Social Learning and Community Adaptation:
Local level study of environmental impacts and adaptation to climate change

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Abstract

This paper looks for a perspective on community adaptation to climate change in the Amazon fisheries. We argue that three sets of factors are influencing their different approaches to adapt to climate change: culture, information and institutions.

First, we propose to understand the processes that mediate perceptions of climate and ecosystem change and the adaptive responses at the levels of the individual and the community. In this context, adaptation and the degree of vulnerability of small fisheries are functions of culture (e.g. repertoire of responses, knowledge of environmental signals), society and economics (e.g. social networks, institutions, infrastructure) and the environment (e.g. land cover, lake systems, rainfall distribution).

Second, we should take into account the production and dissemination of biodiversity and climate information and models to regional and community levels, especially small fisheries. We found that for fisherman in Manoel Urbano (Acre), memories of flooding tend to decrease significantly after 30 years, but for extended drought tend to decrease after 10 years. Fishermen interviewed in 2010 did not remember as significant the El Nino Southern Oscillation (ENSO) drought of 1997, one of the strongest records. This helps explain why fishermen have limitations not changed their management measures in the face of strong climate events.

Third, we will focus on institutions and principles that must be designed for collective action. Adaptation to climate change depends on forms of institutional arrangements that facilitate decision making and response, as well as household economy within and across levels. The conceptual framework of Social-Ecological Systems places fisheries adaptations within a local cultural and environmental setting that includes climate change knowledge.

Amazonian fisheries communities are diverse and dynamic, varying in their knowledge of and dependency on the environment, cropping practices, cultural ties and density of social networks. They are shaped by cycles of forest economy and their connection to environmental systems and regional institutions and infrastructure. Small fisheries communities in Acre and Para states are particularly susceptible to two interrelated environmental conditions associated with climate change: extended drought and duration of floods. These conditions directly affect their economic activities, livelihoods, residential patterns, dependencies on social networks and exposure to diseases. The level of intensity and duration of climate events, such as extended drought, affect the vulnerability of small fishers in terms of food security, credit debt, health problems and social violence.

Introduction

The municipality of Manuel Urbano lies between the Purus and Chandless rivers. Local fishermen either live in the town itself or in small communities on the floodplains of the Purus River where they make a livelihood by cropping and fishing in the river and the neighbouring lakes. Most of the fishermen are descendants of rubber tappers that have lived in the region for several generations having taken part in the great the rubber boom and in the first experiences with community work in the region as was the case with the community of Paissandu em 1969.

Fishing is most intensive in the months of June when it becomes feasible in the seasonal floodplain lakes and again from September to November due to the spawning migration of small catfish like the Mandi, and other fish species like the Branquinha and Curimata. The main species that

are captured the municipality of Manoel Urbano in are Branquinha, Cascuda, Curimata, Mandi, Sauna and Mapara. Also, a small local group are managing the Pirarucu in target lakes.

The fishermen report that in 2009, the waters began to rise in September and the high water lasted until May, one month longer than usual. They remind us that rainfall patterns have also changed insofar as the rains always used to begin in September but nowadays their onset is delayed until November.

The variability of the flood pulse of the rise and fall of the seasonal floodwaters which is itself vulnerable to large-scale climate change, makes the work of identifying climate change impacts in the local sphere a very difficult challenge indeed. The same factors make it essential to register the socio-environmental aspects of climate change in the floodplains and the responses of the riverine communities to those changes in the interests of the region's socio-environmental sustainability over the coming years and decades. Unfolding the social learning process in Manoel Urbano in the State of Acre constitutes an important contribution to generating that kind of knowledge and information.

The aim of the present paper is to present a sociological analysis of the work undertaken by WWF Climate Witness Project[1] in the form of a study in the local sphere of environmental impacts and social adaptations associated to climate change, bearing in mind the inherent variability of the floodplain ecosystems and the adaptability that typifies the lives of fishermen.

Adaptation Conceptual Approach

Much previous work on adapting to climate change ignores the context in which people must evaluate the risks of changing their livelihood strategies or the risks of avoiding change. In adaptive strategies to climate change actors decide whether the new experience is comparable with anything they have experienced or culturally known and classified in the past. If yes, the adaptive behavior will probably repeat the previously used. If no, differences in the new experience will trigger more complex assessment to see whether the new experience can be fitted to the existing cultural categories and behavior or requires more contextual assessment. If the latter is the case, the individual and community must evaluate whether the benefits of producing new routines and practices influence the costs, whether risk and uncertainty are increased and how large the pay-off will be. These risks are assessed depending on the constraints of the individual as a member of a household or a community.

To understand community dimensions of climate change, we need to begin by examining the adaptive mechanisms of human populations to environmental change, the differential responses to the magnitude and the frequency of perceived and actual changes, and the differences between adaptive responses at the individual level and those visible at the community level. Adaptive responses to climate change are mediated by multiple factors, for example, perception of change in cultural dimensions, such as whether there is a repertoire of responses to that specific change. If flooding is a regular pulse in the region, riverine communities are more likely to have a specific terminology and the ways to cope than upland residents who have fewer experienced a flooding. But the memory of past events may not be part of inter-generational cultural knowledge. Manoel Urbano field surveys record that individual-level responses to climate changes are time dependent and heterogeneous, with some individuals coping quickly and others taking more time to adapt.

One of the challenges to community adaptation to climate change is to understand the scale of the problem: most environmental perception is local rather than global, and is manifested in experience with changes in precipitation and temperature and observation of fish and crop responses to current conditions. Achieving a link between local and global understanding of climate change requires connections within a broad information network, and a trust that the information from both levels is credible. Where a connection exists between climate factors and cultural practices, adaptation is likely to be easier and quicker. In the Amazon, research and forecasting models for drought events like ENSO are limited and produced at coarse resolutions and global scale.

[1] *Climate Witness Program*, internet address www.panda.org/climatewitness. *Oficina Testemunhas do Clima – Pescadores de Manoel Urbano* June 21 and 22, 2010 (Climate Witness Workshop Report - the Fishermen of Manoel Urbano.

Information at these levels is unhelpful at local level and often all that is communicated to rural communities, given the limitations of the information system available.

Social-Ecological System conceptual framework

A major problem on the upper Purus river is the potential loss of fisheries, agriculture and water resources. Understanding of the processes that lead to improvements or deterioration of natural resources demands a framework to describe and explain complex social-ecological systems (SESs). Without a common framework to organize findings, isolated knowledge does not cumulate. Manoel Urbano field survey have documented that the development of a community-based system is a continuous process of institutional learning and adaptation to resolve problems created by the different expectations of users and the institutional constraints on the range of possible options. Government participation is welcome, but the system cannot depend on it to function. The framework for SES (Ostrom, 2009) identify indicators that affect the likelihood of self-organization in efforts to achieve a resilient social-ecological system.

Social-ecological systems are composed of multiple layers and variables at multiple levels. In a complex SES, (i) resource systems (e.g., community area, extractive reserve, containing forested areas, water systems and ecological services); (ii) resource units (e.g., trees, fish stocks, and amount and flow of water); (iii) governance systems (e.g., the government, fisher´s union and other organizations that manage the protected area, the specific rules – collective fishing agreements - related to resource use, and how these rules are made); and (iv) users (e.g., individuals who use the resources in diverse ways for sustenance, recreation, or commercial purposes); are relatively separable but interact to produce outcomes at the SES level, which in turn feedback to affect multiple layers and their variables.

The prediction of resource collapse is supported in an open-access system when the resource harvesters are diverse, do not communicate, and fail to develop rules and norms for managing the resource. Direct predictions in Manoel Urbano, however, are supporting conditions that enable harvesters and local leaders to self-organize effective rules to manage a resource in a municipal lake system.

A core challenge in evaluating why some SESs are sustainable whereas others collapse is the identification and analysis of relationships among multiple levels of these complex systems at different spatial and temporal scales. Thus, we must learn how to grasp the complexity, rather than eliminate it from such systems. Figure 1 provides an overview of the framework, showing the relationships among four subsystems of an SES that affect each other as well as linked social, economic, and political settings and related ecosystems.

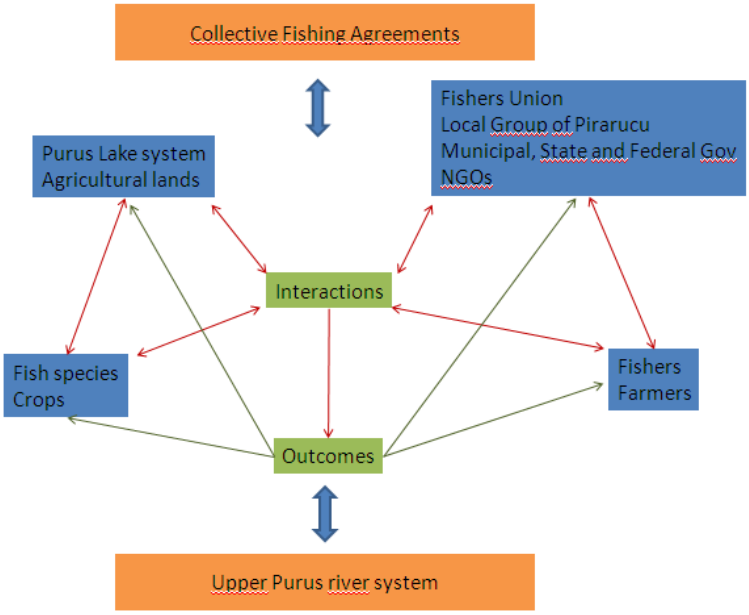

Figure 1. Socio Ecological System framework for Manoel Urbano study case

This framework helps to identify relevant variables for studying a pilot SES, such as the pirarucu fisheries and small farmers in the municipality of Manoel Urbano. It will provide common set of variables for organizing studies of similar SESs. The outcomes of this framework´ evaluation help the designing of data collection and monitoring systems, guidelines of fieldwork, and findings about the sustainability of SESs, specially looking the implementation of adaptation strategies. It also helps on identifying particular policies that can enhance sustainability of SESs.

SES framework, applied in Manoel Urbano will study questions, such as, when will the users of a resource invest time and energy to adaptive strategies to climate change?. Manoel Urbano field survey have found that the fishermen have invested in designing and implementing costly governance systems to increase the household economy and fish stocks (Oviedo, 2006).

Using survey, ethnographic and archival data from Manoel Urbano´ SES, this paper discuss fisheries´ sources of knowledge and long term memory of climatic events, drought, flooding and resource use events; their sources of climate information; their responses to drought and flooding and the impact of changing rainfall patterns on cropping and land use. Method will highlight the challenges of adaptation to climate change created by the influence of culture, information and institutions on collective action and the lack of communications skills to translate large scale forecasts to local needs.

Floodplain dynamics

Variability is intrinsic to the floodplain system and not only to the annual sequence of natural events (especially the seasonal nature of the rise and fall of the waters or flood pulse) but there is also variability over the years (detectable in the variation of the flood pulse rhythm). Local residents recognise two basic seasons, the rainy season or 'winter' which includes the period when the rivers rise and flood and roughly corresponds to the first half of the calendar year, and the dry season or 'summer' when the rivers drop down, occupying the second half of the calendar year. In terms of the ecology of the floodplains and the lives of the populations that live in them, the most critical element is undoubtedly the rhythm of the rise and fall of the waters and the height of the river in the course of the year – the 'flood pulse". (Junk 1997).

The flood pulse itself does not reflect local rainfall patterns. The relations between rainfall in a given place and the level of the river depend on how big the river basin is. In a small basin there is liable to be a direct relationship but in a river basin a big as the Purus, the relationship between river water levels and local rainfall is far more tenuous because the level of water in the river reflects the volume water collected from the entire basin. Added to the regional variations in quantities and

temporal distribution of rainfall in the basin there is also the factor of the "lag" in time between water's falling in one location in the basin and draining past another on the course of the river. There are also variations in the amount of rainfall from one year to another and at a more local level there are geomorphic and micro-basin factors influencing rainfall temporality and the height of the floodwaters. Lastly, the level of the waters is affected by land use and settlement patterns, the use of natural resources and other interventions in the natural environments and spaces that bring about considerable alterations in the relations between rainfall and the regional and local level of the river.

In short, the height of the Purus River at any given spot on its course depends on the socio-environmental and climatic conditions of a very widespread and (socially and environmentally) diversified area. The sheer scale generates a level of inherent variability in the annual flood pulse for a given spot. It means that there is commonly an annual variation superimposed on the great seasonal variation (Figure 2). Looking at that from the community's point of view, there is a considerable degree of unpredictability in regard to the intensity of the floods or the droughts in any given year.

There is no historical temporal series of rainfall data available for Manuel Urbano, but on analysing the rainfall figures for the period from 1970 to 2000 for the Rio Branco region in the eastern part of Acre state, Duarte (2005) observed that the daily rainfall average increased from 1970 to 1990 but that from then until 2003 there was an expressive reduction in the mean daily rainfall as can be seen in Figure 3. The reduction represented is of about 400 mm a year in comparison with the mean annual rainfall for the Rio Branco region of 1,944 mm. The author affirms that the data represent and compose a distinct tendency line.

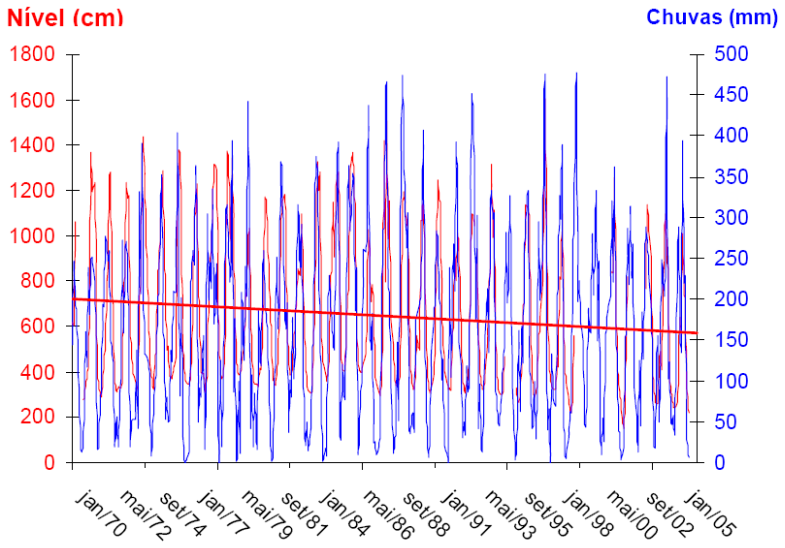

Figure 2. River level patterns in the middle course of the Purus River and rainfall Patterns in the capital of Acre state, Rio Branco; the red trend line shows an overall drop of 1 metre in the level of the river over a period of 35 years. Source: Duarte *et al*. (2005)

Duarte (2005) defines the following seasons for the Rio Branco region: a short dry period (June to August); a month of transition from dry to wet (September); a more prolonged rainy season (October to April) with the most intense rainfall being concentrated in the period from December to March and then, another transition from wet to dry in the month of May. That definition of seasons basically coincides with the one described by the Manoel Urbano fishermen. The author has not analysed the data for the period after 2003 but in an article written in 2006 he warns that the rainy season is taking longer to arrive than before and that the famous drought of 2005 (which the fishermen point to as one of the most significant events of climate change in Manuel Urbano) broke various meteorological records like: (i) the driest January in 36 years; (ii) with the lowest accumulated rainfall in the dry season, only 33% of what was expected; (iii) an annual rainfall deficit of 214 mm; (iv) and maximum diurnal temperature events in the months of August and September that were 7 to 8º C higher than the average maximum temperatures for those months; (v) relative humidity figures in those same two months repeatedly dropped to record lows of 30% (Duarte,

2006). The local fishermen have repeatedly narrated such examples and they also point to the delay in the arrival of the rainy season and its evermore precocious ending. They also remark on significant temperature increases in the months from July to September.

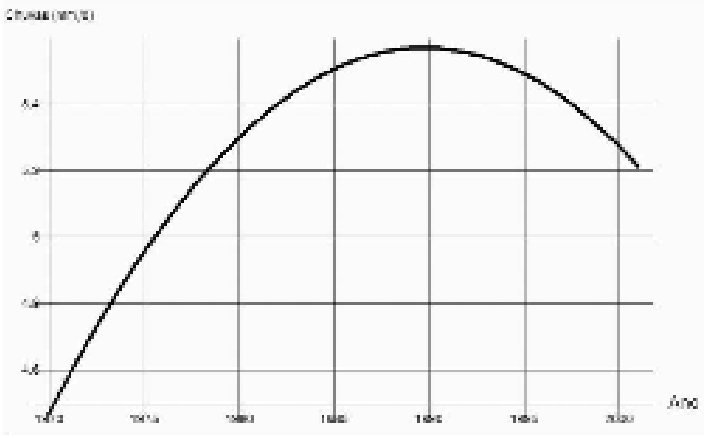

Figure 3 – Rainfall Tendency Curve for the Rio Branco Region in the period from 1970 to 2000. Source: Duarte (2005)

The forecasts of scientists and specialists regarding the impacts of climate change on the floodplains constitute a challenge to develop studies that can delineate impacts on a local scale. The effects on the floodplains are expected to include: (a) hotter and dryer 'summers' (dry seasons); b) increases in the intensity and frequency of events associated to the ENSO, in the form of more intense droughts brought about by El Niño and more intense rainfall in the years when La Niña influences the Amazon region; (c) expansion of the areas inundated by the tidal part of the Amazon river due to the raising of the sea level in the Atlantic Ocean; (d) increases in the volume of water held by the Amazon river during the rainy season in spite of the lower rainfall levels, but as consequence of increased run-off stemming from deforestation; (e) reduction in the viability of agricultural activities with the advent of hotter and drier summers; (f) changes in the distribution of fish species (Costa *et al.* 2003; Angelo 2008; Pinto *et al.* 2008).

Fishermen in Manoel Urbano live side by side with the variability of the floodplain because it also moulds local ecological processes like the migrations of the fish. Local fishermen reported that Pirarucu reproduction shifted in one month and the flood pulse is the major source of environmental variability.

It should be noted that the alterations observed in the floodplains do not stem from natural causes alone and so caution must be exercised in attributing the alterations observed to climate change. Historically, and even more so in the last few decades, deforestation and cattle ranching have strongly contributed to the degradation of the floodplains by eliminating a large part of the vegetation that protects the soil from erosion processes.

Economic flexibility and diversity

In most of the floodplain areas of the Purus river the people live in those parts that do not go under water (highlevel levees). Furthermore it is quite common for there to be considerable variety in the landscapes and aspects of the land occupied by the communities and they include low-lying and (silt) levees, highlevel levees covered with high forest, networks of lake, and perennial and seasonal creeks and streams all of which allow for a varied set of economic activities in different environments during the course of the year. For example in the low-lying and higher-lying levees formations, seasonal crops and fruit trees are grown, and there is cattle ranching and small animals as well as hunting, logging and extracting other forest products and particularly in the higher levees, perennial crops are grown in addition to fishing activities in the river itself and the lakes and streams.

There is also a lot of variety in what is produced in the floodplains as a function of other determinant factors: the environmental conditions in a given year (whether the flood is high and long

lasting, or whether the dry season begins earlier than usual; whether the migrations of fish are prolific or feeble in a given year), the financial situation of the family (whether fishing was good enough to finance the agricultural activities, whether the family experienced any health emergencies); the legislation in force, family preferences and the regional and community socio-economic tendencies.

In addition to making use of the floodplain many families also exploit upland areas (*terra firme*) to make feasible their agricultural activities like growing beans, tobacco, sweet potato, water melon, pumpkins, maize, rice, pineapple and fruit trees and in some cases they use the upland for their cattle ranching activities too. Another aspect is the intense intercourse between life in the floodplain and life in the town of Manoel Urbano, centre of the Municipality, partly due to the nearness of some communities to the town and partly due to the extensive network of family ties that bind the floodplain and the town together socially and economically. Accordingly, the basis of the social and environmental sustainability of the floodplain actually rests on economic diversity and the integrated management of a variety of elements and resources associated to the floodplain and upland areas.

In the past, whenever that economic diversity has been jeopardised, there has always been a subsequent intensification of the floodplain social and environmental vulnerability, as witness the events of the great rubber boom (Goulding, *et al.* 1996).

The socio-environmental context of Manoel Urbano

The municipality of Manoel Urbano lies in the upper Purus river basin, in the state of Acre. The municipal centre is located in the town of Manuel Urbano 215 km from the state capital Rio Branco and it can be got to along Federal Highway BR-364. However, the 85 km stretch between Sena Madureira and Manuel Urbano itself is still unpaved and can only be traversed in the months from June to September.

According to data of the Brazilian Geographic and Statistical Institute-IBGE, only 28% of the local population has completed basic education or secondary education, 26% of individuals over 10 years old have never been to school or have had only one year's schooling (IBGE, 2004). Manuel Urbano lacks infrastructure, only the main streets are paved with bricks, there are no collective transport services and there is no sewage system.

The town and the municipality's economy is based on subsistence agriculture, fishing and on the extraction of natural rubber and timber. 12.9% of its area lies within the Rio Purus Indigenous Area and part of the Xinane Indigenous Area. The area of the municipality which has been deforested represents 1.39% of the whole and is basically associated to the urban area of the town and areas along the course of the Purus river and the BR-364 highway.

Fishing in the region is basically associated to subsistence fishing carried out by the riverine communities and urban residents who in addition to their subsistence catches, sell any leftovers commercially. The Z-5 Fishermen's Union (*Colonia de Pescadores*) has 166 members. In the municipality there are 13 lakes suitable for fishing and there is also the course of the Purus River. Of the various lakes, six alone have more than half their surfaces choked up by aquatic vegetation that hinders fishing activities.

When the waters are at their height the floodplain lakes are flooded by the waters of the Purus River and that is when the movements of fish take place and they leave the creeks and streams and enter the lakes to reproduce. It is also the time when the fishing of some of the river species like the Filhote begins.

During the dry season there is an intensification of fishing in the lakes whose areas gradually diminish. The Santo Antonio lake for example is the object of important fishery management activities like the inventory of Pirarucu stocks and the subsequent capture of a determined quota of adult individuals, defined by the fisherman themselves and approved by the Brazilian Environmental Agency IBAMA.

The nature of the Manoel Urbano floodplains is consistent with economic diversification. The fishermen live in dynamic environmental conditions in the floodplain context and that in turn offers them a certain productive flexibility. They experience months and months with the waters at their

height followed by months and months of low waters. However, according to the fishermen themselves there is not much chance of taking advantage of agricultural activities because of the current decrease in rainfall and the extremely high temperatures in the summer. Furthermore, the long dry season makes the growing of the main crops like potatoes, pumpkins, tobacco, beans, watermelon and maize, unfeasible.

Currently, the productive activities of the communities in the region are practically restricted to fishing, subsistence agriculture and small–scale livestock raising (cattle, pigs and chicken). For most families fishing is the main productive activity and some families have more than one member engaged in it. A survey carried out among the communities in 2010 has shown that in the same year 95% of fishermen owned their own boat (whose average dimensions were 3,5 metres long with a load capacity of 221 kg.) and that 90% of them owned an outboard/inboard engine of the '*rabeta*' type; all of them fished in both the rainy season and the dry and 77% of them received the allowance afforded to fisherman for not fishing in the spawning season (*seguro defeso*). Furthermore, in the winter, they usually fish for 2.5 days a week (8 hours a day on average) and that activity brings in an average catch of 19.6 Kg. of fish (from which they extract 2.9 kg for their own consumption). In the dry season they spend 3.5 days a week (an average of 8.6 hours a day) in fishing activities and they catch, on average 38.6 kg of fish (from which they take out 7.3 kg for their own consumption) (WWF-Brasil, 2010).

The weekly expenditure of a fishing family ranges from R$ 49.70 to R$ 180.73. The income of a fisherman living in the town is made up of his salary as an autonomous producer (10%), his pension (15.1%), closed season allowance (62.5%), federal family allowance (1.8%), and other sources (10.6%). The composition of the income of a fisherman living in the community is as follows: salary (13.9%), closed season allowance (69.3%), federal family allowance (3%), other sources (13.9%).

In regard to infrastructure, the riverine communities in the municipality of Manoel Urbano are poorly served especially in regard to health and education. Very few communities have any kind of institution that offers infant or basic (primary and lower secondary) education and neither do they have a primary healthcare unit manned by an assistant nurse or a community health agent.

Most of the fishermen's houses are made of wood and roofed by asbestos sheets or thatch. Some homes have a generator unit shared with neighbours while others have electricity in their homes because of the Federal Government's Light for Everybody Programme. Among the fishermen that were interviewed in 2010, 63% owned televisions, 27% had radios, 100% owned a stove, 59% had a pan for making cassava flour, and 31% had a water filter in their homes. Most of the families interviewed had their own boats and inboard/outboard motors

Social learning and climate witness

Social learning, as a learning process that takes place in arenas of social interaction (such as work meetings, markets or group of fishers) and plays a key role in enhancing adaptive strategies used by fishers in Manoel Urbano, especially in community areas, where access to information related to climate and resource use decisions might be very limited. In this municipality, social learning was important to cope with factors that contribute to uncertainty in the payoff structure of investments, such as a severe climate event (e.g., drought, excessive rains), lack of infrastructure and markets for fishery products (e.g. pirarucu), and little presence of formal institutions.

By interacting with neighbors and observing their behavior and the outcomes of their decisions (e.g. collective fishing agreements), fishers complement and reconsider the knowledge obtained from their own experiences in important ways. In Manoel Urbano´ local group of pirarucu, managers have used biological indicators to demonstrate the extent to which a project has been successful, as well as revise management rules.

The theoretical basis of social learning is rooted in experiential learning (Kolb, 1984) and on participatory decision-making. It has been gaining strength in the study of human-environment systems, particularly in the fields of adaptive management and in discourses involving questions of sustainable development within the framework of human dimensions and environmental change. Some of the main attributes of processes of social learning include the build-up of a shared perception of problems among actors, build-up of trust as a base for critical self-reflection,

recognition of mutual dependencies and interactions, and engagement in collective decision and learning processes.

Within the social and political sciences, there is a wide range of applications involving the concept of social learning. For instance, 'fishing agreements' models is used to study situations where individuals would fail, according to the tragedy of the commons assumptions, to act as rational agents; however, under broader assumptions of bounded rationality, 'fishing agreements' has been shown to be more efficient in achieving productivity goals than individualistic decision-making processes in the context of lake systems in Manoel Urbano, Acre (Oviedo, 2006). This is the case with the adoption of new management practices by fishers, as uncertainty about possible outcomes often frequently plays an important role in explaining the spatial and temporal patterns observed in floodplain areas.

By observing outcomes of adoption of new management practices by neighbors, fishers make better informed decisions on whether to adopt a new practice or fishing rule. Social interactions with neighbors and social learning processes play an important role on increasing fishers chances of making productive use of the changing opportunities that are available in rural areas.

As 'fishing agreements' age, social learning helps fishers to maximize the use of opportunities related to public policies such as patrolling, public transportation for education and identification of better lines of agricultural credits. Social learning is also critical on enhancing fishers' ability to negotiate better commercial deals when selling their products, bargaining discounts or dealing with politicians on fish ponds projects. Thus, social learning might be seen as a product of intercommunications and sharing of experiences within a forming community. It allows fishers to make more effective use of information, and guides the community in taking advantage of their neighbors' experiences, reducing uncertainties that limit the use of economic opportunities.

Environmental impacts consistent with climate change and community adaptation

The results of social learning process carried out with the fishermen of Manoel Urbano reveal, on the one hand the climate changes that have taken place over the last decade and how consistent they are with the climate change impacts that were foreseen. On the other hand they have also revealed the adaptation strategies that the fishermen have been using with an emphasis on management measures (i.e. fishing agreements) and which have up until now, have made their social reproduction feasible

The social learning process showed that in the perceptions of the residents there have been six environmental alterations in their communities in the last decade: (i) the rainy season has become two months shorter and now goes from November (and not September as before) to April; (ii) the period of high waters has also diminished and now lasts from September to April (and not May as before); (iii) the low-water period has also shortened by one month and now goes from April to October while formerly it was from April to November; (iv) the unusual drops in temperature known as *friagem* have become less frequent and now tend to occur in the month of July whereas before they occurred sporadically in the months from May to July; (v) the heat in the summer months has become more intense; (vi) the reproduction period of the Pirarucu fish has become retarded by one month changing from September/October to October/November.

One of the environmental alterations that has the greatest socio-economic impacts on the communities is the shortening of the rainy season because it is related to the question of water for crops and the floods. Those fishermen that also do agricultural work in the floodplain and in the upland areas have been hampered by the lack of water and the strong droughts. In addition to the very high temperatures, the fishermen have noticed that in the months from July to September there is now hardly any rainfall at all. The second alteration that is mentioned in the fishermen's narratives is that the floods are greater and the storms that accompany them are more intense. That information from the fishermen may indicate that there have been alterations to the flood pulse rhythm. They also comment on changes in the relative abundance of fish species in their area. According to them the stocks of species like the Cascuda, Curimata, Mapara, Piau and the Mandi are smaller than they used to be. Without eliminating the possibility of climate change having to do with such reductions, it is nevertheless probable that the main cause is changes in the forms of land use

and the use of natural resources over the last fifty years, especially over-fishing, deforestation and the expansion of cattle ranching in the region.

In addition to the three abovementioned alterations related to weather and climate patterns, and other effects on the seasonality of the floodplains (including the flood pulse rhythm), there was a lot of attention given in the Manoel Urbano social learning process to mapping the occurrence of events such as exceptionally great floods or severe droughts. The fishermen's statements in that regard did not point to any particular changes in the frequency of extreme events.

In the social learning activity called 'The Line of Time', the fishermen identified three extraordinary floods (1955, 1975 and 1997) and three extremely severe droughts (2000, 2005 e 2010). The greatest threats posed by extreme floods are to property and nutritional security (fishing). According to the fishermen, the impacts of the droughts that bring about the biggest changes in their way of life (loss of crops and concentration of economic activities in fishing alone) are mainly associated to changes in climate patterns and the flood pulse.

Finally a comment must be made on the fishermen's allegations that the alterations they have observed stem from the effects of climate change on the Amazon. An adequate interpretation of such observations (local knowledge) would require a much deeper study of the communities and their residents to clarify inconsistencies in the reports gathered during the social learning process and further enriching and complementing their observations on environmental alterations with other information in the region.

Summary of Environmental Changes and Impacts on the Floodplain Consistent with Climate Change and Fishermen's Adaptations to them

ADAPTATION OF SOCIAL PATTERNS AND THE MANAGEMENT OF NATURAL RESOURCES	ALTERATIONS IN CLIMATE PATTERNS AND /OR THE FLOOD PULSE PATTERN					ALTERATIONS DURING EXTREME EVENTS	
	Shorter Rainfall period	**Shorter high-water period**	**Shorter low-water period**	**Heat more intense in the summer**	**Pirarucu reproduction period one month later than before**	**Great floods**	**Great droughts**
Giving up crop farming							
Concentrate economic activity on fishing alone							
Fishery management (Fishing agreements)							
Fields planted later than before							
Intense use of small boats and inboard/ outboard engines (overhaul or purchase)							
Going to the Purus river for water							
Limited surveillance done by the Volunteer Environment Agents							
Clearing land for planting done later than before (under-bushing and felling)							
Avoiding deforestation							

Limits to fishermen´s sustainability

In spite of all the difficulties fishermen face at the heights of the rainy season and the dry season, Manoel Urbano gives the impression of having considerable fishing potential in the regional context. That potential lies chiefly in the availability of floodplain lakes, the implementation of management measures in some pilot lakes and the benefits to be reaped by the class as a whole through the mediation of the Fishermen's Union especially in conferring the right to receive a closed season allowance. The improvement in family income and its close link to fishing activities is clearly illustrated by the results of a community survey conducted in 2010.

In spite of those apparently improved living conditions however, Manoel Urbano's socio-economic adaptation capability is in great jeopardy as compared with other riverine communities in Amazonian floodplain environments. The riverine communities in Manoel Urbano are extremely dependant on fishing and to make matters worse, most of the fishermen fail to see it as something they should be worried about. They themselves comment on the increase in the number of fishermen in activity locally and the diminishing size of the fishery stocks of some species among which are three of prime economic importance to them (Cascuda, Curimata and Mandi). In other regions the reduction of fish stocks may be an indication of the extent of over-fishing or of failing to bide by the regulations established in the fishing agreements. Paradoxically, the very allowance that is paid for fishermen to cease their activities during the spawning season to enable natural replenishment of stocks seems to give rise to a notion that their fishing activities, practiced with the current intensity are safe and sustainable.

However the community has already woken up to the idea of the danger inherent to unlimited fishing, as witness the fishing agreements that have been drawn up and implemented in *Santo Antonio, Bela Vista* and *Novo* lakes where fishing hours, catch quantities and the type of fishing equipment to be used are all defined and regulated. According to the Fishermen's Union, the fishermen of the *Santo Antonio* lake have the best level of community organisation in regard to fishery management and they effectively address the resistance and limitations encountered in implementing their fishing regulations. Interviews with individual fishermen show that stocks of Pirarucu and Branquinha fish have actually increased in that lake. On the other hand, 33% of the fishermen from the *Bela Vista* lake community still refer to the negative impacts of the fishing agreement established for that lake.

The visible reduction in stocks of the main species is seen as a change that will bring about adaptations in the fishermen's way of life but not as a threat to the social reproduction of the communities themselves. The changes are perceived in a comparison with the situation in the past and not as being indicative of the future and that furthermore the situation is currently being controlled by the existence of the fishing agreements.

Added to the communities' limited adaptation possibilities stemming from the small number of available alternative, there is the question of their increasing vulnerability to changes in the weather and climate patterns and in the flood pulse. If on the one hand the fishermen are better prepared to live with the annual variations in the dynamics of the winters (flood season) and summers (low-water season), on the other, they have practically reached the limits of their capacity for socio-economic adaptation.

Manoel Urbano fishermen have shown ways and approaches that have enabled them to live in a dynamic environment that engenders difficult living conditions. During the social learning process activities concerning scenarios for the future of the communities however, they showed awareness of the fact that if the current climate change trend is maintained and the impacts on the region stemming from them get worse, then the kind of life of that they lead today will be transformed.

Adaptation as cultural trait

From a Marxist perspective, the fishing communities are associated to a pre-capitalist form of production typical of societies where labour has not yet become a marketable commodity. There is a strong dependence on natural resources and the cycles of nature and only a partial dependence on the market. Those communities develop their own ways of managing natural resources, not with a view to making a profit but rather to achieving their own social and cultural reproduction. They also

form their own perceptions and representations of the environment imbued with ideas of association with nature and dependence on its cycles. One characteristic of that kind of situation is that their production, exchange and commercialisation activities are all actually adaptive strategies.

In addition to the diversification and the flexibility of the fishermen's production system there are other cultural factors that contribute to enabling then to adapt to the dynamics of the natural environment. Socio-cultural flexibility and variability go beyond economic practices and construct a socio-cultural universe that resonates with the environmental variability making up a context that is not an ecological determinant but a determinant of identity. It is a livelihood that does not merely react to the environment but that has its own characteristics, rhythms, and ways of perceiving the natural world and the social world. As Harris (2006), puts it, in floodplain culture there is no dichotomy between society and nature.

One notable feature of floodplain culture especially important to the study of climate change impacts, is the way of living time marked by a very strong tendency to living in the present or "presentism" (Harris, 2006) or as Lima and Alencar (2001) put it "being a floodplain inhabitant means living for the present". Social and economic actions in the floodplain do not depend directly on calendar dates (except in the case of those that are determined by relations with social actors external to the community such as saint's festival days, the closed season for fishing and so on). Instead, they depend on the relations among the floodplain residents and their environment as of the 'present' instant. As people say in the region, in the floodplain everything is always beginning over again while on the upland it is possible to build and accumulate and cast an eye on future prospects.

The idea that populations whose livelihood closely depends on natural resources live in a temporal universe strongly focussed on the present is by no means restricted to the Amazonian riverine communities. The idea is equally applicable to chronically poor population groups where constant need and the lack of any alternatives deprives them of any social reproduction perspective. What is important here in regard to the phenomenon of "presentism" as it manifests itself in the population in question is what it means in terms of the past and the future. Given that climate change takes place over very long periods of time then understanding the feelings and experiences of a floodplain community in relation to climate change and the impacts stemming from it requires at least a minimal understanding of the floodplain fishermen's relationships with the past and the future

The example narrated at the beginning of this paper illustrates very well the essence of presentism in the floodplain: in analysing the pattern of rainfall in Manoel Urbano, the fishermen are unanimous in declaring that the rains arrive later than in the years prior to 2005, but they are also unanimous in declaring that every year is an uncertainty. In fact nobody actually mentions how the rains 'will be' but only how they 'are'. The fishermen are aware that rainfall intensity can vary during the months of high water and that in the coming months, more may fall or less may fall.

The example not only illustrates presentism but it sheds a light on how the population relates to the future. A powerful awareness of the unpredictability of the natural environment and his way of life permeates the way the fisherman addresses the future, creating an inner state of the spirit that is basically adaptive. The fisherman thus strongly resists making any projections of future scenarios, whether they are in regard to the natural environment or to family and community life. During the social learning process in Manoel Urbano, the fishermen involved in the activities to create possible future scenarios only did so when they were prompted by specific questions that sometimes had to be insisted on to evoke an answer. Throughout the process, whenever an effort was made to stimulate reflections on the future consequences of climate change it was hard to get away from responses like "It's hard to say…" The most common way of handling the uncertainty involved was to attribute the outcome to Divine will: "It (the rain) may heavy or it may not, it is something that we cannot guess because it is all in God's hands".

While it is true that there is great reluctance to think about the immediate future unless in a sporadic and transitory manner, on the other hand, thinking abut the long-term future is more attractive insofar as it involves reflections on socio-economic practices, livelihood and relations with the environment. That broader future reflects the population's awareness of the elements that make their social reproduction feasible and the maintenance and possible improvement of the family and community's quality of life. The long-term future is more widely embracing and is thought out in

terms of those elements that are most essential to their current way of life — the size of the lakes, the availability of fish and the occurrence of fishing conflicts.

The floodplain communities live out time in a cyclic form that resonates with environmental dynamics and not only seasonal ones like the flood pulse and the availability of natural resources, but also cycles with a much longer duration like the geo-morphological transformations undergone by the lakes; and it is those that call their attention to the climate alterations and their impacts (Lima and Alencar, 2001). Socially, such long-term cycles are identified and denoted with expressions like "In the days of …" as for example "in the days when my parents were young" "In my grandfather's time", "In the days of the rubber tapping boom…" and so on).

In the Manoel Urbano floodplain, socio-cultural presentism is very similar in its way of living the past that some authors describe for the people in the middle course of the Solimões river. On the one hand the past is cyclic. The memory is not chronological, linear; marked by a succession of events, but is marked instead by cyclic events focussed on relations with the environment (Lima e Alencar, 2001). That is where the difficulty to remember dates and to estimate long stretches of time springs from. During the social learning process it became obvious how difficult the fishermen found it to place a date on events when we noticed that different groups were indicating different years for an identical event.

The experience in Manoel Urbano shows that history narrated by the floodplain fishermen is marked even more by periods of distinct socio-environmental contexts than by the cyclic nature of the environmental elements. In other words, those periods in which the environmental conditions (geomorphology, biodiversity, climate, etc.) and the social conditions (production, land use, use of natural resources, family, politics etc.) left their mark on the way of life in a different way from other periods and especially, in a different way from the present. Given the variability that is intrinsic to the floodplain and the adaptability of floodplain culture, the distinction between one period and another involves a complex context and not just the cyclic nature of natural events or even the dominance of a particular kind of productive activity. Given the absence of any formal written record of the history of the floodplain communities, studies of processes that take a very long time, like climate change and its impacts and the adaptation of populations must necessarily seek to understand those periods or cycles and realise that they will not necessarily generate a linear construction of the community's history – and that necessity poses a considerable methodological challenge if it is to be properly addressed.

Apart from their observation of the identification of past cycles, Lima and Alencar (2001) also noted how short the time span of floodplain inhabitants knowledge is rarely going back more than two generations. In the reconstruction of the history of fishing in Manoel Urbano (Line of Time) the memory of past events barely went back 50 years. The chart that was made showing the most notable changes and events in the communities over the last decades shows a considerable concentration of information associated to the last 10 years. Very few elements were remembered from 20 years back or more and significantly almost all of them were of an ample, wide-encompassing nature associated to socio-environmental alterations (like the introduction of cattle raising activities) rather than specific events like "Piraracus became scarce ".

The activity to elaborate the Line of Time reveals another aspect of how the past is lived and addressed by Manoel Urbano fishermen and what that means for any study of the local impacts of climate change on the floodplains. Three groups, each working with a different theme established a similar temporal divide line, namely "somewhere around 1964". Very few events prior to that date were recorded. Instead of delimiting a cycle in the past that date actually set the time limit on the history actually lived out by the older fishermen in the group. In other words, the result of the social learning process which set out to identify the social and environmental impacts stemming from climate change and the adaptation strategies adopted by the fishermen, was in fact basically constructed on the basis of the memories of individuals' own lives. There is no written record nor is there any oral tradition preserving the memory of the communities.

One of the difficulties that relationship with the past poses for studies on the local impacts of climate change on the floodplain and community residents' adaptations to them is that the only time phase that has any richness of texture with records of events and characterisation of environmental, social, economic and relational aspects, is the present. The past blends into certain "times" and it is

difficult to identify events and their details or what collective perceptions of them are apart from the mere identification of the elements that make up each "time".

The method adopted by the Manoel Urbano field work points to a way whereby an outline of the past can be sketched. It includes preparatory meetings, exploratory interviews, and the formal elaboration of procedures. In other words, there was some previous knowledge as to what to look for and how to help the fishermen to remember events as well as how to set about interpreting some of the answers obtained. Technical professionals that work with fisheries and representatives from the Manoel Urbano Fishermen's Union benefited the social learning process with their special knowledge.

The implications of 'presentism' and the way of addressing the future for community adaptation to the effects of climate change on the floodplains

Mentally approaching the future as if it were made up of two discontinuous horizons – one concrete and immediate that blends into the present, and another distant and abstract associated to elements that are of fundamental importance to the social reproduction of future generations, does not mean that floodplain fishermen are incapable of planning and carrying out actions that are aimed at future (or long-term) objectives. Studies in the Amazon have demonstrated the successes of many regions and communities in their management of the floodplain' natural resources especially in terms of fishery management (Castro and McGrath 2003; Almeida 2004; Pereira 2004; Isaac and Cerdeira 2004; Oviedo, 2006). They are the result of a complex process which began as grassroots movements in different regions, gained support from governmental and nongovernmental organizations end eventually brought about transformations not only in fishery policies but also in policies on land use and settlement (Oviedo, 2006); McGrath *et al.* 2007). The construction and implementation of community fishing agreements (which are highly dependent on surveillance) calls for considerable collective planning and action skills – debating, negotiating, planning, executing, learning, evaluating, adapting and so on – all directed at a common goal which is future in essence, namely: the preservation of fish stocks and their habitats.

The thinking behind those community fishing agreements however is orientated towards addressing a situation that exists in the present (the "scarcity of fish") and makes use of elements and strategies to be found in the universe of possibilities that exist in the present (effective area of the natural resource available for use/management, restriction of access to certain areas at certain times of year, existing social conflicts, collaboration in surveillance activities etc.) (Castro 1999).

The same can be said of the results obtained by the activity entitled 'Thinking what to do to deal with Climate Change and its Effects' that was carried out during the during the social learning process in Manoel Urbano (Meneses-Filho and Oviedo, 2010). The activity was an attempt to begin the planning process of actions of adaptation to those climate change impacts identified by the social learning participants. Four problems that had been identified in a previous activity – 'reduction of the stocks of the main species', 'Pirarucu reproduction and management threatened', 'spawning threatened by the migration of the fish from the lakes to the streams', and 'crop losses'- could at first sight, easily be interpreted as problems whose causes lay beyond the communities' governance sphere insofar as they were the fruit of ecological, climatic and social processes occurring over a much wider region than that in which the community lives.

Nevertheless, the reflection on what the communities could do about them generated suggestions for actions that could be implemented immediately or in the short-term - make surveillance more effective by making use of Volunteer Environmental Agents, clean up the lakes that were choked with aquatic vegetation, avoid the use of fine gauge gillnets, avoid deforestation, undertake reforestation, etc. Most of those actions reinforce participative management processes already underway (surveillance of compliance with the fishing agreements), or embrace an idea already successfully introduced in some lakes (like Pirarucu fishery management) or make use of management measures are already being tried (i.e., like the regulations prohibiting the use of fine gauge gillnets, the practices used to count Pirarucu stocks and the periodic meetings to review and revise the fishing agreement regulations).

From the point of view of socio-environmental sustainability in the floodplain, against a background of the ongoing global warming, the process of reflecting on actions to affect the future

may pose a considerable challenge. It is very hard to conduct sustainable socio-environmental planning when the temporal horizon only extends a few months into the future and, to use strategic planning terms, the 'objectives' and 'actions' actually have much more to do with the current situation than the future. In such a situation it is not possible to visualise a scenario situated in a far off future or in a reality that is substantially different from the present one.

With all of that in mind, during the activity 'Thinking what to do to deal with Climate Change and its Effects' the fishermen were asked to construct an adaptation agenda to be presented to the community and addressing the priority problems identified – (i) cleaning and restoration of degraded lakes choked up by aquatic vegetation, and (ii) more educative surveillance on a daily basis undertaken by the Volunteer Environmental Agents. The agenda identified actions corresponding to the various spheres of governance, that is, actions that could be undertaken by the community itself and actions that depended on other institutions to make them feasible (like the state or municipal authorities). In the question of implanting the actions the fishermen focused on the governance actions of the community level but it should be remembered that those actions in which community governance was very low, in other words the solution lies outside the community sphere, are mostly structuring actions related to public policies and which may well guarantee the long-term sustainability of the actions.

The fundamental difference here is that floodplain fishermen's attitude when faced with the unforeseeable, is to adapt. Thus once they had learned about climate change and how it is affecting their environment and livelihood, when the time came to decide what to do, the Manoel Urbano fishermen focused entirely on how to address the effects being experienced in the present and on actions that were within their reach to carry out immediately. In other words they addressed the question of climate change in the same way as they handle other unpredictable environmental processes they have previously lived through (geo-morphological alterations to the lakes, the height of the floodwaters, the severity of the dry season, the availability of natural resources).

In short, a predisposition to adapt (including the various social interaction and organizational aspects of adaptation) to the contexts that emerge from alterations to the environment (whether they are geo-morphological, involve natural resources or the flood pulse or climate change) is one of the characteristics that has historically identified the floodplain culture and enables to achieve its social reproduction and reproduce its livelihood. Adaptation here endows the floodplain residents' livelihood with a certain fluidity that mirrors their relations with a highly variable environment. It is difficult however for planning processes to address those characteristics, especially processes addressing extended time frames, as is the case with the evaluation of impacts and of adaptation to climate change.

Final remarks

The results of the work undertaken among the fishermen of Manoel Urbano under the aegis of the social learning process for climate change and adaptation show that local experiences and/or perceptions of the effects of climate change as lived out by the communities may be at variance with much more ample scenarios portrayed by academic studies. The diversity of effects that can be felt and observed when a local scale is used is far greater and possibly more variable than the projections of scenarios on the broad scale would suggest. There is greater potential for social and environmental losses but the populations' potential for adaptation is also much greater than was imagined.

This experience in Manoel Urbano shows the important role of the social learning process in generating critical knowledge for studies of climate change and its impacts. Furthermore, it shows that what is needed to get to know more about potential or actual adaptation strategies already being used to enhance social and environmental resilience in the floodplains, is to construct a mosaic of "witnesses" that are, at the very least, representative of all the diversity and variability of the environment and of the populations that inhabit it.

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