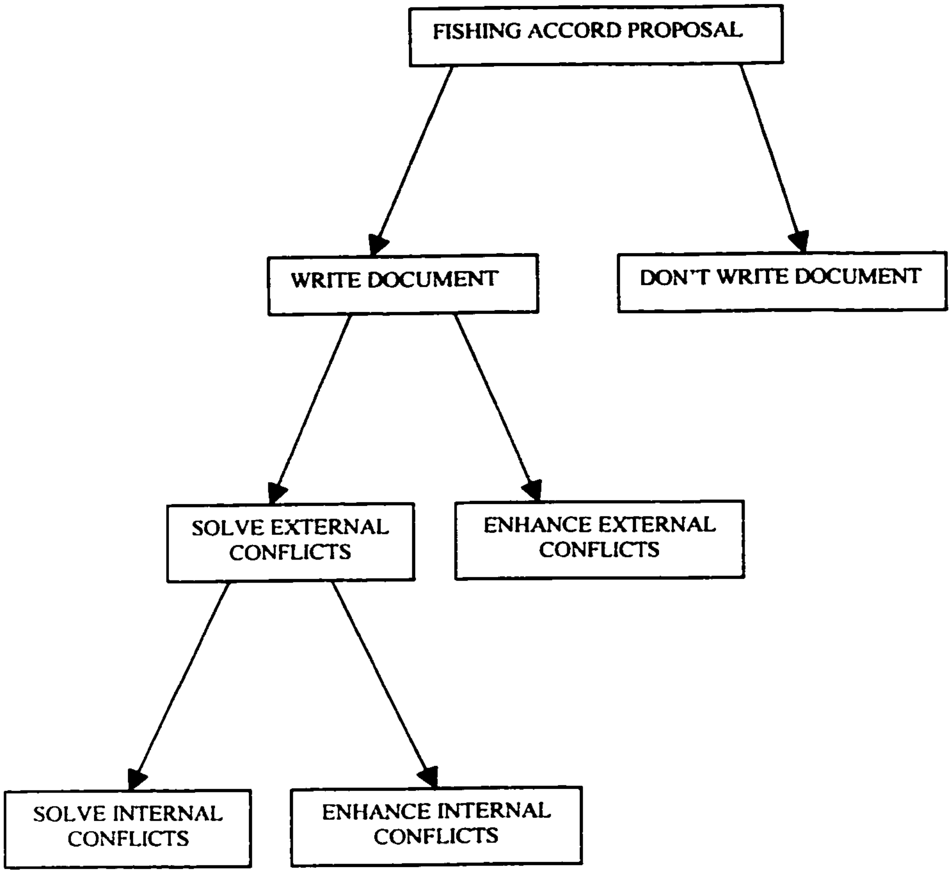

Figure 6.11. Dilemmas faced by local populations during the establishment and maintenance of the fishing accords in the Amazon.

Implementation – The establishment of a fishing accord is a relatively easy task to accomplish. It requires a community mass meeting, a quorum (which can vary in criteria), and the formulation of a document endorsed by the majority. In many cases, meetings are not representative and fail to address appropriately the congruence of the rules formulated with the social and ecological reality. Therefore, the existence of innumerous fishing accords does not represent a success in the management of the fish resource in the region. Rather, the successful establishment of a fishing accord heavily depends on a consensus based on a common interest. Such a condition is more likely to be met when households enjoy relatively homogeneous socioeconomic and political positions. In particular, the resource managed (fish) can have major economic importance in the household budget. Thus, the involvement of households that rely strongly upon commercial fishing in their economic strategy in the establishment of the fishing accords is important, since those households will face a higher cost in decreasing their fishing efforts. Once those households are committed to the collective action, the success of that enterprise is likely to increase.

Solving Conflicts with Non-residents – One of the major goals of a fishing accord is to expel non-residents. Thus, the early stages of the establishment of fishing accords usually lead to the increase of conflict between local residents and non-residents, since the rules established directly affect the fishing strategy of non-resident fishers. The ability of the appropriators to solve those conflicts is fundamental to lowering the monitoring cost as well as to gaining political support from both the governmental and non-governmental organizations related to fishing, such as the Fishers' Union, IBAMA, and the Navy Department. Communities more isolated from areas exploited by commercial boat fishers, such as ISM, are less impacted by those conflicts that are mostly related to fishers from neighboring communities. Once support from those agencies is present, the success in expelling non-residents increases and the population is able to concentrate their effort to solve internal conflicts.

Solving Internal Conflicts - Solving conflicts with non-residents is an important accomplishment in the process; yet, fishing accords will not become consistent institutions if internal conflicts are not equally addressed. Similar to conflicts with non-residents, internal conflicts are likely to increase when rules of activity are established. The early stage of the establishment of the fishing accord is a delicate period; it demands a structure that enables the users to gradually craft the institution into an arrangement congruent to the ecological and social system. During this process, some rules may eventually be changed according to decisions where massive participation of the residents should take place. Thus, the ability of users to solve internal conflicts increases if a check and balance system is promptly assessed whenever conflictive perceptions toward collective decisions emerge among residents. In particular, the efficiency of a monitoring system is fundamental to maintaining the accomplishment of the rules and, thus, creates incentives to users to keep up with their commitment toward the local management system. Internal conflicts are more intense when the community lacks economic opportunities to substitute the fish resource in their economic strategy. In addition, the level of heterogeneity among the user group is higher when the lake system is shared with residents from other communities (which increases the chance for a different structure of economic opportunities), and the social relationship with farm owners is weak. Finally, the ability to solve internal conflicts is directly related to the ecological resilience of the system, which strongly influences the pace of ecological improvement (productivity) from the institution re-arrangement (decreasing of fishing effort). When a positive outcome is achieved relatively quickly, the perception of improvement by the users may increase the incentives to support the fishing accord, thus creating a positive feedback system.

Chapter 7

CONCLUSION: FISHING ACCORDS AND FLOODPLAIN MANAGEMENT IN THE AMAZON

7.1. INTRODUCTION

The main goal of this dissertation has been to understand the origin, maintenance and outcome of fishing accords, and to evaluate their potential within a cooperative management strategy. Throughout the dissertation, I have focused mainly on the first part of this inquiry, since the comprehension of the local management provides the theoretical underpinnings upon which to evaluate its potential in terms of policy. In this chapter I present the conclusions of the dissertation by emphasizing the compatibility of the fishing accords with the systemic approach to the management of the Lower Amazonian floodplain.

As discussed in Chapter 1, formal systems of fisheries management are mainly based upon scientific models; these models overlook local institutions that can regulate the use of the fish resource. Bioeconomic models of fishing hold four major assumptions regarding human behavior, which affect the results of the policy implementation. They assume, first, that social aspects related to fishers' behavior are accounted by the analysis of fish commercialization; second, that fishers are treated as a homogeneous group; third, that fishers are isolated individuals, who do not communicate with one another and respond only to market influences; fourth, that fishing is an isolated activity, unrelated to other economic activities.

The increasing control of fishing activity by policymakers, who follow a sectorial approach, has led to the replacement of prior local controls by simplified models that have little consideration for the broader ecological and social dimensions within which fishing takes place. The discussion in the former chapters shows that the recognition of the fact that both the resource and the users are heterogeneous entities interconnected by ecological and social processes is essential to achieving a more reliable picture of the floodplain system. Chapter 2 shows that the ecological complexity of floodplain systems stems from the interdependence of its subsystems. The interface between aquatic and terrestrial phases makes the floodplain a dynamic and patchy ecosystem. The continuous landscape change directly affects the structure of non-human communities regularly, according to the flooding pattern (Junk 1997b). Consequently, the adaptation of fish to the "flood pulse" is closely related to the spatial and temporal habitat patchiness (Junk 1984b, Goulding 1981, Junk et al. 1997), which has led scholars to propose that fish conservation should be based upon a systemic approach to habitat preservation (Goulding et al. 1996).

The shift in focus from the fish to the floodplain system has major implications for ensuring the ecological processes that enhance and maintain lake productivity. Yet, the bias toward floodplains as non-human systems remains central to the habitat protection approach. Treating floodplains as non-human systems is misleading and can lead to the failure of management strategies. Ecological interdependence among *varzea* subsystems is reflected in the socioeconomic features in the system. Chapter 3 shows that human beings have coped with the floodplain system for more than 10,000 years (Roosevelt 1989) and have developed several adaptations to the system (Meggers 1971, Moran 1993). Recent external factors transformed the human system into a more complex, diversified socioeconomic and sociopolitical system, which in turn directly has affected the ecological system (Smith 1985, Chapman 1989). The Lower Amazon is home to more than 45,000 inhabitants who live on the floodplain and depend on its resources (Chapter 4). This does not include the non-floodplain population who are involved in the commercial fishing sector, and their respective families, which adds up to about 600,000 individuals whose livelihood relies upon the floodplain.[1] Therefore, an analysis of the sustainability of the floodplain cannot be developed unless the human dimension of fishing is integrated.

Small-scale fishing, which is carried out by several thousand families who live at the river's edge, is only a part of the production system. As discussed in Chapters 3 and 4, the local populations have traditionally alternated floodplain subsystems year round in order to develop an integrated production system of agriculture in the high levee, cattle ranching on grassland, and fishing in the lakes. Thus, the fishing effort also depends on how other natural resources are used, since fishing is part of a closely interdependent socioeconomic environment. In addition, the decrease in fishing productivity has resulted from a complex process of socioeconomic changes such as an increase in the fish demand due to urban growth through immigration as development projects progressed in the region (Smith 1985); inappropriate techniques that capture immature species or species in their reproductive stage (Isaac et al. 1993); habitat destruction by the intensification of cattle ranching (Goulding et al. 1996); and erosion of local management by an increase in the number of fishers (McGrath et al. 1993a).

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[1]http://www.geocities.com/RainForest/Canopy/1243/Iara03.htm.

In sum, the problem of fish depletion is multifaceted; it includes different types of fishers (resident fishers, motor boat fishers, neighbor fishers, and urban fishers); but also non-fishers (e.g., ranchers) who affect the fish population through habitat destruction. Therefore, a systemic approach to fisheries management should integrate the social system if it is to address adequately the different interests affecting the fisheries, i.e., the integration of ecological heterogeneity and interdependence among ecological subsystems should accompany the integration of social heterogeneity (different actors involved) and interdependence among natural resource use (production systems).

Chapter 5 shows that fishing accords address the use of the fish resource systematically. Fishing rules created by local populations focus on the floodplain system and integrate both ecological and social variables. Therefore, fishing accords offer the potential to enhance the management of the fish resource in the floodplain. Yet, local rules are intricately related to social relationships between local actors, a fact which may affect the outcome of that local management system. In chapter 6, I discussed how the outcome of fishing accords may vary according to particular features of the system at the local level. Therefore, the potential of fishing accords to foster a co-management system is not a simple issue. Rather, it is related to the limitations of local institutions, i.e., under what conditions fishing accords may or may not enhance fish productivity.

This chapter will discuss the local management of fishing through a systemic perspective of the Lower Amazonian floodplain. The chapter is divided into three sections in order to address the three major questions of the dissertation. In the first section, I present a synthetic analysis of the factors related to the origin and maintenance of fishing accords in the Amazonian floodplain. In the second section, I present a discussion related to the outcomes of fishing accords in regard to three aspects: 1) ecological sustainability of the resource/system; 2) institutional sustainability of the local management; 3) balance between local and regional social justice. Finally, the third section addresses the policy aspects of fishing accords by providing general guidelines for building co-management of the floodplain based on fishing accords, taking into account: 1) the nature of the collaboration; 2) screening of the potential community; and 3) designing a monitoring system.

7.2. THE ORIGIN AND MAINTENANCE OF LOCAL MANAGEMENT SYSTEMS

The findings from the study of the origin and maintenance of fishing accords in the Lower Amazon contribute to the elaboration of a more general framework to address the theory of the commons. Based on the discussions presented in chapters 2-5, five major factors affect the process of development of fishing accords in the Amazon: 1) *perception of scarcity*, which influences decisions taken at the individual level; 2) *ability to organize*, which influences decisions taken at the group level; 3) *historical background*, which influences the social context in which a fishing accord has emerged; 4) *ecological background*, which influences the ecological response from the local institution; and 5) *access to alternative resources/systems*, which affects the degree of flexibility of individuals to change their pattern of resource use. Each factor is influenced by two attributes that have a pervasive influence on the whole set of incentives: 1) *pace of change*, which directly affects the ability of the ecological and social setting to recover from impact (resilience); and 2) *demographic structure*, which affects the withdrawal capacity in terms of labor force and demand for the resource, the control and access of the resource due to land tenure changes resulting from population density and urbanization process, and the ability to organize due to the heterogeneity of actors.

These factors play a major role in the relationship between user groups and CPRs in a pervasive way, which affects the incentives mediating the use of resources in different levels of decisionmaking. Therefore, the discussion of each factor is a useful means to address questions regarding origin and maintenance of local management systems — key questions in the theory of the commons. Below I discuss each of the five factors in more detail. This section aims to present a general picture of the relationships among major components affecting incentives in regard to collective action toward natural resource use by including the social and ecological contextualization of the system where the decisions are made.

7.2.1. Historical Background

Historical background is a basic starting point in analyzing a local organization, in that it describes the origin and development of the group. In this regard, the historical analysis must extrapolate the goal of the descriptive background, and pursue the analytical endeavor of uncovering variables that have played roles in the process of change undergone by the population.

The analysis of local organization through a historical perspective can unfold factors embedded in the social relationships that are difficult to understand in the current social context, such as social norms and internal conflicts. Historical analysis can also reveal past experiences faced by the population; this helps evaluate the ability to respond to social changes. Populations who have experienced relatively little change throughout their existence may be socially organized but are more unlikely to present social resilience to abrupt changes in comparison to populations that have been exposed to frequent changes throughout their history. Likewise, populations with a long residence history are more likely to present a better internal organization in comparison with populations who have recently arrived. This is particularly evident in recently formed groups from top-down projects, such as planned settlements in dam and road projects (Cernea 1991, Moran 1981), or imposed cooperatives (Poggie and Pollnac 1991).

Caboclos are neo-traditional populations who have relatively recent history (about 200 years) in comparison with indigenous populations (about 12,000 years), but a long history in comparison to settlers (about 30 years). *Caboclos* have proved to be a highly resilient group since they have resisted several social transformations (Wagley 1953, Moran 1974, Ross 1978b, Parker 1985a). Fishing intensification has taken place under complex social changes involving demographic, technological, political, and economic factors at a pace never experienced before. Therefore, the extent to which this combined strategy can resist the increasing speed of social transformations depends on many factors.

7.2.2. Ability of Users to Organize

Besides the current local organization and social resilience, which are related to the history of the group, the ability of users to organize also depends on factors from different levels of organization. At the regional level, external support helps in the provision of basic information to develop an organizational structure and to recognize the legitimacy of local arrangements. The analysis of fishing accords shows that local residents received external support from the Catholic Church to develop their organizational structure; from farm owners to support their informal rules; and more recently, from the international media, which has pressured the government toward conservation strategies through community-based institutions (Chapter 3). Consequently, residents have been relatively successful in sustaining rules of access to keep non-residents away from the lakes. In addition, local institutions have recently been backed up by grassroots organizations, and by the attempt of the government to develop co-management systems. At the group level, decisions to join in a collective action to manage common-pool resources also depend upon other individual agendas that may or may not be directly related to the resource or system to be managed.

Such agendas may have positive or negative impact on the ability to organize. Despite the different factors that bind subgroups together in the participation in collective actions, the ability to organize increases when powerful subgroups drift. That was the case in the early stages of the fishing accord when farm owners, concerned with cattle piracy, supported the local rules to expel poachers (Chapter 3). Other agendas can halt group organization. For example, individuals may refuse to join a collective action because of other conflicts between the appropriators, even when the conflicts are not related to the collective action per se (Chapter 6). In this regard, the farm owners, who were important in the emergence of fishing accords, currently represent a threat to the success of this local institution due the enhanced local conflicts regarding control over the resources. Chapter 5 shows that the tension between conflict and collaboration among different actors is a delicate issue that has a profound affect on the outcome of collective actions.

The fishing accords may result in the domination of powerful groups over local decisions. Since local populations articulate their decisions in several interdependent social arenas, analysis of decisions must be carried out on a systemic basis, taking into consideration other social relationship that can eventually affect the ability to organize in a democratic manner.

7.2.3. Perception of Scarcity

Perception of scarcity is affected by a set of factors: resource value, pattern of distribution and abundance of the resource, withdrawal capacity of the household, control over the resource to be managed, and access to other resources. The resource value can be divided into symbolic, nutritional, and commercial values. The symbolic value of a resource/system is strongly influenced by emotions mediated by a culturally constructed environment. Chapter 3 describes mechanisms in which symbolic values manifested through fear (myths) and respect (sanctuaries) may affect the decisions regarding the use of a resource. The nutritional value of a resource is influenced by the importance of that resource in providing food security. In general, peasants strongly favor food security by preserving their subsistence system, which is a major component in their social resilience. *Caboclo* populations are a case in point; their social resilience in the face of abrupt socioeconomic changes has assured them the maintenance of their subsistence system of production, even in periods of intensive commercial activity. Finally, the commercial value of a resource is an external pressure that can affect both its symbolic and nutritional values. This has been the case for fish, which has become the most economically important resource in the floodplain.

The weight of the nutritional value of a resource depends on the alternative means of obtaining food (including purchased food). The balance among the three sources of values (symbolic, commercial, and food security) is a major feature in this analysis. For example, non-consumptive resources are more prone to be conserved through symbolic means. When a resource or system has strong symbolic value, it may retain the commercial exploitation regardless of its economic value, such as the case of sacred forest in India (Gadgil et al. 1998) or conservation-oriented communities in the USA (Gibson and Koontz 1998). On the other hand, access to other alternatives may not be enough to make the local population shift or decrease the pressure on the resource when its commercial value is high. The decision regarding shifting resources of commercial value depends on the opportunity cost of using alternative resources in comparison to the resource/system to be managed. Finally, when the resource is a staple food for users, incentives to regulate its use are more likely to occur even when other alternatives are available. Food preferences are strongly related to cultural custom and are one of the most difficult aspects to change in the short term. This is the case of the Amazonian floodplain, where the fish resource is a major protein source that is highly preferable over any other protein source (Smith 1981). Therefore, the reliance on the fish resource as a staple food has driven the population to manage the lake in order to maintain its productivity. Yet, despite similar availability of technology, labor force, and food security, distinctions in the commercial importance of the fish resource among households partially explain the failure to reach a consensus for a collective action in a community (Chapter 6).

In addition, the perception of scarcity depends on the efficiency of capture, which is a result of the balance between the spatial and temporal distribution and abundance of the resource and the assets related to withdrawal capacity, such as technology, local ecological knowledge, and labor force. In regard to spatial and temporal distribution of the resource, efficiency of capture depends on the behavioral attributes of the resource, such as the degree of aggregation, pattern of mobility, diet, and reproduction. Therefore, the ecological knowledge of the resource increases the withdrawal capacity. *Caboclo* populations have retained a great deal of information on ecological aspects of the resource from their indigenous ancestors. Floodplain populations can rely on their ecological knowledge to overcome low productivity, while populations from other areas need technological input to overcome low productivity (Chapter 2). However, local ecological knowledge can be better exercised when the knowledgeable population is able to maintain their control over decisions regarding resource use.

Scarcity is more likely to be felt by individuals who lose access to the resource. When access to resources is threatened, local populations usually seek the help of organizations to rescue their right of use. Therefore, regardless of who controls decision, users may not have incentives to organize to manage a resource/system until their access is constrained (Chapter 5). Fishing in the Lower Amazon is a case in point in which lake use was under farm owners' control until the 1960s, but no fishing accord was established until the threat of loss of access to fish resources arose (see Futemma et al. 1998 for a similar case regarding flooded forest). Therefore, depending on other factors, local populations have two paths: to rescue their access by controlling the resource in order to define a local management, or to lose control over the system and overuse the resource.

When the level of control varies among users, perception of scarcity may vary among households within the community, leading to different levels of incentives to join in a collective action. For example, families in which the value of the resource is mainly computed by commercial purposes are less prone to conserve resources than those in which symbolic or food security purposes are major components in calculating the resource value. Likewise, households with more withdrawal capacity will not feel scarcity as promptly as those households with a lower level of assets. As stated in Chapter 2, differences in technological assets between residents and non-residents create a distinct perception of scarcity. Therefore, the higher the socioeconomic heterogeneity of the households, the more difficult it is to design a stable fishing accord.

7.2.4. Access to Alternative Resources

Access to alternative resources is a major factor enabling the local population to shift (or distribute) the pressure from the "scarce" resource. The perception of scarcity is not enough to trigger the individual's interest to join collective regulation of a given resource – regardless of its value – unless other alternatives are available or can be pursued. Thus, other things being equal, the relationship between diversity of resources and collective action would present a bell-shaped curve. In systems where no alternative resources or several alternative resources are present, users are less prone to develop collective actions toward conservation of the scarce resource. In the first case, excessive poverty, which allows the group no means to develop social or technological innovations in order to overcome scarcity, would lead the population into a trap where overexploitation and starvation is likely to follow. In the latter case, the prompt availability of several resources would lead populations to prioritize in order to shift the effort to other resources instead of engaging in a collective action toward regulation of the scarce resource. Between those two extremes, there is a wide range of cases where alternative resources that are not promptly accessible or not traditionally used by local populations are included in the local production system through social and technological innovations.

Chapter 6 discusses how social arrangements and the use of alternative resources were prioritized over technological improvement in order to solve scarcity problems. Nevertheless, not all attempts to create local institutions are successful. As discussed in Chapter 4, populations along the riverbank are more likely to be successful in the fishing accords, due to their access to a wider range of resources, than populations living on the levees. It is important to note, however, that access to alternative resources must be analyzed in terms of their value in comparison to the scarce resource in each case. For example, the "alternative resource" may not represent a "natural resource," but rather institutional support from other sources. For example, when the resources to be managed are mainly used for commercial purposes, their use can be alleviated by the provision of other sources of money, such as credit line, salary insurance, or retirement salary. On the other hand, other natural resources that are promptly accessible to be used as "alternative resources" in a community may be constrained by local institutional arrangements of tenure (Chapter 5).

7.2.5. Ecological Background

Ecological background affects the response to collective actions by influencing the perception of scarcity and the access to alternative resources. Physical characteristics of the ecosystem influence the spatial and temporal distribution and abundance of the resources by affecting their predictability and the ability to monitor them. For example, mobile resources are more easily monitored in closed ecosystems (such as lakes) than in open systems (such as rivers and forests). Likewise, other physical aspects of the ecosystem such as level of soil quality, rainfall, topography, temperature, and flooding patterns directly affect the ability of the system to recover from disturbances (ecological resilience). In this regard, the floodplain system represents a complex ecological background where boundaries of physical systems exist according to the annual flood pattern from closed to opened system, and the managed flow unit (fish) presents different levels of mobility, distribution and abundance according to the species.

In addition, the ecological resilience of the floodplain is related to the distribution of other resources, such as flooded forest and floating meadows, and the use of highly nutrient soil is constrained by relatively unpredictable flooding patterns (Chapter 2). Therefore, like historical background, ecological background is not a static scenario where dynamic social actions take place but, rather, a fundamental source of dynamic change that affects and is affected by local decisions. It is also influenced by large-scale ecological changes that cannot be controlled at the local level, and can affect directly the ability and pace of the ecosystem to recover from local impact. Ecological resilience is an essential means of supporting positive feedback in collective actions, since incentives to invest in such collective actions is higher as the system shows quick signs of an increase in productivity. Hence, more stressed systems are less likely to reinforce local management than highly resilient ecosystems (Chapter 6).

Resilience of the system is directly related to climate change, such as El Niño, which indirectly affects the flooding pattern in the Amazon through its influence on the rainfall regime (Richey et al. 1989). Since the flood pattern is a major ecological feature that affects local decisions (Chapter 2), the uncertainty of the flood pattern decreases the ability of the user group to be prepared for eventual ecological hazards. Therefore, this impact of climate change negatively affects the social resilience by increasing the unpredictability in the ecological patterns. Climate change has also triggered indirect positive effects by affecting the broader society's perception of scarcity, thus creating incentives for them to help local users to organize. The development of a conservation ideology at the international level has had an indirect impact on the Amazon, where political and economic support of local populations has opened a new channel for negotiating their interests (Chapter 3).

7.2.6. Pace of Change and Demographic Structure

Two major variables that have pervasive impact in the compatibility between local institutions and ecological conservation are *pace of change* and the *demographic structure*. Most local management systems are the result of a long-term, slow-paced, locally based shaping process. In the last 30 years, environmental changes have taken place under complex processes, strongly influenced by external factors occurring at a rapid pace. This trend leads to the issue of the extent to which social and ecological systems are able to resist environmental change. This issue is of major importance in dealing with local management in a dynamic fashion. In other words, the finding that a given local institution has been able to maintain or increase the productivity of a system is not enough to conclude that that system will be stable in the long run. Considering the fact that most ecological systems have been suffering strong and abrupt changes, any evaluation of a local management system should address sustainability in a dynamic fashion by looking at features that tell about its ability to resist environmental changes. In this regard, historical ecology is of major importance in that it explains how populations have responded to abrupt environmental changes in the past (Crumley 1994, Balee 1998). Similarly, institutional analysis can provide important information about the structure of the local management — this enables a system of checks and balances that provides institutional robustness. Finally, ecology has improved a great deal through the development of an ecosystem theory which integrates dynamics and human actions (Folke and Kaberger 1991, Costanza et al. 1997).

No less important has been the change in demographic structure, which has triggered changes in the pattern of demand, access, and control of resources. In this regard, issues of population structure of the household and of the user group, gender-related differences, and urbanization are particularly important attributes affecting the control of and access to resources, changing the value of resources, and withdrawal capacity. The rapid demographic transition that the Amazon has undergone creates a complex scenario where collective actions take place. Therefore, the analysis of migration patterns, household and community structure, urbanization, and regional population growth are fundamental to understanding the demographic dynamics behind collective actions.

7.3. PERFORMANCE OF THE LOCAL MANAGEMENT OF FISHING: FISHING ACCORDS AND THE CONSERVATION OF THE FLOODPLAIN SYSTEM

The fishing accords are a recent institution, and as such, they have rarely been able to achieve all their goals. In general, local control has been ensured more successfully by establishing rules of access to expel non-residents than by conserving the resource through the establishment of rules of use to control the local activity. The major problem faced in the fishing accords is the difficulty of enforcing the rules of activity at the local level. However, the success of a fishing accord cannot be foreseen only by improving the monitoring system. The rules should be congruent with the ecological system in order to achieve resource conservation. Likewise, the institutional structure should present features that enable stability in the decision arenas. Finally, the local control of the ecosystem should envisage a better quality of life at the local level without jeopardizing quality of life on a broader scale. These three aspects are discussed below in terms of how fishing accords can contribute to the goal of congruence between conservation, development, and social justice.

7.3.1. *Biological Sustainability of the Fish Resource*

Despite the large range of literature on community-based management, little effort has been taken to measure the ecological effect of local institutions on resource conservation. Yet, basic measurements of biological sustainability are necessary to evaluate if fishing accords represent not only a discursive strategy to keep local control, but also a commitment to conservation. In many cases, conservation outcomes of local management are taken for granted while evidence to support the conclusions is rather anecdotal (Ruttan 1998). Efforts to remedy this problem have been more successful in relation to forestry resources (Smith and Berkes 1993, Gibson et al. 1998) and irrigation systems (Ostrom 1992a, Tang 1992), while the methodological difficulties of measuring mobile resources have constrained similar analysis for aquatic resources (see discussion in chapter 6). Some examples of the evaluation of conservation outcomes in the local system of fisheries management include experimental fishing (Berkes 1977), size measurements (Acheson 1975), and the counting of the number of specimens (Smith and Berkes 1991).

The effect of a given management system varies according to the degree of mobility of the resource. The major puzzle in the management of fugitive resources is that the boundaries of the managed physical system (lake) and the unit flow (fish population) overlap only partially (Schlager et al. 1994). In addition, the abundance of the resource is directly related to the carrying capacity of the system, i.e., productivity decreases if the conditions of the physical system are not maintained at the level necessary to support the unit flow. Those two dilemmas are discussed in more detail below.

7.3.1.1. Fish Mobility

Evidence for positive ecological outcomes in community-based management of aquatic resources is usually found among relatively sedentary species, such as lobster (Acheson 1975), sea-urchin (Smith and Berkes 1991), and marine gastropod (Ruttan 1998). Chapter 2 shows that Amazonian fish species have different degrees of mobility: sedentary species, which spend their life span in floodplain lakes and have limited mobility between lakes; short-distance migratory species, which spend their life span between lakes and main channels; and long-distance migratory species, which spend their life span between the main channel and the estuary system. Since fishing accords are limited to lakes, this management system is expected to be more efficient toward sedentary species, whereas its application to migratory species is likely to be less efficient.

According to the comparison presented in Chapter 6, sedentary species may present a rapid response to local fishing regulations. In particular, the effect of rules on the populations of *pirarucu* (*Arapaima gigas*), which provided high fishing efficiency with considerable economic revenue, played an important role in creating incentives to local populations to maintain the accord. The ability of the *pirarucu* population to recover under controlled fishing pressure, due to its relatively high fecundity (Queiroz 1999), has allowed the local residents to alternate between intensified commercial fishing of this species and a fishing closure season. This annual cycle represents a period of restraint that is manageable in the household economy (Chapter 6).

A crucial question regarding a local management system is whether or not short-distance migratory species return to the same lake after the reproductive migration. The limited information on the migratory behavior of the species makes it more difficult to draw any conclusive evaluation of the effect of local management on these species (Ribeiro 1983, Cox 1988, Goulding 1988). Yet, some evidence of potential conservation is revealed by the analysis presented in Chapter 6. The comparison between fishing production in lakes with distinct management systems shows that some short-distance migratory species present a larger average body size where rules of activity are monitored. This fact suggests that well-managed fishing accords seem to have two major positive ecological implications in those species. First, they help prevent overfishing due to pressure on young and small fish, thus directly affecting the potential to accumulate biomass through growth (growth overfishing). Second, they help in fish recruitment by providing a nursery site where the fish can mature and, later, spawn.

Long-distance migratory species are unlikely to be affected by fishing accords. They can only be indirectly affected if commercial fishing is replaced by other local-based activity in the floodplain. Yet, since those species are mainly used for export markets and are highly pressured by large-scale fleets (Chapter 2), the commercial fishing carried out by the local actors is relatively insignificant. Therefore, the management of long-distance migratory fish is unlikely to be efficient if enacted through fishing accords. Rather, a regional monitoring system, involving even international regulations should be established, since some species are transboundary resources (Barthem and Goulding 1997).

Therefore, the ecological features of species groups, such as mobility, reproduction, and diet, are reliable indicators to evaluate the ability of local rules to ensure the maintenance of those biological processes.

7.3.1.2. Ecological Resilience

Lake systems are essential to the survivorship of both sedentary and short-distance migratory species because they represent a source of food, growth, and protection against predation (Chapter 2). Due to the low primary production of lakes, the flooded forest is a major source of energy for the aquatic system. Likewise, the large extension of floating meadows plays a major ecological role in providing shelter and substrate to micro-organisms, on which fish feed. The floodplain system in the Lower Amazon was altered during the jute boom, when large extensions of flooded forest were removed to provide space for jute cultivation. Recent intensification of cattle ranching has impacted the floodplain system as well (Goulding et al. 1996). Therefore, besides monitoring and congruence, the effect of fishing accords on the biological sustainability of the fish resource depends on the ability of the floodplain system to restore itself and support the recolonization of the fish populations.

The ability of a fish population to recover depends on the biology of the species and on the conditions of the system where the population lives. Chapter 6 shows that the *pirarucu* seems to be a species with the ability to recover rapidly when ecological conditions are appropriate. As a large predator, its mortality rate depends on the efficiency of parental care. Thus, recruitment is more successful when adults are not caught until the offspring are old enough to protect themselves. In addition, *pirarucu* has relatively high fertility (about 4,000 eggs) and a fast growth rate (about 5 years to reach maturity). This period coincides with the period in which Ilha de São Miguel (ISM) residents perceived improvement in the lake system. However, the ability of *pirarucu* (as well as any other species living in the lake) depends on the carrying capacity of the lake system. In this regard, the preserved flooded forest area surrounding lakes seems to be a major factor that has helped the fast recovery of the fish populations.

Therefore, the time frame for a fishing accord to show positive outcome in the perceived fishing productivity depends on the congruence among the established rules, the ecological features of the resource/system to allow the recovery of productivity, and the willingnes of the human population to practice restraint until perceived productivity is achieved. In other words, an institutionally sound fishing accord is not enough to succeed if it does not address the level of impact on the ecosystem and the ecosystem's ability to recuperate under the new arrangement.

7.3.2. *Institutional Sustainability of the Fishing Accord*

As discussed in Chapter 3, fishing accords take place in a social environment, which includes several user groups and organizations. The latter are institutions related to the establishment and enforcement of the rules in regard to resource use at both local and regional levels. The maintenance of such systems depends on the level of organization of the different actors involved as well as on how institutions are arranged in order to maintain a stable system of checks and balances. It is essential to recognize that actors have different incentives in order to address the institutional sustainability of the fishing accord with a focus on negotiation and conflict resolution. In addition, the success of fishing accords depends on the availability of alternative economic activities that can reduce pressure on the fish resources. The performance of fishing accords depends on the organization and provision of economic incentives to disperse the effort concentrated in the fishing activity and to direct it toward alternative production systems.

7.3.2.1. Social Structure

The structure of the floodplain population is heterogeneous on different levels; this fact may affect the ability to maintain a sustainable fishing accord. Dropping the assumption of a homogeneous population places the focus of analysis on social relationships and emphasizes the bargaining power of each subgroup to support a negotiation process toward a common interest. At the community level, when geographic limits do not correspond to the sociocultural boundaries, internal conflicts between family groups may arise (Araujo 1994). Likewise, differences in resource access within and between communities lead households to face distinct incentives to change their pattern of resource use in the floodplain (Chapter 4). In this case, it is easy to enforce rules of access to exclude non-residents, since they are based on common interests among residents (chapters 5 and 6). Nevertheless, the rules of use that control local fishing are poorly enforced where conflict among family groups is more intense. A family group, for instance, may refuse to participate in a fishing accord if the organization is run by a member from another family group with which they have a history of conflict. Therefore, representativeness in the fishing accords is an issue that must be carefully addressed (Chapter 5).

In addition to the internal structure of the community, the residents may face conflicts at the intercommunity level during the establishment of a fishing accord. Cooperation between communities is an important matter when the managed lake is shared by more than one floodplain community. When communities differ in terms of access to resources, they tend to present conflicts of interest (Chapter 4). In those cases, a strategy to build a collective action should envisage a way to compensate for the imbalance of bargaining power among the communities involved in regard to access to resources. For example, it is difficult for Aracampina (ARA) residents to cultivate cash crops due to high ecological risks in comparison with the other communities involved in the accord (Chapter 6). The lack of economic alternatives creates incentives for residents to cheat.

Although fishing accords are organized at the community level, their success depends on other social interactions as well. At the floodplain level, the success of a fishing accord depends on the cooperation of farm owners, because those actors occupy large areas of the floodplain and are economically and politically strong. Their support has been important during the emergence of fishing accords in the region (Chapter 3). In the early stages, the interaction between these two actors was based on their common interest in excluding non-residents (Chapter 3). Despite their very different agendas — local residents sought to balance the technological externality while farm owners sought to avoid cattle piracy — fishing accords were quite an efficient strategy for satisfying both goals. The analysis in Chapter 6 reveals that communities where cooperation between the two actors is still effective are more likely to succeed in their local management. On the other hand, the declining participation of farm owners combined with the intensification of ranching activity tend to enhance internal conflicts and ecological effects such as overgrazing and soil compacting, affecting directly the floodplain system, and in turn the fish populations (Chapter 2).

Finally, at the regional level, fishing accords are an institutional unit that must be connected with higher-level organizations in order to control region-based problems such as legal support, and conflict with non-residents. Such a nested-structured organization should rely upon the participation of grassroots, non-governmental, and governmental organizations. Grassroots organizations are important actors in the process of addressing local grievances and needs. Both the Fishers' Union (FU) and the Rural Workers' Union (RWU) have a strong history of peasant resistance to the autocratic political system during the 1970s. Chapter 3 discusses in detail how residents fought collectively for the democratization of those organizations. After the 1980s, the RWU became the representative of upland peasants, while the FU became the representative of floodplain peasants. This division has created an artificial dichotomy *upland/agriculture* and *floodplain/fishing*, which has weakened the political organization of floodplain agriculture. The discussion in Chapter 4 reveals that floodplain communities have different economic aptitudes according to their access to resources. Therefore, close integrative work with both grassroots organizations would yield a great ability to represent populations who rely upon both systems (land and aquatic) for their survival, and in particular to address questions related to the relationship between fishing accords and the support for other economic activities.

Several non-governmental organizations have affected the occupation and use of natural resources in the *várzea* system. The Catholic Church has played (and continues to play) a major role in the formation of the political structures of leadership systems in local communities as well as the development of grassroots organizations in the region (Chapter 3). Likewise, research centers have been carrying out participatory development projects to develop models of collaborative management systems. However, the short time frame of the research, the biological bias, and lack of personnel are among the many problems that create a barrier to accomplishing a real bottom-up approach that recognizes the social aspects of the local management.

Governmental agencies are equally important actors in this social arena. IBAMA, the government agency in charge of the management of renewable natural resources, has limits in terms of solving regional problems due to its hierarchical structure; thus, regional offices are often unable to solve local conflicts. In addition, there is a conflict of competence between IBAMA and the Ministry of the Navy, the governmental agency in charge of monitoring the tenure system in the floodplain. Since floodplains are state property, their occupation is regulated through usufruct rights, a bureaucratic system that tends to favor farm owners who have access to information and institutional support. Both agencies have been inefficient in organizing a strategy to provide consistent support to communities willing to establish fishing accords. The dual "property" system of the floodplain, in which IBAMA regulates the use of the biological system (natural resources) and the Ministry of the Navy regulates the physical system (floodplain land), needs to be jointly evaluated by both institutions. Both institutions have proved to be efficient in helping local management systems in particular situations (chapters 3 and 6). Therefore, a strategy of collaboration between those agencies would enhance the ability to achieve more appropriate co-management systems with floodplain communities.

7.3.2.2. Economic Factors

Economic incentives have been one of the major factors driving individuals' decisions in the region. Floodplain activities have been influenced by economic cycles, and fish is currently the most economically important product in the floodplain (Chapter 3). Therefore, as the establishment of fishing accords implies a decrease of fishing effort by the local residents, the incentives to give up this economic activity depend on the availability of other activities that will generate at least as good an economic revenue.

The intensification of fishing activity has resulted from a lack of other economic activities both in the floodplain and in the urban centers (Chapter 3). Both urban and rural populations have been attracted to the fishing sector due to its low opportunity cost. For urban fishers, the lack of job opportunities has pushed them toward the fishing sector while floodplain populations were attracted to the economic efficiency of fishing on highly productive lakes to replace risky agricultural activities. In addition, economic differences in the production system due to environmental and social risks affect on how the local populations choose fishing over agriculture in the floodplain. Fishing is economically appealing to floodplain residents due to the provision of short-term revenue in comparison with agriculture. In general, fishing trips last up to a few days while agriculture involves longer periods of time (three to six months) and generates one-time seasonal revenue (at harvest). As a result, the failure of a fishing trip represents the loss of workdays whereas a failure in the crop harvest represents seasonal loss. Therefore, the short-term investment and revenue of fishing is an important factor driving households' decisions (Chapter 4).

The economic trend of fishing intensification in some floodplain communities (Chapter 4) opposes the findings that fishing accords are more likely to succeed when the household economy is based on mixed activities (Chapter 6). It reveals the dilemma between the unsustainable immediate return of fishing intensification and the sustainable middle-term return from mixed economic activity. McGrath et al. (1994) present a model to demonstrate that there is an economic cost to the implementation of a fishing accord, when a short-term efficient fishing strategy is replaced by techniques that are much less efficient under low lake productivity. After the lake productivity is recovered, the fishing efficiency increases and maintains a sustainable level. For this reason, the authors conclude that the implementation phase of a fishing accord is a delicate period, when the support of alternative economic activities should be ensured to achieve success.

In short, the maintenance of a mixed strategy is essential to maintaining the sustainable use of the floodplain system. The trend of floodplain populations toward specialized activities can threaten their ability to cope with local changes (Chapter 4). Therefore, any strategy to establish fishing accords should envisage the economic aptitudes of a given region and create technical and institutional support according to the local context.

7.3.3. Local and Regional Social Justice

For floodplain communities who have suddenly lost control over a system that is essential for their subsistence, and that had been locally managed for generations, the establishment of fishing accords represents social justice (Chapter 3). On the other hand, fishing accords have some implications for the broader society. While the local populations deserve compensation for the external pressure they have suffered, one cannot forget the rapid growth of the urban population who will be deprived of resource use. The high unemployment rate combined with a narrow range of economic opportunity leave fishing as one of the most attractive activities. Depriving urban populations from floodplain resources is likely to increase the social cost through fishing conflicts between floodplain residents and the growing number of unemployed urban populations who are engaging in commercial fishing. This limitation of access could increase the poverty and violence in the riparian urban centers. In addition to employment restriction, the floodplain population's limitation of commercial fishing may ensure the fish availability to those households, but may also threaten the availability of fish in the regional markets.

Therefore, the implementation of fishing accords should present a structure in which some degree of access to urban fishers and food security for the urban population are ensured in order to achieve the balance of social goals on different scales.

7.3.3.1. Suppling the Market

Chapter 3 showed that a commercial fishing ban is one of the most common rules of activity in the fishing accords. In order to avoid fish shortages in the regional market, those rules should be carefully evaluated. For instance, if all floodplain communities follow the same strategy taken by ISM, which set up the ban for commercial fishing of scaled fish, the provision of fish in the Santarém market will be strongly impacted. On the other hand, the local rule of commercialization of the sedentary species *pirarucu* (*Arapaima gigas*) represents a contribution to the provision of a highly ranked fish in the market four times higher than in the other area where no local management of that species is carried out (Chapter 6). In other words, the steady provision of *pirarucu* (and catfish) in the market during part of the year occurs at the expense of its absence for six months and no provision of scaled fish throughout the year.

Although the ISM case shows that local management affects the distribution of fish in the regional market, it also points to a sustainable provision of some species for a period of the year. In this sense, the best approach is to establish a diversified system of local management based on the local aptitude of the communities. Chapter 4 demonstrates that floodplain communities face different ecological constraints, all of which may affect their capability to manage their local resources. For example, commercial fishing could be supported in communities with low potential for developing other economic activities, through local restrictions on gear or fishing spots. In other words, a fishing accord should not be seen as a blueprint-like strategy. Rather, it should be evaluated within local and regional contexts in order to integrate the local potentialities into the regional demand.

Since there are not many successful cases of fishing accords in terms of ecological and institutional sustainability, those accords, that present satisfactory outcomes should be supported regardless of the direct return to the broad society. They represent social capital in terms of local organization, a source of information regarding what variables are important to make a fishing accord work, and an incentive to other communities to see how successful local management can be if some particular steps are followed.

7.3.3.2. Source of Employment

One of the major problems of small-scale fishing is the relatively easy access to the system, and the low investment in endowment, including material and knowledge (Chapter 2). Therefore, as previously mentioned, the low opportunity cost of the fishing activity in the region represents one of the major threats to achieving the balance between local and regional social justice. While local populations deserve local control of the system, urban populations have been no less socially disadvantaged throughout their history. In fact, urban populations are partially represented by floodplain populations who migrated to the urban centers after selling their property. Another group is represented by unsuccessful settlers who equally experienced the lack of opportunities after suffering the failure of their production system along the roads. Regardless of their origin, the urban population has in common the lack of a subsistence production system, and this fact lowers their social resilience toward socioeconomic changes.

The urban fisher population has increased in the last 10 years due to economic change at the national and regional levels. The economic policy delivered by the national government in 1989 led to a national economic crisis followed by an increase of the unemployment rate. At the regional level, the collapse of the mining sector brought people back to the urban centers in the region. Therefore, although urban fishers emerged with commercial fishing, this population has increased rapidly. They also depend on fishing to supply their basic needs. Hence, if rules of access which prohibit the entrance of non-residents in lakes is established, urban fishers will be able to exploit only the main channels which are productive during only part of the year (August to December). This has major policy implications since a substantial segment of the society will be left out of the fisheries management system.

Therefore, access to lakes by urban fishers should be foreseen and ensured in the fisheries policy. This goal could be achieved by creating a strategy to support negotiations in areas of conflict between floodplain populations and urban fishers, and by establishing a zoning system where urban fishers could have access and control of a particular area as well.

7.4. THE CO-MANAGEMENT ENDEAVOR: TOWARD MULTIDIMENSIONAL MANAGEMENT

According to Charles (1992), conflicts raised by fishing management strategies stem from the polarization of three major policy goals that are treated separately:

biological efficiency (Maximum Sustainable Yield), economic efficiency (Maximum Economic Yield), and social efficiency (community-based goals). The author advocates a criterion of efficiency which accounts for these three axes. A similar argument has been made in this dissertation, in which conservation, development, and social justice have been accounted for in the analysis of the fishing accords.

Fisheries policy in the Amazon has emphasized the biological-economic axis. The fishing regulations are based on a homogeneous national legislation, and supported by several regionally based decrees that are not necessarily congruent with the ecological reality of the region (Isaac et al. 1993). Fishery biologists argue that fishing management in the Amazon can be analyzed in terms of four possible management models: 1) permanent prohibition of commercial fishing, 2) establishment of administration to preserve the present diversity of catch, 3) establishment of administration to obtain maximum yield, and 4) doing nothing (Bayley 1981).

Petrere (1991) advocates the implementation of a fishing policy based on a mix of the first three strategies with accountability to regional particularities. The author proposes four main types of regulations: access limitation, gear and mesh size restrictions, seasonal closure, and lake reserves. In 1996, several inconsistent regulations were invalidated as result of a negotiation process among local fishers, researchers, and the government (Chapter 3). However, the shift to a more congruent structure of the rules has not been able to halt illicit fishing. Similarly, salary insurance received from the government during the fishing closure season has not kept fishers from fishing. Therefore, besides the need for a regionally based fishing regulation congruent with the system, fishing management needs an efficient monitoring system. In addition, while fishing regulations may control fishing effort, other environmental factors that affect the fish population, such as habitat destruction, have not been addressed in the fishing policy (Goulding et al. 1996). In this regard, the implementation of "lake reserves" seems an appealing strategy to address fisheries management in a systemic fashion that focuses on floodplain productivity and local monitoring. The concept of the lake reserve represents an effort to integrate the systemic approach with the human dimension of the floodplain system. McGrath et al. (1999) define lake reserves as systems of integrated use for commercial and subsistence purposes that are compatible with the ecological and social features of the system. Therefore, fishing management should focus on the floodplain system with a compatible strategy of monitoring. Nevertheless, one of the major goals of this dissertation is to show that the challenge in integrating fishing accords in a broader sustainable zoning system stems from the lack of accountability for social and ecological heterogeneity of the floodplain.

Fishing accords are social capital that can be a starting point in the process of implementing management of the Lower Amazonian floodplain. Yet, the participation of the local population in the process of implementation is essential to make lake reserves work. Therefore, steps should be taken to move from a centralized, imposed structure of management to a participatory co-management system. In a broad sense, co-management systems are institutions which combine scientific and local ecological knowledge (McGoodwin 1990), and distribute organizational responsibilities between users and the government (Pinkerton 1989b). Thus, the legal recognition of fishing accords represents a pathway in which both goals can be achieved. Yet, like any other local management system, a fishing accord is a package, including both "social capital" and "social costs," such as class interest, local conflict, and discursive manipulation (Davis and Bailey 1996, Palmer and Sinclair 1996, Ruttan 1998).

As pointed out by Davis and Bailey (1996), "the rhetoric of fairness and equity (implied in community-based management) can frequently mask pursuit of self-interest and entrenchment of power, particularly in local community settings where status and economic elite are embedded" (p. 253-54). If the representation of different groups is not ensured, local elite can dominate the arena of decisions and "participation" and "local knowledge" input will take place only among a small fraction of the users. As pointed out by Palmer and Sinclair (1996), users can select the information to be shared according to their economic interest; and the users are heard according to their individual power. Therefore, the implementation of a co-management system by the devolution of the power of decision to the local users may only enhance the power of the local elite (e.g., middle and large-scale ranchers) by biasing the local knowledge and decision power toward those individuals.

Fishing accords are not necessarily a result of democratic decision-making processes by floodplain residents. In some cases, farm owners influence community members to create fishing rules only to protect their own interests, such as prevention against property invasion and cattle poaching (Chapter 3). Similarly, fishing accords may not represent a commitment to fish conservation by local residents either. Sometimes, local residents can establish fishing accords to keep non-resident fishers out but are not able to control their own fishing (Chapter 6). Therefore, a co-management model that is based on the integration of local management requires a careful analysis of the social context in which the implementation of fishing accords will take place. The recognition that local management systems take place in a complex social arena may help to improve the implementation of any local collaboration by emphasizing the mechanisms that enhance social capital and alleviate the influences of the "social cost." In this regard, the process of building local cooperation should focus on: 1) the nature of collaboration with scientists and government; 2) how to screen communities with high potential to accomplish local duties; and 3) how to monitor the accomplishment of duties by the partners.

7.4.1. Nature of Collaboration

One of the most important contributions of scholars with regard to natural resource management has been their advocacy of the integration of local management systems into a larger policy framework (Pinkerton 1989a). Forms of community-based management have been extensively described in the literature and claim the importance of strong social ties (McCay and Acheson 1987a), value for biological conservation (Berkes 1989), and their positive implications for policy (Ostrom 1990, McGoodwin 1990, Bromley 1992). In the Lower Amazon, a similar approach has been taken to demonstrate the potential of local management for conservation of fish resources (Hartmann 1989, McGrath et al. 1993b, Castro 1995, McGrath et al. 1999). However, local management systems are not a panacea, and their efficiency varies according to the ecological attributes of the resources to be managed. Therefore, the success of local management in a co-management strategy depends on how well its social and ecological boundaries are defined (McCay and Jentof 1996). The discussion in the former chapters shows that fishing accords have relatively clear social boundaries (including local residents and farm owners) and ecological boundaries (lake systems and, eventually, the surrounding grassland and natural levees). Therefore, the role of fishing accords in the implementation of floodplain management is socially limited to local occupants while the problem of urban fishers should be solved through other policy strategies. Likewise, fishing accords are a more efficient way to conserve sedentary species whereas their effectiveness in controlling short-distance migratory species remains to be tested, and will surely not efficiently conserve long-distance migratory species. The recognition of such limits in the fishing accords is essential if we are to clearly define the role of such institutions so that reasonable expectations can be outlined and strategies to complement the general goal can be designed.

The second aspect related to the nature of collaboration is how local users can participate in the management design. Management systems are backed by scientific information, while input from resource users is rather rare. Usually, collaboration between the government and local users depends on how the two parties find a mutual interest in cooperation, a condition that is more easily met in developed countries. For example, the economic importance of the resource and historical factors have led to a stable co-management system in Japan (Ruddle and Akimichi 1984). Likewise, the importance of the economic value of fish has driven co-management in countries where fishers' unions have been efficient in addressing the fishers' interests, such as in Denmark (Sen and Nielsen 1996, Nielsen and Vedsmand unpubl.) and in Norway (Eythorsson 1995). Even in more complex cases, like the British Columbia salmon case, in which grassroots and NGOs, backed by popular support, were able to exert strong enough pressure upon the government to force it to cede some control to the local population

(Pinkerton 1994a). The Maine lobster industry is also a case in point. Local fishers, fishing industries, and governments have been working together to change, monitor, and enforce legislation (Acheson 1989). Therefore, developed countries have effective mechanisms, which force the governments to engage in co-management, through economic importance and/or popular claim. On the other hand, attempts to create a co-management system in developing countries have been merely cosmetic governmental plans (Sen and Nielsen 1996), such as in the Caribbean region (Sandersen 1995, Brown 1996) and the South Pacific (Doulman 1993). In order to implement an efficient co-management system, the two sides (users and government) should be provided with incentives.

The interest of local populations to participate in a co-management system based on a fishing accord is easier to achieve. They can participate by sharing information about the system (local knowledge) with researchers, defining regulations with governmental agencies, and monitoring. Chapter 5 discusses how local populations rely upon local knowledge to formulate some rules in the fishing accords. The combination of scientific knowledge with local knowledge can enhance the ability of policymakers to negotiate fishing regulations that are congruent with the ecological and social settings. Chapter 5 also shows that local populations are efficient in monitoring some fishing rules (e.g., rules of access). However, the violent sanctioning system currently used in the fishing accords should be re-formulated in order to avoid further conflicts. On the other hand, local populations will not give up their sanctioning system unless the government is committed to an efficient enforcement system in which violations reported by local agents are punished. While local populations are efficient in monitoring non-residents, they usually fail to monitor themselves. Therefore, the right to manage the local system should be given to the local populations in return for the commitment agreed upon following a set of enforceable duties. Considering the learning process of the co-management system, data on production, violations, and conflicts offer an essential basis for a continuous evaluation of the process. In this regard, local populations should provide policymakers with regular reports on those subjects. Because of the multiple uses of the floodplain system, monitoring should not focus solely on fishing, but on the whole system in order to ensure the ecological integrity of the floodplain ecosystem by regulating the use of the subsystems (such as grazing rights, forest timber extraction, burning of grasslands). The increasing frequency of accords that focus on the system as a whole shows a potential trend toward engaging local interest in the systemic management of the floodplain (Chapter 5).

Persuading the government to accept local collaboration is more difficult. Pinkerton (1989b) argues that government support is more likely to take place if a combination of four main factors is present: 1) fish are a valuable economic resource for the country, 2) the institutional structure has clear mechanisms of checks and balances, 3) there is strong pressure emanating from the society, and 4) users are well organized. Most of those factors are missing in the Amazonian floodplain. Therefore, the interest of the government in designing co-management systems may represent a major problem in such an enterprise. If governments have no incentives for a long-term commitment, a co-management system may become simply a political action to solve immediate fishing conflicts with no further effort to achieve sustainable use of fish resources through local development. Such a process has been taking place on the uplands, where land titles were given to migrant settlers in order to alleviate land conflict in other regions. As a result, due to the major short-term political goal, those "development" projects were carried out without provision of minimum institutional support to solve technical, social, and ecological constraints, leading to high social and ecological costs (Bunker 1985, Schmink and Wood 1992). In this regard, grassroots organizations play a major role in maintaining pressure on the government to make a long-term commitment (Schoenenberg 1994). In short, not only should local organization be emphasized, but also organization of governmental offices. Moreover, the collaboration between the government and the local users requires a matrix of rights and duties, and a way to enforce such an agreement (Pinkerton 1989a). Therefore, once the nature of collaboration from local populations is defined, criteria to choose the communities to collaborate should be carried out. This issue is discussed in the next section.

7.4.2. *Screening Potential Communities for Cooperative Management*

Despite the potential of fishing accords, their implementation as a starting point for a collaborative management system represents a double-edged sword. On the one hand, such a strategy aims to achieve the participatory approach, which has been emphasized in the scientific and political discourse. On the other hand, the success of a collaborative approach depends on a consistent design to avoid such perverse behavior as free-riding and rent-seeking.

Although IBAMA has shown interest in helping communities to design fishing accords, this governmental agency is understaffed and underbudgeted, a fact which limits its ability to work with many communities at the same time. Every year, dozens of communities submit their "fishing accords" to IBAMA in order to obtain formal endorsement from the government; therefore, the effort to design a co-management system should focus on the support of a small number of experimental cases in order to avoid threats of institutional instability in this enterprise. The approach of "demonstrative projects" has been adopted by the Pilot Program to Conserve the Brazilian Rain Forest of the Group of Seven (PP-G7)[2]; yet, there has been little discussion regarding criteria to choose the settings. Although failures will occur, the definition of clear criteria in screening potential collaborators is essential to minimize the chance of those failures, as they can affect the local populations' credibility in the eyes of the government.

The criterion necessary prior to choosing a community is the local interest in participation. Local interest should be carefully evaluated, since local elites tend to manipulate the discourse in their favor. As discussed in Chapter 4, floodplain communities are not homogeneous, and local interest should come from consensus in order to avoid internal conflicts. In addition to local interest, the community should offer the potential to successfully address the diverse and complex array of challenges involved in the process of implementation of fishing accords. In order to evaluate such a potential, the definition of a Minimum Data Set in which several aspects affecting fishing accords would be assessed in the requesting community.

In the previous chapter, I pointed out that the success of fishing accords depends on ecological, historical, political, and socioeconomic factors. Table 7.1 is an attempt to synthesize the major factors that should be addressed during an evaluation, which could

[2]http://www.gtz.de/pp-g7/english/index.html.

be carried out through rapid participatory assessment; such an evaluation is a powerful methodological strategy for several reasons. First, it can be undertaken in a short-term fashion (one week on average), and allows periodic revisiting. Second, it allows the collaboration of the local population in the evaluation, which creates a closeness with researchers and governmental agencies. Third, it is based on a multi-disciplinary team who can more efficiently address the integrative issues listed in Table 7.1 through the gathering and analysis of collective data (Nieuwkoop et al. 1994, Beebe 1995). Finally, rapid appraisal is flexible enough to integrate different methodological tools that are appropriate for the region. Methodologies used in this study, such as CEC (rapid community census), remotely-sensed data, historical analysis, socioeconomic survey, and conflict analysis proved to be efficient in generating information on demography (both at the household and community levels), spatial distribution of different landscape units, resource access, and social organization of floodplain populations.

In short, the strategy for collaboration should "start small," from demonstrative projects with high potential of success to a gradual move toward more complex systems. The rationale behind this strategy is the need for strengthening both government and grassroots institutions; such a process is more likely to take place in a less conflictive context. Since this process is based on a trial and error process, it is important to choose systems which can better recover from the impact of eventual errors that may take place during this learning process. Successful experiences can create incentives to local populations to be committed to co-management in their communities. This trend was observed in neighboring communities of ISM, where several residents have manifested their interest in organizing similar management systems. Therefore, in order to establish a formal collaboration, it is important to evaluate whether the willingness to participate comes from all the different segments of the community and if the community has the potential to coordinate the local management.

Table 7.1. Minimum data set to evaluate potential success of fishing accord systems.

Ecology	Methodology
Resource distribution	Remotely-sensed data
Fishing productivity	Rapid survey
Environmental risk	Questionnaires
	Risk assessment
Socioeconomy	
Household economy	Rapid assessment
Economic alternatives	Rapid census
Strategy of resource use	Household sample
Demographic pattern	
Local Organization and Institutional Analysis	
History of the group	Rapid census
Leadership system	Key informant interviews
Rancher/Smallholder relationship	Conflict analysis
Internal conflicts	Historical analysis
Local tenure system	Rapid assessment
History/Structure of the fishing accord	
External conflicts	
External support	

A second component that must be assessed is the ecological condition of the system. A system's ability to recover depends on how impacted the system is. Therefore, the ecological assessment would give information on how fast the system could recover under local management. The ecological analysis should approach the floodplain on a systemic basis to consider the interconnectiveness of subsystems and to evaluate the level of ecological resilience.

In sum, a combination of a minimum of data in social (economic, political, demographic, and cultural) and ecological (biotic and abiotic) aspects of the system should be generated in order to provide a short-term assessment of the potential of a community to carry out a successful co-management task. However, the evaluation of potential for a community is not enough to ensure the success of the collaboration. Once the collaboration is created, a monitoring system should also be established in order to evaluate the accomplishment of commitments between the parties. This issue is discussed in the next section.

7.4.3. Monitoring System

The specific social and ecological context in which resource use takes place demands a strategy of action. There is no "model" of local development or conservation, but a process of institutional crafting which is shaped according to the particular context (McCay 1988, Ostrom 1992a, Pinkerton 1994a). Such a process demands careful checks and balances which provide an arena where negotiations for conflict resolutions are solved and mistakes/achievements are constantly evaluated (Ostrom 1990, Oakerson 1992). Therefore, a monitoring system is a major component of any co-management system. It should represent a strategy of "followup" on ecological and social issues, addressed in a dynamic fashion, in order to use both positive and negative lessons in favor of an adaptive management.

Monitoring the effect of institutions on conservation and development is not an easy task. Researchers, policymakers, and local populations usually do not share the same perceptions toward how to measure the performance of the managed system. Therefore, measuring the changes that occur between implementation of a fishing accord and a scheduled review, perhaps one year later, should be defined among the three actors in order to compare expected and actual outcomes.

Particular indices should be defined, including representatives of each actor in charge of the designing and monitoring of the system. Such indices should emphasize four major aspects of the collaborative management: 1) ecological patterns such as lake productivity and land cover change (e.g., flooded forest and grassland); 2) social dynamics such as communication network, conflict analysis, and level of participation; 3) welfare such as household economy, health indices, and food security; and 4) the level of violations among the parties in the collaboration.

The indices should be periodically checked in order to address negative outcomes. Local populations should be strongly involved in the monitoring system through data gathering and analysis. For example, lake productivity could be based on landing statistics at the communities coordinated by local residents. Likewise, social dynamics and welfare could be checked through meeting minutes, conflict reporting, and a household socioeconomy survey. Such data should be contextualized by a broader analysis taken through rapid participatory assessment, including land cover analysis through satellite imagery techniques, and further evaluation of welfare and social dynamics.

The monitoring system should track two major aspects of the management system. The first aspect encompasses the number and degree of violations by any participants of the party. Commitment between the parties should be strongly enforced in order to keep transaction costs low. The second aspect is related the evaluation of the effect of welfare improvement on the strategy of resource use. As discussed in chapters 3 and 4, local populations are flexible in their patterns of resource use according to internal and external factors. Any change in the structure of opportunities (such as economic assets, labor force, land tenure) is likely to influence decisions to invest in other activities that may affect the ecosystem. For example, control over one resource may trigger a new set of opportunities for resource use that may be harmful to the ecosystem integrity. In this regard, the increasing involvement of floodplain households in cattle ranching in the floodplain may represent the issue of most concern as far as the increase of household income is related (Futemma et al. 1998). Thus, the accomplishment of welfare vis-à-vis resource conservation demands a careful institutional development that is able to check trends, foresee possible negative effects, and discuss alternatives in advance, in order to ensure the sustainability of the system as a whole.

7.5. CONCLUSION

The strategy of natural resource management has been problematic on two levels: 1) identifying the problem; and 2) implementing policies. The problem of open access has been taken for granted by policymakers who, in solving the "commons problem," have undermined the potential for social capital to be used in the management of natural resources. On the other hand, several scholars who advocate collective property uncritically assume that such a type of property regime is always pro-conservation of resources. There are innumerous examples of analysis that move from the polarization of skeptical and romantic approaches to a thorough analysis of local management systems in terms of their potentials and limitations vis-à-vis the incentives faced by the actors in the system. The focus on the strengths and weaknesses of the fishing accords reveals that fishing accords have enough strength to be included in a co-management system, but also have enough weaknesses to fail unless constraints are appropriately addressed. Such an integrative approach, which contextualizes local management within historical, ecological, and social dimensions, seems to provide a strong analytical tool for helping policymakers integrate fishing accords into a broader management plan.

The issue of co-management raises the second-level problem of how to implement a policy. Decisions on how to intervene in order to solve problems related to the dual goal of conservation and development depend on the theoretical approach used to design the strategy. Modernization theory, upon which the fisheries management in the Amazon has been based follows top-down, blueprint-like strategies stressing technological improvement of large companies in order to strengthen the economies of scale while monitoring systems are carried out by centralized governmental agencies. This approach can lead to a rapid increase in fish production in the early stages; however, fish depletion, fishing conflicts, land concentration, and urbanization are unaccounted long-term consequences which represent high economic costs at both the local and regional levels. The process of fisheries development in the Amazon has led to a two-way trend toward resource use. The social conflicts, lack of economic support, and encroachment of floodplain systems have drawn local populations to the urban center while unemployment in the cities has pushed the urban population into the fishing sector. Should this process continue, the floodplain will experience a new socioeconomic change, in which fishing will be carried out by populations with no incentives to maintain the lake productivity, while the grassland will be taken over by cattle ranchers. This scenario could strongly threaten the integrity of the floodplain system (McGrath et al. 1993a).

The shift of focus toward a local-based development model has initiated an alternative approach to policy by promoting a bottom-up strategy in which local actors have an active part in the decision process. However, effective results from this process are usually far slower than those provided by modernization theory. The tradeoff between short-term outcome in production through ecologically and socially unsustainable policies and long-term outcome through ecologically and socially sustainable policies is a dilemma faced by policymakers and users. The increasing fishing conflicts in the Lower Amazon reflect the result of the modernization-based policy, which calls for a humanized approach to fisheries development. The beginning of co-management through the legal recognition of the fishing accord represents a major step in this direction. However, the recognition of the complexity of the floodplain is fundamental to designing a long-term management strategy which can gradually fit the ecological and social features of the system. Such a process has been dubbed "adaptive management" (Walters 1986), "muddling through" (McCay 1988), or, as Ostrom (1992a) calls it, "institution crafting." Regardless of the name, the concept is that the management of the floodplain should be envisioned as a learning process in which the many mistakes that will be made can be used to re-shape new measures. Therefore, an institutional arrangement that can efficiently screen potential collaborators and develop a check and balance system to monitor the management strategies is the most important focus for sustaining this process.

As a conclusion, this analysis of the fishing accord confirms the hypothesis that groups influenced by relatively similar, larger-scale external factors may respond differently according to the ecological and social structures of opportunity and constraints defined at the local level. Therefore, the emergence of fishing accords reveals the human agency in responding to constraints but also creating new opportunities in the social and ecological realms. Thus, this adaptive strategy to a complex system can vary in performance according to the local endowments provided by the communities' residents. Resource management is a social enterprise in which incentives drive performance. However, the floodplain populations face ecological, social, and institutional heterogeneity. The acknowledgement of diversity of incentives and interests by the actors involved in the use of resource in the floodplain is essential to drive a strategy of co-management system in which local empowerment is accompanied by mechanisms of conflict resolution. In particular, internal conflicts are a key issue in the implementation of a local management in which local representation in the decisions can be achieved. In order to assess the problems related to fishing in the Lower Amazon, it is necessary to analyze the matrix of fishing depletion and institutional problems. Such a strategy is possible only by integrating ecological, historical, socioeconomic, and political factors at both local and regional scales.

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BIOGRAPHY

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