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Evaluation of farmers' vulnerability from a multidimensional point of view in the coastal plain of Tabasco, Mexico

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EVALUATION OF FARMERS' VULNERABILITY FROM A MULTIDIMENSIONAL POINT OF VIEW IN THE COASTAL PLAIN OF TABASCO, MEXICO.

Master thesis

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ABSTRACT

The evaluation of agro-ecosystems sustainability requires transforming complex aspects in others, more simple, that permit to point out tendencies at a system level. To do so, indicators are an efficient tool to get a general analysis in the most objective way. The aim of this master thesis was to develop a set of indicators that would evaluate the vulnerability of tropical agro-ecosystems in Tabasco, southeast Mexico. The work took place in two different areas of Tabasco, both in a lagoon context. The analysis was realized at two scales, the community scale and the activity of production scale, according to three dimensions: social, economic and environmental. The indicators showed clear vulnerability tendencies in the two areas of study and between the different activities of production. The vulnerability depended a lot from the contextual factors (geographic isolation, infrastructure, climate pattern, agricultural policies) and structural factors (nature of agricultural activities, governmental authorities, natural resources exploitation). The most isolated communities, of poor infrastructure and rural development plan were clearly the most socially, economically and environmentally vulnerable. The crop and cattle farming, sensitive to pests and diseases and hydric stress, that depend a lot on inputs and soil quality presented real difficulties whereas fishing and alternative productions were not that linked to the soil or natural resources quality and showed relative resilience.

Keywords: indicators, vulnerability, multi-criteria analysis, rural communities, Tabasco.

"The conscious and organized participation of local communities is the fundamental base to any sustainable kind development initiative"

The World Bank

SYNOPSIS

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SIGLES AND ABREVIATION

CBM	Corredor Biológico Mesoamericano
CCAD	Comisión Centroamericana de Ambiente y Desarrollo
CITES	Convention on International Trade of Endangered Species
CONABIO	Comisión Nacional para el Conocimiento y Uso de la Biodiversidad
ECOSUR	El Colegio de la Frontera Sur
ESI	Environmental Sustainability Index
EVI	Environmental Vulnerability Index
GEF	Global Environment Facility
GIS	Geographic Information System
HSVI	Household Social Vulnerability Index
INEGI	Instituto Nacional de Estadística y Geografía
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
NGO	Non-Governmental Organization
NIGEAE	Northern Ireland Guide to Expenditure Appraisal and Evaluation
PEMEX	Petroleros Mexicanos
PNUD	Programme des Nations unies pour le développement
PROCAMPO	Programa de Apoyos Directos al Campo
PROGAN	Programa de Producción Pecuaria Sustentable y Ordenamiento Ganadero y Apícola
SAGARPA	Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales
$MP	Mexican Pesos

1. INTRODUCTION

Tabasco is the example of the inherent vulnerability of tropical ecosystems. It has experienced changes that have been particularly strong in a very short time (Tudela, 1989). This is due to a very specific strategy of resources utilization responsible for the complete transformation of the biophysical environment and the society. Social processes that have determined these big changes have been various and very representative of what is happening in other in development tropical countries: deforestation, extensive cattle farming extension, agricultural modernization and intensification, accelerated urbanization and finally the spectacular peak of the petroleum industry. What makes Tabasco a very specific case is the fact that all these processes happened whether successively o simultaneously. The ample spectre of ecological problems that are facing Tabasco are the result of a complex interaction between the society and the environment: hydrological alterations, soils degradation, erosion, salinization, biotic resources losses, and contamination of diverse kinds.

In this context, traditional smallholder farmers are those that are suffering the most from the modernization consequences. The traditional systems of itinerant, shifting or slash and burn agriculture used to include ancestral knowledge in their agricultural practices (Vallejo Nieto, 2010). They applied rotational systems in order to break pests and diseases cycles and to maintain soil fertility. They used to sow a large variety of species, considering beneficial plants association and selecting seeds adapted to the physical and climatic context. The practice of agroforestry systems was very common. Their subsistence depended also from the exploitation of natural resources. A big part of their food came from hunting, fishing and picking. The industrialization and the agricultural modernization of the last decade are responsible for the complete destruction of this traditional system. The degradation of the natural resources from which their subsistence depended on as well as the integration of modern agricultural practices and technics changed completely the ancestral farming structure, ecological stability and system sustainability. By adopting commercial productions, they have seen their vulnerability considerably increase. Their actual production systems are more sensitive to the environmental conditions and climatic variations and they have a high dependency towards external input and market. In this critical context, identifying and analyzing the different aspects of vulnerability become a main issue and this study focused its starting point on these considerations. The problematic developed here is the evaluation of the vulnerability of smallholder farmers from a multi-dimensional point of view (social, economic, and environmental) using indicators. The vulnerability was defined here as the degree to which a system is susceptible or unable to cope with adverse effects (IPCC, 2007). The work was carried out in two municipalities of Tabasco. The analysis was realized between the municipalities and between the productive activities in order to give a comparison and then present the structural and contextual factors that explain the vulnerability.

This work has been conducted within the framework of “El Colegio de la Frontera Sur” (ECOSUR) and takes part in the project of the Mesoamerican Biological Corridor (CBM). The CBM is a multinational initiative from various countries of Mesoamerica (Belize, Costa Rica, El Salvador, Guatemala, Honduras, México, Nicaragua y Panamá) that aims at the conservation and the protection of the ecological connectivity. Wildlife corridors are physical linkage between patches of native vegetation that permit the ecologic connectivity that is the maintaining of a connected system of open space throughout an ecosystem.

In this context, ECOSUR, a multidisciplinary scientific research center that intend for sustainable development in the southeast border of Mexico, participate for numerous project of corridor definition.

The first part of this study aims to describe theoretically the problematic. It firstly tries to present the contextual and structural factors that determined the evolution and development of rural communities in Tabasco. The attention will be then focused on the definition of vulnerability and on the previous scientific works that have already been carried out. In a second part, the methodology will be tackled with in its theoretical and practical aspects. Finally, the results will be presented in the third part and discussed in the fourth part.

2. CONTEXT PRESENTATION

2.1. The development of the humid tropic

Tabasco is situated in the humid tropic of Southeast Mexico, along the Mexican Gulf coast (see figure 1). Its modernization started with the myth of its supposed extraordinary fertility (Tudela, 1989). The tropics constituted the real national richness: it could produce three abundant harvests per year and had what the rest of the country missed, water. The utopia of the Agricultural Empire was an intellectual work product from governmental bureaucracies. It was a "collage" between the Nile oasis and the Tennessee Valley or Holland plain. The engineer L. Echeagaray said in a speech that "Nature has offered 2 million of the world most fertile hectares. And they are almost uninhabited!" Mexico also thought that it could resolve the main part of its productive rural problems with the active integration of the humid tropics into the national development. The increasing importations of basic grains associated with the expansion of rural population whose land demand could not be satisfied contributed to feed the Southeast potentialities dream.

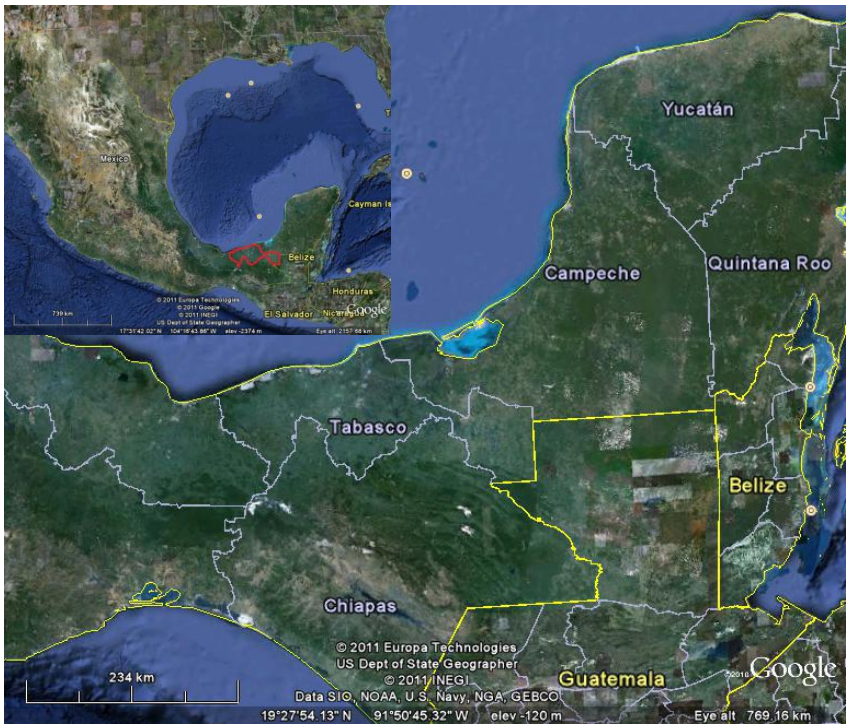

Figure 1: Tabasco region (Google Earth, 2011)

2.1.1. The Agrarian Reform and the land distribution

Before the 1930ies, there was no social pressure against land appropriation. Tabasco was rich in natural resources and there were an abundance of virgin lands available for the agricultural colonization (Abreu, 2009; Tudela, 1989). The practice of a traditional itinerant agriculture of short cycle production based on slash and burn technology implied that there was a total dissociation between soil appropriation and possession of formal property title. The land distribution started after the Mexican Revolution with

the inauguration of the Agrarian Decree of January 1915 but reached its real importance under the Cardenist[1] land reforms and the Agrarian Code of 1935. Lands were distributed through the "ejido"[2] system which was introduced as an important component of the land reform program. This system permitted to a large peasant sector to have legal access to the land and continue to develop subsistence economies. However it imposed a severe limitation for the practice of slash and burn technology. Indeed, when becoming ejidatarios, a delimitated and individual area was attributed for each farmer. They could not thus, moved temporarily and clear new virgin land like they used to without losing their ejidal rights.

However, the modernization of the Tabasco rural sector could not really rise without any serious planning efforts. From the 1950ies to the early 1970ies, the state started a great work of hydraulic and communication infrastructure constructions.

2.1.2. The planning of Tabasco

Three main obstacles prevented the good development of Tabasco modernization (Tudela, 1989):

a. The inexistence of communication infrastructure that would connect the production of Tabasco to the national market.
b. The regional hydrology. Perpetuation of occasional inundation zone, the impetuous September and October floods that provoke catastrophe in the crops as well as the settlements, and the absence of an efficient technology compatible with the local hydrology make impossible the implementation of grandiose project of agricultural exploitation.
c. The strong presence of forestry. The great reserve of forestry resources is incompatible with the commercial grain or any capitalist production. Furthermore, logging management that has the appropriate technologies to conserve the forestry resources does not exist.

These three factors are intimately linked together. It is difficult to build and maintain a terrestrial communication network in lands subject to flooding or in areas or very dense vegetation. The deforestation has been the first step to the Tabasco agricultural conquest.

2.1.2.1. The deforestation

The new ejidal lands were mainly established on forested areas. Big clearing effort of deforestation started in the 1930ies and reached its mayor intensity between the 1940ies and 1950ies (Márquez 2007, Martinez Assad 1996). In 1940, forest still covered 46% of the Tabasco area. In 1950, only 28.5% of the territory was still occupied by the original vegetation. It is important to say that the deforestation process has not been an isolated initiative but a real productive strategy. The disparition of the banana sector determined the change of agricultural orientation. Indeed, the cattle farming interests

[1] Lázaro Cárdenas was the president of the united states of Mexico from 1934 to 1940.
[2] In Mexico, the communal farmlands of villages are assigned in small plots to farmers that will use it under a federally supported system of communal land tenure.

have been present since the beginning of the phenomenon. From all the deforested areas, the great part has been converted into pasture. The public sector participates largely to the process. The agricultural council even concedes credits for opening new areas.

2.1.2.2. The control of the regional hydrology

A large program of hydraulic construction followed in the 1960ies (Garcia Garcia, 2004). The irrigated agriculture constituted a dominant paradigm for the agro-productive technology. The aim was to introduce water in adequate quantities at the right time. To do so, it was first necessary to eliminate the water that covered permanently of temporally most of the plain. The initiative reached its peak during the Green Revolution (1970-1980) with the implementation of many irrigation drains. The high risk of inundation represented a real obstacle for the development of a productive agriculture. Indeed, it is common to assist to dramatics floods several times a year.

Figure 2: Grijalva-Usumacinta Watershed (modified from Google Map, 2011)

When high intensity rain in the downstream coincides with arrivals of strong floods from the high-stream of the Chiapas mountains, the phenomenon can be very destructive. Thus, it was primordial to develop a politic of water management in order to control the Grijalva-Usumacinta system (see Figure 2). Various construction works have been managed following specific priorities: the control of inundations, drain of areas of agricultural potential, construction and maintenance of transport network, monitoring of irrigation projects (dams in Chiapas river blindness, closure and board constructions, drains, re-channeling) that deeply modified the entire water system of Tabasco. However, it is important emphasize that the positive effect of the inundations on the soil fertility should has been taken into account (Tudela, 1989). Instead of being spread through the floodplain, the main part of the fertile alluvium were accumulated in the bottom of the dams. Besides, the new stream regime produced the progressive siltation of the riverbeds. Due to the reduction of water speed, the sediments that reached the

lower basin are deposited with higher intensity in the bed. The absence of overflows that used to pull out the sediments intensified the phenomenon.

2.1.2.3. The territorial conquest

Once the watershed hydrology controlled, the public sector started the construction of an efficient network of terrestrial communication (Sanra et al, 1979). In fact, until the 1950ies, there was not any transport system but the railway. The communication system was entirely based on a complex net of fluvial connections. All the ways converged to a unique harbor from which all the agricultural production was exported. The population distribution pattern has been determined by the fluvial activity. Every big city is located on the shore of some navigable stream. The first tests of road network have been made to subordinate the fluvial system. In 1949, the first axe was built. From then, various other construction works have been undertaken. Fluvial transport has been completely abandoned for the terrestrial one. The physical connection has permitted the insertion of Tabasco into the national economy. The agro-production could therefore be more easily transported into the national market.

The implementation of the terrestrial net implied drastic changes in the social organization (Romo López, 1994). The game of specialization took a considerable importance. A new social agent appeared: the transporter which acts as an intermediary between the producer and the final market. Before, every farmer that had surpluses in his production was able to transport and commercialize it directly into the market through the fluvial network. They depend now from a specialized intermediate agent. Everybody can afford to buy launch but not everybody can afford a truck. Apart from this, roads' network altered pattern of water drainage and provoked semi-permanent water stagnation. Moreover, it is also responsible for increasing the deforestation rate. From then, the process of agriculture and livestock modernization could initiate.

2.1.3. The livestock reorientation

From the second half of the 1950ies, and above all during the 1970ies, Tabasco assisted to a spectacular boom of the extensive cattle farming (Sanra et al, 1979; Tudela, 1989). The international trend of the postwar induced in the peripheral tropical humid countries the specialization of livestock production. It was after all a very easy source of currency to exploit in the way that it does not require heavy financial investment. In 1970, half of the tropical surface was already covered by pasture. In a very short time, Mexico, that had always been a country dedicated to the crop production, turned into a cattle farming country. This transformation did not distinguish itself precisely for its spontaneity. More than anything else, it has been an undeclared government objective. The cattle domination rose during the mandate of the president Lázaro Cárdenas. His policies tended to intensify the agrarian reform measures and the consolidation of the ejido as a specific organization for production. The Cardenas regime considered as strictly different the livestock sector from the agricultural one. It estimated that the livestock development was beyond the economic reach of the ejidos. The productivity of the land owner

was guaranteed by a strong legal protection against the agrarian reform measures of the proper regimen. Indeed, the political strategy was such that it allows the land owner to enjoy from a generous fiscal and credit status. In all, crop farmers paid the treasury 7 times more than cattle farmers. Moreover, the government subsidized an important collection of inputs, even if the technology remained very rudimentary (artificial pasture seeds, veterinary products).

2.1.4. Black gold and Tabasco

The "petrolization" of Tabasco started in the 1950ies with the discovery of various oil fields. During the 1970ies, Tabasco was the scene of a rapid intensification of the petroleum activities (Martinez Assad 1996; Rendón Corona, 1997). In 1974 Pemex[3] generated 30% of the national gas. Mexico stopped being crude oil importer to become a real exporter. In 20 years, the production passed from 92 000 barrels a day to 600 000. However, petroleum activity let little benefits in the zone of implementation and did not improved citizens welfare. Over all the people contracted, only 41% came from Tabasco. It also had a great impact on the migratory flux and on the productive structure. By investing in petroleum activities and construction work (building, roads, bridges, drains, canals, pipeline), it employed a great number of non-qualified workers that came generally from rural areas of the region. Pemex became the vector of "temporal migrations" and proletariat. The agricultural sector suffered also from governmental investments shifts: from 11.7%, of the total investment in 1977, it passed to only 2.2% in 1982. By contrast, investments dedicated to the secondary sector increase during the same period, from 68.4% to 93.2%.

2.2.The modernization costs

2.2.1. Impacts on the agricultural pattern

In the beginning of the 1970ies, Tabasco agricultural landscape presented still important domination of cattle farming and a diversification of commercial crops (cacao, coconut, sugarcane) (Márquez 2007; Martinez Assad 1996; Tudela, 1989). The majority of Tabasco's surface was dedicated extensively to unproductive cattle farming. By competing with the traditional system of shifting cultivation, it destroyed the rich culture associated with the management of the forest and the natural ecosystems of Tabasco. In addition, there was a real polarization of the countryside: the business sector represented by cattle farming and commercial plantation that beneficiated of financial governmental support and investment opportunities; and the smallholder farming sector, of little scale production (maize, beans and complementary crops). At this point, the opportunities that offered the colonization process and land distribution for smallholder farmers started to end. The lack of economic and technical assistance as well as the cattle farming domination were the main vectors. As a result, the crop farming sector economy did not stop to loose importance. Rural unemployment and "proletarization" processes

[3] Pemex is a Mexican State-owned petroleum company

started to increase: 60% of the proletarian peasant was linked to the cattle farming process. More and more families offered their services as day laborers. In this context, the irruption of the petroleum industry during the 1970ies offered new employment possibilities for the peasant sector. The majority of the rural labor force started to migrate to non-rural labor through a process of temporal migration. Heads of family abandoned temporally or permanently their land to benefit of the employment opportunities. The phenomenon contributed even more to the drastic decrease of maize and traditional culture production. Above all, with the introduction of new cultural values, Tabasco suffered from a great phenomenon of acculturation. However, since the 1970ies, the expansion possibilities of cattle farming reduced a lot: the best unliable-to-flooding lands that permitted to grow high quality pasture already were occupied. With the drastic increase of input prices during the beginning of the 1980ies, the production costs became very elevated. The smallest farmers suffered immediately from the consequences of the inflation. Besides, they were those that were the most affected by the petroleum activities: land expropriation, water and soil contamination, livestock loss. However, the real crisis began with the national crisis in 1982 and the collapse of the consumers demand. In the first part of the 1980ies, the big benefits of cattle farms, obtained with minimal investment and low level of technics came to an end. During this time, commercial crops conserved certain stability even if they observed consequent oscillations. Technical changes, climatic and pests and diseases factors impacted a lot on the production (banana, sugarcane, coconut, and cacao).

2.2.2. Natural resources degradation and social costs

The ecologic damages and the social costs of the modernization have been very tardily taken into account. The general awareness started to disseminate after the crisis. It did not respond to any political or cultural reason but more to the realization of the current situation. The accumulation of environmental deterioration in the three last decades started to severely limit the activities of the primary sector and the quality of life of the majority of the population (Romo López, 1994).

2.2.2.1. Deforestation consequences

The vegetation of the coastal plain of Tabasco has suffered a considerable diminution of its fauna and flora richness (Márquez RI, 2007; Martinez Assad 1996). The areas of primary vegetation have been drastically reduced and replaced by secondary vegetation and agricultural zones. As a result, a drastic decrease of diversity and productivity has been observed (banana production decreased from 7,7 tons/ha to only 2,49t/ha in ten years). Originally, Tabasco was covered by different type of forests, savanna, hydrophyte vegetal community and mangroves. In 1980, the evergreen forest reached only 3% of Tabasco area while it covered 50% in 1940. The pasture and savanna occupation passed from 8% of the state area to 46.5% in the 80's. In this decade, the traditional practice of shifting agriculture completely disappeared to the benefit of pastures. The most fertile layer were buried or submitted to erosion process. In general, pastures aren't fertilized due to the high costs of fertilizer. The agricultural development, has destroyed all

the natural processes of soil fertilization, and is responsible for the needs of technologic pack introduction.

2.2.2.2. The hydrology modification

The deforestation, the development of the hydraulic and terrestrial communication infrastructures modified considerably the hydrology of Tabasco (Romo López, 1994; Tudela, 1989). These changes have a great relevancy because they disturb the whole hydraulic natural systems by diminishing its capacity to retain water runoff. The Gijalva[4]-Villahermosa[5] basin has been particularly touched.

The biggest water runoffs are produced with high intensity rains that are concentrated in a very short time (1 or 3 days) (Garcia Garcia, 2004). A local high precipitation in the high plain is really important because it can bring in few hours the main part of sediments that are registered in one or various years. The riparian vegetation plays an important role in the regulation of flux and sentiments charge. Its elimination provokes negative ecologic effect. Apart from it, the roadway infrastructure act like dikes and prevent water runoff. Indeed it prevents water fluxes between streams, bogs, lagoons, and plains and leads the water runoff to the sea with mayor rapidity. That way, erosion-transport-deposition processes, that used to occur in the whole basin is altered.

2.2.2.3. Vulnerability to pests and diseases

The human intervention transformed diverse, multi-structured ecosystems of complex trophic interaction into simple ecosystems of homogeneous population that are more vulnerable to any disruptive elements (Tudela, 1989). The modernization, by enhancing communication processes multiplied the introduction of new biological agent that can damage the ecosystems. The continued apparition of new pests and diseases and the resulting deterioration of phytosanitary conditions constitute an important limiting factor to the development of the agriculture in the tropics. The utilization of agrochemicals has permitted the control of pest and diseases but not their elimination. Firstly, biological resistance has been observed and obliges to constantly increase doses or application frequency. In addition, they provoked the apparition of an important contamination effect. Finally, the input prices considerably increased the production costs and affected economic viability. For instance, the cacao, which is a native species that have a real tradition of production, never needed agrochemicals before the modernization of Tabasco. Another poignant example is the banana case and the fungi disease that completely destroyed the production.

[4] Stream which crosses Villahermosa
[5] Capital of Tabasco

2.2.2.4. Contamination

Tabasco suffered from all kinds of pollution: contamination from pathogens, heavy metals, hydrocarbons (Sanra et al, 1979; Maldonado, 2007). From all, Pemex activity impacts are the most serious and have the most severe consequences (acid rain, gas emission, liquid chemical toxic waste that ruin the cultures). Moreover, the impacts of the contamination are even more serious due to the fact that many streams and other water bodies run Tabasco. Toxic components are therefore easily disseminated. Urban contamination is also an important problem. Black waters that come from cities, and villages or agro-industrial waste for which there is not any treatment are released in the regional water bodies. Coastal lagoons have been severely damaged because they are the central point of all the arrival of contaminated water. The phenomenon is even more serious during the dry season when the washing effect of water runoffs is very limited. In addition, modifications in the hydrologic regime and construction work in the coast are responsible for soil salinization.

2.3. Conservation initiative: the Mesoamerican Biological Corridor (CBM)

The CBM is a multinational initiative initiated in 1995 by the CCAD and the PNUD within the implantation of the project "Mesoamerican Regional System of protected areas, buffer zones and biological corridors". The general objective is the conservation of representative sample of every different environment in the region with the creation of groups of interconnected or related areas. That way, biological corridors allow the genetic and biologic exchange between fragmented populations, continuity of biological processes, and the integration these areas into land use plans. More than that, it aims also to the social and economic development and the reduction of populations' vulnerabilities. The conviction is that biodiversity conservation has to be thought jointly with poverty reduction and reinforcement of economic viability.

Mexico integrated the project in 1996 trying to focus on the mainstreaming of biodiversity criteria in public expenditure, and in selected local planning and development practices. It has been firstly developed in with 4 states of the southeast Mexico (Yucatán, Quintana Roo, Campeche and Chiapas) followed in 2009 with 3 other states (Oaxaca, Veracruz and Tabasco). In this context, different governmental and non-governmental institutions participated to the elaboration and consolidation of the CBM Mexico. ECOSUR is a non-governmental research center that contributes to sustainable development in the Mexican South border through knowledge and human resources generation. It tries to connect social and natural sciences, which is essential for the conservation of cultural systems and biological resources as well as the promotion of sustainable practices. It also participates for the development of technical capacity to the local population benefits **(**CCAD-PNUD/GEF, 2002; ECOSUR, 2012). Lately, it lead several micro-projects within the CBM framwork.

This study is part of the project "Agroforestal knowledge application for the definition of a methodology for the implementation of the Mesoamerican biological corridor in Tabasco" lead by ECOSUR between May 2010 and March 2012 within the CBM initiative. The objective is to evaluate the

impact of agroforestry systems for the biodiversity conservation and local population welfare and generate technical capacity for agroforestry introduction into cultural systems as a tool for ecosystem connectivity and social services (Hernandez Daumas, 2011). Agroforestry systems are defined as production systems in which perennial woody trees interact with traditional components (animals, forage and herbaceous species) below an integrated management system (Gliessman, 2007).

In Tabasco context, where the extension of cattle farming has been identified as one of the leading contributor to deforestation and environmental degradation, it is then important to improve the actual land use and look for practices that would mitigate the negative effects (Kandji, et al., 2006). To do so, ECOSUR focus its work on silvopastoral systems (association of tree component with cattle grazing). They are indeed an efficient tool to limit cattle farming negative impacts by contributing to reforestation and degraded pasture conversion (Hernandez Daumas, 2011). The integration of trees into pastures increases soil fertility and structure and decrease erosion processes. That way, animal benefit of better quality pastures even in critics period of droughts.

The current study comes uphill as a vulnerability diagnostic in Tabasco CBM priority sites. The objective is to highlight threat and difficulties that are facing rural population and their causes. The study will identify triggers and potential that can be used in the future for developing relevant action plans coherent with the CBM objectives. Other studies will then evaluate to what extent Agroforestry systems can be a solution for sustainable development in Tabasco context.

3. STATE OF ART

3.1. Vulnerability definitions

Vulnerability concepts take their origin in the natural hazards and poverty literature. Numerous studies have been carried on to understand which social groups were most exposed to risks and hazards, what were the drivers of the increasing vulnerability to losses or the likelihood to fall below a consumption threshold. They were human centric approaches that were leaded at a social-economic level (Cutter et al, 2009). Recently, with the increasing worries of global environmental issues, vulnerability appeared essentially like an emerging area of climate change impacts assessment and sustainability studies (Luers et al 2003; Vincent et al, 2004). Nowadays, there aren't any universally accepted definitions as a very large number of disciplines are conducting vulnerability assessment, each one using their own concepts (Deressa et al, 2009). Nevertheless, it is important to specify that the present study isn't a vulnerability assessment from the climate change issues. It only considers works that were already made.

Several classifications of vulnerability have been proposed in the climate change assessment area (Füssel, 2009). It identified two main diverging schools of thoughts (biophysical and socio-economic) that are managing the terms in very different ways:

The Socio-economic approach considers that the vulnerability depends on the structure or the internal state that had a system before it encounters a hazard. The vulnerability is firstly constructed by the society, according the institutional and economic evolution. It varies in terms of education access, health status and access, services, technological transfer, integration (Deressa et al, 2008). According to Mitchell et al and Chambers in 1989 (Luers et al, 2003), vulnerability is the potential for loss, in which a system is exposed to external shocks and perturbations and for which it has an internal ability or lack of ability to respond and recover (resilience). The principal weakness of this approach is that it only considers variations within the society but does not include environmental factors that can have severe impacts. The Biophysical approach is more focused on global impacts that have a perturbation on a specific system. Deressa et al (2009) define vulnerability as the level of damage that a given environmental stress causes on both social and biological systems and Luers et al (2003) considers it as the degree to which human and environmental systems are likely to experience harm due to a perturbation or a stress. However by only focusing on physical damages, it doesn't take into account the social consequences that also have impacts on the system (Deressa et al, 2008).

There is then a real fragmentation and a competition between both schools of thoughts, theory and terminology conflict, that created a real polarization. It is therefore important to bridge the gap and combine both socio-economic and biophysical approaches to determine more holistic vulnerability assessment (Vincent et al, 2004). The Interdisciplinary research or integrated assessment approach tries to combine both socio-economic and biophysical sciences and correct so, their respective weaknesses

(Deressa et al 2009). The Intergovernmental Panel on Climate Change (IPCC, 2007) conformed its vulnerability definition to the integrated approach:

"The degree to which a system is susceptible, or unable to cope with adverse effects of climate change, including climate variability and extremes, and vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity."

The Vulnerability is then conceptualized as a function of exposure, sensitivity and adaptive capacity of a system in front of a stress (Luers et al 2003), where the sensitivity correspond to the biophysical approach and the adaptive capacity to the socio-economic approach (Deressa et al, 2008). However the lack of standard methods or robust metrics that model and measure vulnerability and combine both biophysical and socio-economic approach at the same time is a real obstacle to the realization of integrated studies. Moreover, implementing vulnerability integrated measures is complicated by the real disagreement on the exact meaning of the term and the complexity of studied systems (Deressa et al, 2008; Luers et al, 2003).

Another very common classification found in the climate change literature distinguishes the "internal" and "external" side of vulnerability to a stress (Füssel, 2009)(see figure 3). The internal vulnerability is there defined as the contextual vulnerability. Indeed, the internal characteristics of a system determine its vulnerability for stresses. The external or outcome vulnerability expresses the vulnerability of a system determined by drastic environmental change. It represents the capacity of a system to cope and adapt (Füssel, 2009).

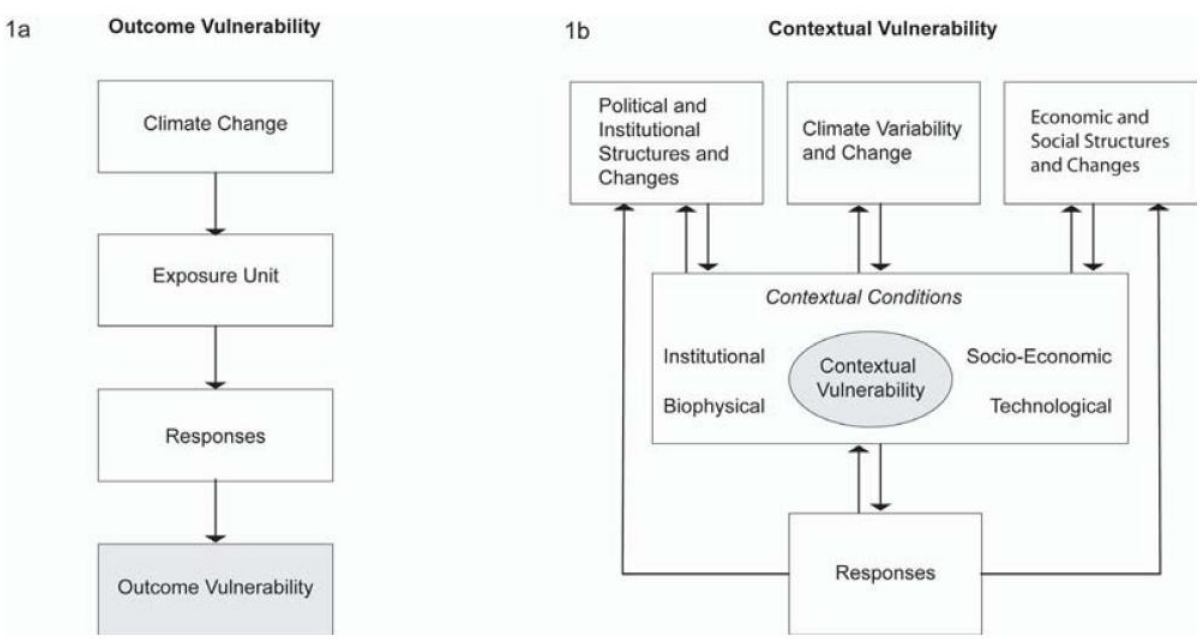

Figure 3 : Framework depicting two interpretation of vulnerability to climate change **(Füssel, 2009)**

In all, there is a real confusion of terminology, theory and concepts for vulnerability. Many studies linked several classifications together, using outcome concepts with socio-economic approaches

for instance. On top of that, integrated approaches that are trying to provide new insights contribute largely to the general confusion (Füssel, 2009).

The objective of the study is to evaluate the contextual vulnerability of various communities through a multi-dimensional point of view (social, economic, environmental). We recognized climate seasonality as factor of vulnerability and can be considered as the external side of vulnerability. Changes in the climate pattern will be considered but not integrated in the analysis.

3.2.Methods to measure vulnerability

Vulnerability is a very dynamic phenomenon that can't be directly observed. It is then very difficult to objectively measure or quantify it. Lot of studies has been managed using different methods of analyze. However, we identified two methods that are the most common in the literature.

The quantitative metrics methods are commonly applied for economic and agricultural studies (Luers et al, 2003) or poverty and development studies (Deressa et al, 2008). They usually construct measures by applying a mathematical expression that estimate the welfare, production, or economic loss attributed to shocks. Thresholds are generally used, above which, the system is considered as vulnerable (Luers et al 2003, Ligon and Schechter, 2003).

The indicators approach is another method to measure vulnerability. Indicators are "*quantitative measures intended to represent a characteristic or a parameter of a system of interest using a single value*" (Cutter et al, 2009). They can provide information on very complex situations and translate it in simple terms; highlight trends or processes that wouldn't appear otherwise; permit comparison between space and time. They are very common for climate change vulnerability assessments and are very useful to guide policy development on vulnerability reduction or can serve to measure progress (Cutter et al 2009). Thus, various vulnerability indexes have been elaborated, mostly for national scale analysis. The Environmental Vulnerability Index (EVI) aims to describe environmental vulnerability of a country to future shocks through three aspects: social, economic and environmental. A total of 50 indicators have been selected distributed in three categories: 32 indicators of hazards, 8 indicators of resistance and 10 indicators that measure damage. The variables were then mapped onto a 1-7 scale where 1 indicates low vulnerability and 7 translate a high vulnerability (Kaly et al, 2004). Likewise, the Environmental Sustainability Index traduces the ability of nations to protect the environment. It is based on 67 variables represented by 21 indicators within 5 broad dimensions: environmental systems, reducing environmental stresses, reducing social vulnerability, social and institutional capacity, and global stewardship (Yale Center for Environmental Law and Policy, 2005). Other analyses have been driven at smaller scales and appeared more similar to the present study. The Household Social Vulnerability Index (HSVI) has been created to analyze an African village vulnerability to climate change. It is based on 7 indices (Market value of livestock assets, Dependency ratio, Households with a member suffering from a long term/recurrent disease, Range and scope of social capital contacts, Membership of social capital groups, Contribution of farming to household wellbeing, Quality of housing and roofing materials) distributed

through 5 composite sub-indices (financial capital, human capital, social capital, natural capital, and physical capital) (Vincent et al, 2010). Another study realized by Sarandón et al (2006) used indicators to evaluate the sustainability of smallholder farmers' agro-ecosystems in a province of Argentina. Five Farms have been analyzed on the social-cultural, economic and environmental aspect and results have been then translated onto a 0-4 scale for which 4 was the highest value of sustainability and 0 the lowest (Sarandón et al. 2006). The analysis was realized with 21 indicators distributed in three dimensions (social, economic and environmental): production diversification, auto-consumption production area, selling diversification, commercialization ways, external input dependency, vegetal coating management, cultural rotation, cultural diversification, predominant slope, vegetal coating, furrows orientation, temporal biodiversity, special biodiversity, housing, education access, health access, services, acceptation of the productive system, social integration, knowledge and ecological conscience.

The present study was realized according to the internal and external vulnerability classification. Nevertheless, it was tried to integrate the integrated assessment vulnerability definition concepts. We considered the exposure as the contextual vulnerability and the sensitivity as the outcome vulnerability (which in our case isn't the climate change but changes in the micro-climate due to anthropogenic activities). Vulnerability aspects have been analyzed according to three dimensions: the Social Dimension, the Economic Dimension and the Environmental Dimension. We measured vulnerability using the indicator approach according to the Sarandón method. It was indeed the best method as it was the most adapted to the context of the fieldwork. A sample of 19 indicators was elaborated: housing, health, education, services, social integration, acceptation of the system, production diversification, regulation, land access, agricultural dependency, input dependency, commercialization way, pests and diseases, water stress exposure, tree use, adapted species, climate seasonality, production cycle. According to Sarandón method, we use a 0 to 4 scale in order to be able to give a comparison between indicators and analyze the results. Finally, we identified the different strategic responses to stresses in order to define the adaptive capacity of the systems.

4. MATERIAL AND METHODOLOGY

The study divided in three parts. In the first part, it was tried to define the work and means with which we will collect the data. The areas of study and how they have been chosen are first presented. Then, the different actors that are going to be interviewed were identified. The survey has finally been elaborated according to the nature and the objectives of the subject.

The second part consists of scoping the activity. It was important to test the pertinence of the survey firstly, in order to avoid mistakes during the fieldwork. A first round data was gathered in a trial community. The actual work could then be carried out avoiding main mistakes.

The analysis was finally performed using a qualitative approach. The results have been first processed with NVivo9 (QSR international, 2011), a software specially designed for qualitative data analysis. A scoring and weighting method was then used to measure the vulnerability. The adaptive capacity was lastly evocated in the discussion.

4.1. Antecedents: The Mesoamerican biological corridor (CBM)

The areas of study have been selected in order to take part in the elaboration of CBM (CONABIO, 2009). According to the work accomplished by the CONABIO, areas can be eligible to integrate the CBM only if they respect a set of various criteria of priority such as biological richness, conservation and connectivity. The methodology used to design the CBM has been realized in two parts:

- The selection of priority sites for the biodiversity. A rank of conservation for each species have been established according to national and international classification (NOM-59-SEMARNAT-2001, IUCN, CITES) as well as the endemic and rarity rate. The addition of all criteria gave a final value that permit the prioritization of the different areas.
- The identification of zones with the main conservation priority. A spatial superposition using the Geographic Information System (GIS) has then been performed between the priority sites and other indicators (primary and secondary vegetation rate, species richness…).

Municipalities with the higher value of biological richness and the most important areas of primary and secondary vegetation were eventually selected to be part of the CBM. In Tabasco, there are currently 11 municipalities that are participating to the project.

4.2. Area of Study

In a context of high natural resources degradation, it is important to conserve connectivity between Tabasco ecosystems in order to protect the biodiversity and improve the adaptive capacity against current and future threats. From all these municipalities, 5 zones have been designated in such a way that a real connectivity between one another is established (SEMARNAT, 2009) (see figure 4):

- Lower coastal area (Paraiso, Jalpa de Mendez)
- Chamilapas montain area (Huimanguillo)

- Zoque mountain(Teapa, Tacotalpa)
- Mascuspana
- Usumacinta watershed (Tenosique, Centla)

Figure 4: Tabasco Subregions (Google Earth, 2011)

In the context of the CBM, El Colegio de la Frontera Sur in Tabasco realizes several projects with rural communities in the areas of Tenosique, Tacotalpa, Huimanguillo and Paraiso. For the present study, the work was carried out on the municipalities of Huimanguillo and Paraiso because they present a relative homogeneity in their physical context. Both of them are lagoon areas and have consequently developed their activities around the lagoon resources. They also have adapted their management to the same seasonality pattern (annual inundations and droughts). However, from a social and economic perspective, each one has followed its own pattern of development with their own characteristics. It is thus interesting to identify for each one which dynamics can explain their actual situation, their potentialities and their vulnerabilities.

We have investigated more than one community for each municipality in order to have a better overview of their specific situation. Depending on the diversity of activities inside one municipality, we decided to interview two or three communities.

4.2.1. The Costa Baja of Paraiso

4.2.1.1. General presentation

This area is very specific because of its hydrographic situation. It has the most complete hydrographic network of Mexico through the run of the two biggest streams (Usumacinta and Grijalva)

and the various rivers that result of them. The high quantity of water supply as well as its spatial and temporal unequal distribution caused the formation of different meanders, lagoons and islands (Palma-Lopez, 2007). Consequently soils are made of the accumulation of various sediment materials dragged through the different water canals or deposited by floods. Therefore they present a very good fertility (Fluvisol soils).

The climate is hot, humid with rainfalls in summertime: tropical rainforest climate, according to Koeppen classification (Kottek et al, 2006). A very light drought period is observed between August and September and a much more severe between March and May. The medium annual temperature is 26.7°C and the medium maximum of 30.7°C in May and June. It can reach extreme temperature of 42-43°C during May. The annual medium precipitations along the coast vary from 1500mm to 1800mm, with the highest ones from June to December (=77.3% of the annual total). During winter time, the movement of the air cold mass movement to the south generates violent winds called "Nortes" (Palma-Lopez, 2007). The evergreen forests used to cover the main part of the area. They are very dense vegetal community with a considerable diversity of species, dominated by 30 meters high trees that conserve their foliage all year around. Nowadays, they have been replaced by vegetal secondary communities or "acahuales". Another important arboreal community is the Mangrove. The vegetation is dense, from 2m to 25m high, which grow in very low and muddy coastal zones. They have the particularity to resist to estuarine conditions due to their radicular systems that presents multiple adaptations to external conditions. The mangrove plays an important role in the coastal lagoons ecology: it participates to soil fixation and provides abundant organic matter.

4.2.1.2. The Communities

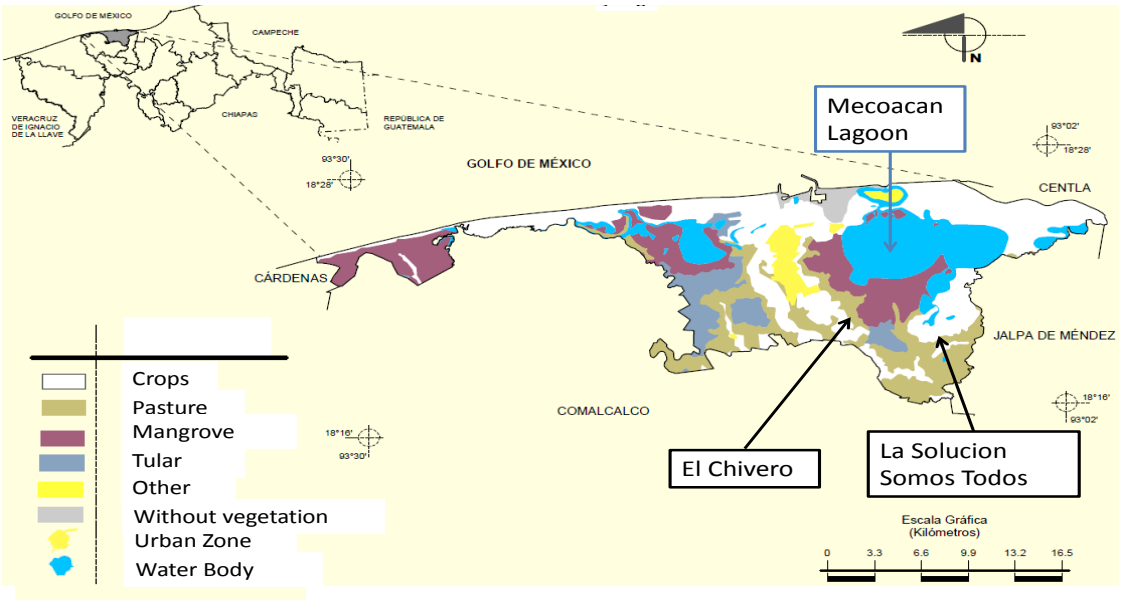

Figure 5: Paraiso Land Use **(INEGI, 2005)**

The study takes place in two communities that surround the Mecoacan Lagoon. This lagoon has the particularity of being situated just along the sea. Therefore, it permits thus the connection between sea water and fresh water. In the areas of interest, Libertad 1st section[6] (called El Chivero) and Nicolas Bravo 2nd section (called La solución somos todos), the entire activity has been influenced by the lagoon dynamics (see figures 5 and 8). The area around the lagoon is quite homogeneous in its agricultural activity. Therefore, the investigation in only two communities was sufficient enough:

- Libertad 1st Section (El Chivero) depends largely on the oyster fishing and the activity of the numerous restaurants that opened these last few years. Therefore, it has a large proportion of its population who is dedicated to the tertiary sector (34.72%). The primary sector concerns 53.70% of the population (INEGI, 2010). The population counts 1907 (Foro-Mexico, 2011).
- Nicolas Bravo 2nd section (La solución somos todos) shared its activities between the exploitation of the mangrove and fishing. However, due to external factors that prohibit the mangrove exploitation, a large part of the population found activities in other sector. It is why, only 41.67% of them are dedicated to the primary sector (INEGI, 2010). The population counts 505 inhabitants (Foro-Mexico, 2011).

For both, the livestock production is in real decline.

4.2.2. The savanna of Huimanguillo

4.2.2.1. General presentation

The area of Huimanguillo is made of large area of savanna, with small hills formed through ancient erosive current (approximately during the Pleistocene) (Palma-Lopez, 2007).

Soils are a mix of minerals dragged by erosive processes. It presents a high rate of sand, and is rich in aluminum and iron. It is very sensitive to erosion, due to the slope, the thick superficial texture as well as the little soil aggregation. The agriculture development has generated lots of erosion problems on the superficial layer. Nowadays, soils are acid with low rate of natural fertility. Therefore it is not favorable for the crops development (Acrisoles and cambisoles soils).

The Climate is hot and humid, with high precipitation during summer time: Tropical Rainforest climate according to Koeppen (Kottek et al, 2006). The annual medium temperature is 26.5°C, with a maximum of 39°C in May and a minimum of 13.7°C in February. The total annual precipitations are 2 123 mm, more than 70% happens between May and November. The annual evaporation reaches 1 316 mm with its highest rate during the dry season. The vegetation is mainly very antic savannas which already existed before the conquest period (Palma-Lopez, 2007). They are anthropomorphic vegetation communities probably formed by the shifting cultivation practices with a predominance of native pastures that are tolerant to the slash and burn cultivation. Before the intensification of human activities, they used to cover 5% of the territory. Nowadays, they occupy a vaster area, around half the Tabasco area.

[6] Administrative division within municipalities.

4.2.2.2. The Communities

As for Paraiso, the study took place in communities located on the lagoon bank (see figure 6 and 13). Their activities also depend on the lagoon dynamics. However, livestock management largely dominates the area and important differences exist between the communities that we wanted to take it into account according to their integration in the cattle farming system. Our study was carried in three of them. That way, we could show a richer panorama that could include the main dynamics.

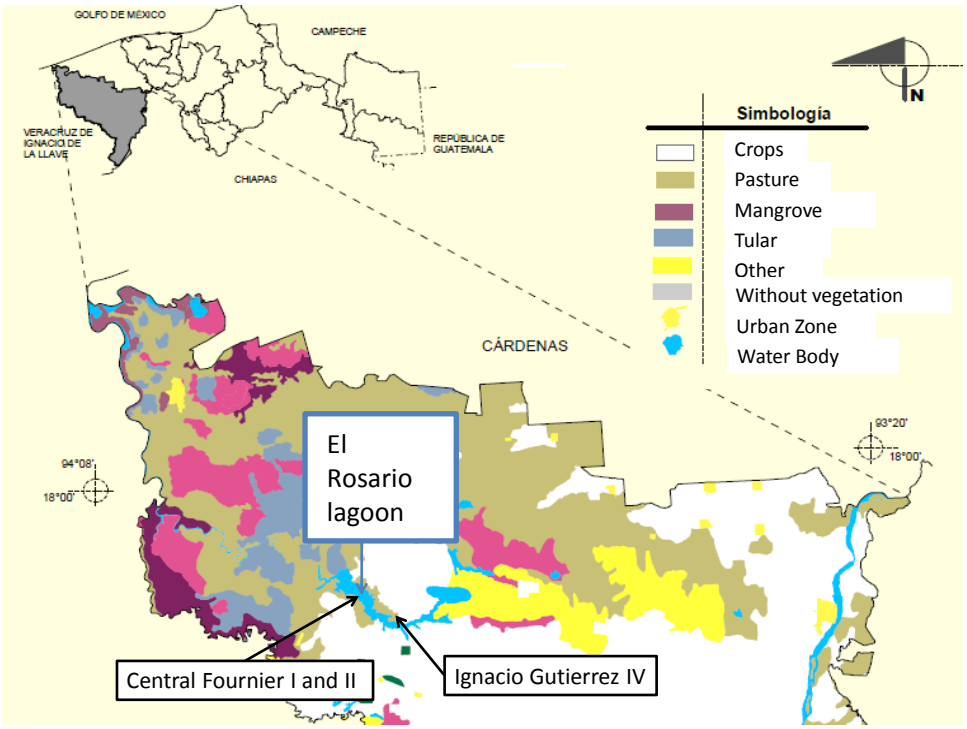

Figure 6: Huimanguillo Land Use (INEGI, 2005)

- Central Fournier 1st Section is the furthest one from the lagoon. It has not developed its activities around fishing but on other productions such as pineapple and corn. 90% of its population belongs to the primary sector (INEGI, 2010). The population counts 546 inhabitants (Foro-Mexico, 2011)
- Central Fournier 2ndSection is located on the lagoon bank. They took advantage of it to develop fishing as well as tourism. 80% of its population is working on the primary sector which is a bit lower than for the 1stSection due to services that tourism has created (INEGI, 2010). The population counts 205 inhabitants (Foro-Mexico, 2011).
- Ignacio Gutierrez 4rthSection is also located in the lagoon bank. Most of its population is dedicated to fishing and like Central Fournier 2ndSection, 80% of the population belongs to the primary sector. However, there is no tourism activity (INEGI, 2010). The population counts 234 inhabitants (Foro-Mexico, 2011)

4.3. Work Preparation

4.3.1. Population Sample Identification

The people interviewed (see table 1) belonged to two different categories. At the farm scale, farmers themselves gave explanations about the land management and their production system. The main questions were: which production they have, which difficulties do they cope with, what practices do they use and why. The authorities (delegates or decision makers) could bring a better understanding at the community scale such as the distribution of the different activities, the community organization and the main issues. At last, experts brought understanding on the external factors and causes that had generated the actual situation. In all, 15 persons were interviewed in Paraiso and 21 in Huimanguillo. It hasn't been possible to meet more people due to the little time we had to manage the fieldwork.

4.3.1.1. Authorities

The highest figure, the delegate, is elected by the community. There is one per community. He is responsible for the communication and the organization of municipal and federal programs. He also deals with management of the community resources, the public works and the distribution of governmental support. The delegate is the canal through which the governmental dependencies communicate information to the population. The second most important figure is the representative of all the ejidatarios, the ejidal commissary. His function is essentially for agricultural purposes. He organizes ejidal reunions in which farmers can express their worries, difficulties and expectations. He also deals with solving conflicts that can happen between the ejidatarios (land or activities conflicts) and applies governmental rules for production (restrictions, prohibition). Last but not least, he is responsible for enforcing ejidatarios' rights. The Vigilance Council is another figure that is quite important. He is the one who is in charge of overseeing that the rules and restrictions are correctly applied. His function is essentially oriented toward the mangrove production in Paraiso for example. The Administrative structure of the community implies also a secretary, a treasurer and 4 substitutes.

In every community, we interviewed at least the delegate and the ejidal commissary.

4.3.1.2. Farmers

The objective was to meet a panel of people who represents each group of activity, in terms of particularities, difficulties and priorities. Based on the area of study, several groups have been highlighted: Cattle Farmers, Fishermen, Crop Farmers, Day Laborers, Alternative Producers[7] and Professional[8]. The number of persons hasn't been defined. The degree of complexity in each category was so different that it wasn't relevant to investigate the same number of people. For example, the activity of the Day Laborers is very simple, so that their profile can be elaborated with very few participants. On the

[7] Famers that tried to diversify their activities : beekeeping, fishpond, carbon wood, experimental variety plots.
[8] The first activity of these people is out of agriculture but they are still exercise farming as a secondary activity.

contrary, Cattle Farmers show high complexity of practices that make the definition of their general characteristics more difficult. In that case, various farmers had to be investigated

Table 1: Number of interviews realized per community

Municipality	Community Name	Activity	n° of interviewees
Paraiso	«*La solución somos todos*»	Mangrove	2
		Alternative Production	3
		Fishing	2
		Day Laborer	1
		Professional	2
SUB-TOTAL			**10**
	« El Chivero »	Mangrove	1
		Alternative Production	2
		Fishing	1
		Professional	1
SUB-TOTAL			**5**
TOTAL			**15**
Huimanguillo	Central Fournier I	Livestock	3
		Alternative Production	1
		Agriculture	1
		Day laborer	1
SUB-TOTAL			**6**
	Central Fournier II	Livestock	3
		Fishing	3
		Agriculture	1
		Day Laborer	3
SUB-TOTAL			**10**
	Ignacio Gutierrez IV	Fishing	3
		Day Laborer	2
SUB-TOTAL			**5**
TOTAL			**21**

The number of interviewees depended also on the structure of the community. If a community had a large proportion of Cattle Farmers, a larger number of them were interviewed. For instance, in "La solucion somos todos", there were few persons dedicated to livestock production and even though it is a

complex activity, only one was interviewed. The distribution of interviews in Central Fournier 1st Section is also representative of its structure: Livestock is the main activity so that it was represented by three people; Agriculture is secondary and one person was interviewed; finally the fishing activity was not taken into account as it was inexistent. Day Laborers represent an important proportion of the total population but due to the simplicity of their activity, only one was interrogated.

4.3.2. Survey elaboration

The information has been gathered through 2 semi-opened surveys (see appendix 1and table 2):

- one at the community scale with the authorities,
- another at the farm scale with the farmers.

Most of the data collected are qualitative. Both surveys are built according to the same structure and respond at the same objectives:

- Description of the community.
- Identification of vulnerabilities.

Table 2: Survey Contents

	Authorities	Farmers
Physical context	Structure of the community Principal activities Infrastructure (water, electricity, shops) Transports and communication (phone, internet)	Production system and management Land use Land status Land history
Social situation/vulnerability	Social groups Emigration rate Land access Education and health services	Education access Health problem Family Capital Project participation Well being
Economic situation/ vulnerability	Commercialization possibilities Prices variation Issues	Input expenses and dependency General income Presence of non-agricultural activities Diversity of buyers Production restrictions
Environmental situation/ vulnerability	Natural resources degradation (contamination, deforestation) Causes and consequences Agricultural situation	Management issues (impact of inundations and droughts on the production, yield loss…) Potential (use of trees, adapted species, diversity of production…)

4.4.Scoping Study

4.4.1. Preliminary community test

The survey was firstly tested in a community called Santo Tomas, located in the municipality of Tenosique, in the frontier with Guatemala (see figure 4). The objective was to identify gaps, misunderstandings and redundancies. According to interviewees' answers, we were able to point out concepts they did not understand, the information that they were not able to give. These results enabled us to design clearer questions. The survey was re-arranged, adapted and completed to fit with the study objectives.

Moreover it was the opportunity to observe the community organization, the social rules and relationships in order to elaborate a strategy of investigation.

4.4.2. Information gathering

4.4.2.1. Interviews on communities

In average, a one-week stay in each community was necessary in order to get an accurate picture of the situation. The first person who was contacted and interviewed was the communal delegate. Thanks to him, it was possible to get a more precise idea of the community structure and get contacts of person who represent a good example of each category of activity.

The interviews lasted around 1 or 2 hours each. More people were interviewed until the information they gave became redundant for the key questions. At this point, it was considered that additional data would not be collected anymore.

One difficulty was to avoid distortions that the delegate or commissary could generate. For instance, because they are representing a political party, they very often mentioned members of their own party and family. Another distortion consisted of collecting only data from the farmers themselves. Their opinion is limited to their education, their social background, their political party, and their sensitivity to the environment… Besides, they didn't have scientific knowledge that could help us to understand the environmental dynamics and the government management impacts. It was then necessary to supplement information with professionals and experts.

4.4.2.2. Experts interviews and scientific literature review

We interrogated people from various governmental institutes (SAGARPA[9], SEMARNAT[10]) that worked or were familiar with the concerned areas. The objective was to get another point of view, more scientist and evaluate as well the gap between institutions and farmers. We didn't analyze them in the results but there are considered in our reflection. It was interesting as well visiting university libraries to bring together various local studies.

4.5.Data Analysis

4.5.1. Analysis of the qualitative data: NVivo 9

The interviewed were processed with the software QSR NVivo 9, specially conceived to analyze qualitative investigations. It permitted to segment the information through thematic fields, organizing it in such a form that it facilitated its interpretation (Werner, 2009). Thematic fields were created based on the survey structure. All of the farmers' answers were then classified into its own thematic field.

[9] Mexican chamber of Agriculture, Livestock, Rural Development, Fisheries and Food.
[10] Mexican chamber of Environment and Natural Resources.

4.5.2. Evaluation of the Vulnerability: Scoring and weighting method

The weighting and scoring method is an alternative to the multi-criteria approach that enables to give numeric values to qualitative data (NIGEAE, 2011). It allocates weight to each indicator depending on its relative importance. A score is then given for every response of each indicator according to its performance. A final single score is then obtained.

To do so, a few steps were followed:

- Identification of indicators from dynamics that we want to measure
- Scoring of the responses
- Weighting every indicators
- Calculation of final Vulnerability

It is important then to keep in mind that weight and scores are elaborated on judgment and are thus an opportunity for subjectivity. They are not precise measurements against an interval scale and are not linear. In addition, the results of scoring studies are specific to individual cases and are likely to be relevant to other assessment in similar context or objectives but not extendable further.

4.5.3. Dimension and Indicators Identification

Three dimensions were defined at the very beginning of the study: the social aspect, the economic aspect and the environmental aspect. Obviously, evaluating the Vulnerability from an Agroecological point of view implies the integration of these three main dimensions in order to get a holistic overview of the situation. Moreover, it enabled us to take into account a rich panel of factors and dynamics that influence and impact the agro-ecological system and therefore determine its vulnerability.

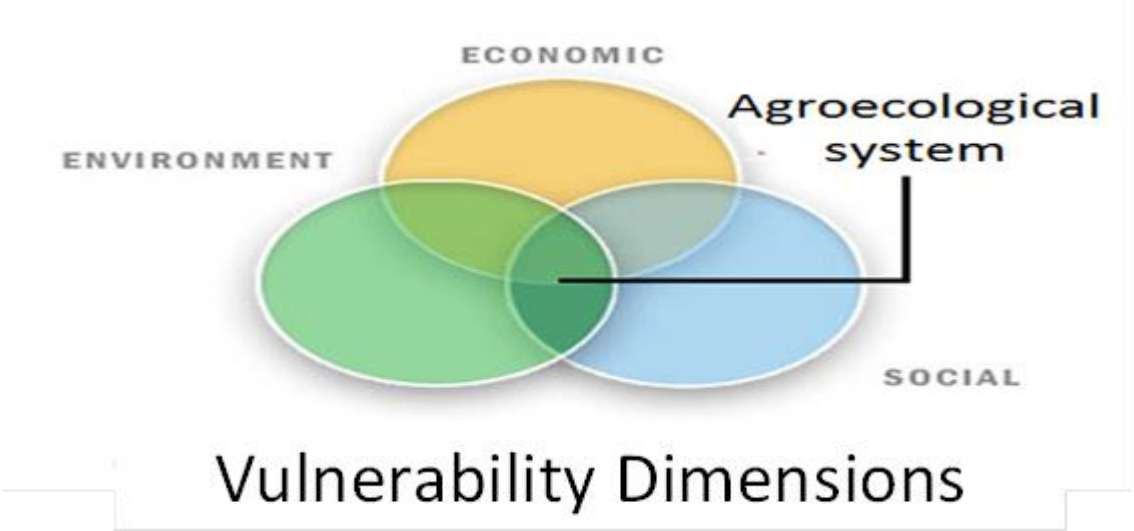

Figure 7: Dimensions of Vulnerability (http://ideaplants.org/2008/01/what-is-sustainable-development/**)**

A sample of few indicators was pre-established through the literature investigation and according to our objectives: what social, economic and environmental factors make farmers vulnerable? The work of Sarandón et al (2006) that identified sustainability in small farms of Argentina as well as the study of Gonzales (2010) in a community of Tabasco, were largely taken into account in the indicator selection. As for the survey, indicators relevancy was firstly tested during our preliminary community test. Farmers' answers helped identify the main issues as well as their origins. That way, it was possible to re-arrange and complete the indicators' sample (see table 3):

SeeTable 3: Indicators Presentation

SOCIAL DIMENSION		
Well being	Housing (H1)	House commodities (fridge, washing machine, car, air conditioner)
	Health (H2)	Presence of health problems that affect the family
	Education (E)	School system access and opportunities.
	Services (S)	Basic commodities (electricity, water supply)
Integration	Social integration (SI)	Relationships inside the community
	Governmental Support (GS)	Presence of social help, project financial Government Support, subsidies
	Acceptation of the system (AS)	Perception of their situation
ECONOMIC DIMENSION		
Income source	Production diversification (PD)	Commercialized products number.
Production Restriction	Regulation (R)	Permits, activity prohibition.
	Land Access (LA)	Land status (proprietary, ejidatario, landless).
Economic Risk	Agricultural dependency (AD)	Household income percentage from agriculture
	Input dependency (ID)	Household income percentage spent in input purchase.
Market Risk	Commercialization ways (CM)	Nature and diversity of commercialization ways (company, intermediaries, direct sales)
ENVIRONMENTAL DIMENSION		
Environmental quality	Pests and diseases (P&D)	Attacks nature and frequency
Production resiliency	Water Stress Exposure (WS)	Production exposition for water surplus or/and shortage.
	Tree use (TU)	Nature of tree use and abundance.
	Adapted species (AS)	Use of native, adapted species
Resources Availability	Climate Seasonality (CS)	Seasons impact on the production.
	Production cycle (PC)	Time period between harvest or sale

4.5.4. Indicators Weighting

In the literature, indicators are weighted through experts' judgment (Kaly U et al, 2004) or by principal component analysis (Cutter et al, 2009; Deressa et al, 2008). We decided to apply another method that assumes that all the indicators of vulnerability have equal importance and thus giving them equal weights (Cutter et al 2000, Deressa 2008).

4.5.5. Indicators Scoring

It is from this part that qualitative data of the interviews were transformed into quantitative ones. Scores were attributed to indicators according to NVivo software results. In each thematic field, the main issues and difficulties expressed by the farmers themselves were used to balance indicators. That way, each one received 5 scores from 0 to 4 depending on the Vulnerability degree of the response (0 for very high Vulnerability, 4 for a low Vulnerability):

Table 4: Vulnerability Degree and Score

Vulnerability degree	Very High Vulnerability	High Vulnerability	Vulnerable	Medium Vulnerability	Low Vulnerability
Score	0	1	2	3	4

Qualitative responses were identified by generalizing farmers' answers in order to fit to the largest panel of situation (see appendix 2).

For instance, 5 qualitative responses were attributed for the indicator "Regulation":

- If the production was completely free from any regulation, farmer got 4.
- If a permit that wasn't limited in time was needed, farmer got 3.
- For a permit that needed to be renewed frequently, farmer got 2.
- If there was a temporal prohibition in the production (like fishing prohibition during reproduction time), he got 1.
- For an unlimited prohibition (as mangrove regulation), farmer got 0.

4.5.6. Indicator Analysis

The results were classified between communities and main activities depending on farmers' scores. To do so, we calculated the average scores of each farmer for each indicator of every dimension (social, economic, environmental). The work was realized by community and productive activity. The results obtained (from 0 to 4) for each indicator were presented in tables and then modeled in spider webs. The next step was to compare for each dimension the distribution of the communities and main activities average scores within the spider web. We classified them according to their vulnerability degree:

Table 5: Community or Main Activity Scores according to their Vulnerability Degree

COMMUNITY	MAIN ACTIVITY	RANGE
Community of Low Vulnerability	Activity of Low Vulnerability	From 3 to 4
Communities of Medium Vulnerability	Activities of Medium Vulnerability	From 2 to 3
Vulnerable Community	Vulnerable Activities	From 1 to 2
Community of High Vulnerability	Activity of High Vulnerability	From 0 to 1

5. RESULTS

In this part, we will first draw up a description of each area of study according to the data collected along with the principal productive activities and their dynamics. The results of the scoring analysis will be then presented and explained. Finally, the outcomes will be modeled in spiderwebs and from which the different trends and profile categories will be identified.

5.1. Communities Description

In this first part of results, communities are described, as well as their different agricultural activities dynamics. The objective was to present a "snapshot" of the situation in order to get the indicators results analysis presented later more understandable. All the information given here comes from data collected in the field, interviews and observations.

5.1.1. Paraiso Presentation

In Paraiso municipality, two ejidos were investigated: « La Solucion Somos Todos" and "El Chivero". The structure of « La Solucion Somos Todos" is very particular. There are 1985 ha of communal lands distributed between 97 ejidatarios. 98% of the area is pure uninhabited mangrove that is under governmental protection. Therefore a lot of ejidatarios are living in other communities or cities. The main part of them belongs to two communities, Campo Mecoacan and Nicolas Bravo. Both are located alongside the ejido's borders (see figure 8)..

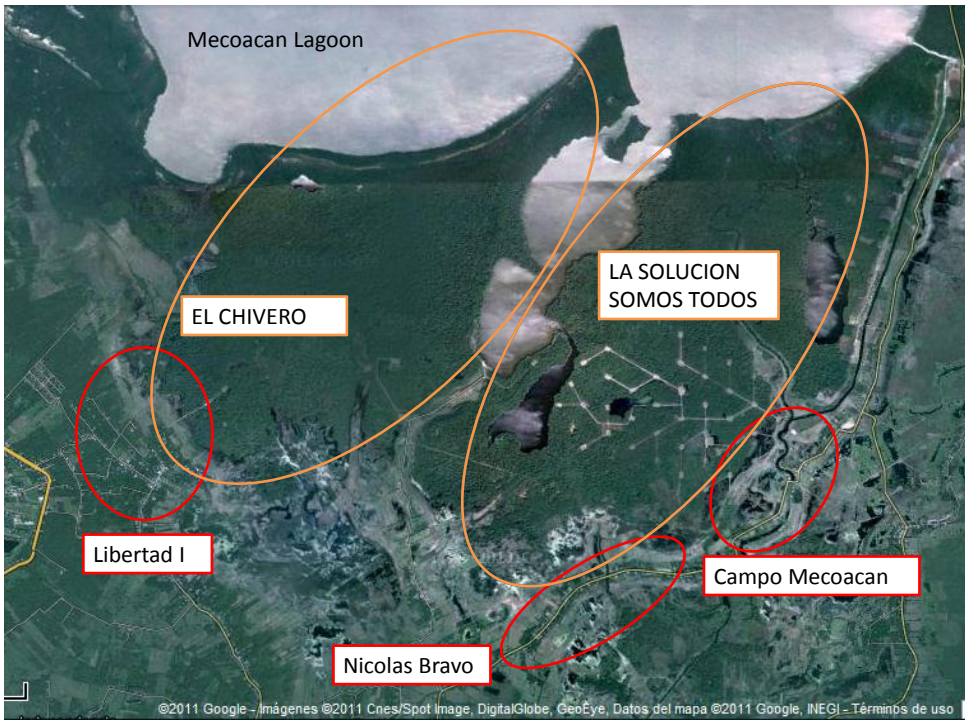

Figure 8: Location of the Communities of Paraiso (Google, 2003)

The first one is adjacent to two rivers that lead to the Mecoacan lagoon whereas the second one is a bit more inside the land. Activities are mostly linked to the exploitation of natural resources like mangrove wood extraction and lagoon fishing. Agricultural production is then marginal or at a very little scale. "El Chivero" is quite similar to "La solucion somos todos". It is constituted of 1278ha of protected mangrove managed by ejidatarios that belong to various communities. The community investigated was Libertad I which has 45 ejidatarios. Like the other community, there are little agricultural activities left. The principal differences lie in the organization of mangrove exploitation and how they took advantage of the lagoon resources to develop the touristic sector. We can see on the map below the network of old Pemex oil pipelines and wells that are nowadays abandoned. Indeed the area has suffered and is still suffering from contamination of Pemex activities

The area used to be dedicated to cacao and coco production but during the last two decades, farmers observed a drastic diminution of yield due to the increase of uncontrolled pests, diseases and contamination. Nowadays we can still see the old unproductive cacao and coco plots that are abandoned. Cattle farming is almost inexistent. The increase of soil salinity during the last decades has affected a lot the pastures and the climatic conditions makes the cattle farming of very low profitability. The agricultural activities are therefore very limited and communities' activities turn mostly toward fishing and mangrove wood exploitation.

5.1.1.1. Activities and their dynamics

The mangrove exploitation was the most lucrative activity. Lots of farmers used to get almost the totality of their income from it. However, this activity was lately more controlled. It has been prohibited to extract wood for two years (2009-2011). It put a lot of farmers in a very difficult financial situation. Most of them intensified their secondary production (fishing, coconut, cattle breeding) but are in a very vulnerable situation. Others tried to find other activities out of the agricultural system. At last, some took advantage of government support projects and developed alternative productions.[11]

5.1.1.1.1. The Mangrove System

This system used to be quite profitable before the mangrove exploitation prohibition and the natural resources degradation. Nowadays, it is only the older generation that still manages it mostly because they were not able to adapt and change the production to the actual issues.

It is composed of three subsystems (see figure 9). The Forestry Subsystem does not require any input except for the labor force. It is the simplest and the most profitable system. Mangrove wood is collected and commercialized through the cooperative. However the exploitation is now prohibited by the

[11] For more explanation about Paraiso dynamics and issues, refer to appendixe 3

government regulations and threatened by the apparition of a new pest that causes a lot of damage to the trees. The Livestock and Agricultural Subsystems are both in decline. The coconut plantations and livestock suffer a lot from the climatic (drought, inundation) and environmental conditions (salinization, pest and diseases) and Pemex contamination. Trees and pastures are less and less productive. The lack of pasture obliged farmers to rent other fields or to buy forage and fodder. During the rainy season, they also have to move the animals because of the inundations. Meat is commercialized directly to the market. The numerous little butcheries that buy it guaranty a certain liberty and independency of choice. There is one cooperative that is in charge for coconut commercialization but that imposes low prices. It is more profitable for farmers to sell their production on the market themselves. The livestock production is the only production that receives subsidies from the government. PROGAN is the first program of direct support for cattle farming in Mexico. The goal is to stimulate the cattle productivity through the forage production increase. A value of 300$MP/head/year (17 Euros) is allocated with a limit of 20 head/ejidatario and no more than 1 head/ha. In order to get the support, farmers must complete some administrative formalities that are quite complicated and difficult to fulfill when unschooled. For that, various cattle farmers don't get anything at all.

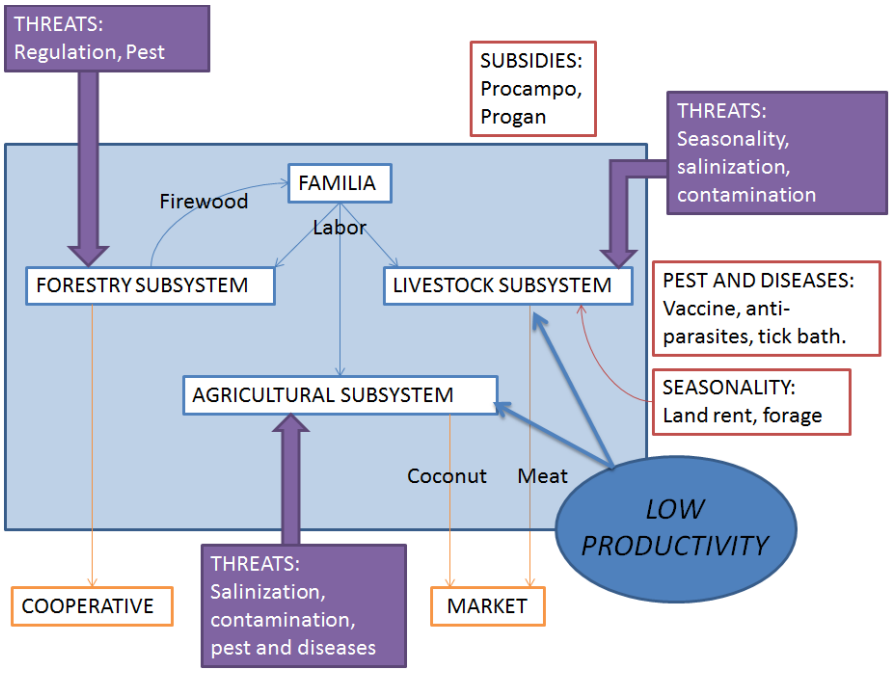

Figure 9: Paraiso Mangrove System Dynamics

This system used to be quite productive. Farmers used to have more than 40 heads for meat 30 years ago. Now they can hardly breed more than 10 animals and the activity is more for subsistence purposes. The coconut production also used to be very profitable. Yields were usually three times above what they can harvest now and associated with mangrove wood exploitation, farmers benefited from diverse and stable income sources.

5.1.1.1.2. Fishing System

Fishing is one of the most lucrative activities. The lagoon's connection to the sea creates a subtle exchange between sea and fresh water that produces optimal conditions for oyster population development. The Chivero developed its activity essentially around oyster fishing and established strategic associations with local restaurants to sell the production. By contrast, La Solucion Somos Todos produce only fishes and shrimps.

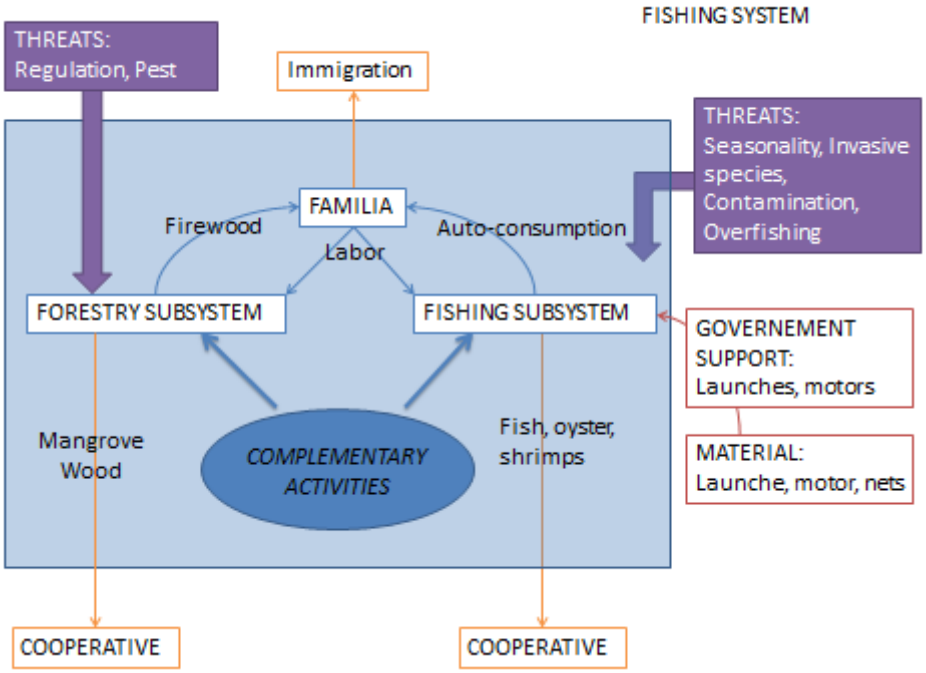

Figure 10: Paraiso Fishing System Dynamics

The systems used to involve forestry and fishing production (see figure 10). These activities were quite complementary. When the conditions to fish weren't optimal, farmers used to cut wood. That way, they benefited from stable and secured sources of income. Nowadays, numerous fishermen stay essentially upon fishing production, and had to intensify the activity in order to sustain the family. The production is essentially commercialized through the cooperative but it is common to see farmers directly sell it to the consumer. The activity requires heavy investment to get the fishing material and tools (launch, motor, nets). The government used to provide some of them but most of the resources have been hoarded by the local authorities and supports that were allocated at the fishing cooperative never get to fishermen. Apart from it, fishing system is threatened by lot of environmental factors. The lagoon over-exploitation decreased a lot the fishing opportunities. Reproduction period are not respected and it is common to observe shortage periods during dry season (April, May, June). The lagoon fish native population is in serious danger of extinction. Besides being overfished, they are suffering from the introduction of invasive species like the "devil fish"(*Scorpaena histrio).* Now the distribution of species is quite perturbed. We can observe an overabundance of mojarra "tilapia"(*Oreochromis spp)* and "castarrica" (*Cichlasoma urophthalmus)* and crab. Before, it was common to find "pejelagarto"

(*Lepisosteus* spp.) and "robalo" (*Dicentrarchus labrax*). To respond to this issue, alternatives of fish farm activity using artificial ponds are considered. The lagoon of Mecoacan also suffers seriously from the contamination of the work of the petroleum complex "Dos Bocas" harbor (see figure 11).

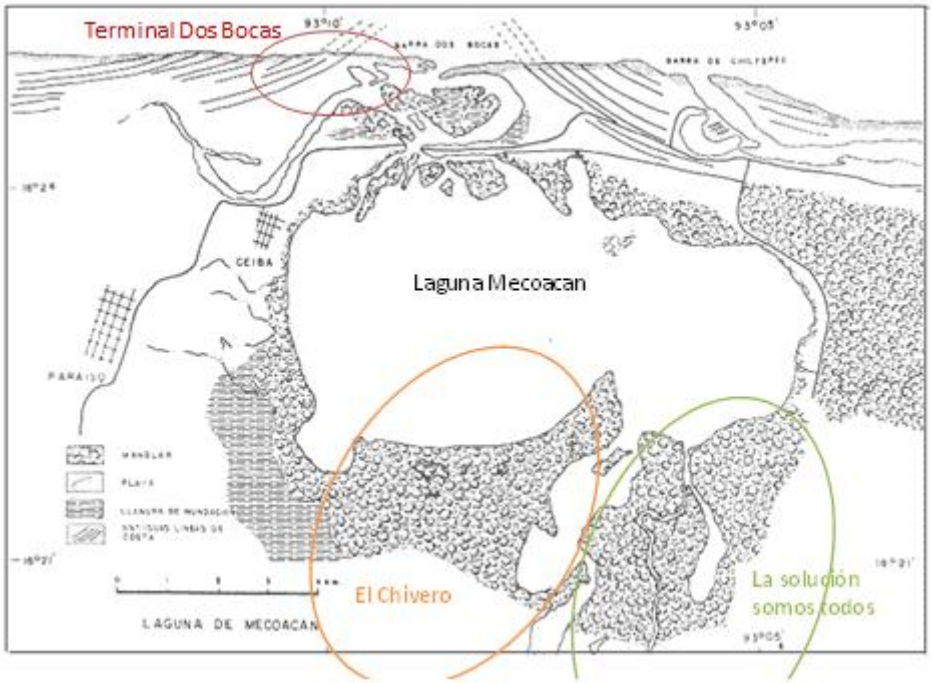

Figure 11: Map of the Mecoacan Lagoon (Galavíz, et al., 1985)

Fishermen observed a diminution of the population of oyster, shrimp, crab and fish. The oysters are the ones that are the most affected by the contamination. In 1991, the oil spillage of a damaged burner provoked the death of 80% of the oyster production. Besides, modifications in water dynamic in the lagoon system have been observed.

5.1.1.1.3. Alternative Production System

To respond to the environmental issues that prevent any agricultural work, some farmers tried to consider other production alternatives. A new class of young diversified farmers emerged, that takes every opportunity to develop new projects.

Various projects financed by the government have been developed recently. The objective is finding other alternatives of production to enhance the activity in the community. Projects are usually conducted by groups of ten people and are still in the experimental phase:

- The beekeeping group: one beekeeper in the community that has started one year and a half ago. He hasn't reached the full production potential yet. Another farmer has several beehives in his garden but he really misses management capacity. Training lessons are offered by the government and are financed for 70%. It is the women who are in charge of the project.
- The Coconut group: the aim is to experiment another variety of coco that could be more productive. The government gives the seedlings.

- The crab fattening group: it needs more people to begin. The government is financing 100% and gives training support.

The fish pond group: it has been supported 100% for the construction and 50% for the equipment, young fish and food.

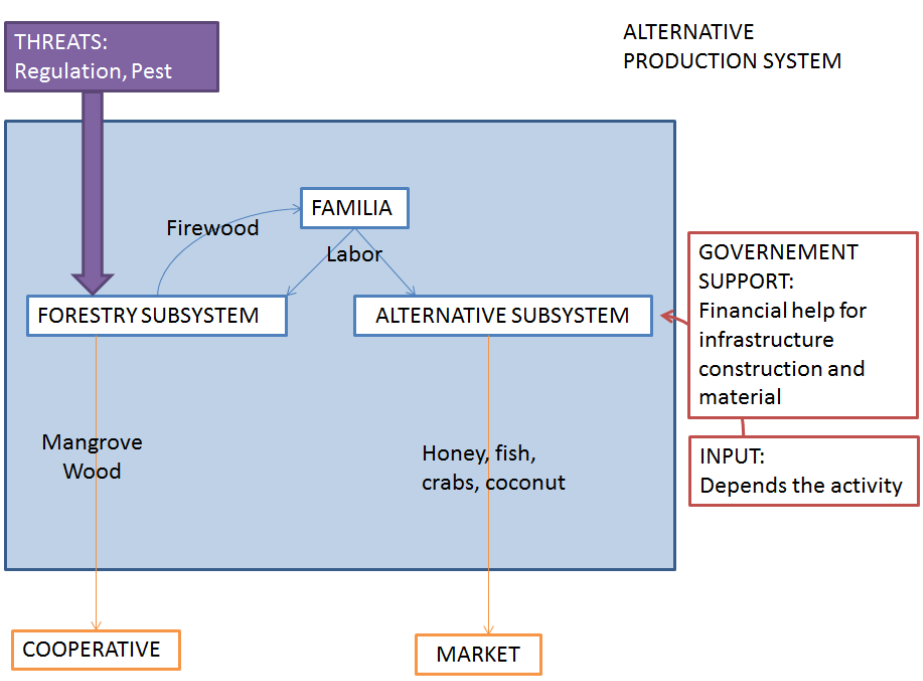

Figure 12: Paraiso Alternative Production Dynamics

From an environmental aspect, these productions have the advantage of not depending so much from natural resources or climatic conditions. That way, they don't suffer from drastic drought, sever inundation or soil salinity increase and can be good alternatives for the future. They offered good financial potential. For instance before its diversification, the beekeeper used to gain only 4000$MP/year for the harvest of coco. Today, its beehives bring him 21000$MP/year.

5.1.2. Huimanguillo Presentation

There are 11 242 ha of communal land divided between 365 ejidatarios. A little proportion are producing pineapple on very little surface (1 or 2 ha). Around 40 ha in the total area are dedicated for the pineapple production. The rest is completely occupied by pasture for livestock production purposes. The distribution of the land is quite unequal: 3 or 4 farmers have around 500 ha, 60 own less than 10 ha, the rest are middle weight farmers of 50 ha in average. Two communities are included, Central Fournier I and Central Fournier II. Central Fournier II is located alongside the lagoon El Rosario whereas Central Fournier I is situated 10 km away (see figure 13). Consequently, each one presents its own dynamics even if the environmental context is very similar. Ignacio Gutierrez has a very distinct profile. For that reason it will not be integrated in the characterization that will follow but we will treat its situation apart.

Cattle farming largely dominates the agricultural landscape. However, both communities have other very distinct productions. Central Fournier I is famous for its pineapples whereas Central Fournier II takes advantage of the lagoon benefits for fishing and touristic activities.

Figure 13: Location of the municipalities of Huimanguillo (Google, 2003)

5.1.2.1. Activities and their Dynamics[12]

5.1.2.1.1. The Livestock System

The Cattle production exploded during the 1970ies. Enormous areas have been deforested to implement pastures and now, it is very common to observe a large quantity of overgrazed tree-free pastures. Herds are composed by dairy/meat cows. This is a double purpose production in which cows are milked and calves are sold when they reach 250-300kg. The milking production is the most profitable activity in the area.

This system is commonly composed of the livestock subsystem and an agricultural subsystem (see figure 14). Maize or pastures for forage purposes are grown to feed the animals. They are essentially auto-consumption productions but it happens that exceeds are sold on the market. Nowadays, only few farmers carry on producing. The maize indeed is affected by drastic decrease of yield, and suffers from the attack of pests and diseases. Livestock production is also facing a real decline. Infestation of diseases (rabies, ticks) as well as pasture and water shortage (due to overgrazing, drought or inundation) are very

[12] For more explantion about Huimanguillo dynamics and issues, refer to appendix 4

common and affect seriously yields. The seasonality plays also negatively in the productivity. During the rainy time, lowlands can stay under the water for 3 or 4 months. On the other hand, highlands suffer a lot from hydric stress during the dry season. Some farmers rent lands, other buy forage except for those that produce hay. The use of veterinary product is also indispensable to maintain the level of production. The proximity between farms' field increase the possibilities of pests and disease dissemination. The dairy production is commercialized to a company which sends a delivery van every day to collect milk paid at very low price. Farmers don't have other alternatives. The meat is commercialized through intermediaries called commonly "coyotes". This system is the only way for them to send their production to the market. The community is indeed very isolated from the city and there isn't any local market in which farmers can commercialize directly. Therefore, the degree of dependency toward intermediaries is very high.

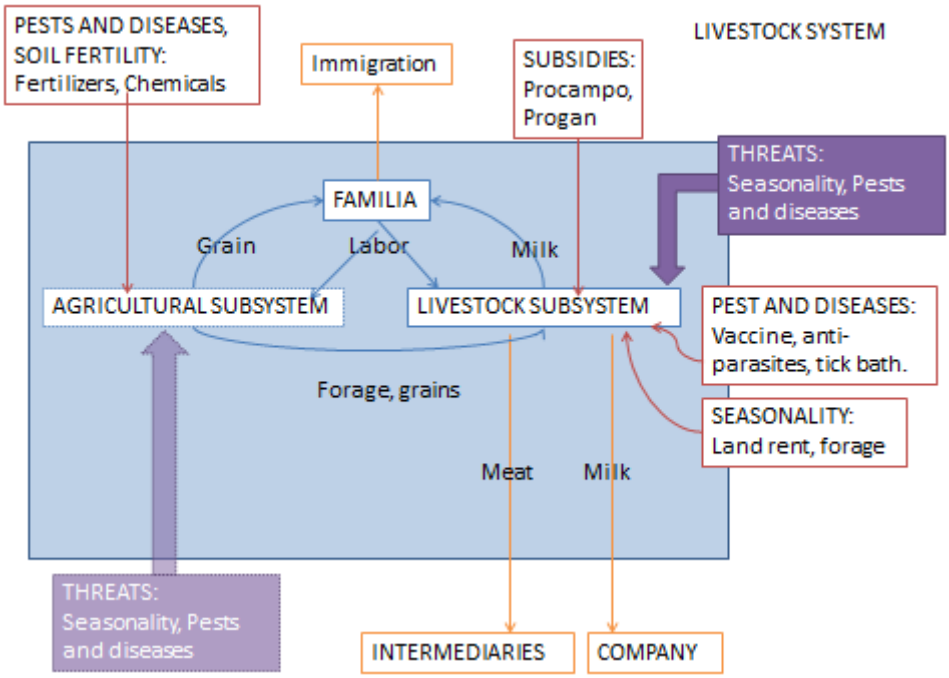

Figure 14: Huimanguillo Livestock System Dynamics

5.1.2.1.2. Fishing System

The fishing activity has much more impact on the economy of the Central Fournier II families. Every landless person is dedicated to it. The lagoon still represents a very rich and easy resource even if there aren't as many fish as before. The only difficulty is getting the launch, motor and net which represent a very heavy investment.

The production is essentially commercialized through a cooperative (see figure 13). The cooperative is also in charge for the government support distribution but as for Paraiso the relations of power completely corrupted the system. The launches and motors government's donation have been hoarded between the delegate's relatives. Apart from this, fishermen are facing the consequences of decades of overfishing. A single man used to fish about 80 kg of fish a day whereas now, he can hardly

fish more than 10kg. The Seasonality also is prejudicial: during the rainy season, the lagoon current is so strong that fisherman cannot go out. Therefore, they offered they labor force in big cattle farms that contract them only for short periods (few days).

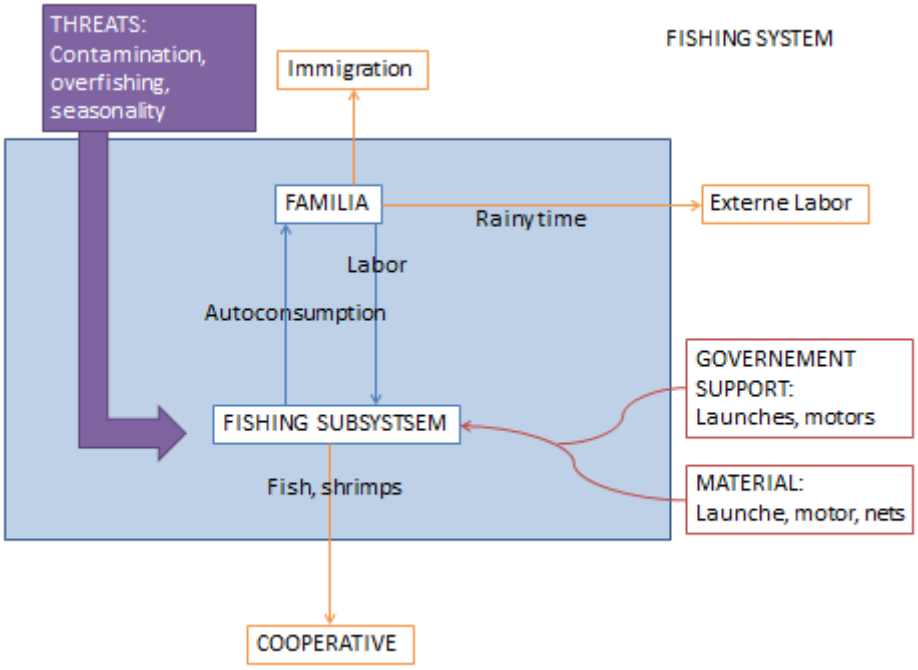

Figure 15: Huimanguillo Fishing System Dynamics

5.1.2.1.3. Agriculture System

The pineapple production used to be quite important during the 1950ies. People were growing big plot getting good yield without using chemicals. They exploited the soil until it tired all its resources. The livestock age finished the process, letting the soil unfit for any agricultural production. Nowadays, on the few pineapple plots left, farmers have to use big amount of fertilizer to be able to produce 30% less than before. Pests and diseases are also affecting the production more than before.

Crop Farmers are usually diversified (see figure 16). The Agricultural Subsystem is indeed kept under the season pattern. Therefore, there isn't any pineapple production possible in the lowlands for floods. In this context, they have to look for other income sources. They usually offer their labor force but some of them take advantage of the lagoon when the current isn't too strong. They also diversify their homegardens for selling poultry and pork directly into the community. The pineapple production is commercialized through intermediaries' network.

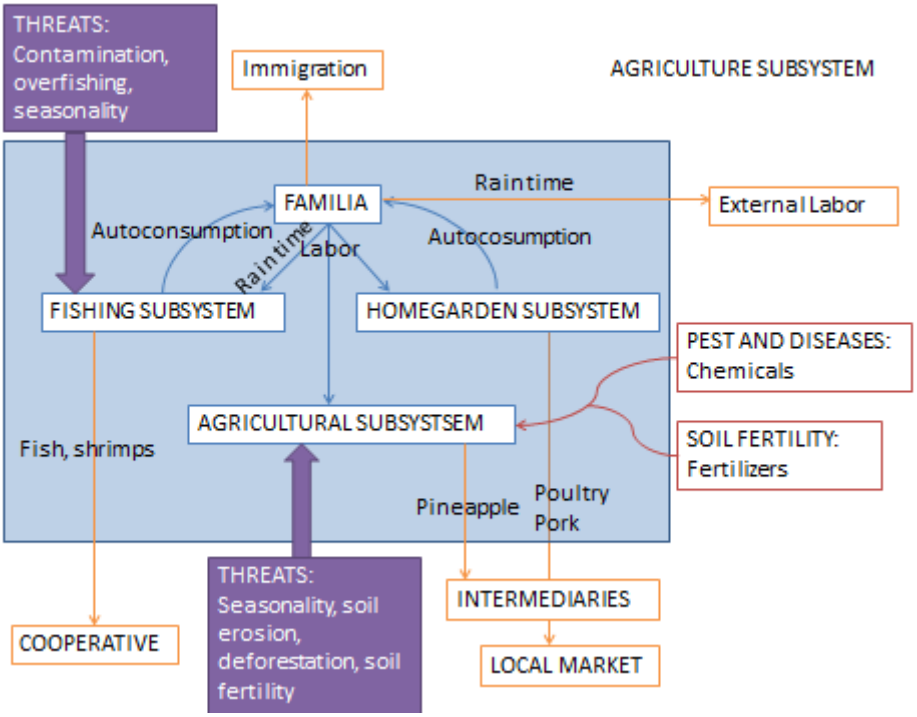

Figure 16: Huimanguillo Crop system Dynamics

5.1.2.2. The particular situation of Ignacio Gutierrez IV

Ignacio Gutierrez IV doesn't have any real agricultural activities. Indeed, the majority of the farmers are landless and contract themselves for day labors or are dedicated to fishing if they have launches and net. But globally, most of them can't afford it.

This community is much more marginal than the others. The only way to reach it is by boat or through a non-asphalted road. There are not any public transports, nor electricity network.

5.2.Analysis

In this section, the indicators results are analyzed according to two different processes. Individual farmers' scores firstly processed are presented in tables and explained. Then, a generalization is elaborated, using spiderwebs representing each indicator average. The distribution of the indicators can be seen in the appendixe 5.

We will commonly use abbreviations for community names : ST for "La Solución Somos Todos", Ch for "El Chivero", CFI for "Central Fournier First Section", CFII for Central Fournier Second Section" and IgIV for "Ignacio Gutierrez Fourth Section".

5.2.1. Scoring Analysis

5.2.1.1. Paraiso Vulnerability

5.2.1.1.1. Social Vulnerability

Tendencies are not that marked. For both communities we can observe that Government Support is really poorly scored (see Table 6). Government programs are largely dedicated to livestock production and even for this, administrative formalities make it difficult to get. From now, Mangrove sector doesn't get anything; fishing material is offered but in general, these resources are badly distributed. The only category of people that get Government Support are Alternative Producers (see ST2, ST5, ST8 in Table 6). A Consequent financial Government Support is offered to them to start new activities. The other indicators show differences between Ch and ST. Ch got bad scores for Health due to the poor treatment and care access. Acceptation of the System also presents bad result. In fact, mangrove regulation is seen as very unfair and each one that has a 0 is those that used to exploit mangrove wood (see Ch1, Ch2, Ch3). The tendency is quite similar for ST where those that depended on Mangrove activity are those that accept the least the system. ST present good results for Services, Education and Health. Indeed, urban center proximity guaranties quality and access facilities. The Chivero obtained its highest scores for Education.

5.2.1.1.2. Economic Vulnerability

The majority of Paraiso economic vulnerability results vary between 3 and 4. Activities are mainly based on the exploitation of natural resources and so, the Agricultural Dependency is quite low. The other strength is based on the production diversification. ST has good results because most of farmers have at least 3 different productions except for ST3 whose activity is essentially fishing. Farmers that present the best results are indeed the Alternative Producers. The situation is a bit different in the Chivero in which the population is mainly dedicated to fishing and, as ST3, isn't very diversified but present an better Agricultural Dependency. We can observe also differences between both communities in the Input Dependency and Commercialization Ways. ST still has livestock and it is clearly cattle farmers that show the lowest scores for the inputs (ST1, ST6, ST7 got 2). Concerning the Commercialization Ways, Ch

presents facilities. The dense net of restaurant guaranties a stable and diversified demand. There is clear complementarity between both activities. On the other hand, ST depends from cooperatives and intermediaries monopole to access the market.

The main weakness concerns the Regulation. The mangrove exploitation interdiction is a real factor of vulnerability. Farmers that used to get the majority of their income from it, are now obliged to entrench on their secondary productions. ST6 and ST7 are very good example: nowadays their income depends essentially on livestock and coconut production. The worst is that these productions are those that present a drastic decline of productivity due to the salinization (livestock) and pests and diseases (coconut). These people are thus, very vulnerable. The other part of the population that used to exploit the mangrove converted their activity on new alternative productions (ST2, ST5, ST8).

We decided not to take into account the Land Access indicator. The totality of the population interviewed are ejidatarios and as a result are owners. Nevertheless, it is important to emphasize that 30% of the population in both community is landless.

5.2.1.1.3. Environmental Vulnerability

Communities of Paraiso show globally good results with a majority of scores between 3 and 4. Activities are largely turned to the exploitation of natural resources (lagoon and Mangrove).The main strength concern Tree Use (the majority of scores are equal to 4) for the fact that Mangrove covers the majority of the land and every farmer owns a piece. Production Cycle is quite good as well. Farms are quite diversified and have different productive cycles that are distributed all year long. Best scores are indeed obtained by farmers that are diversified (Ch2 and Ch3) or that have developed an alternative production that does not depend that much from the climate (ST2, ST5, ST8). ST3 also present good scores: the fishing activity is indeed integrated in the exploitation of natural resources and doesn't depend on the climate.

On the other hand, few weaknesses can be highlighted. Pests and Diseases is very low firstly because of the apparition of a new disease on the mangrove that is still unknown for any cures. The area also experienced a severe problem of disease on the coconut and the cacao and overall, a serious increase of soil salinity made all crops unfit to produce. The second factor of weakness is the climate seasonality. Strong floods or drastic droughts affect pastures and animals. The repercussion can be observed on people that produce cattle (ST1, ST4 and Ch4): all present the lowest scores. ST9 is as well very vulnerable in front of the Climate Seasonality due to the fact that during the drought, he cannot go out in the lagoon because the access is completely blocked by plant proliferation. The lagoon is suffering from overfishing and pastures from overgrazing. Deforestation is the main cause of vulnerability.

Table 6: Paraiso Social, Economic and Environmental Vulnerability

	SOCIAL DIMENSION							ECONOMIC DIMENSION						ENVIRONMENTAL DIMENSION					
FARMERS	H1	E	H2	S	AoS	SI	GS	PD	R	LA	AD	ID	CW	P&D	PC	CS	WS	TU	AS
ST1 Professional	4	4	1	4	4	2	0	3	0	3	3	2	2	0	3	1	1	4	3
ST2 Alternative Production	1	4	4	2	3	2	4	4	4	4	1	3	3	4	3	4	4	4	2
ST3 Fishing	2	1	3	2	3	1	2	2	1	3	4	1	2	2	3	3	3	4	4
ST4 Professional	4	4	3	4	3	2	2	3	0	3	3	2	2	1	3	2	1	4	3
ST5 Alternative Production	4	3	3	4	1	4	4	3	4	4	4	3	4	4	4	4	4	4	2
ST6 Mangrove	1	1	4	2	1	1	0	3	0	3	1	4	2	0	4	2	2	4	3
ST7 Mangrove	3	3	0	4	1	1	0	3	0	3	2	2	2	0	4	4	2	4	3
ST8 Alternative Production	3	3	3	4	4	3	4	4	4	4	4	4	4	4	4	2	2	4	3
ST9 Fishing	2	2	3	3	1	4	2	3	1	3	3	4	2	0	4	0	4	4	3
ST10 Day Laborer	1	3	4	3	4	0	0	0	4	0	4	4	2						
Ch1 Mangrove	1	2	1	2	0	0	0	1	0	4	4	4	4	0	4	0	4	4	4
Ch2 Alternative Production	3	3	2	4	0	4	0	2	1	4	4	4	3	4	4	2	4	4	4
Ch3 Alternative Production	1	3	0	2	0	2	1	4	0	4	4	4	4	2	4	3	3	4	4
Ch4 Professionnal	4	4	3	4	4	1	0	2	4	3	3	2	4	1	3	2	2	1	2
Ch Fishing	1	3	0	2	4	3	0	2	0	4	4	4	2	2	4	3	3	4	4

H1: Housing, E: Education, H2: Health, S: Services, AoS: Acceptation of the System, SI: Social Integration, GS: Government Support, PD: Production Diversification, R: Regulation, LA: Land Access, AD: Agricultural Dependency, ID: Input Dependency, CW: Commercialization Ways, P&D: Pests and Diseases, PC: Production Cycle, CS: Climate Seasonality, WS: Water Stress Exposure, TU: Tree Use, AS: Adapted Species, White squares: no possible response

5.2.1.2. Huimanguillo Vulnerability

5.2.1.2.1. Social Vulnerability

The table 7 shows net differences between the two CFs and IgIV. The last is very bad scored for almost all the indicators. Housing and Health are the worst firstly because that nobody has electricity and thus, any electric machine as fridge and secondly because the majority of the population had to sell their land in order to pay treatment and care. As a result, the Acceptation of the System is very low as well. The community is really isolated and doesn't benefit from a real schooling access or services. The only education access is the primary school and the community doesn't have any electricity, nor water services. Both Indicators (Education and Services) are as a consequence, quite low. CFI and CFII do not have very good score for education and housing. The secondary school is indeed very far from the community and very few people can get more than a fridge. The authorities and his family are the only ones to get 3 or 4. Health is not a real problem for these communities. The health center is not really good but only a small part of the population is affected by health problem (CFI3, CFII2 and CFII9). Service is not very good either, there isn't any water service but the majority of the population is connected to electricity network. To finish, we can see similarities between all the communities for two indicators: the Government Support indicator is very low, very few people except authorities themselves benefit from financial program; social integration by contrast is very highly scored but not very relevant because the majority of the population interviewed was on authorities advices and were thus from the family or close relationship.

5.2.1.2.2. Economic Vulnerability

The situation of Huimanguillo differs completely. Unlike Paraiso, Regulation is the best scored indicator. The only control should be exercise by the fishing cooperative to regulate the exploitation and avoid overfishing. However, in reality, there isn't any regulation. We scored nevertheless fisherman according to what it should be. CFI1, CFI6, CFI7 and IgIV4 are therefore the only ones to have a low score for regulation. Huimanguillo is also poorly scored for Production Diversification. Farmers rarely have more than one production (cattle or fishing). The factor that pushed scores up is the nature of livestock production (double purposes, meat and milk). We can see that cattle farmers (CFI1, CFI6, CFII3 and CFII4) are better scored than the others. CFI2 transgress the rule with a very diversified production (pineapple, maize, manioc, poultry, pork).

Some indicators differentiate both CF and IgIV. The last is poorly scored for Land access and well scored for Agricultural and Input dependency whereas CFI and CFII present opposite results. Indeed, the majority of farmers in IgIV is landless and thus, is getting their income from laboring. They don't have any agricultural production and thus, no agricultural neither input dependency. On the contrary, we can see that the two CFs are quite vulnerable concerning Agricultural and Input Dependency for the cattle activity (the only ones to have good scores are fisherman or day laborers) but has a better situation than IgIV for Land Access.

Finally, we can see that all the communities are vulnerable concerning the production commercialization. Communities are really isolated from any market access and the only way to commercialize the production is through intermediaries or companies that exercise a real monopole. CFII8 is an interesting case of extreme vulnerability. He presents all the communities' weaknesses: one production highly input dependent, commercialized via intermediaries, grown on a rented land.

5.2.1.2.3. Environmental Vulnerability

Huimanguillo is mainly dedicated to the livestock production. There isn't any exploitation of natural resources except for fishing that is however responsible for the overexploitation of the lagoon resources. The area presents therefore a higher environmental vulnerability than Paraiso with a majority of scores between 0 and 2.

Worst Results are found for Climate Seasonality and Pests and Diseases. High concentration of animals grazes in restricted areas. The risk of pest and diseases proliferation and dissemination is therefore very high (CFI3, CFI5, CFII5). The only exception is found for CFI4 and CFII7 that own very vast areas with few animals. Apart from this, the climate seasonality is a real problematic whether for fisherman than for cattle farmers. Strong inundation and drought generate severe pasture shortages that are even graver with overgrazing (observed for CFI3, CFI5, CFII5, CFII3, CFII4). The fishing sector is even more affected by the seasonality: it is then impossible for them to go fishing because of the intensity of the current. These productions are then very dependent from the water dynamic. Crop farmers (CFI2 and CFII8) are as well very vulnerable for Seasonality and Pests and Diseases but also for Production Cycle: Pineapple can be grown essentially on highlands that are not affected by inundation. It is harvested only once a year and need more and more chemicals each year due to the proliferation of pests and diseases.

Unlike Paraiso, there isn't a strong use of forestry. Cattle Farmers present low scores for Tree Use except CFI4 that still have a large part of "acahual". Best scores are found for Production Cycle and Adapted species. The majority of the cattle is crossed with zebu, and the pineapple specie come from the old farmers generations that have selected the most adapted ones. Cattle farmers enjoy from a daily milk production and present thus a low vulnerability for this indicator.

Table 7: Huimanguillo Social, Economic and Environmental Vulnerability

	SOCIAL DIMENSION							ECONOMIC DIMENSION						ENVIRONMENTAL DIMENSION					
FARMERS	H1	E	H2	S	AoS	SI	GS	PD	R	LA	AD	ID	CW	P&D	PC	CS	WS	TU	AS
CFI1 Alternative Production	3	3	4	3	4	3	4	3	4	3	0	1	1	1	3	2	2	1	3
CFI2 Crop Farming	2	2	3	2	1	2	1	3	4	3	0	2	2	1	0	0	2	3	3
CFI3 Livestock	3	2	0	3	0	3	0	1	4	4	0	0	1	0	4	1	1	2	3
CFI4 Livestock	1	1	3	3	1	3	1	2	4	2	0	2	2	3	4	3	4	3	2
CFI5 Livestock	1	4	4	2	0	1	3	0	4	0	4	4	2	1	1	1	1	1	2
CFI6 Livestock	2	2	2	2	3	4	2	2	4	2	0	1	2	1	4	2	2	1	4
CFII1 Fishing	2	2	3	2	0	3	0	1	2	0	4	2	2	2	4	0	2	2	4
CFII2 Day laborer	2	2	1	2	2	3	0	0	4	0	4	4	2						
CFII3 Livestock	3	3	4	2	4	3	0	3	4	4	0	0	1	1	4	1	2	1	2
CFII4 Livestock	4	3	4	2	3	4	4	2	4	4	0	0	1	1	4	1	3	1	2
CFII5 Livestock	1	1	2	1	4	3	0	2	4	4	2	0	1	1	4	1	1	1	2
CFII6 Fishing	3	3	3	2	1	3	0	1	2	0	4	2	2	2	4	0	2	2	4
CFII7 Fishing	3	3	4	2	4	3	0	2	2	4	4	1	2	3	4	0	2	1	4
CFII8 Crop Farming	2	2	3	2	1	3	0	1	4	1	0	0	0	1	0	0	2	3	3
CFII9 Day Laborer	2	1	1	2	3	3	0	1	4	0	4	4	2						
CFII10 Day Laobrer	0	1	1	1	1	2	1	0	4	0	4	4	2						
IgIV1 Fishing	0	1	1	1	2	3	0	0	4	0	4	3	2	2	4	0	2	2	4
IgIV2 Day Laborer	0	1	1	1	0	0	0	0	4	0	4	4	2						
IgIV3 Fishing	0	2	0	1	1	3	1	0	4	0	4	3	2	2	4	0	2	2	4
IgIV4 Livestock	0	2	0	1	0	3	1	1	2	4	4	3	2	2	4	0	2	2	4
IgIV5 Day Laborer	1	2	1	2	0	0	1	0	4	0	4	4	2						

H1: Housing, E: Education, H2: Health, S: Services, AoS: Acceptation of the System, SI: Social Integration, GS: Government Support, PD: Production Diversification, R: Regulation, LA: Land Access, AD: Agricultural Dependency, ID: Input Dependency, CW: Commercialization Ways, P&D: Pests and Diseases, PC: Production Cycle, CS: Climate Seasonality, WS: Water Stress Exposure, TU: Tree Use, AS: Adapted Species, White squares: no possible response

5.2.2. Identification of trends and profile categories

For the present vulnerability classification, we used scores obtained in the preview tables to obtain a general average for each indicator. Results were then modeled in spider webs. All spiderwebs have the same construction: We placed 0 at the spider web origin and 4 at the spider web perimeter. The different indicators were dispersed around the circle. The spider web could be therefore interpreted easily: low vulnerability results will be distributed in the perimeters whereas the high vulnerability results will be concentrated around the spider web origin. This approach allows us highlighting the main tendencies that characterize each areas of work and each productive activity. It also permit to identify the differences

5.2.2.1. Trends for Paraiso

The distribution of the ST social mean indicators average is quite homogeneously distributed within indicators (see figure 17). Most of them are situated between 2 and 3 (Housing, Education, Health, Social Integration). The best scored is services with its average above 3; the worst scored is Government Support with its average below 2. By contrast, Ch presents a high heterogeneity among its indicators. Housing, Health, Acceptation of the System and Social Integration obtained scores between 1 and 2. Education and Services are very close to 3 and Government Support got a 0. Health present the biggest difference between the two communities, with high score for ST and very low for Ch.

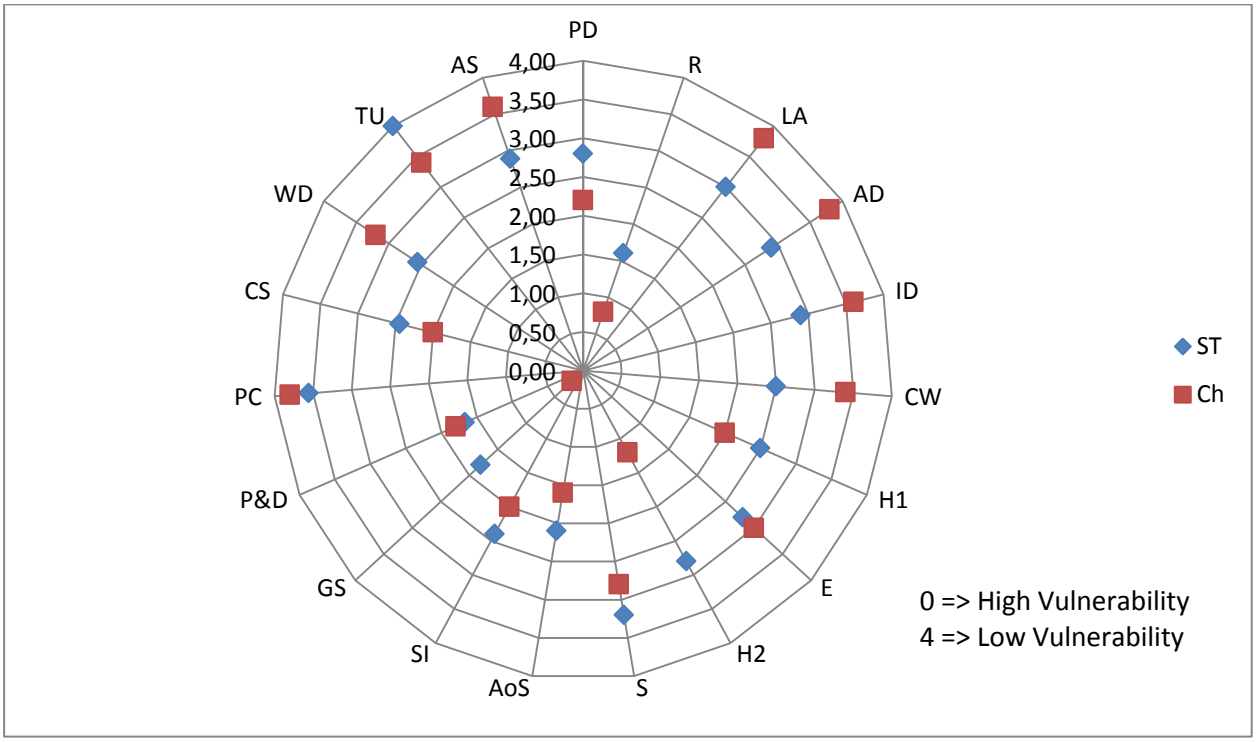

Figure 17: Paraiso Spiderweb Vulnerability

R: Regulation, LA: Land Access, AD: Agricultural Dependency, ID: Input Dependency, CW: Commercialization Ways, H1: Housing, E: Education, H2: Health, S: Services, AoS: Acceptation of the System, SI: Social Integration, GS: Government Support, P&D: Pests and Diseases, PC: Production Cycle, CS: Climate Seasonality, WS: Water Stress Exposure, TU: Tree Use, AS: Adapted Species, PD: Production Diversification, White squares: no possible response; ST: La solucion somos todos; Ch: El Chivero

The Economic Dimension shows quite the same pattern for both communities with ST always scored a bit lower. Land access, Agricultural and Input Dependency as well as Commercialization Ways obtained the best results with scores around or above 3. For the last two indicators, the pattern is conserved but ST presents better results. Production diversification is in the middle with scores around 2.5. Regulation obtained the lowest score with 1.5 for ST and below 1 for Ch.

Community's vulnerability characteristics are also quite similar for the environmental dimension. Best scored indicators (above 3) are obtained by both communities for Production Cycle, Tree use. Climate Seasonality has a medium place with scores between 2 and 2.5. Pest and diseases present the lowest scores (around 1.5). Results differ for Water Stress Exposure where Ch got a score above 3 and ST got a 2.5 and for Adapted Species where Ch got a 3.5 and ST a 3.

In all, both communities present higher vulnerability for the social dimension with a strong variation of scores for Ch. The economic dimension is quite well and regularly scored with only one very low indicator (Government Support). Results are more dispersed for the environmental dimension. Two low scored indicators (Pest and diseases and Climate Seasonality), two medium scored indicators (Water Stress Exposure and Adapted Species) and two highly scored indicators (Tree Use and Production Cycle). Globally we can see that Ch is more vulnerable for the social dimension and less vulnerable for the environmental one. They are quite equal for the Economic aspect.

5.2.2.2. Trends for Huimanguillo

Huimanguillo results show a higher dispersion and a higher agglutination in the spiderweb than what we have seen for Paraiso (see figure 18). CFI and CFII presents quite the same scores pattern with few exceptions but IgIV differs completely in its vulnerability characteristics.

The social dimension presents the lowest results. CFI and CFII present regular pattern for the majority of their indicators: Health and Social Integration above 2.5 and Housing and Education between 2 and 2.5. Lowest scores are found for Government Support, where CFI got 2 and CFII 0.5. Results differ for Acceptation of the System (1.5 for CFI and 2.5 for CFII) and Services (almost 2 for CFII and above 2.5 for CFI). The situation is worse for IgIV, for which the totality of the indicators' scores are below 2. Education, Services and Government Support are the best scored (between 1 and 2); Health, Acceptation of the System and Social Integration are quite low (below 1); the worst scored is Housing with 0.

The Economic Dimension is the most heterogeneous within indicators and within communities. As usual, CFI and CFII are quite similar: highest score for Regulation (above 3.5), Land access around 2; Production Diversification, Commercialization Ways, Input Dependency around 1.5. Agricultural Dependency shows big difference between both communities: CFI is below 1 whereas CFII is above 2.5. Another pattern appears for IgIV: good scores are found for Regulation, Agricultural Dependency and Input Dependency (above 3.5); Commercialization Ways got 2; but Production Diversification and Land Access are poorly scored (below 1).

Patterns of the Environmental Dimension are very similar among the three communities. Highest scores are found for Production Cycle and Adapted Species (IgIV scores are globally higher than CFII and CFI has the lowest ones). Water Stress Exposure and Tree Use present scores between 1 and 2. Finally, Pest and Diseases as well as Climate Seasonality obtained the lowest scores: around 0 for CFII and IgIV in Climate Seasonality and around 1 for CFII and CFII in Pest and diseases. However, CFI doesn't show high vulnerability concerning Climate Seasonality as well IgIV for Pest and Diseases.

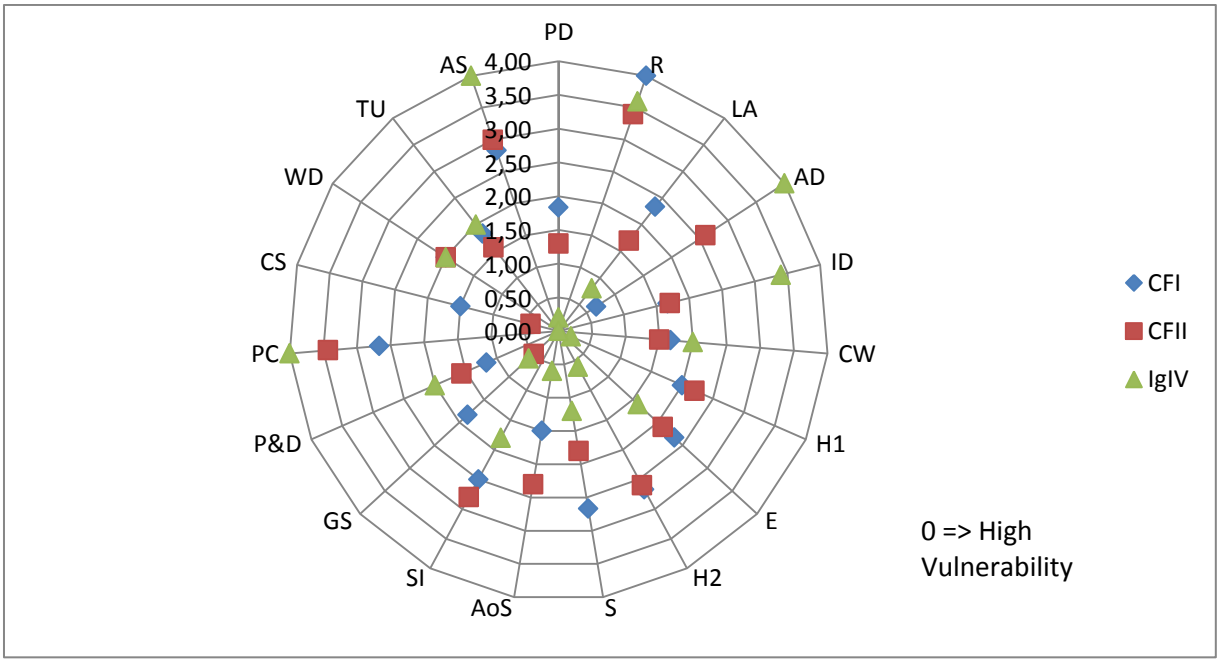

Figure 18: Huimanguillo Spiderweb Vulnerability

R: Regulation, LA: Land Access, AD: Agricultural Dependency, ID: Input Dependency, CW: Commercialization Ways, H1: Housing, E: Education, H2: Health, S: Services, AoS: Acceptation of the System, SI: Social Integration, GS: Government Support, P&D: Pests and Diseases, PC: Production Cycle, CS: Climate Seasonality, WS: Water Stress Exposure, TU: Tree Use, AS: Adapted Species, PD: Production Diversification, White squares: no possible response; CH1: Central Fournier I; CFII: Central Fournier II; IgIV: Ignacio Gutierrrez IV.

In all, Vulnerabilities are quite higher for these communities than for Paraiso. Results are very heterogeneous (very high results as well as very low) among the Economic and Environmental dimension yet there is a net tendency to agglutinate to the center. Social Dimension is a bit more constant, there are not that many high or very low scores, except for IgIV.

A synthesis is presented in the table below:

COMMUNITIES	SOCIAL DIMENSION	ECONOMIC DIMENSION	ENVIRONMENTAL DIM
ST	Medium Vulnerability	Medium Vulnerability	Medium Vulnerability
Ch	Vulnerable	Medium Vulnerability	Low Vulnerability
CFI	Medium Vulnerability	High Vulnerability	Vulnerable
CFII	Vulnerable	Vulnerable	Vulnerable
IgIV	High Vulnerability	Vulnerable	High Vulnerability

Table 8: Summary Community Vulnerablity

5.2.3. Activity Category Profile

5.2.3.1. Paraiso Activities

Social Vulnerability patterns are quite different between each activity (see figure 19). Mangrove has the lowest results; there aren't any scores above 2.5. Acceptation of the System, Social Integration and Government Support are all below 0.5. Housing, Education and Health are in the middle, between 1 and 2. The best scored indicator is Services (around 2.5). Fishing Activity and Alternative Production show a better situation. Fishing Results are quite regular with all its scores between 1.5 and 3. Best scores indicators are Social Integration, Acceptation of the System and Services with scores above 2. Then, Health, Education and Housing come with scores around 2. Finally, Government Support, which is below 1. Alternative Production present the best results, the main part of its indicators has their scores above 2. Education, Services and Social Integration are above 3; Housing, Health and Government Support are scored between 2 and 3; and Acceptation of the System is the lowest with score around 1.5.

The Economic Dimension is also very heterogeneous between activities. As for the Social Dimension, Alternative Production is the least Vulnerable; all its results are above 2.5. Best Indicators are Land Access and Input Dependency (almost 4) and the lowest one is Regulation (2.5). Fishing and Mangrove activities show very distributed results through the spiderweb. Land Access and Agricultural Dependency (for Fishing) and Input Dependency (Mangrove) got both scores above 3 whereas Regulation got a 0.

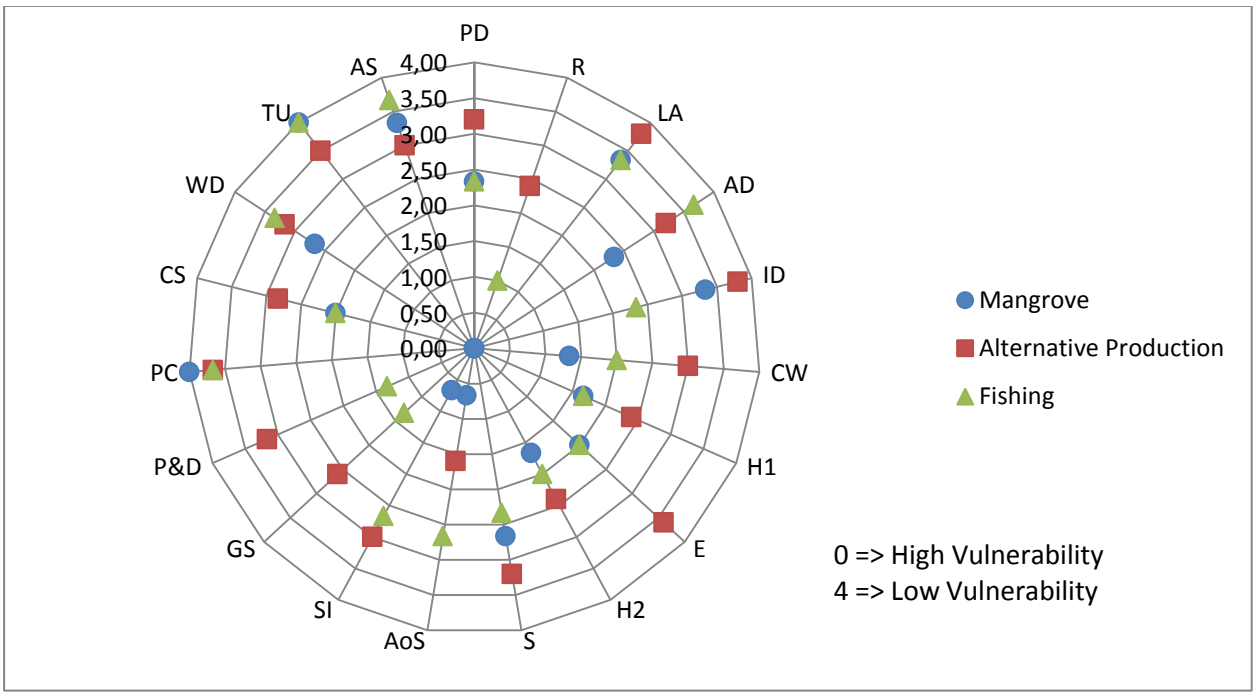

Figure 19: Paraiso Activities Spiderweb Vulnerability

R: Regulation, LA: Land Access, AD: Agricultural Dependency, ID: Input Dependency, CW: Commercialization Ways, H1: Housing, E: Education, H2: Health, S: Services, AoS: Acceptation of the System, SI: Social Integration, GS: Government Support, P&D: Pests and Diseases, PC: Production Cycle, CS: Climate Seasonality, WS: Water Stress Exposure, TU: Tree Use, AS: Adapted Species, PD: Production Diversification, White squares: no possible response.

Environmental Dimension scores are a bit more homogeneous and higher than the other dimensions. As usual, Alternative Production shows regular results that got all their scores above 2.5. The best scored is Production Cycle with almost 4; the lowest indicator is Climate Seasonality with score a bit under 3. Fishing and Mangrove present relatively the same pattern: Adapted Species, Tree use and Production Cycle are the best scored (above 3); Pests and Diseases got the lowest scores (below 1.5 for fishing and 0 for Mangrove).

In all, we can see that the Alternative Production is the most resilient activity in Paraiso. It presents high scores for almost all its indicators. They have a few weaknesses concerning the Social Dimension but are quite resilient in front of the Environmental Dimension. Mangrove and Fishing are globally more vulnerable in each aspect. They got extreme scores that go from 0 to 4. Mangrove is socially and economically the most vulnerable.

A synthesis is proposed in the table below:

Table 9: Paraiso Activity Summary Vulnerability

	MANGROVE	ALT. PRODUCTION	FISHING
SOCIAL DIM.	Vulnerable	Medium Vulnerability	Medium Vulnerability
ECONOMIC DIM.	High Vulnerability	Low Vulnerability	Medium Vulnerability
ENVIRONMENTAL DIM.	Medium Vulnerability	Low Vulnerability	Medium Vulnerability

The Professional sector case

We didn't include the professional category in the analysis because it wasn't very relevant. They get a stable and high income, their economic and social vulnerability is therefore quite low. However, we couldn't evaluate their environmental vulnerability. They all exercise an agricultural activity but more like a hobby or a habit. They don't get any consequent income from it and in general, it isn't profitable.

5.2.3.2. Huimanguillo Activities

The Social Dimension has the least variation while agriculture presents the most: the best indicator is Health with 3 whereas; the lowest ones are Acceptation of the System with 1 and Government Support with 0 (see figure 20). Livestock show the best results: the majority of indicators are scored around 2. Integration is the best one with almost 3.5 for livestock and 3 for Fishing; Government Support is the lowest scored with only 1 for livestock and 0 for Fishing.

The Economic Dimension shows very different patterns for each activity. There is high variation of scores through the spiderweb with very high and very low results. The agglutination to the center shows however a net tendency to vulnerability. Agriculture presents very low results. The best indicator is Regulation with 4 but the other ones are quite low. Input dependency and Commercialization Ways got both 1 and Agricultural Dependency got 0. Livestock has Regulation and Land Access's scores above 3

but Input and Agricultural Dependency below 1. Finally, Fishing best scored indicator is Agricultural Dependency with 4; Land Access and Diversification are the lowest one with scores below 1.5.

The 3 activities follow quite the same pattern for the Environmental Dimension. Agriculture's best indicators are Tree Use and Adapted Species with 3; the lowest indicator is Pest and Diseases with 1 and Production Cycle and Climate Seasonality with 0. Best Livestock indicator is Production Cycle with score above 3 and the lowest ones are Tree Use, Climate Seasonality and Pests and Diseases. Finally, Fishing best indicators are Adapted Species and Production Cycle with scores equal to 4; Climate Seasonality is the lowest one with 0.

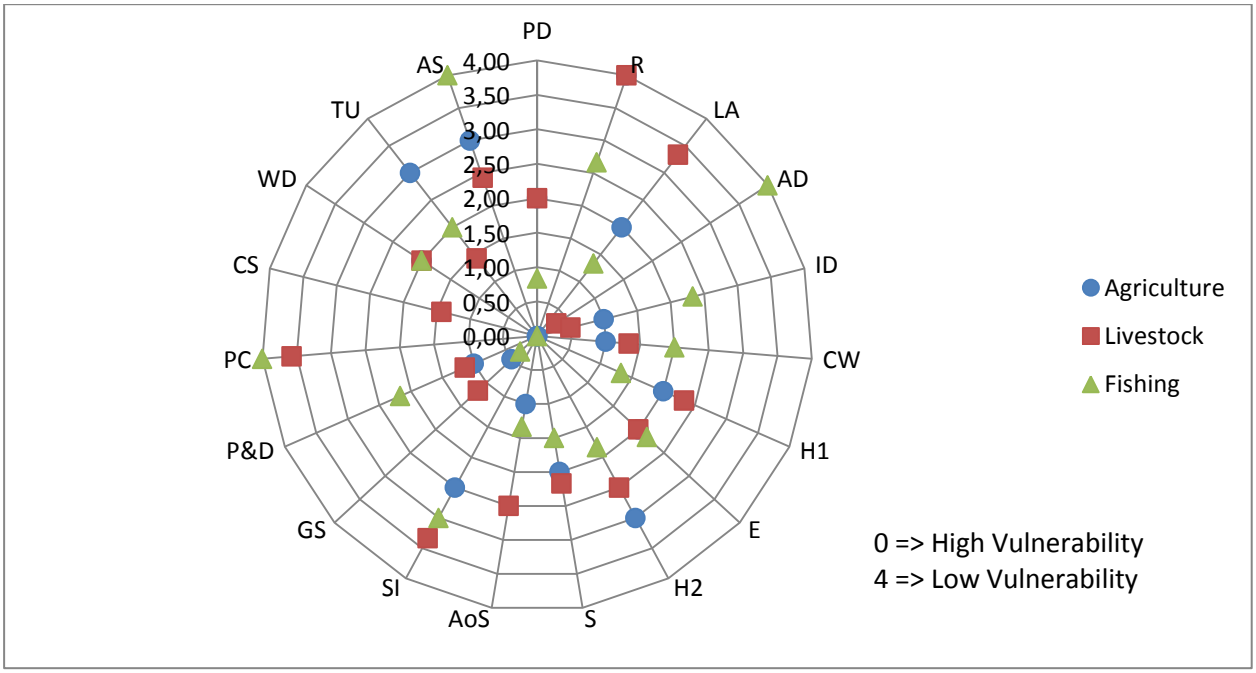

Figure 20: Huimanguillo Activities Spiderweb Vulnerability

R: Regulation, LA: Land Access, AD: Agricultural Dependency, ID: Input Dependency, CW: Commercialization Ways, H1: Housing, E: Education, H2: Health, S: Services, AoS: Acceptation of the System, SI: Social Integration, GS: Government Support, P&D: Pests and Diseases, PC: Production Cycle, CS: Climate Seasonality, WS: Water Stress Exposure, TU: Tree Use, AS: Adapted Species, PD: Production Diversification, White squares: no possible response.

In all, Environmental and Economic Dimension present high variation of scores (from 0 to 4) with a net agglutination in the center of the spiderweb. This shows that the activities are quite Vulnerable. The Social Dimension is a bit more regular. Nevertheless, it is important to emphasize that Agriculture is clearly more vulnerable than the other activities.

A synthesis is presented in the table below:

Table 10: Huimanguillo Activity Summary Vulnerability

	AGRICULTURE	LIVESTOCK	FISHING
SOCIAL	Vulnerable	Vulnerable	Vulnerable
ECONOMIC	High Vulnerability	Medium Vulnerability	Vulnerable
ENVIRONMENTAL	High Vulnerability	Vulnerable	Medium Vulnerability

The Day Laborer Case

We couldn't take them into account in our analysis because it is impossible to evaluate their environmental Vulnerability. They are landless and work for other landowners. Therefore the environment does not have a direct impact on their vulnerability. However, they are socially and economically the most vulnerable category. The majority of them present the housing and health indicator close to 0. Indeed, it is very common that health problems lead them to sell their land and patrimony. They generally contract themselves for one or several days but don't have any job security. Their income is therefore very unstable and children often quit school to help the family economy.

5.2.3.3. Fishing

Fishing is the only activity in common between Paraiso and Huimanguillo. It is therefore interesting to compare and point out the main differences. Concerning the Economic Dimension, Paraiso shows better results for Land Access and Production Diversification. Huimanguillo fishermen are indeed generally landless people and fishing is the only activity they can dedicate to. Therefore, Production Diversification, Tree Use indicator is quite low for them as well as their Acceptation of the System. There have also more vulnerabilities concerning Climate Seasonality and Water Stress Exposure. During the flood time, the lagoon's current is so strong that then can't possibly go out.

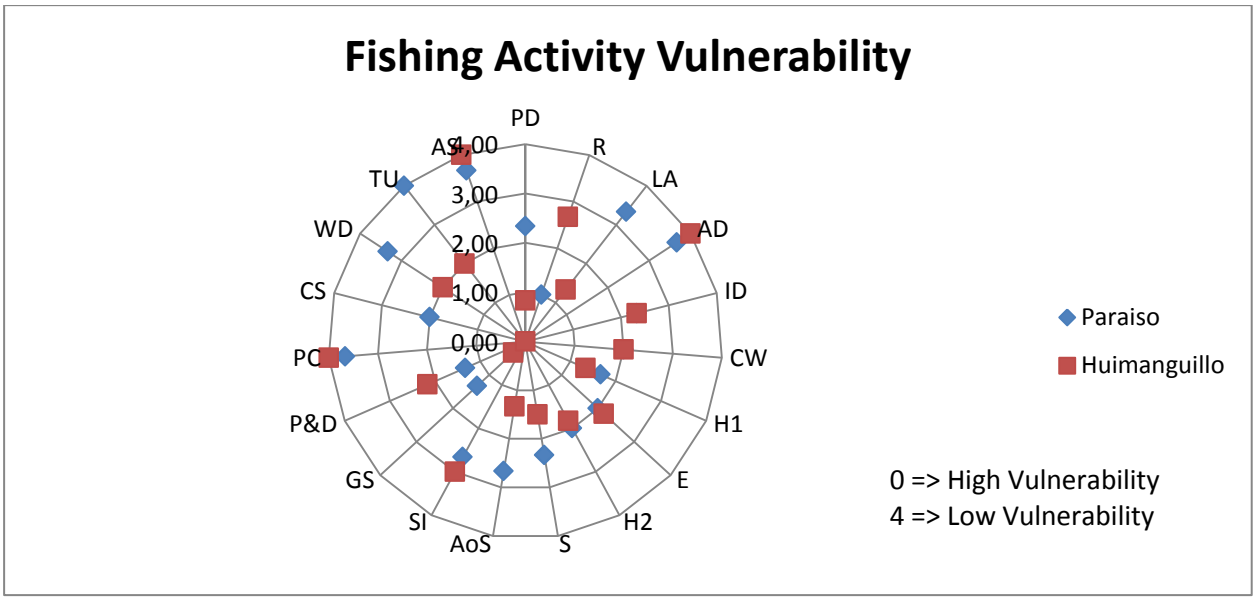

Figure 21: Fishing Spiderweb Vulnerability

R: Regulation, LA: Land Access, AD: Agricultural Dependency, ID: Input Dependency, CW: Commercialization Ways, H1: Housing, E: Education, H2: Health, S: Services, AoS: Acceptation of the System, SI: Social Integration, GS: Government Support, P&D: Pests and Diseases, PC: Production Cycle, CS: Climate Seasonality, WS: Water Stress Exposure, TU: Tree Use, AS: Adapted Species, PD: Production Diversification, White squares: no possible response.

6. DISCUSSION

The first part of the results allows getting an overview of the general organization and main issues within the communities and the activities. That way, it permitted a better understanding of the vulnerability analysis conducted then. The tables and spiderwebs presented identified the key tendencies that could explain the vulnerabilities and permit to model the situation. Communities Vulnerability depends a lot on their productive activities. We observed that both regions (Paraiso and Huimanguillo) had their own agricultural system, and that each one had their proper sensitivities and vulnerabilities to the environment and the socio-economical context. In this part, we will firstly draw up a diagnosis that will present the structural factors of vulnerability of each area. Then we will concentrate on their adaptive capacity to the external perturbations in order to evaluate their potentiality. Secondly, we will take a step back in a situation retrospective and appreciate the coherence of the study with the CBM objectives. Finally, a state of play will be drawn up to evaluate the consistency of the CBM objectives with the field reality. It will be the opportunity to think about sustainable solutions and see to what extent ECOSUR could generate technical means.

6.1. Diagnosis

6.1.1. Vulnerability Factors

Paraiso and Huimanguillo have very different dynamics. Each one experienced their modernization in different ways. The agricultural colonization happened much earlier in Paraiso than in Huimanguillo. The augmentation of the population increased the pressure on the natural resources. Therefore, the urbanization also spread much more in Paraiso and has already encroached upon agricultural lands. Huimanguillo still has wide areas of pastures, plantations and secondary forests plots and doesn't suffer from the urban and demographic pressure. The socio-economic context is thereby quite different one from another and participated largely to the agricultural landscape construction. The environmental dynamics are quite similar in the seasonality pattern and changes. However, contamination and natural resources degradation followed a different pattern. Indeed, the fact that Paraiso experienced the deterioration of its natural resources is really important to understand the actual dynamic. The deadlock concerning the agricultural activities forced the population to look for other opportunities. On the other hand, Huimanguillo hasn't worked out completely the natural resources and is thus still carrying on environmentally unfriendly productions. The Table below presents the vulnerability factors for the communities.

Table 11: Communities Vulnerability Factors

Paraiso	- Natural resources degradations and contamination (Pemex contamination, soil salinization, modification in the water dynamics that threaten aquatic population , overfishing) - Sanitation problems (extinction of cacao production, drastic decrease of coconut yields, emergence of mangrove disease) - Regulation
Huimanguillo	- Geographic isolation of communities from urban centers (Transport service and electricity network is really insufficient, Health and Education are poorly represented, access to the market is only possible through intermediaries) - High degree of corruption - Domination of the Extensive Cattle Farming (dependency for veterinary and forage inputs, poor diversity of production, pests and diseases pressure) - Seasonality (dependency of cattle farmers toward permanent pasture, floods, droughts, fishing activity disruption) - Environmental damages (extensive livestock in deforestation rate, erosion and floods and droughts intensification)
Both communities	- Inadequacy of the health services and government support management - Agricultural policies - Rural unemployment - Access to the land

6.1.2. Adaptive Capacity

The adaptive capacity is the internal capacity of a system to absorb external shocks, mitigate damages, take advantage of the opportunities, and face the consequences. It is not equal between societies or societies' components. We can see persons or group of persons inside societies that haven't sufficient capacities to deal with external or internal stresses or shocks (IPCC, 2007). The adaptive capacity is indeed really different between Paraiso and Huimanguillo and between production groups:

	Strategies of resistance	Strategies of adaptation
Paraiso	- Land rent and forage purchase for livestock. - Abandonment of agricultural production to exploit natural resources. *Production group concerned: Mangrove*	- Development of alternative productions (fishponds, crab breeding, beekeeping, palm leaf production, experimental coconut varieties plots and carbon production). *Production group concerned: Alternative Producers* - Developing tourism (catering services). *Production group concerned: Fishing*
Huimanguillo	- Land rent and forage purchase. *Production group: Livestock* - Modification of the crop cultivation pattern (one maize harvest a year during the dry season instead of twice a year, pineapple production only in the highlands). *Production group concerned: Agriculture*	- Diversification to produce their own forage and grain. *Production group concerned: Livestock*

How households or communities adapted is strongly linked to:

- The economic resources: we have seen that the investment capacity of cattle farmers determined a lot their possibilities to respond to pests and diseases pressure or pasture shortage due to climatic events.
- The natural resources: the degradation of natural resources of Paraiso forced farmers to look for other alternatives of production.
- Social networks and communitarian organization: the communitarian and social participation have a strong importance in the definition of adaptive actions and adoption of strategies to face shocks. The local sphere and communitarian assemblies impact a lot the decision-making. It is through them that the population can decide their participation degree to programs. A higher communitarian investment would improve a lot the adaptive capacity of the community (Landa, et al., 2008).The absence of strong social network in Huimanguillo affects a lot the most

vulnerable household in their possibilities to adopt coping strategies. By contrast, lots of farmers in Paraiso managed governmental supports and created alternative production groups.

- Institution and public resources management in the rural development: the inherent corruption in the authorities' relationships prevents the equal distribution of public resources. Besides, the lack of investment for smallholder farmers induces little capacity for them to face economic and environmental shocks. Farmers would require new crop varieties or cattle breed that could deal with stronger and longer droughts or floods, introduction of alternative productions that would be competitive on the market, better infrastructures to transport or to process the production, training and knowledge transfer programs for pests and diseases management or erosion and deforestation control (Soto Pinto, et al., 2010). Apart from it, the lack of training in rural communities in Mexico, as show Herrera Tapia et al in 2008, is also an important restriction for rural development.

6.2. Retrospective: consistency of the study with CBM

The initiative of developing a biological corridor in the region of Mesoamerica responds to various objectives that have already been presented in the context. In this paragraph, we will present in what ways the present study fits and feeds the corridor objectives and means.

The Mexican corridor already focused its goals and aims now to the promotion of biodiversity by sustainable productive processes that improve life quality of local populations and contribute to natural resources conservation (UNDP, GEF, 1999). The figure below shows the elements that are shared between the MBC general goals and the study realized at a local scale.

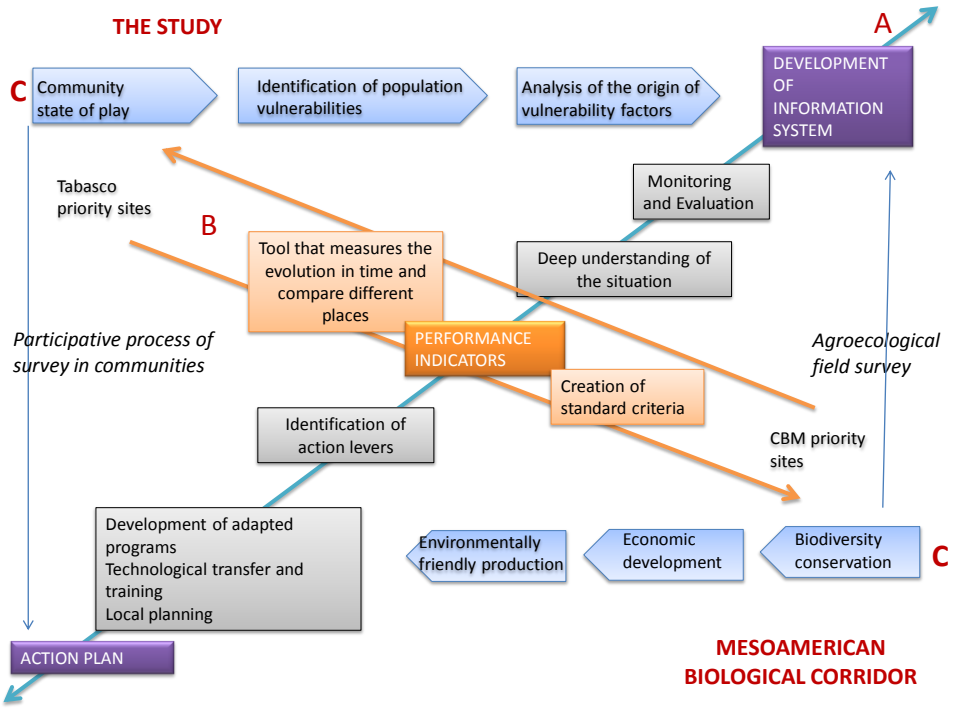

Figure 22 : Vulnerability study and CBM common objectives (elaborated from data from UNDP, GEF, 1999; CCAD-PNUD/GEF, 2002; Miller K et al, 2001)

The separation between the CBM and the present study is materialized with the blue line (A in the figure) which comport all the actions or method in common. Tools and means are in orange (B in the figure). Ones that are on the CBM side are specific to it whereas the other ones are specific to the study. The dynamic symbolized by the arrow suggest that means from our study can contribute to the elaboration of CBM tools and vice versa. The performance indicator is the common tool and the central point of the figure. It is the starting point to go to each extreme of the blue line (A) and the crossroad between tools/ means and action/methods. The respective objectives of each initiative are related in the big arrows (C in the figure). Their final objective is to feed the information system and create action plans (A in the figure). To do so, they will use their own tool and elaborate performance indicators that will permit to pass through the different steps until the development of the information system or action plans (situated at the extremes of A).

For instance, the CBM want to conserve the biodiversity, stimulate the local economy and develop environmentally friendly practices. The creation of standard criteria of analysis like the conception of performance indicators permit to easily understand the key issues and identify the action levers that will allow the development of a strong and complete information system and the proposition of relevant action plan.

On the other side, the vulnerability assessment tries to draw up a community state of play in order to identify the population vulnerabilities and analyze the main factors that explain them. The creation of performance indicators permitted to easily obtain the key issues and the action levers that will permit to elaborate adapted local programs of capacitation and training and assure the sustainable development of the communities. Indicators are also an efficient tool to measure the spatial and temporal variations of development strategies. Moreover, the study results will contribute to the amendment of the global information system.

In addition, both approaches involve the mobilization and participation of the population.

6.2.1. Performance Evaluation Tools

The success of the CBM initiative required to develop instrument which permit to evaluate the different projects evolution. The idea was to elaborate a tool that was able in one hand to collate, organize and better understand linkages between land degradation, biodiversity loss, and community impacts and on the other hand, compare the situation in space and the evolution in time (GEF, 2002). To do so, it was necessary to develop a sample of indicators, closely related to the objectives of the project, the attentive monitoring of project progress, and the introduction of triggers (World Bank, 2000).

Key performance indicators are exposed in the project appraisal document of the CBM realized by the government of Colombia, Venezuela and Mexico in 2000. They proposed five main indicators for the evaluation of project performance over which 3 can be associated with the study. The figure 24 tries to explain the relation between CBM and Vulnerability indicators.

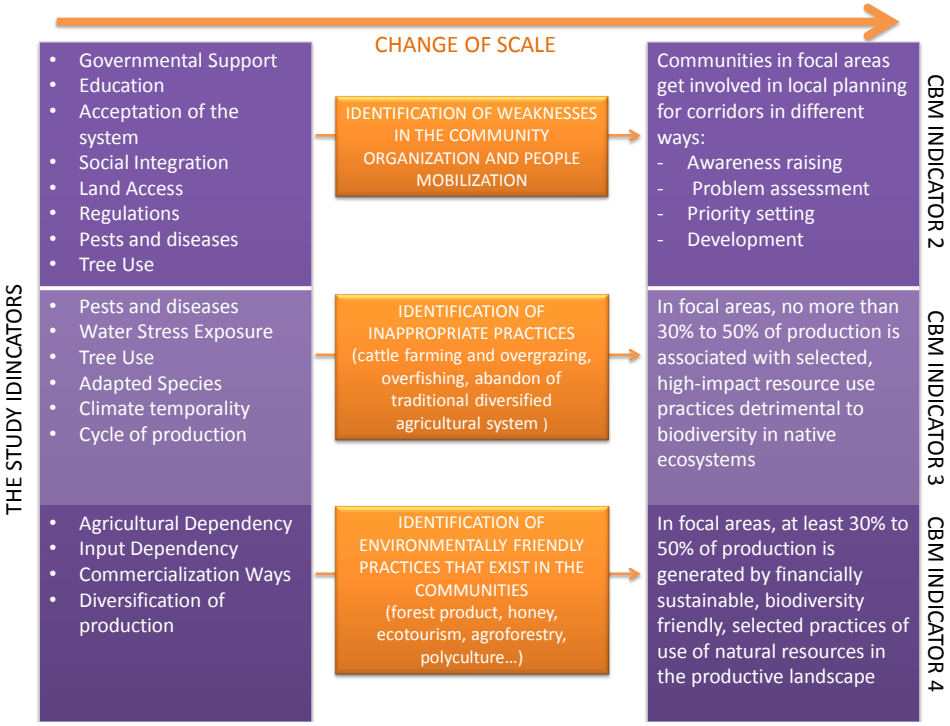

Figure 23: Relation between the CBM and the study

However there is a real changing scale problem. CBM indicators were conceived according to the general goal of the project. Therefore, they need to meet common criteria in order sufficiently general and fit the entire Mesoamerican region..

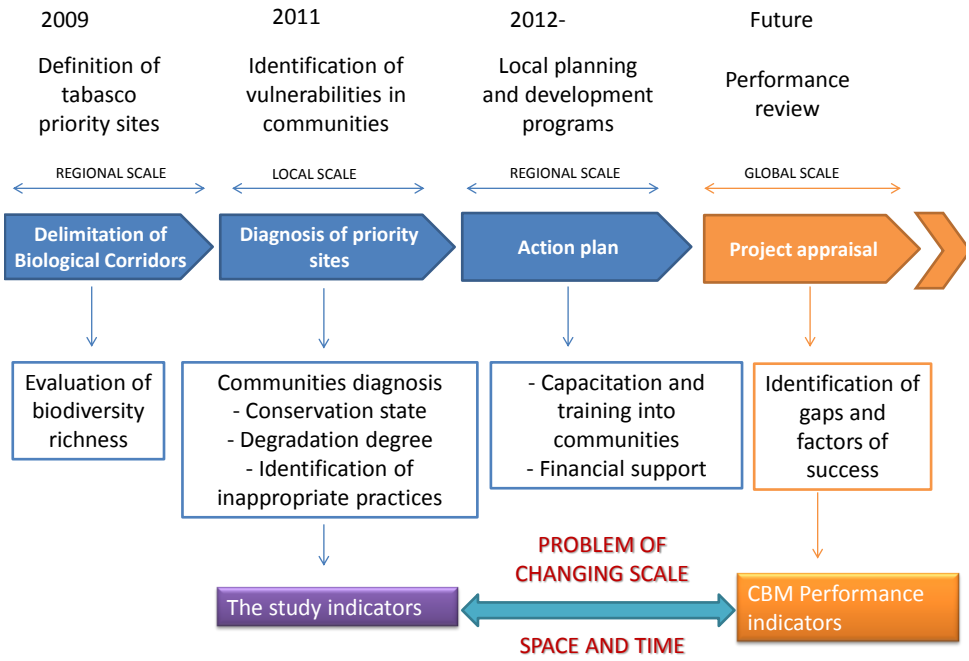

Figure 24: Tabasco and CBM Project Timeline

On the other hand, those developed for the study respond to very specific objectives and are meant to be used only within Tabasco context. Therefore, they cannot be adapted at a larger scale. They can only respond to general objectives. In addition they intercede in very different phase of the project.

CBM indicator will give a general appraisal of the project during the evaluation phase whereas those in this study participate to the diagnosis within communities. There is thus a problem of scale in space and time.

Nevertheless, the use of indicators permits to introduce flexibility into project design and management (GEF, 2002). Indeed, they can be adapted to its maturity and its progress. However, this method contains significant holes and distortions important to take into account.

6.2.2. Limit of the method

6.2.2.1. Scoring indicator method

For this study, the scoring indicator method was considered as the best tool as allows to identify and explain the general vulnerabilities that was facing farmers in Tabasco and could in the same time transform qualitative data in quantitative ones. It was also proposed by the World Bank for the evaluation method of the CBM. However, even if the indicators permitted to simplify and identified the main strength and dynamics that characterized and determined agro-ecosystems vulnerabilities, they also presented consequent holes. Firstly, by reducing the complexity of the reality and only by showing big trends and tendencies, there is a real danger to not include all the issues and therefore to not represent the real conditions of the situation (Luers et al, 2003). It has indeed been found that the environmental issues and the rural development policies were the main factors of vulnerability (indicators climate seasonality and regulation and support). However, from a holistic point of view, these factors can only be the causes or the origins of other factors. The choice of indicators is thus conditioned by what the interviewer saw in the field and considered as the most important, which lead to the other limit: subjectivity. The selection of the different variables and indicators are a real opportunity for subjectivity (Deressa et al, 2008). Indeed, when evaluating vulnerability or sustainability of agro-ecosystems, indicators choice depends a lot from the structural and contextual system characteristics that have been pointed out. All the sustainability or vulnerability assessments present their own indicators sample that is only valid for their current study. That way, it doesn't exist a collection of indicators which allow a universal use (Füssel H, 2009) except some index that tried to propose universal methods like the EVI Index. Therefore, the indicator identification has to be realized according to the local characteristics of the agro-ecosystems studied and according to the analysis objectives (Sarandón et al. 2006). Finally, they can't really represent dynamic processes as they only captured a "snapshot in time" (Vincent et al, 2010). Nevertheless, in the context of this study, the use of indicators turned out to be the best tool in terms of feasibility.

6.2.2.2. Limit of the present study

By following a methodology that already contained important holes, the present study start inherently with consequent weaknesses. Firstly, the lack of consensus on the exact meaning of vulnerability make

any studies complicated to lead. Secondly, the literature concerning the use of indicators in vulnerability assessments is very scarce. Vulnerability concepts are mostly used in climate change or natural disaster literature and indicators are found mainly in sustainability assessments. Consequently, the methodology used here adapted vulnerability concepts to sustainability studies.

The other weakness lies in the nature of the word itself: vulnerability isn't a directly observable phenomenon. It's a complex multidimensional concept that is difficult to quantify with traditional measurement tools. That way, this study presents a real subjectivity in the indicator selection, the scoring, the analysis and the generalization. Nevertheless, all the tendencies and profiles that finally were modeled are representations that agree faithfully to the reality.

Finally, the quantity and the quality of the interviews realized made difficult the generalization of the analysis. The restricted number of interviewees notably in crop farming systems was not sufficient to be able to obtain a complete profile of this activity. In addition, the distortion created by the delegate in the selection of the head of family interviewed is also important to take into account. The few households visited out of the delegate advices were really marginalized and presented thus a more vulnerable situation. Therefore, it is possible that the real vulnerability of the communities is likely to be underestimated.

In all, the method has been adapted to the complexity of the context and the means available. Even if the general idea of this study was to give an evaluation of the vulnerability of farmers' in Tabasco, it also aim to elaborate an indicator sample that would then be used in other communities of Tabasco without having to realize previously all the investigation to identify them. It also participates to the elaboration of data specific to the region of Tabasco. In a larger scale, it can help designing development programs adapted to the specific conditions of every community concerned. Finally, from a very optimistic point of view, the method could be homogenizes and generalizes in every CBM area.

6.3.State of play: consistency of the CBM objectives and field reality

6.3.1. Which Results?

The CBM has been defined as the most ambitious project of sustainable development around the world. It counts approximately 35 regional partnership programs for which projects generally performed satisfactorily for having strong links with country operations on rural development and land administration (MBC Regional program review). According to the GEF in 2011, the adoption of adaptive management in the strategy is one of the key success of the CBM. Budgets, logical frameworks and staffing needs are adapted and amended during the life of the project according to changing local conditions, monitoring of assumptions, and also to take into consideration lessons learned through project activities. In spite of the fact that individual national projects generally performed satisfactorily, the success was more uncertain at the regional scale.

In Mexico, the project is fully integrated into the national program since 2008 and beneficiate from a real economic sustainability. Between 2005 and 2009, 215 subprojects supporting biodiversity-friendly production were financed. In addition, an extension was adopted in 2009 in which 3 more state were integrated (Oaxaca, Veracruz and Tabasco). However by being part of the national prerogative, modification in the administration put the project on hold for about half of the implementation period. It is then necessary to integrate directly the concerned institutions and create an inter-institutional collaboration. Secondly, despite of the objective of integrate local population into the project, a study showed that in reality local communities were completely excluded from the CBM delimitation and didn't get any information concerning the project. Even management institutions and other organizations that should have been participated were absent. Finally, the regional program review affirmed that Mexico placed a higher degree of emphasis on mainstreaming of biodiversity than into strict conservation that would include the social aspect and could therefore prejudice the success of the actions (EIP, 2011; Elizondo C, 2002).

In Tabasco, initiatives for introducing CBM into the local programs were very few. In the work area, no one ever heard about the CBM or knew that they were part of it. Even if Tabasco integrated the project recently, there is a need of better project communication. More than that, there is a real antinomy between the CBM objectives and the governmental policies. The emphasis is focused on cattle farming through supports that encourage farmer's conversion and subsidize the production. Traditional agricultural systems like the "milpa" which contribute to preservation of natural resources and biodiversity are completely excluded from any kind support (see context for deeper explanation). The study clearly showed that the agricultural producers were the group that presented the highest vulnerability. In all, there is a real lack of coherence between the CBM objectives and the actions realized, between governmental programs and communities' needs, between the global and the local scale. Directives and action plan have already been decided but the application in the reality is still very difficult. Local populations are excluded from the decisional process, technical and financial assistance. In addition, the communitarian organization that existed before and contributed to the relative community sovereignty completely disappeared.

In all, it is important to canalize economic resources in a more effective way through an inter-institutional collaboration and participative work (Elizondo, 2002). Rural development programs have to be more consistent and should contribute to population empowerment. In that way ECOSUR can be a key actor as it already is the intermediary and facilitator between institutions and local populations.

6.3.2. ECOSUR, toward a sustainable solution?

The ECOSUR Tabasco unit works on the integral understanding of the modification experimented in Tabasco region during the last decades (changes in land use, exploitation of natural

resources, population conformism). It aims to create and maintain connection between producers' organization, research institutions, social or student organization, NGOs, government entities at the federal, state or municipality level, produce technical reports and database, and provide support in diagnostics, laboratory testing, consulting and training.

Within the framework of the CBM, ECOSUR participates to the implantation and management of the action plan at the local scale. It notably contributes to:

- The empowerment of communities: it assures the communication and information divulgation between institutions, government and communities; it mobilizes local populations through participative workshops; increases public awareness to environmental issues and tries to impulse the re-appropriation of communities' traditional system.
- Technological support: it tries to develop environmentally friendly practices through capacitation and training.

Recently, ECOSUR conducted a series of studies concerning agroforestry systems. Tree elements are indeed very common in the traditional landscape of tabasco and before the implantation of commercial crops and pastures; there was a large diversity of agroforestry systems or subsystems. The objective of the program was to expend the knowledge about the eco-physiological and productive functioning of tabasco agroforestry systems. It appeared that these kinds of system, despite being environmentally and economically attractive, represent a good option for the recuperation of forest cover (Hernandez Daumas, 2010).

In an ecosystem of high vulnerability, where the deforestation is the main cause of shifts in the season pattern and inundation disasters, and where the domination of cattle farming still persist, the use of silvopastoral systems seems to be the most viable way of farming. Finally, in the CBM context, the implementation of agroforestry elements could play an important role in the ecosystem connectivity.

Table 12: Services that could bring agroforestry systems within communities

Environmental Services	-Erosion control: the high level of deforestation is responsible for the soil erosion in Tabasco. -Soil water storage: stronger droughts during lasts years threatened crop production and pastures. -Improve microclimate: farmers' noticed consequent negative changes in the microclimate. Agroforestry could mitigate them. -Increase soil fertility: farmers' are facing the impossibility to grow vegetables and fruit because of soil degradation. -Pests and diseases control: numerous productions are threatened because of pest and diseases pressure (cacao, bananas, livestock).
Economic Services	- Diversified production (timber, fodder, resins and fruits): alternative and additional sources of income for a production vulnerable because of its low diversification -Risk buffer in case of crop failure: the variability in floods and droughts intensity can easily be responsible for the loss of the production. - Reduce dependence on unpredictable and volatile world market -Improve farmers' capacity to adapt to drier and more variable conditions: nowadays, local climate is unpredictable and it is difficult to anticipate floods and droughts. -Improve farmers' dependency from inputs: We have seen that cattle farmer vulnerability was strongly linked to their dependency toward inputs.
Social Services	- Stable income: the economic security permit families have a better access to education and health and improve food security. - Job creation: agroforestry systems require more handwork and are a good way to fight against rural unemployment. - improve production dependency from governmental support and intermediaries: by being viable economically, farmers can become emancipated from all kind of support and be more independent in their decision taking. - increase of work interest and involvement: farmers' emancipation permit to give them back their work sovereignty. - re-appropriation technics and knowledge: agroforestry systems were characteristics of tabasco cultural landscape. Technics and practices conservation are important for the local identity

CONCLUSION

Even if the ejidos of Paraiso and Huimanguillo present similar contexts (lagoon proximity, seasonal floods and droughts, climate and agricultural policies), our study could identify the determinant differences that characterize their vulnerability:

The geographic isolation, the infrastructure quality, the rural development, and the natural resources exploitation and degradation were identified as the main contextual causes of vulnerability. Huimanguillo was more vulnerable due to its geographical isolation, the lack of infrastructure and the poor soil quality due to overgrazing and deforestation. The strengths of Paraiso were the opportunity of exploiting the natural resources and that farmers managed to take advantage of the governmental project support. From all these causes depend then the different activities of production which were identified as the structural causes of vulnerability. Crop farming, livestock production, mangrove exploitation, fishing or alternative production were indeed affected differently. The most vulnerable activities were crop and cattle farming are really affected by the poor soil quality, pests and diseases, and climate seasonality. Fishing and Mangrove extraction, which are both natural resources exploitation activities, present an intermediary vulnerability. Finally, the alternative productions don't really depend from the climate and soil quality and benefits from governmental support. They are therefore the activities that are most resilient.

The indicators highlighted two main factors of vulnerability. Firstly, the impact of the governmental policies is really important. The crop productions don't benefit of any kind of support whereas there are quite a lot for alternative productions. Apart from this, the reform that prohibits mangrove wood extraction affects a lot the activity. For all, the lack of a good rural development plan (lack of infrastructure, corruption etc…) prejudices a lot the communities. Secondly, the environmental problems that recently became a real issue contribute a lot to farmers' vulnerability. The degradation of natural resources, the high degree of pollution and the intensification of floods and drought reduce a lot the productivity and increase the production costs.

In all, the first obstacle to adaptation is the complete absence of rural development plan and the poor social and political organization within communities. The communitarian work that used to be the essential pillar completely disappeared. To have an impact on the governmental policies is a titanic task but rethink the communal organization and try to develop communitarian activities could be a real way to fight again the social and economic vulnerabilities. From a more ecologic point of view, the actual use of the natural resources doesn't at all consider the negative impacts of the agricultural practices on the environment. The complete loss of traditions aggravated even more the phenomenon. Re-integrate old farming knowledge that used technics completely adapted to the climatic and soil conditions while trying to develop sustainable innovative practices could mitigate the environmental and economic vulnerabilities. In that way, agroforestry systems bring together various aspects of resiliency considering the social, economic and environmental aspects.

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Appendixe 1: The survey

FARMERS SURVEY

Este cuestionario es parte de un estudio sobre el Corredor Biológico Mesoamericano que lleva a cabo El Colegio de la Frontera Sur. La información que usted nos brinde en este momento y durante todo en proyecto de investigación será manejada de forma confidencial y sólo se utilizará en el marco del

Nombre del entrevistador: Mélanie VOISIN_____ Fecha:_____

Nombre del entrevistado:_____ Edad:_____

Comunidad y Municipio:_____ Jefe de familia:_____

Familias Campesinas

1. SISTEMA PRODUCTIVO
   1.1. Cuáles son las diferentes actividades en su parcela?

Actividad Productiva	Area, animales	Rendimiento	Consumo	Compradores	Precios
Agricultura					
Ganaderia					
Forestal					
Huerto Familiar					
Traspatio					
Otro					

1.1. Cuál es la producción la más importante?
1.2. El uso del suelo era diferente antes? Cuáles son los cambios, cuando y porque?
1.3. Tenencia de la tierra: herencia, comprada, ejidal, comunitaria, rentada?
1.4. El Manejo e insumos (Atenciones, cosecha/venta, químicos, veterinario, alquiler, forraje…). Cambio recientemente algunas cosas?
1.5. Piensa que las practicas aplicadas perjudican al medio ambiente?

2. VULNERABILIDAD AMBIENTAL
   2.1. Problemas de Manejo
      2.1.1. Cuáles son los problemas de manejo y producción que encuentra?
      Problemas climáticos (sequia, inundaciones), tierras inundables?
      Problemas profilaxis (enfermedades, contaminación)
      2.1.2. Pierdas de rendimiento, de animales
      2.1.3. Cuál es la temporada la más difícil para usted?
      2.1.4. Cuáles son las especies utilizadas? Son adaptadas?
   2.2. Modificación de los recursos naturales
      2.2.1. Se ha visto una disminución de la fertilidad del suelo? Cual podrían ser las causas? No se puede manejar lo cómo antes?

2.2.2. Se ha visto un cambio en el clima? Como le afecta? Ya pasó una catástrofe? Potencial para Agroforesteria

2.2.3. Usas especies arbóreas? Dónde, mucho? Como las aprovechas? (madera, frutas, sombra, cercas)

2.2.4. Que son los beneficios?

2.2.5. Qué tipo de árboles querías plantar? Porque no lo has hecho todavía?

3. VULNERABILIDAD FINANCIERA
   - 3.1. Que otras actividades productivas tiene usted o algún miembro de la familia?
     - Comercio (tenditas, comida…)
     - Otro empleo
     - Jornalero
   - 3.2. La mano de obra es
     - Familiar
     - Contratada (que frecuencia?)
   - 3.3. Existencia de restricciones de producción (permiso)?
   - 3.4. Cuáles son las fuentes de ingresos/gastos?
     - Insumos (gasolina, forraje, agroquímicos, semillas, veterinario…)
     - Otros gastos (mano de obra, alquiler, comida…)
     - Ingresos
   - 3.5. Tu producción depende mucho de los insumos? Produces tus propios fertilizantes, semillas…?
   - 3.6. Temporadas en que no hay producción?
   - 3.7. El estado de las carreteras es suficientes para entregar la producción todo el año?

4. VULNERABILIDAD SOCIAL
   - 4.1. Estructura Familiar
   - 4.2. Comida
   - 4.3. Servicios (luz, agua, teléfono, mercado)
   - 4.4. Acceso a la educación (su nivel, sus hijos, facilidad de acceso en la comunidad)
   - 4.5. Acceso a la salud:

     En tu familia, se tienen problemas de salud? Impacto sobre economía? Se puede ir fácilmente al médico?
   - 4.6. Capital familiar: Cuantos cuartos hay en la casa? Refrigerador, lavadora, clima, ventilador, carros?
   - 4.7. En relación a su comunicación con los miembros del ejido, se relaciona bien con la comunidad
   - 4.8. Hace o hizo parte de proyectos, apoyo y capacitación del gobierno, subsidios, oportunidad

1. EL FUTURO
   - 1.1. Cuál es el escenario el más probable para cuando piensa en el futuro?
   - 1.2. Que te gustaría hacer, que tipo de producción querrías desarrollar o te parece más interesante? Que piensa de la actividad de campesino, que imagen la gente tiene?
   - 1.3. Que recursos te faltan?

Las autoridades

Descripción de la comunidad

1. Capital físico
   1.1. Estructura del ejido (área, repartición de las actividades…)
   1.2. Actividades agrícolas:

Actividad Productiva	La más importante	Que cultivo, animales	Consumo (porcentaje o proporción)	Venta (porcentaje o proporción)
Agricultura				
Ganadería				
Forestal				
Traspatio				
Otras				

   1.1. Actividades non agrícola?
   1.2. Cuáles son los principales problemas que encuentran los campesinos en cada actividad (enfermedad, venta, pierda de producción, falta de recursos…), cuales son los inquietudes, angustia que ellos expresan?
   1.3. Cuál es la actividad que le parece la más rentable?
   1.4. Servicios:
      1.4.1. Transporte es suficiente? De buena calidad?
      1.4.2. Acceso al medios de comunicación? Teléfono público, red para celulares, internet?
      1.4.3. Agua, electricidad
      1.4.4. Mercado

2. Capital Humano
   2.1. Se ha observado emigración de la población joven en las ciudades? Hay presencia de grupos indígenas?
   2.2. Como se ve (percibir) la actividad del campesino (productor) en la sociedad? (Describa)
   2.3. Acceso a unidades de salud, medicamentos? Hay un medico disponible? A qué frecuencia? Como considera la calidad? Muy malo, malo, regular, bueno, excelente
   2.4. Acceso a la educación pre-escolar, primaria, secundaria, superior? Presencia de escuelas? Como considera la calidad?
   2.5. Actividades comunitarias
   2.6. Cursos de capacitación, presencia de técnicos o profesionistas? Cuales… ¡Estos pláticas/cursos ha permitido mejorar los sistemas de producción y aprovechamiento?
   2.7. Cuáles son los tipos de apoyo, subsidios, oportunidad que se perciben?

3. Capital Financiero
   3.1. Comercialización de los productos en la comunidad (mercado local) o fuera (mercado regional, nacional)? Existencia de trueque?
   3.2. Cuáles son las principales dificultades que se encuentran?
   3.3. Existe grandes variaciones de precios?

4. Capital Natural
    4.1. Acceso al agua para toda la comunidad (gratis o se compra? En cual porcentaje?) Temporada de escasez? Como considera la calidad?
    4.2. Acceso al combustible: Leña o gas? (Se tira o se compra? Cual porcentaje?)
    4.3. Se ha observado una degradación de los recursos naturales (vegetación, suelo, contaminación)? Que tan? Muy degradados, degradados, mediamente, poco o nada?
    4.4. Se ha observado un cambio en el clima?
    4.5. Cuáles son las actividades o los factores responsables?
    4.6. Ha escuchado sobre el corredor biológico? Qué opina? Piensa que la gente se preocupa del medio ambiente, tiene una consciencia ecológica?

5. Identificación de informantes claves
    5.1. Quería entrevistar personas que representan cada categoría, pueden me dar nombres?
    5.2. Existen personas de fuera (profesionistas, ingenieros, prestadores de servicios) que ya han trabajado en la comunidad?

Appendixe 2: Indicators

SOCIAL INDICATORS

Housing: The house is a very good indicator. Furniture gives a lot of information on the financial family capacities and thus, family vulnerability. We select some key furniture that indicates the economic level: Air Conditioner, car, washing machine, and fridge. These objects are the first one that a family acquires when they got the financial possibilities. We observed that families followed the same pattern: fridge is the first one to be purchased, then washing machine, then car and to finish air conditioner.

Health: Family Health is an important factor of vulnerability. Cares are quite expensive in Mexico and when a member got ill, all the financial capacities are monopolized to buy treatment. Is it not rare then, to see families sell their patrimony or to see member unable to exercise any work for health problem.

Education: Access to studies contributes to the social vulnerability. Families that cannot afford or that don't have the possibilities to send their children to school are more vulnerable.

Services: Services are all the commodities that a house should beneficiate (Electricity, water access, phone), those that are handed out by the community (transports) and shops. Some families that are really isolated don't even get the electricity access. These families are in general really vulnerable.

Social Integration: The family integration within the community guaranties an easiest access to communal help, support and programs. Due to the high degree of corruption, resources aren't equally distributed and the preference is allocated essentially for authorities' family and friends. Those that aren't in good relationship with the authorities don't beneficiate of anything.

Support: Subsidies, financial help and training are all factors that contribute to families' resilience. Subsidies are the most regular and safe support that can get a family. Project supports are very interesting but are only available for a specific time-period. Opportunities are financial support to help most humble families to access to school. We can evaluate families' vulnerability by the type of support got. Subsidies are quite difficult to access, it needs heavy formalities and capacity to read. Project support as well needs a good integration within the community to be able to get the information.

Acceptation of the System: It is interesting to evaluate to what extent farmers accept the system in which they are living. Some are happy with the agricultural policies, the work's difficulties, the income they get from it and don't have any complaints. Others are completely disillusioned. They only keep on farming because they can't do anything else.

ECONOMIC INDICATORS

Diversification of production: We evaluate the vulnerability on the number of commercialized production that one family had. The most commercialized production they had, the most different source of income they get and thus, the less vulnerable they are.

Regulation: We found out that regulations were an important factor of production restriction. They are government prohibition to produce or exploit and can be temporal or unlimited in time. They are a real problem for families' economy that can afford to stop to produce even temporally.

Land Access: Access to the land is a real factor of vulnerability. We identified few status:

- Land that have been acquired by heritage. There are in the family since a long time and farmers have been able to develop activities. They prove certain income level and production stability.
- Ejidal Land: They have been offered by the government. They can assure a security for the farmers.
- Land that has been purchased: Prove a good income level but are usually recently acquired and thus, haven't permit any stable production to begin.
- Landless farmers: are dependent on day laboring. They don't have any contract and have no work security. Nowadays it is very difficult to find a job in the country. Some people have to travel more than one hour by bike to get to their job.

Agricultural Dependency: We considered that the most dependent was a family to the agricultural production, the most vulnerable it was. We made the difference between agricultural activities (cattle farming, pineapple and coconut production, maize production…) and exploitation of natural resources (mangrove exploitation and fishing). We have estimated the economic proportion that had the agricultural activities on the total income.

Input Dependency: The dependency to input is an important factor of Vulnerability. Some productions need heavy quantities of input in order to be profitable. Inputs are quite expensive and some farmers observe high decrease of yield because they can't afford to buy them. We have estimated the economic proportion that had the input purchase on the total income.

Ways of Commercialization: There are a few ways to commercialized farmers' products. The most used one are through intermediaries that imposed very cheap price. Cooperative are quite common as well and should propose some interesting prices for farmers but in reality, they are often under group of power's control. Some companies buy directly the product to the farmers. Nevertheless, prices stay very low. The direct or local sells are still quite uncommon. We considered the last as the more resilient ways possible, followed by cooperative, companies and then intermediaries.

ENVIRONMENTAL INDICATORS

Pests and diseases: We classified them through different level of gravity that traduces level of vulnerability:

- Ecosystem free of any pests and diseases
- Pests and diseases that occasionally occur
- Invasive species or overexploitation
- Pests and diseases that occur regularly but that can be cured
- Pests and diseases for which there isn't any treatment, or new ones for which no treatment has been found yet.

Water Stress Exposure: This indicator to what extent the water surplus or water shortage affects the production. If the production isn't affected by both situations, it has no dependency for water and is more resilient. We include the principal production (I) and the secondary ones (II).

Tree use: We identified degree of tree use. Farmers that are still exploitating forest resources; those that still have some secondary forest or that are using trees as fences or for other purposes; others that have tree plantation like coconut trees; those that only have trees on fences and stream shores; and finally those that don't have any tree on their land.

Adapted species: We have evaluated the use of native or adapted species for the principal production (I) and the secondary productions (II). Farmers that used Native Species were more resilient that those that used commercial ones.

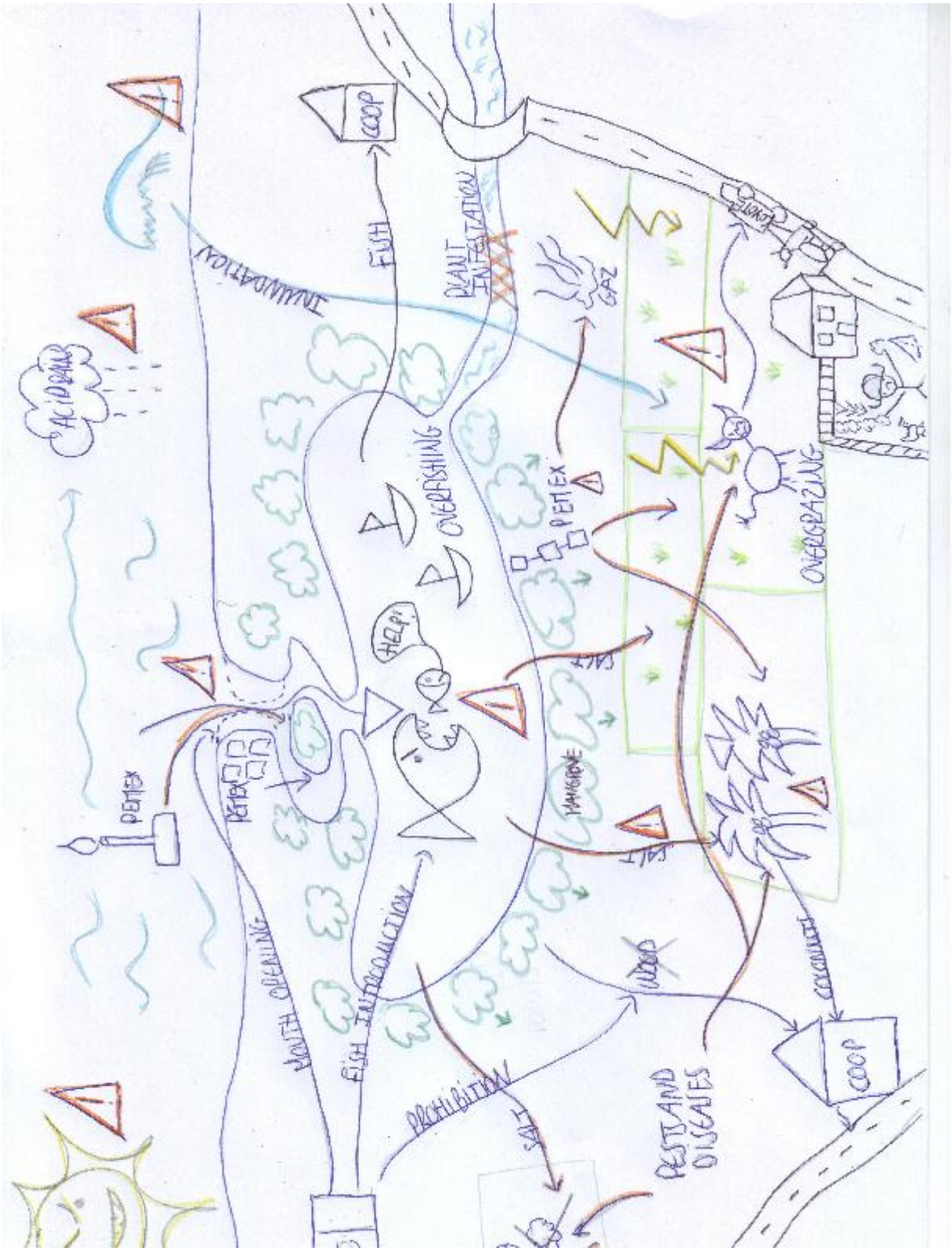
Climate temporality: The seasonality has great impacts on the farmers' production. Some are only facing decreased of yields, some are confronted to an increase of their expenses in order to maintain the production (land rent or forage purchased for example), for one or even for both seasons, and others cannot produce anything.

Cycle of Production: We considered the cycle of production as a factor of vulnerability. A production that generate a source of income once a year (like pineapple) increase he family vulnerability whereas a production that generate an income daily (dairy cows) increase the family resiliency.

	4	3	2	1	0
SOCIAL DIMENSION					
Housing	Fridge + washing machine+ car + air conditioner	Fridge+ washing machine+ car	Fridge+ washing machine	Fridge	Nothing
Health	No problem	Problem without severe impacts on income	Problem with consequent impact on income	Patrimony sell	Impossibility to work
Education	Access to university	High School	Secondary Education	Primary	No access
Services	Electricity+ water+ phone	Electricity+ water	Electricity+ water from proper well	Without electricity+ water from communal well	Without electricity+ water well far away
Social Integration	Authority	Family or close relationship	Independent	Has relations	doesn't have relations
Support	Various	Subsidies	Project support	Opportunity, social help	Nothing
Acceptation of the system	Happy	Income problem	All that he can do	Surviving	Doesn't want his children doing the same
ECONOMIC DIMENSION					
Production Diversification	More than 6 product	Between 4 and 5 products	3 products	2 products	1 or 0 products
Regulation	Free	Unlimited permit	Renewable permit	Temporal prohibition	Unlimited prohibition
Land Access	Heritage	From the ejido	Bought	Rented	Landless
Agricultural dependency	Between 0% and 20%	Between 20% and 40%	Between 40% and 60%	Between 60% and 80%	Between 80% and 100%
ENIRONMENTAL DIMENSION					
Input dependency	Between 0% and 20%	Between 20% and 40%	Between 40% and 60%	Between 60% and 80%	Between 80% and 100%
Commercialization ways	Various	Particular (I)[13]	Particular (II)[14], cooperative or company(I)	company (II), intermediary (I)	Intermediary (I and II)
Pests and diseases	Healthy	Occasional	Invasive species/ overfishing	Often but cured	Often without any cure, new disease
Water Stress Exposure	No dependency (I)	Little dependency (I)	Various sensitive productions	I sensitive for the 2 periods	Various production sensitive for 2 periods
Tree use	Natural, forestry exploitation	Various: fences, dispersed, acahual	Plantations	Little, fence, stream shore	Nothing
Adapted species	Native (I)	Adapted I, Native II	Adapted I, no II	No I, adapted II	Nothing
Temporality	No temporality	Temporality with decrease of yield	Temporality with expense increasing on 1 period	Temporality with expense increasing on 2 periods	No production
Production Cycle	Regular sell I	Temporal sell I, Regular II	Various temporal sell	Temporal I, nada mas	I once a year, temporal II

[13] (I) means the production from which farmer get the most of their income.
[14] (II) is the secundary production.

Appendixe 3: Paraiso Rich Picture



The mangrove exploitation is the activity that is the more lucrative. Lot of farmers gets almost the totality of their income from it. But lately, this activity has been drastically controlled and during two years (2009-2011), it has been prohibited to extract wood. It put a lot of farmers in a very difficult financial situation. Most of them intensified their secondary production (fishing, coconut, cattle breeding) but are in a very vulnerable situation. Other tried to find other activities out of the agriculture system. Lastly, ones took advantage of government support projects and develop alternative productions. The fishing activity is the second most lucrative activity. We can count for 20 official fishermen but the lagoon is in reality exploited by numerous little fishermen and is suffering from overfishing. They are fishing mostly "Mojarra" tilapia and "Robalo" with large nets of 400 meters in average. Lately, the government decision of opening the mouth that connects the lagoon to the sea has completely changed the lagoon dynamics; fish population, current, seasonality. The area used to be dedicated to cacao and coco production but during the two last decades, farmers also observed a drastic diminution of yield due to the increase of uncontrolled diseases and contamination. Nowadays we can still see the old unproductive cacao and coco plots that are abandoned. The cattle production is also in a very difficult situation. Farmers used to have more than 40 head for meat 30 years ago. Now, they can hardly reach more than 10 animals and the activity is nowadays more for subsistence purposes. Climatic conditions affect a lot the pasture and the animals and it is now difficult to sustain the production without high amount of inputs. Finally, families used to have very diversified home-garden. Since several years, they have observed the death of many tree species (cacao, avocado ….). Nowadays, there are only few trees that can resist the actual climatic conditions

Natural Resources Degradation

During the last decades, with the introduction of cattle and deforestation, people have seen the soil becoming unfit for any agricultural purposes. Wheat, beans and other vegetables aren't sowed anymore and fruit trees are dying. Even pastures are suffering and can't deal with the summer temperature and drought anymore. In addition, pests and diseases infestation are affecting the agricultural production (cacao and coconut) in such a way that they are now unproductive and unprofitable.

The lagoon is facing a serious problem of overexploitation. Indeed, there aren't any other activities that can complete inhabitant income and every community that is located on the lagoon shore live from fishing exploitation. Reproduction period are not respected and it is common to observe shortage periods during dry season (April, May, June). The lagoon fish native population is in serious danger of extinction. Besides being overfished, they are suffering from the introduction of invasive species like the devil fish. Now the distribution of species is quite perturbed. We can observe an overabundance of "mojarra tilapia" and "castarrica" and crab. Before, it was common to find "pejelagarto", "guabina", "sabalo", "robalo". To respond to this issue, alternatives of fish farm activity are considered.

Contamination is also a big issue. The petroleum extraction let its mark on the mangrove landscape. Pemex drilled around 105 oil wells, exploited them during… and abandoned them without any politic of reconversion. The inadequate design of the infrastructure, lack of maintenance, as well as accidental spillage or even programmed dumping have contaminated entire zones of mangrove. "We started to see fishes dying; we met dead ducks full of oil, birds, animals that used to live next to the lagoon… All died soaked with Pemex oil". Nowadays, it is still possible to observe left overs. "The acid rain and the contamination stayed. They haven't gone with them when they left". It is also said that the various offshore wells release contaminated particles in the air that affect a lot the cultures. As well, toxic underground gas goes up and contaminates the soil. "We are only harvesting half of what we used to. For instance, I need two harvests of coconut to reach what I could take out in one". The lagoon of Mecoacan suffered seriously from the impact of the activity of the "Dos Bocas" harbor. A diminution of the population of oyster, shrimp, crab and fish has been observed. The oysters are the ones that are the most affected by the contamination. In 1991, the oil spillage of a damaged burner provoked the dead of 80% of the oyster production.

Climate Characteristics Impacts

The year presents two distinctive seasons: the drought period and the rainfall time. Every agricultural activity is the victim important impact that causes the climate temporality.

The drought period is characterized by high temperatures with very short rainfalls. It is common to observe several months without any rain at all. Serious water shortages are then affecting cattle, crops and pastures. The production that presents the most damages is the livestock. More than losing animals, farmers have to buy forage or rent other fields for 200$/head/month in average (11 euros) in order to fill cattle feed requirement. What is more, cattle suffer a lot from the excessive insolation. Trees are scarce and most of the time, there isn't any shadow at all to protect them during the toughest hours. Consequently, animals mobilized all their resources to resist against excessive temperatures and hydric stress instead of gaining weight. Serious impacts are observed on the productivity. The fishing sector also suffers from the climatic conditions. Fish shortages are common and fishing prohibitions are common. In "Campo Mecoacan", the river that connects the community to the lagoon is completely invaded by aquatic plant and makes the way impossible. Some fisherman cannot exercise their activity anymore and have to wait high currents that bring the rainfalls for cleaning the way.

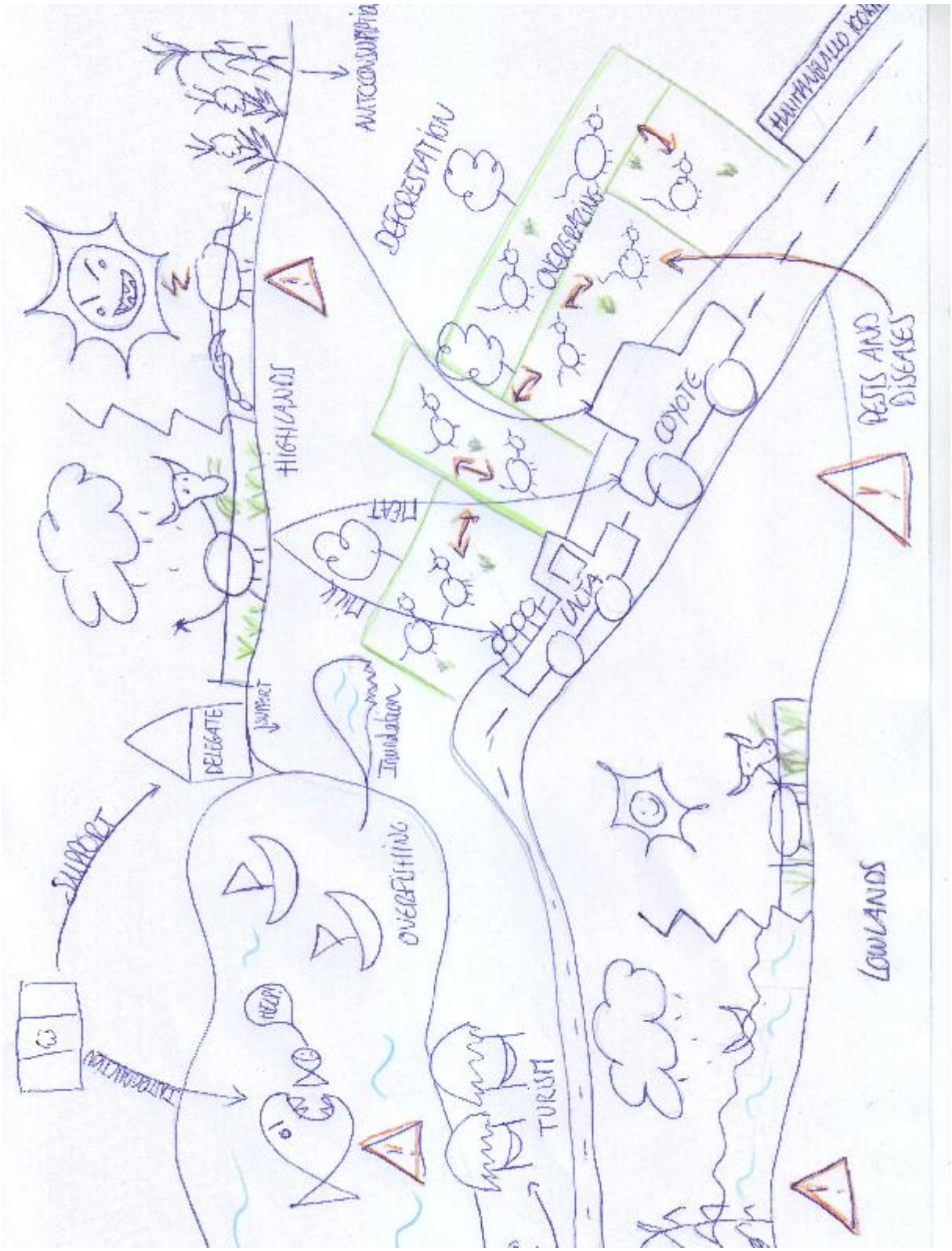
The rainfall time is also quite difficult for farmers. The geographical situation of the lagoon makes it very vulnerable in front of inundations. In fact, rivers of Tabasco (mainly Samaria, Carrizal and Cuxcuxapa) that supply the lagoon receive high quantity of water from the mountain of Chiapas during this period. Surpluses arrive in very short time and the current can be very violent. Likewise, the livestock is very affected. Pastures are completely under the water and it is not rare for the animal to die from the strength of the current or even though, from coldness. Only highlands are spared from the waters growth.

Farmers follow the same strategy: they rent other fields or buy forage. In the same way, water covers entirely the most accessible part of the mangrove. It is then impossible to keep on extracting wood.

Commercialization

The livestock production is quite independent because it exists various little butcheries that can buy it. It is difficult to find buyers for the coconut production. There is one cooperative that buys all the production but imposes price that are quite low. It is more profitable for farmers to sell their production themselves. The Cooperative "La Negrita" is responsible for the fishing production. The mangrove wood also is delivered firstly to a cooperative before being sent to the market.

Appendixe 4: Huimanguillo Rich Picture



The livestock production is facing a real decline. Infestation of diseases (rabies, ticks…) and pasture and water shortage are very common and affect seriously yields. We can observe quantity of overgrazed tree-free pasture. Some farmers rent lands, other buy forage. The luckiest ones produce maize or hay. The pineapple production used to be quite important. People were growing big plot getting good yield without using chemicals. They exploited the soil until it tired all its resources. The livestock age finished the process, letting the soil unfit for any agricultural production. Nowadays, on the few pineapple plots left, farmers have to use big amount of fertilizer to be able to produce 30% less than before. Pests and diseases are also affecting the production more than before. Maize used to be the main production for auto-consumption (animals and human). Nowadays, only few farmers carry on producing. Like the pineapple, the maize is affected by drastic decrease of yield, and suffers from the attack of pests and diseases. The manioc seems to be the most resilient crop as it doesn´t need that many inputs. The fishing activity has much more impact on the economy of the Central Fournier II families. Each landless person is dedicated to it. The lagoon still represents a very rich and easy resource even if there aren't as many fish as before. The only difficulty is to get the launch, motor and net which represent a very heavy investment. The tourism is essentially located on the lagoon shore. They offer Palma shelters and bungalows to rent as well as food (mostly fish or derived). The affluence time is mainly during the week ends of the dry period (from January to June), and there is a great peak for the Semana Santa.

Homegardens are almost inexistent. Nevertheless, there is still a domination of poultry in the patio.

Natural Resources Degradation

The area has been largely deforested and therefore, soils are severely eroded. The implementation of cattle farming made the situation even worse. Now, there is a real problem of soil fertility. The lagoon also suffers from overexploitation. Overfishing is responsible for the loss of around 90% of the original lagoon's abundance. In addition, the introduction of devil fish threatened the native species.
Petroleum contamination is controversial. Farmers complain about acid rains that destroy roofs and wires or about the soil fertility loss attributed to Pemex oil well contamination. However, there isn't any study or any concrete evidences that can prove the phenomenon.
Sanitarian problems are a serious issue. The high concentration of livestock increased a lot pests and diseases transmission. Now animal are suffering from various illnesses (brucellosis, ticks, diarrhea viral bovina, rabies....)

Climate Characteristics

The climate represents the main issue for any agricultural activity in the community. More than a half of the lands are lowlands. They are really affected by the inundations during the rainy season and can stay under the water for 3 or 4 months. The other part is situated higher and don't get anything. The most serious problem is the pasture shortage that occurs during the drought as well as

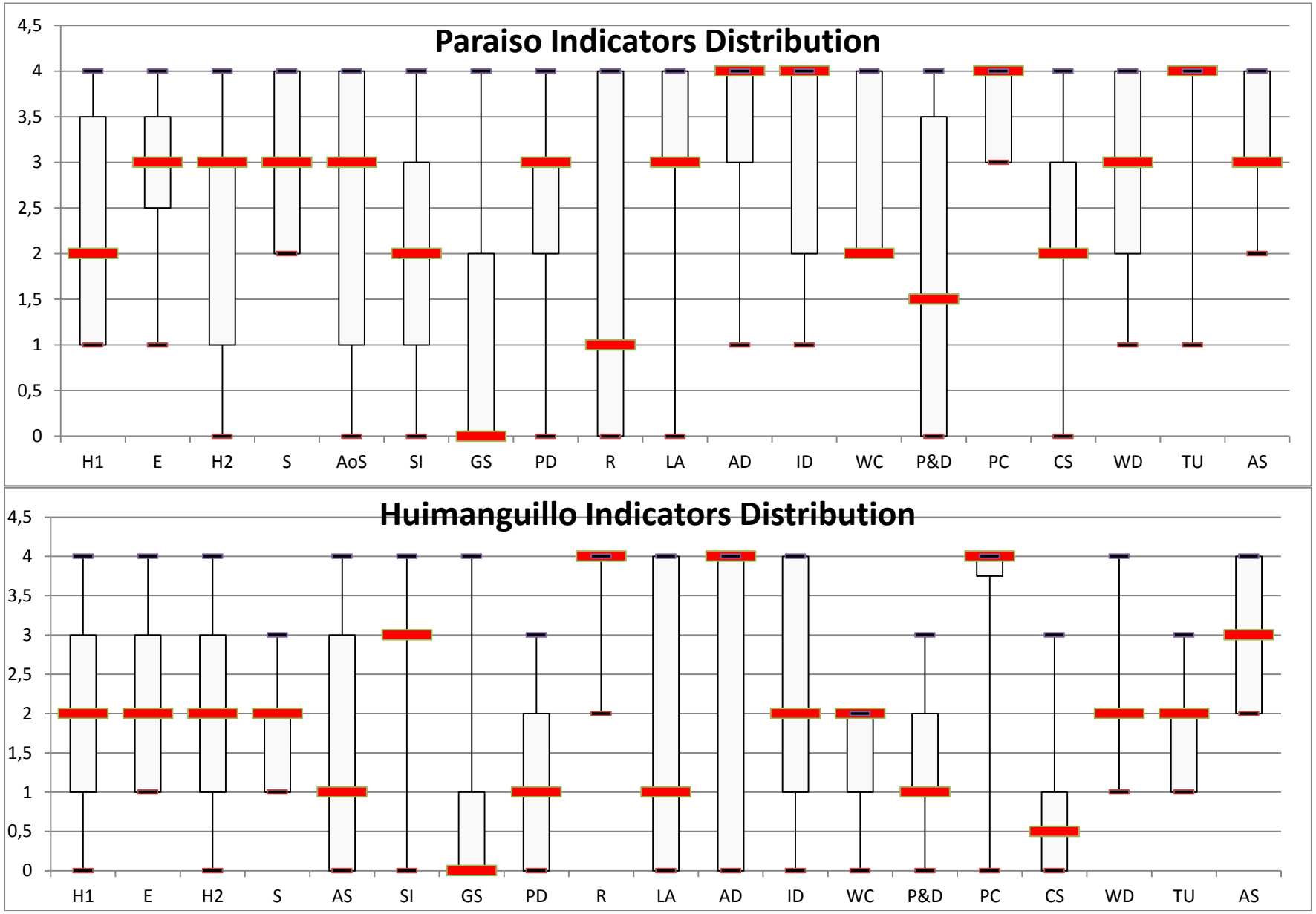
during the rainy season. Firstly for lack of water and overgrazing, then for inundation and water logging that kills the pasture. The phenomenon has been graver this last decade. The drought have been seen tougher and longer and the inundation higher and more violent. The temperatures as well reach the extremes. From 35°C, it can easily get up to 44°C. Colder temperatures are also observed during the winter time causing the apparition of a new illness (neomia).

For the agricultural crops, the change in the distribution and intensity of the rain is as well a problem. Farmers use to sow at the beginning of the rainfalls and harvest right before the inundations. Nowadays the instability make difficult for them to decide when it is the best to sow. If the rain is delayed, the crop cannot have a good development and is at the mercy of pests. Equal for the inundations that destroys everything. Besides, it became impossible to grow pineapple in the lowland for the water logging because of its 2 years cycle. Fishing also is affected by during the rainy season. The current is so strong that it becomes dangerous to go out.

Commercialization

The dairy production is under the monopole of unique company. A delivery van passes every day to collect milk paid at very low price. Farmers don't have other alternatives. All the other productions are commercialized through intermediaries called commonly coyotes. This system is the only way for them to send their production to the market. The community is indeed very isolated from the city and there isn't any local market in which farmers could commercialized directly. Therefore, there is a high degree of dependency toward intermediaries. The fishing production is goes firstly to a cooperative before being sent to the market.

Appendix 5: Indicators Scores Distribution



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