COASTAL AQUACULTURE AND SUSTAINABLE LIVELIHOODS IN MECOACAN, TABASCO, MEXICO

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RESUMEN

El propósito de este estudio es la evaluación de los factores que afectan el desarrollo de la acuacultura en el área de la laguna Mecoacán, Tabasco, basado en el esquema de desarrollo sustentable. A pesar que la acuacultura ha sido desarrollada en el área como un apoyo para el mejoramiento de la producción pesquera y como una alternativa de empleo, los resultados muestran que las condiciones de las pesquerías en Mecoacán se han deteriorado ya que la organización colectiva no está produciendo beneficios a las comunidades locales. La reducción en el acceso a los recursos y de la regulación formal a través de las sociedades cooperativas ha tenido un efecto significativo en la integración de esta actividad en el portafolio económico de las comunidades. Considerando las tendencias internacionales de integración económica, es imposible proponer una estrategia para el desarrollo sustentable aislada del contexto global. Los resultados de este estudio sugieren que el establecimiento de la acuacultura concuerda con las normas culturales y puede jugar un papel importante en el desarrollo en áreas costeras como Mecoacán. Por lo tanto, es necesario la creación de nuevas políticas que reduzcan los cambios en los parámetros sociales que dispersan la distribución de beneficios en las comunidades rurales, a través de la incorporación de planes y programas de desarrollo que contemplen la integración de los aspectos socioeconómicos y de la administración de recursos en la zona costera de Tabasco.
Palabras clave: Acuacultura, desarrollo sustentable, manejo de recursos, Tabasco

ABSTRACT

The aim of this study is the measurement of driving forces taking place at the Mecoacan estuary, Tabasco using the sustainable livelihoods approach. Although aquaculture practices have been implemented as an alternative to fishing and to improve current levels of fisheries production, the results showed that conditions within Mecoacan fisheries have deteriorated significantly, as collective aggregation is not producing a positive outcome for the local communities. The reduction of access to resources and formal regulation through fishing cooperatives were demonstrated to have a significant effect on the integration of aquaculture into the livelihood portfolio of local communities. Considering the trends for international economic integration, it is impossible to conceive a sustainable livelihoods strategy that is isolated from the global context. Results suggest actual aquaculture establishment appears to fall within current cultural norms, and it may play an important role in the development of the Mecoacan estuary. Therefore, a major challenge is to create new policies that reduce the changes in social parameters that disperse benefits distribution, through the incorporation of socioeconomic and resource management aspects in the coastal zone of Tabasco.
Keywords: Aquaculture, sustainable development, resources management, Tabasco

INTRODUCTION

It has been pointed out that the rapid expansion of aquaculture was due to the failure of capture fisheries to supply the growing demand for aquatic products and the development of aquatic farming as an income and diversification source for rural communities by integrating aquaculture production with agriculture to produce commodities for import replacement, export and local consumption (Mohamed and Dodson, 1998; Boyd and Schmittou, 1999).

Issues about its sustainability have been raised regarding its rapid growth, as social and organisational discrepancies have been major constraints in the implementation of aquaculture practices among rural communities along with poor planning and management, have resulted in a range of economically unsustainable activities (Hugues-dit-ciles, 2000; Srinath *et al*., 2000).

In Latin American countries repeated economic crises have resulted in conventional strategies being limited in their ability to promote equitable and sustainable development. Although, in some countries neoliberal economic models have appeared to be successful at the macroeconomic level, the introduction of new technologies, privatisation of public services, commercialisation of common property resources, changes in government policies for resources management and the general decline of agricultural produce trade exert pressure on rural communities towards change (Altieri and Masera, 1993; Rigby *et al*., 2000).

In the rural sector, sustainable development is difficult to implement because institutional arrangements, market forces, politics and research efforts may be biased against communities composition and organisation. A major challenge, therefore, is to create new policies that permit key sustainable development objectives to be operationalised by using a set of standards or indicators (Garcia and Staples, 2000; Rigby *et al, 2000*).

There are different definitions of what an indicator is and different understandings of their primary role. There are also varying opinions on the use of quantitative versus qualitative indicators. In spite of the lack of consensus on the operational meaning several authors point out that in order to be able to compare across places and situations from a sustainable livelihoods perspective indicators that can generally be defined to assess conditions and changes should be user derived (Carney *et al*., 1999; Howlett *et al*., 2000).

In general terms indicators "are often continuous variables indicating changes in the state of a system's components and important tools to communicate, and make accessible, key information of a statistical, scientific or technical nature to non-technical user groups with policy, decision-making, oversight and auditing functions" (Garcia *et al*., 2000). Hence, they can be used to assess focal issues of development and management conditions and trends. Although indicators are not themselves a solution, only a way to define objectives, scope and priorities for development and to reinforce best practices, as sustainability is a multidimensional concept with nested and interactive domains, which could be analysed at various levels and scales (Ashley and Carney, 1998; Garcia and Staples, 2000).

Sustainable livelihoods have been defined as "the secure access to adequate stocks and flows of food and cash to meet basic needs, where security is defined in terms of ownership or access to resources and income-earning activities, embracing the need for reserves and assets to offset risk" (DFID, 2000). Therefore, the aim of this study is the qualitative measurement of the main factors affecting the development of aquaculture and their impacts on the livelihoods of Mecoacan communities.

STUDY AREA

The coastal resources of Tabasco are enclosed in 11 800 km^2 of continental platform, 29 800 ha of estuaries and 40 km^2 of mangrove forest. Approximately 12 700 registered artisanal fishermen depend on Tabasco water resources to endure their livelihoods (López and Ezcurra 1985; Gobierno del Estado de Tabasco, 1999). Aquaculture is limited to small-scale Tilapia *oreochromis* spp and Oyster *Crassotrea virginica* farming with a total production of 29 537 t/yr representing 52.7% of the total fishery production with a total value of pesos $101.9 million (SEMARNAP, 1999).

The Mecoacan estuary is located at the North of Tabasco between 18º15' – 18º26' North latitude and 93º01' – 93º15' West longitude. It is a shallow area with an average depth of 1.50 meter with a total extension of 5 160 ha. The seaward side of the estuary is formed by a chain of small islands with the largest (3 km in length) located in the middle of the mouth which

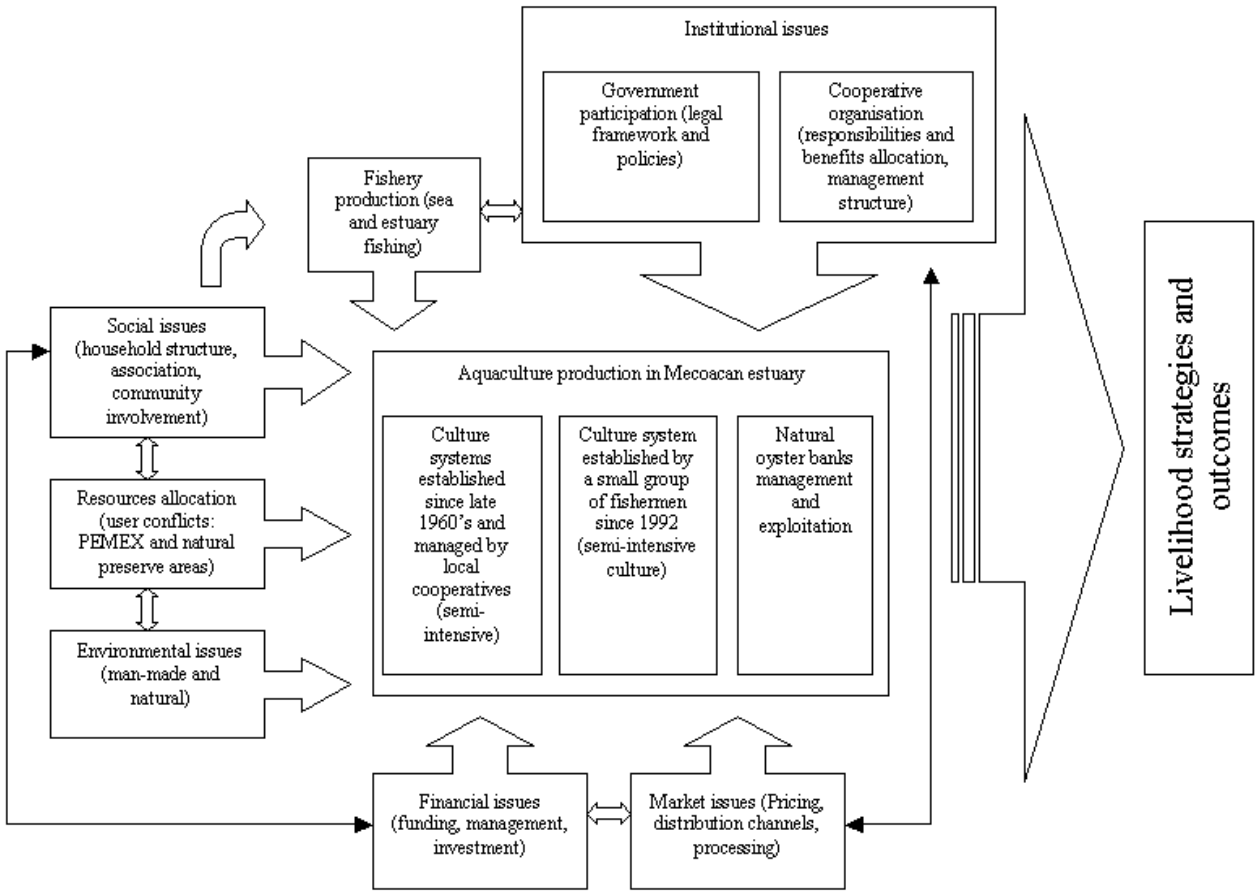

Figure 1. Sustainable livelihoods framework for Mecoacan fishing communities

stretches to the sea trough a narrow bar of 400 m known as Dos Bocas. Along with its tributaries Seco, Escarbado, Cucuchapa, Cunduacán and Arrastradero rivers Mecoacan area is considered the second most important coastal lagoon system of Tabasco with extensive oyster banks at its bottom and bordered by mangrove areas which have been reduced due timber exploitation activities (Domínguez-Domínguez, 1991, Valdes, 1998).

MATERIALS AND METHODS

Livelihood characteristics of Mecoacan fishing communities

Although the definition of sustainable development means different things to different people (Rigby *et al.*, 2000) information sets from different data sources were produced to help in the collection of data for developing the sustainable livelihoods framework for Mecoacan fishing communities (Figure 1).

This study is focused on the household characteristics of associated and independent fishermen in the Mecoacan estuary area to have a comprehensive analysis of the interactions amongst them. Respondents were located in the boundaries of the estuary area in the following towns: Ranchería José María Morelos (Andres García Island and Bellote), Ejido Chiltepec (Banco and Tanque section), Puerto de Chiltepec, Ejido Libertad (El Chivero section), Ejido Carrizal, Puerto Ceiba (Villa and Carrizal section), Colonia Nuevo Torno Largo and Colonia Miguel de la Madrid.

Sampling design

The fishermen from the four fishing cooperatives established in Mecoacan were selected as they are entitled by law to extract oyster species from the wild to manage culture sites and to participate directly in the

management of estuary resources. Independent fishermen were selected for the study as they represent the strongest competition to associated fishermen in terms of economic benefit of resources use.

Random sampling methods were used a cross the Mecoacan estuary to make samples representative. The snowballing method was carried out to survey the independent fishermen that is based on the contact of one or two potential respondents at the beginning of the survey to lead in turn to other similarly oriented people (Watts and Halliwell, 1996). Associated fishermen were interviewed based on an address list provided by the president of each association before the interviewing process took place. The total number of fishermen interviewed in Mecoacan estuary was 442.

Data collection design and analysis

The collection of data was based on the rapid rural appraisal (RRA) and participatory rural appraisal (PRA) approaches using questionnaires and interviews (McArthur, 1994; Townsley, 1996). Seasonal calendars were used to identify the stakeholders using participants' local knowledge and experience as appropriate in relation to social and environmental impacts on accessibility, benefits, cost, technical requirements and power over livelihood capitals (DFID, 2000). The stakeholder composition in Mecoacan area was recorded in a tabular format (Howlett *et al.*, 2000) through the classification of the different levels of participation, and impact and access to resources.

A set of indicators was identified from the livelihood system of Mecoacan communities. In order to define criteria of successful aquaculture and other farming practices, the livelihood status of fishing communities, the use of resources, and sustainability of production systems two sets of indicators were determined through participatory meetings and semi-structured interviews with the different groups and key informants.

Then after a combined list of indicators was produced in order to address the specific, relevant question of whether aquaculture can collectively develop. The items provided by the stakeholders were condensed by similarity into a sub-set of 20 factors based on a consensus amongst the respondents and according to the availability of data (Garcia *et al.*, 2000; Garcia and Staples, 2000). Then after, the evaluation was done through a ranking survey of the indicators considered being the most important for fishermen to define the criteria for sustainability. The ranks corresponded to the subjective threshold made by the authors (Table 1).

Table 1. Threshold levels to assess

Good	10 – 8
Fairly good	8 – 6
Moderate good	6 – 4
Poor	4 – 2
Very poor	2 – 0

The assessment is based on qualitative multicriteria data to identify potential factors in order to be able to display ranks and avoid having to aggregate through different scales (e.g. having to aggregate income level and quality of water resources). The multicriteria analysis provided a convenient mean to define their hierarchical structure. A non-parametric statistical analysis was used to define the level of agreement amongst stakeholders.

RESULTS

Livelihood characteristics of Mecoacan fishing communities

Most of the strategies of the people from Mecoacan estuary depend on the capacity for building opportunities within the area, despite significant constrains produced by environmental and economic conditions. Fishermen commented that environmental impacts induced mainly by the oil industry are the most significant concern due to the pollution shocks and estuary ecology changes. Although, they also acknowledged that seasonal changes are also significant factors decreasing capture fishery volume and value, as rainy season and physical limitations of the agro-ecosystems such as

drought, flooding and marginal soils have lead to insecurity and migration.

Ecological changes in Mecoacan estuary have been widely discussed in the literature. Although there has not been an agreement of who or what is producing these changes the fact is that the estuary is under pressure from several natural processes and human activities (Galaviz-Solís *et al.*, 1987; Arredondo *et al.*, 1993; Díaz-González *et al.* 1994; Moguel, 1994; Sima-Alvarez *et al.*, 1996; López *et al.*, 1997; Rodríguez, 1998).

Table 2. Stakeholder composition in Mecoacan estuary

Stakeholder		Sector	Function	System importance	Power over livelihood capitals
Category	Label				
Primary	Associated fishermen	Individual-household Organised-production Private Fishing Agriculture	Primary production (Estuary and sea fishing, harvest oyster farms, shrimp enclosures, tilapia ponds, coconut plantations)	Very important Key decision maker over resources use and farm output	Low Minimal power over financial, physical and natural capital. Moderate power over social capital. Control over human capital
Primary	Independent fishermen	Individual-household Private Fishing Agriculture	Primary production (Oyster and sea fishing, shrimp enclosures, coconut plantations)	Very important Key decision maker over resources use	Low Minimal power over financial and physical capital. Control over human capital
Secondary	Local brokers	Fishery-entrepreneurs Private Input supply	Provide in some extent physical capital (outboard engines, boats) Provide credit	Important to quantity and quality of production yields	Moderate High power over social capital. Moderate power over physical capital
Secondary	Large retailers	National fishery-entrepreneurs Private Input supply	Provide credit to reliable clients Market production from selected groups	Important to quantity and quality of production yields	Moderate High power over financial capital Moderate power over physical capital
Secondary	Local and national illegal middlemen	Fishery-entrepreneurs Private Input supply	Provide physical capital (outboard engines, boats) Provide credit in exchange of labour	Important to quantity and quality of production yields Significant to farm operations	High Moderate power over natural capital. High power over social, physical and financial capital. Moderate power of human capital
Secondary	NGO fishery and agriculture delegates	Technicians Non-profit-organisation Private	Promote group organisation Linkage organisations to credit institutions Provide technical and financial advice	Important Alternative influence over fostering social association Vital in giving advice	Moderate Low power over physical capital. Moderate power over financial and natural capital. Moderate power over social and human capital
External	Delegates of the fishery secretariat	Fishery bureaucrats and technicians Local government Public	Provide technical advice Influence group membership. Represent fishery regional sector at national level. Linkage organisations to other government institutions. Provide credit. Oversees fishery production and regulation	Important source of credit Facilitates farm operations Significant influence over social interactions	High Moderate power over physical capital High power over social and natural capital

Fishermen activities are varied and they may participate in different levels of fishing and aquaculture activities (Table 2). The breeding and growth out season of oyster is relevant, as 78% of fishermen depend on this fishery (Table 3). They commented that the freshwater (September-February) and seawater (March-August) inputs are the major events they observed in order to identify the areas where the most of the oyster seed would occur either to collect and transfer to on-growth systems (May-September) or to be able to calculate the time of harvest for natural banks (December-August).

Amongst the macro and microeconomics effects, the most commented factors were the price variation of fishery products and the prevailing market system controlled by local middlemen and large retailers located in Mexico City. Fishermen have access to better value per catch from February to July, as the availability of high value species and high market demand due to religious traditions and tourism. Fishing is only reduced during the rainy season (October-January). During this period some fishermen get involved in agriculture activities, mainly in coconut production, which is the most important agrarian commodity for export in the area. Others put all their fishing effort on oyster fishery and estuarine species, and a reduced number keep fishing marine species, as they possess more and better equipment and experience.

The use of participants' local knowledge and experience produced an appropriate identification of social relationships, environmental impacts, accessibility to resources and technical constraints. Among the different groups in the area competition exists because of a combination of development policies change and the physical limits of renewable natural resources. These have become underlying causes of conflicts, as most of the stakeholders described in Table 2 may interact inside and outside fishing cooperatives through diverse kin relationships, and group control exists by the wealthy few over the poor or low income households.

One way for families to sustain income is by employing more family members as wage earners. Most of households use labour as a buffer against adverse economic conditions, drawing on labour reserves of women where infrastructure such as schools free up time for employment. In several cases children are also involved. Housing also represents a buffer against economic difficulties, as most of the households have secured title to land

Table 3. Mecoacan estuary seasonal calendars produced by fishermen

Issues	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Management												
Veda Shrimp												
Veda Oyster												
Eco-biological												
Freshwater input												
Sea water input												
Oyster breeding												
Oyster wild seed availability												
Oyster growth												
Production seasons												
Oyster												
Shrimp												
Cutlass fish												
Snapper												
Mackerel												
Coconut												
Market												
Higher prices												
Medium/low prices												

and are able to use their homes as both a residence and business location for livestock production such as chicken and pig, or for small local stores, or rent space to others (e.g. freezers, garages), thus supplementing their income.

There are few options for a predominantly rural society (Fig. 2) to improve their activities due to the rural dislocation produced by the overlooked development policies through NAFTA (Fraser and Restrepo-Estrada, 1996; McDonald, 1997). In the area of the Mecoacan estuary, causes of problems involve complex inter-linkages between the biophysical, technological and socio-economic conditions at the local level and the socio-political structures at the national level. Amongst factors affecting the social and economic development of fishing communities of Mecoacan are: (1) increased conflicts due to open access conditions, (2) unmanaged ecosystems, (3) poor and unmanaged cooperative organisations, (4) poor market conditions and regulation, (5) production disorganisation, (6) diminished aquaculture production, (7) diminished institutional involvement, and (8) local labour force underused.

The effects of these constraints range from a temporary reduction in the efficiency of resource management to the complete collapse of community initiatives or abandonment of sponsored projects. In extreme cases conflicts over natural resource management and environmental impacts sources have escalated into physical violence (Moguel, 1994).

Sustainability indicators

As the aim of the study is the measurement of driving forces affecting the sustainability of livelihood of Mecoacan communities, a list of indicators was produced from the PRA interviews with fishermen and cooperatives' management committees (Table 4) to produce information sets that helped in the collection of data and to explore livelihood priorities of local people and institutional intervention effects within the proposed sustainable livelihoods framework (Fig. 1). Although this assessment only reflects value judgments, underlying information was conserved through the aggregation of indicators.

The results from the ranking matrix produced by fishermen showed that the highest ranked factors were human resources, employment and water resources (Table 5). Effects of institutions and other processes have also reduced people's ability to achieve sustainable livelihoods, as indicated by the low rank given to activities and farms interaction. Examples of these effects include the absence of proper regulations or enforcement regarding the access to resources by unemployed populations and free riding fishermen who capture species regardless of fishery laws and fishing season or zone, as they claim to

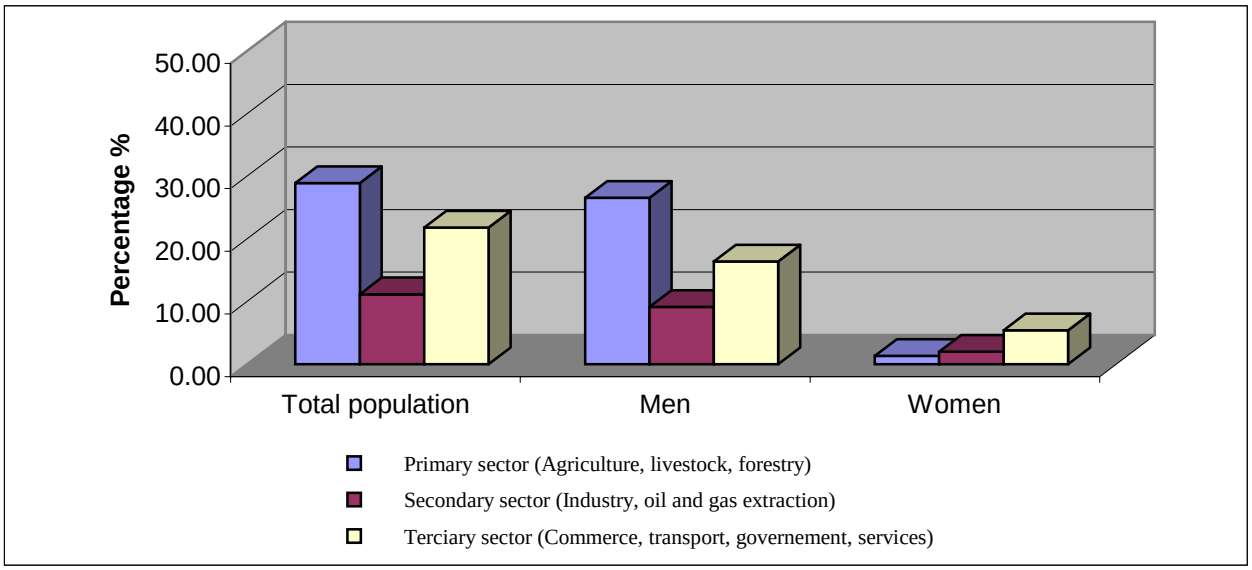

Figure 2. Tabasco's population distribution according to activity by production sector and gender (INEGI, 2002)

Table 4. List of sustainability indicators, aquaculture success and failure

Indicators of successful farming	*Indicators of farming failure*
Small groups of participating household	Household lack of participation within large groups
Efficient technology transfer	Lack of technology to improve aquatic produce
Storage facilities available nearby aquaculture sites (freezers)	Lack of storage facilities (freezers)
Planning for production	Lack of planning for production
Resilient timing for aquaculture operations	Lack of follow-up procedures in scheduled operations
Size selection to improve oyster on-growing systems, tilapia pond management	Lack of stock and pond management
Perimeter fences and surveillance to avoid poaching	Diminished or abandoned surveillance and free access to sites
Set of combined indicators: Indicators of sustainability identified by head of the household	
Availability and access to extension services and knowledge	
Availability of market for produce	
Availability and capacity of land	
Group interest in aquaculture enterprise	
Availability of good aquatic sites for semi-intensive production	
Access to capital for investment	
Restructure of cooperative organisations	

have the same rights as associated fishermen to extract any species to support their livelihood. This condition is aggravated by the disjointed services administered by different local agencies and the entry of private aquaculture investors without the participation of cooperatives in the allocation of culture sites. This leaves fishing organisations unable to access opportunities that could assist them in managing the estuary's resources properly.

Despite that coastal aquaculture may be the only technical option to farmland under saline conditions (FAO, 1999), inappropriate land-based aquaculture systems have been developed in the area. In the case of water-based systems the major constraints for the promotion of aquaculture are often not technical. Problems are more complicated as deeper conflicts prevail regarding structural inequalities inherent in legal definitions of resource use and the complex arrays of developmental regulation, which can skew access to natural resources, accentuating latent levels of competition and concentrating resource degradation within small areas.

DISCUSSION

Aquaculture has been identified as one of the few profitable and expanding sectors of the agricultural sector. During the 1990s, aquaculture contributes with <15% of total fisheries production and <1% of agricultural GDP and exports of Mexico (World Bank, 1997). Considering the trends for international economic integration, it is impossible to conceive a sustainable

Table 5. Sustainability indicators ranking for aquaculture development

Environmental indicators	Ranks					Socio-economic indicators	Ranks				
	A	*B*	*C*	*D*	*Mean*		*A*	*B*	*C*	*D*	*Mean*
Water resources	10	10	9	10	9.8	Human resources	10	8	10	7	8.4
Soils	9	3	1	2	3.6	Employment	9	9	6	9	8.4
Roads	8	1	2	1	2.6	Activities interaction	8	5	3	3	4.6
Oil industry	6	7	7	4	5.8	Land ownership	7	3	2	1	3.0
Agriculture	5	4	5	5	5.4	Inputs	6	6	7	6	5.6
Livestock	7	8	8	8	7.0	Urban areas	5	4	5	5	4.0
Forestry	2	6	4	6	5.0	Farm-gate sales	4	10	8	10	8.0
Existing farms	4	2	3	3	2.8	Interaction between existing farms	3	2	4	4	3.8
Urban areas	3	5	6	7	5.4	Income	2	7	9	8	7.2
Population density	1	9	10	9	7.6	Energy	1	1	1	2	1.2

A= Associated fishermen, B= Independent fishermen, C= NGO extensionist, D= Government officers. Good= 10-8, Fairly good= 8-6, Moderate good= 6-4, Poor= 4-2, Very poor= 2-0. $W = 0.53$ $X^2 = 50.45$ Chi $X^2_{r\ 0.05,4,9}=7.08$

livelihoods (SL) strategy that is isolated from the global context. As immediate priorities are more equitable distribution of wealth, securing adequate living conditions, improving the conditions of popular participation in the decision making process and management enhancement of the region's natural resources, a new pattern of growth is needed, which is different from that of the past.

The analysis models employed here, while in need of refinement, can be use as conceptual frameworks for a variety of development scenarios. Results suggest actual aquaculture establishment appears to fall within current cultural norms, and it may play an important role in the development of the Mecoacan estuary. However, several social factors may preclude local participation and investment. One of the main problems is that aquaculture producers must compete frequently with more powerful groups for resources and market access. Sustainable aquaculture in the Mecoacan estuary will be difficult to improve if access to resources remains skewed and institutional arrangements (e. g. technical assistance) and market conditions still favour unregulated free riding.

Although new policies are an important requirement for SL in the coastal zone of Tabasco, it is not enough as profitability at the household level depends not only on what communities can do, but also mainly on the macro conditions under which the rural production operates, (Bebbington, 1999). At the macro level there are important obstacles such as the increasing external debt, distribution of resources, appropriate technologies and international forces. These effects may be reduced by the empowerment of local organisations and the effective participation of communities in policy making regarding technical change, and economic and social investment, but the effective participation of communities will depend "on their ability to speak with one voice" as McCay and Jentoft (1996) point out.

However, development approaches have followed the paternalistic fallacy (Wanmali, 1999), government agencies have believed that they posses all the knowledge to achieve development objectives and communities should only be the recipients of this knowledge. As noted by respondents, people have not participated in decision making processes regarding resources management, nor is there a clear definition of the roles and responsibilities held by fishing organisations in current sectoral affairs.

It has been reported by the Federal Government that capacity building promoted for integration of coastal management has been carried out in order to improve management policies for the coastal zone and that there have been several attempts to improve, enhance, and foster the administration of the coastal zone by means of inter-sector political integration for sustainable development. These efforts have been focussed on information and discussion panels regarding taxes and fee system for administration of beaches on federal marine/terrestrial zones for 13 States including Tabasco (NOAA, 2000). However, there are no references to other activities or to aquaculture.

On the issue of free riding a policy climate that improves the terms of trade for rural production by providing competition to local monopolistic intermediaries may allow fishermen to capture the externalities that a rural-sustainable aquaculture might produce (Glomm and Lagunoff, 1995; Barg *et al.*, 1999). These may be achieved by a) the vertical diversification of the sector to provide a degree of specialization in the economy, b) the definition of adequate tax policies to charge free riders, and/or c) tradable use or property rights.

However, the conditions working for and against sustainability in fisheries and aquaculture are significantly related to economic and social interdependence between fishermen. Free riders face similar problems in accessing resources and in trading fisheries products. Jentoft (1989) states that the crucial question is to get both associated and independent fishermen voluntarily to advance their collective interests at the expense of their private ones. Therefore, a major challenge is to create new policies that reduce the changes in social parameters that disperse benefits distribution (Montgomery, 1991). This is only possible if

fishermen find the regulatory scheme legitimate by participating in the decision-making process and getting directly involved in implementing and in enforcing regulations (Jentoft, 1989).

Bardhan (1993) stated that people sometimes might be able to leave their conflicts behind and settle rules for allocation and monitoring of common resources, enhancing the chances of survival. The more the regulations coincide with fishermen definition of problems, the more the regulations will be accepted as legitimate (Pomeroy and Berkes, 1997). This may be achieved based on the compromise and consensus approaches (Warner and Jones, 1998) in order to promote capacity building within communities in the context of a participatory intervention strategy through formal and informal organisations (Rivera-Arriaga and Villalobos, 2001). Participatory approaches showed to be helpful in the understanding of the role of aquaculture in the Mecoacan estuary, as opposed to focusing purely on aquaculture as a technical activity and in understanding the attitudes and perceptions of the people involved.

Finally, although conflict over resource access and allocation remain as a major social and economic constraint the conditions to promote a multi-sectoral planning approach are available and the consolidation of previous and new successful approaches represent a significant role in the process of evaluating coastal trends and the effectiveness of management measures, including those related to aquaculture development, to achieve sustainability in the coastal zone of Tabasco.

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