Semi-subsistence and Sustainability: Aquaculture in Tabasco, Mexico

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Angel Galmiche Tejeda

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ABSTRACT

This thesis explores the physical and the socio-economic conditions for aquaculture in Tabasco, Mexico, seeking to find how aquaculture can best be supported to reduce poverty. On-farm physical, technical and social surveys were carried out in four municipalities, covering different physiographic regions. The surveys establish that the environmental conditions are frequently good for aquaculture. Despite efforts to bring farmers into more intensive commercial systems, aquaculture has developed mainly to improve subsistence, as one component of semi-subsistence farms. In order to evaluate these semi-subsistence systems, the thesis explores current debates on 'sustainability' and on 'subsistence'. As no single approach to sustainability *per se* seems appropriate to apply to these systems, new indicators and methods need to be developed which are appropriate to evaluate systems poor in cash generation but rich in social assets. Subsistence aquaculture is arguably more sustainable than commercial, monocultural aquaculture in environmental and social terms. It has become part of the economic diversity of the communities, increases food security, reduces the use of fossil fuels, promotes the careful management and recycling of wastes and the careful stewardship of natural resources, can help in the protection and enhancement of biological diversity and yields a feeling of self-empowerment. From the surveys, socio-economic and cultural realities are more important than physical conditions in determining the present state of aquaculture in Tabasco. The existence of some successful farmers' micro-businesses shows that once farmers receive continuous technical assistance, subsidies and access to markets, bringing them into commercial aquaculture is possible. Such help however, *is* rarely provided at present by the local extension institutions, which face internal problems resulting from inadequate budgets. This thesis argues that, in these circumstances, semi-subsistence aquaculture is a good option for the poor as many semi-subsistence systems are highly valued and have the potential to become more efficient and productive if locally based research is conducted with an understanding of farmers' cultures and motivations.

Declaration:

No part of this thesis has previously been submitted for the degree at this or another University.

Statement of Copyright

A mi padre- ya no estas con nosotros, pero sé que estas sonriendo.

A mi madre, mujer admirable, fuerte y generosa, siempre luchando por salir adelante y cuyo ejemplo me ha motivado para lograr mis metas.

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ABREVIATIONS

ANEC	Asociación Nacional de Empresas Comercializadoras de Productores del Campo (National Association of Trade Enterprises of Farmers)
APS	Aquaculture Production Societies
CEPAL	Comisión Económica para América Latina y el Caribe (Economic Commission for Latin America and the Caribbean).
CRSP	Collaborative Research Support Programs
EMS	Ecological management systems
FAO	Food and Agriculture Organization of the United Nations
FG	Farmers' Groups
FONAES	Fondo Nacional de Apoyo a Empresas de Solidaridad (National Program of Support for Solidarity Enterprises)
GDP	Gross Domestic Product
GPI	Genuine Progress Indicator
IAAS	Integrated aquaculture-agriculture systems
ICLARM	International Center for Living Aquatic Resources
IED	Institute of Environment and Development
INDUVITAB	Instituto de Vivienda de Tabasco (Tabasco's Housing Office)
INEGI	Intituto Nacional de Geografía e Informática. (National Institute of Geography and Computing Sciences)
INI	Indigenous National Institute
ISPROTAB	Instituto para el Desarrollo de Sistemas de Producción del Trópico Húmedo de Tabasco (Institute for the Development of Production Systems in the Tabasco's Humid tropics)
LCA	Life cycle assessment
NGO	Non Governmental Organisation
PEMEX	Petroleos Mexicanos (Mexican Petroleum)
PRD	Partido de la Revolucion Democratica (Democratic Revolution Party)
PRI	Institutional Revolutionary Party
PRONASOL	'Programa Nacional de Solidaridad' (National Programme of Solidarity)
SEDES	Secretaría de Desarrollo (Development Secretariat)
SEDESPA	Secretaría de Desarrollo Social y Protección Ambiental (Secretariat of Social Development and Environmental Protection).
SEFOE	Secretaría de Fomento Económico (Economic Development Secretariat)
SEMARNAP	Secretaría del Medio Ambiente, Recusos Naturales y Pesca. (Environment, Natural Resources and Fisheries Secretariat)
SEMARNAT	Secretaría del Medio Ambiente, Recusos Naturales y Pesca. (Environment, Natural Resources and Fisheries Secretariat)

TNC	Trans National Corporation
WBCSD	World Business Council for a Sustainable Development
WCED	UN World Commission on Environment and Development

CHAPTER 1
INTRODUCTION

"When the dry season comes, people from the village meet to collect small fish which are dying in the puddles and stock them in the streams… We know that they are going to come next year…but bigger."
Fish Farmer, Jose Mª Morelos, Tacotalpa

Many programmes have been designed and implemented by both official and independent institutions for developing aquaculture in lower-income countries (FAO, 1993). Nevertheless, numerous reports indicate that those programmes are generally far from successful (e.g. Lee, 1997). There is still a lack of published, in depth research as to why. Is it, as some researchers (e.g.

Hishimunda, 1998a, 1998b) consider, that aquaculture is not suitable for improving the standard of living of rural communities in lower-income countries? Or is it that the programmes, plans and policies implemented by different governments suffer similar weaknesses in different places because they derive from the development community, not from local needs? (See Townsend *et al.*, 1995, on land settlement, Chapter 6). Furthermore, is aquaculture something that people want and are able to perform? It is possible that the root of the problem is a particular notion of development, which Esteva (1993) calls a "violent colonising power", imposing an industrial type of production. This, once no more than one among many forms of social life, has nowadays become the mainstream of social change, causing people of different cultures to lose the right to define their own forms of social life.

Having been born and bred and having worked in Tabasco, I always wondered why in such a fertile region, rich in natural resources, rural people have lived and still live in poverty despite more than forty years of 'development'. As a biologist I started looking for answers, first through my work in aquaculture extension and later through teaching and research. Unlike other regions of Mexico, in Tabasco aquaculture seems to be a natural way to improve the standard of living, first because water, the main limiting factor for aquaculture, is abundant; second because there is a wealth of aquatic species with potential for culture, and finally because the protein content of fish makes small-scale aquaculture an ideal means to raise the nutritional standard of the rural poor. My research work in technical aspects of aquaculture yielded few answers (technology can be present, yet not necessarily adopted) but led me to look at the problem from anther perspective: problems limiting aquaculture are not disciplinary, so finding solutions requires us to explore not only the technical side but also the socio-economic, cultural and environmental aspects. This thesis is the result of such reflection.

1.1 Background

Since 1980 'sustainable development' and 'sustainability' have become widespread as fashionable terms in the design of programmes and projects in order to express an environment--friendly alternative to development. It is no longer enough to evaluate the economic feasibility of any activity without relating it to its impacts on nature and society. Although this quality of sustainability is still difficult to measure, this trend has reached almost all human activities including aquaculture where a common approach is a search for sustainable technologies focused mainly on minimising environmental impacts.

To understand aquaculture in Tabasco, this panorama obliges us not only to evaluate it in terms of technological performance, productivity and economic feasibility but to explore its cultural, socio-economic and environmental dimensions.

From its introduction in Southern Mexico in the mid 1970s, aquaculture was expected to become an engine in the development of the rural areas, mainly in Tabasco where rainfall and topography give large amounts of both surface and artesian water. This abundance of water was the key reason why it was considered suited to the development of aquaculture. In the beginning, technology transfer in aquaculture was socially orientated, towards the production of good quality protein, to improve the nutrition of the average farmer in rural Tabasco, but due to the limited production and small number of aquaculture enterprises, according to most aquaculture professionals, after 20 years aquaculture as an economic activity for development is now thought to have failed in Tabasco. Nevertheless aquaculture in its subsistence form seems to play important socio-economic and environmental roles which are rarely recognised by local development institutions.

This is because for many experts, the only way to overcome poverty is by the inclusion of the poor in the market economy. Other forms of economic life, especially if social and environmental values have an importance equal to or greater than material values, tend to be seen as primitive. Despite views to the contrary (Sahlins, 1974, Bennholdt-Thomsen and Mies, 1999), subsistence production is often seen as backward and in need of change, regardless of open or silent local opposition. 'Poverty reduction', inclusion into 'modernity' (as opposed to 'primitivism') and more recently 'inclusion into globalization' are widely used to legitimize cultural aggression directed against subsistence modes of life and production.

'Subsistence', 'aquaculture' and 'sustainability' must first be defined. Pure *subsistence production* traditionally refers to self-contained and self-sufficient units where all production is consumed and none is sold, and where no goods or services from sources external to the units are purchased. These are systems characterized by the total absence of commercialization and monetization (Wharthon, 1970). 'Subsistence' is also used to denote low levels of living. *"But 'subsistence living' must be distinguished from 'subsistence production' even though the two often go together. While it is true that subsistence production usually results in levels of living which are best described as abysmal by most standards, it is possible, though rare, to find cases where the associated level of living is reasonably adequate"* (Wharthon, 1970, p3). Under this definition, subsistence production is now extremely rare, as cash income has penetrated almost everywhere but semi-subsistence production is widespread. Bennholdt-Thomsen and Mies (1999, p.20) propose a new and radical definition of subsistence production as the *"production of life* (which) *includes all work that is expended in the creation, re-creation and maintenance of immediate life and which has no other purpose. Subsistence production therefore stands in contrast to commodity and surplus value production. For subsistence production the aim is 'life', for commodity production it is 'money', which 'produces' ever more money, or the accumulation of capital"*. To them, subsistence does not mean the absence of trade and markets but a less materialistic lifestyle, based on sufficient consumption to secure a healthy life.

This thesis argues that human groups must have the right to choose freely their production systems and perhaps a way of life poor in material goods but rich in social satisfactions. In this scenario, the role of development must be to provide people with the tools to improve their conditions while respecting their values. There are arguments to support the free choice of human groups to define their own direction of change. Esteva and Prakash (1998) stress the value of the local and the diverse in the search for a better, richer world, and the rights that human groups should have to choose their own paths. For such thinkers, diversity could be the engine for a real human development. 'Universal' truths in social life, such as a consumerist economy as the only goal, seem an intellectual tyranny, because they disqualify all other, alternative forms of social life. In the words of Esteva (1993, p17), economics as a conceptual construction '*strives to subordinate to its rule and to subsume under its logic every other form of social interaction in every society it invades. Establishing economic value requires the devaluing of all other forms of social existence*'. Similarly Escobar (1995) concludes that capitalist regimes undermine the reproduction of socially valued forms of identity. Subsistence has thus been devalued as a marginal or sub-human form of production (Illich, 1993) but it has virtues (greater sustainability, less materialism, etc) lacking in today's widespread but unsustainable systems of production. Subsistence and the people who believe in it as a decent way of life have a right to survive and even to transform themselves into a more efficient and sustainable lifestyle.

It will be argued here that even in cases where subsistence production does not yield a good livelihood, technical support may improve it and enhance well-being. This offers more real possibilities for poverty reduction than transforming such farmers into waged labor, especially where unfair conditions of work for unskilled workers prevail.

Aquaculture can be defined as the science and art of managing aquatic ecosystems to produce crops of animals and plants. Fish farming or pisciculture, refers specifically to the culture of finfish while aquaculture is a broader concept. Both terms are used recurrently in this thesis because aquaculture systems in Tabasco sometimes include turtles and freshwater prawns, although they do not produce plants. Fish farming as an organized activity is know at least from 3000 BC in China, where the carp has a long history of domestication and the *fish culture* of Fan Li of 460 has often been quoted as showing the well established husbandry that had developed by that time (Coull, 1993).

Together with socioeconomic and environmental benefits, material aspects of aquaculture also need to be explored particularly because modern ways of life have reached rural areas and households progressively depend more and more on cash income. In aquaculture the production per unit area generally is far above than of the best conventional fisheries, characteristically higher than that of livestock farming on land, and often higher than for food staples like wheat and rice (Coull, 1993). The challenge is to transform this potential productivity into real and accessible technologies and in economic benefit for the poor, on a 'more sustainable' basis. This thesis suggests that that is possible when the poor are provided with favorable trade and infrastructure conditions and appropriate technical support.

One important question in studying aquaculture systems is that of *sustainability*. Can these systems be considered sustainable? Sustainability is a difficult concept. Despite all the debates, no satisfactory concept has been developed to cover all that sustainability implies in human-environment relations, economy, and society. I argue that sustainability rather than sustainable development is still a valid concept but, using Sneddon's (2000, p540) words, we *"should be mindful of the multiplicity of meanings and uses to which 'sustainability' is attached, a task that geographers are readily able to assume due to a long and diverse* *tradition of human-environment thinking"*. At present, we can most usefully refer to systems not as 'sustainable' but as 'more sustainable' than others.

This thesis argues that it is through its greater sustainability that aquaculture-agriculture semi-subsistence systems (Branckaer, 1995; Ruddle and Zhong, 1988; Edwards *et al.*, 1997; Folke *et al.*, 1998) can compete with commercial aquaculture systems which, though financially profitable in the short term, often not only prove very energy-costly and environmentally hazardous (Beardmore *et al.*, 1997, Kautsky *et al*, 1997, Folke *et al.*, 1998) but disrupt local social relations (Dewalt *et al.*, 1996).At the same time, the challenge of group commercial aquaculture enterprises set up by small farmers is to avoid falling into the unsustainable but highly profitable practices which characterize private business, with which at any moment they may have to compete.

This work seeks to express the farmers' view of their own reality, but of course this is limited by the author's interpretation. Farmers' views and management of their production systems will be argued to mirror a subsistence culture.

1.2 Justification of this research.

Vincke (1995) reports that for African countries, in most cases, plans and programmes for aquaculture take the form of catalogues of projects rather than co-ordinated, integrated programmes linked with real development strategies. Similarly, the evidence suggests that social and economic constraints on intensification are still poorly understood and may constitute an important barrier to improving resource utilisation (Lewis, 1997).

On the basis of my own experience in aquaculture extension, research and teaching in Mexico, I feel that one cause of the failure of programmes has been that the staff who create them often lack knowledge about the *specific* environment, natural resources and people. They often have a reductionist approach, treating aquaculture as a technical issue (paying attention to quality of fry, pond design, fertilisation, feeding etc.), and disregarding other important aspects such as environmental (temperature fluctuation, soil, water quality, pollution, etc.) and socio-economic factors. There is some research reported into these issues, but in general it has offered either too narrow or too broad a view of the problem (Chapter 7). As we shall see, some research has been conducted with an emphasis on a particular field: educational constraints (Kigeya, 1995), motivation (Harrison, 1996b), extension (Crew and Harrison, 1998) institutional limitations (Kalinga, 1993), technical aspects (Thomas, 1994), research priorities (Coche, 1995), marketing (Pingali and Rosegrant, 1995), etc. Other studies have broader approaches but the information is more quantitative than qualitative. This is the case of Vincke (1995), who listed constraints for aquaculture development in Africa, including administration, socio-economic, technological and physical environment.

With the exception of some surveys of the present situation of aquaculture in specific areas (Mendoza *et al.*, 1991), and the description of the socio-economic structures of some communities engaged in aquaculture (Pierard *et al*, 1993), there are remarkably few studies exploring the links between techno-environmental and socio-economic factors influencing the success or failure of aquaculture.

1.3 Aim and objectives

The aim of this research is to contribute to the knowledge of factors affecting the development of aquaculture in rural areas of Southern Mexico, in the hope of identifying practicable solutions. The project was initially designed to look at attitudes, culture, environment and physical and technical conditions which are related to the practice of this activity in the region. Both general and local factors influencing the growth of fish farming were investigated, initially in the interest of establishing the role of aquaculture in Tabasco's rural households.

This research focuses on the accomplishment of 4 main objectives.

1) To identify physical and environmental constraints on aquaculture.

2) To identify socio-economic factors which facilitate and constrain the implementation of fish farming.

3) To analyse the role that the government has had in the development of aquaculture in the last 20 years.

4) To analyse the linkages between the three previous categories.

1.4 Research questions

Six research questions were adopted. The first four would permit the identification of socio-economic, physical and environmental factors which have influenced the development of aquaculture in the region studied and the characterization of these aquaculture farming systems to enable comparison. The next three research questions sought to establish the role of government institutions in the development of aquaculture in Tabasco and to assess whether or not the strategies implemented had the desired results.

1. Is the area suitable for fish farming and does it have the necessary conditions to allow this activity to grow?
2. What is the present state of aquaculture in Tabasco?
3. What are the factors affecting aquaculture in rural areas of Tabasco?
4. What is the current working unit for fish farming?

5. How appropriate was the government intervention in the development of fish farming?
6. How appropriate are government extension services?

1.5 Thesis structure

This introductory chapter has outlined the position of this research in a theoretical context and set out the objectives of this thesis. Chapter 2 offers basic definitions and characteristics of aquaculture systems in terms that will be frequently used in this thesis. Background information on previous research in aquaculture in areas relevant to this thesis follows. This deals mainly with socio-economic and environmental work in low- and middle-income countries, including Mexico and specifically Tabasco, and with work on the technical and socio-economic constraints of rural fish farming in such environments.

The objective of chapter 3 it to present some deliberations on critical development, ecofeminism and alternative development which are the major theoretical influences on this research; and a description of the methods and the area in which the fieldwork took place.

Chapter 4 explores the debate on sustainability. What does it mean? What are its weaknesses? Is it still an appropriate term? It also reviews the environmental dimension of aquaculture (both commercial and artisanal) in the context of sustainability and explores the place of sustainable aquaculture in aquaculture research. Finally some guidelines for the evaluation of sustainability in subsistence aquaculture are proposed.

Chapter 5 describes fish farming in Tabasco from the analysis of questionnaires and interviews with farmers and evaluation of physical parameters (water quality and soil characteristics). It includes the technical (pond design and pond management) and socio-economic and cultural constraints defined by the farmers themselves and case studies of successful farms in material terms, at both individual and collective levels.

Chapter 6 is about subsistence. It explores the contribution, present and potential, made to human well-being by subsistence aquaculture in Tabasco, and its wider significance. Can Tabasco's aquaculture professionals really consider semi-subsistence agriculture-livestock-aquaculture systems primitive? Can we talk about a failure of rural aquaculture in Tabasco? What is the place of fish farming there? Can its success only be measured in cash income and yields? Here, subsistence aquaculture systems in Tabasco are examined in the context of sustainability.

Chapter 7 seeks to explore the aquaculture professionals' side of the question. What is the present stage of aquaculture in Tabasco according to aquaculture professionals, including extension officers? What is their view of subsistence production?

This thesis closes with Chapter 8, which presents the main findings of this research. Leading socio-economic, cultural and environmental values of subsistence aquaculture in Tabasco are set in the context of sustainability along with the scope of communal fish farming, its limitations and advantages. Some conditions for the commercial success of small-scale aquaculture are presented and a list of technical proposals, including research needs, is offered.

In this exploration of technical, socio-economic and cultural factors affecting the development of aquaculture in Tabasco, sustainability emerged as an important element in the evaluation of aquaculture semi-subsistence systems, which proved to be the most numerous in the region studied. Could these systems promote their survival in the modern age? When farmers cannot or do not want to go into entrepreneurial activities, does subsistence aquaculture have possibilities to become at once more efficient and a real option in improving the standard of living of the rural poor? Can they build on their culture in ways that they choose?

CHAPTER 2
TABASCO AQUACULTURE IN WORLD AQUACULTURE

2.1 Introduction

This chapter will give a general overview of aquaculture, selecting themes relevant to this research. It will begin with Pillay's (1994) classification of aquaculture systems, to be used in this thesis. Then it will give a brief account of environmental and social problems created by the fast development of intensive and semi-intensive commercial aquaculture in the tropics. Aquaculture in low and middle-income countries will then be characterised, followed by a review of socio-economic research on aquaculture in low-income countries. Integrated agriculture-livestock-aquaculture systems will then be described, given their importance as natural models for aquacultural change in Tabasco. The chapter will conclude with an introduction to the development of aquaculture in Latin America, Mexico and Tabasco.

2.2 Basic concepts

A summary of the commonest aquaculture systems classified according to level of intensity and technical performance is presented in table 2.1.

Extensive systems involve low capital investments and operating costs, are labour-intensive, use low stocking densities and external inputs, depend mainly on natural food and feed stuffs, employ low levels of management, and are expected to provide only low levels of yield per unit area. The general perception is that these are the least economic of all systems but experience seems to show that this need not to be the case, when availability of space and labour is not a major constraint (Pillay, 1994).

Intensive systems use dense stocking rates, frequent water exchange, high rates of feeding with formulated feeds, exercise environmental control, and mechanise many of the farm operations, and target high production levels (Pillay, 1994).

Semi-intensive systems come in between extensive and intensive systems, combining their characteristics in varying degrees (Pillay, 1994).

Super-intensive systems involve much higher levels of sophistication of culture techniques, involving greater consumption of energy, less of land and water resources, often resort to recycling water, and aim at a maximum possible production from limited areas, often on a factory level (Pillay, 1994).

Table 2.1. Freshwater aquaculture systems and their possible impact and potential producer benefits based largely on experience in tropical Asia.

System Type	Species used and principal characteristics	Possible environmental impact.	Potential introduced benefit
(A) Extensive (a)	No inputs to system other than fingerlings stocked, labour and capital (Mainly as opportunity cost)	Few, in general	Income and employment generation; directly improved nutrition; enhanced prestige and other social benefits
1. Ponds	Carp, catfish and tilapia. Simple physical structures (Pond and water inlet) and basic management (Pond reshaping and clearing)	Possible local disruption of hydrological system and retardation of sediment transport. Conflict over water resource right	As above.
2. Reservoir stocking	Carp, catfish and tilapia. Infrequent stocking and harvesting is limit of management usually practiced	None foreseen	As above. (Also enhancement of capture in natural water bodies)

Table 2.1 cont.

System Type	Species used and principal characteristics	Possible environmental impact.	Potential introduced benefit
3. Pen and Cage culture	Carp, catfish and tilapia. Use made of eutrophic waters and/or rich benthos. Stocking, equipment maintenance and harvesting are limit of usual management practices.	Area conflicts with traditional capture fisheries, leading to social disruption and management difficulties. Deforestation and related ecological problems owing to infrastructure demand	As above
(B) Semi-intensive	Additional inputs include some feed and fertiliser.	Same as A1	As above
1. Ponds	Carp, catfish and tilapia. Physical infrastructure may be better than above, and usual management may be more frequent, and carefully performed to ensure supplementary inputs made.	Same as A1.	As above
2. Integrated agriculture-aquaculture.	Carp, catfish, tilapia, integrated farming of combination rice-fish; livestock/poultry-fish; vegetable-fish.	Same as A1. (Also accumulation of toxic substances from livestock feeds in pond sediments and fish; accumulation of agricultural chemical residues in fish. Competition for inputs from other on-farm uses.	As above. (Also synergistic interaction between/among integrated components; low cost sourcing of inputs by recycling on-farm residues)

Table 2.1 cont.

System Type	Species used and principal characteristics	Possible environmental impact	Potential introduced benefit
3. Sewage-fish culture.	Carp, catfish and tilapia. Fish culture in sewage-laden environments: waste treatment ponds, cages in wastewater channels, latrine effluents and sewage used as pond inputs.	Same as A1. (Also possible health risks to farm workers, and fish processors and consumers, consumer resistance).	As above. (Also reduces waste disposal and health hazards problems by converting wastes to resources)
4. Pen and Cage culture	Carps, catfish and tilapias. Use made of eutrophic waters and/or rich benthos. Stocking, equipment maintenance and harvesting are limit of usual management practices.	Same as A3. More dependence on fossil energy.	Same as A3
(C) Intensive	Systems rely mainly on externally sourced feed and fertilisers.	Possible local disruption of hydrological system and retardation of sediment transport. Possible heightened health risks from waterborne diseases. Conflict over water resource rights.	As above.
2. Pen and Cage culture	Carp, catfish and tilapia. Use made of eutrophic waters and /or rich benthos. Stocking equipment maintenance and harvesting are limit of usual management practices.	Same as A3 (Also accumulation of anoxic sediments below cages from faecal matter and other wastes)	Same as A (Except only slight employment generation. Also generates foreign exchange)

Table 2.1. Cont.

System Type	Species used and principal characteristics	Possible environmental impact.	Potential introduced benefit
3. Others (a)	Carp, catfish, tilapia and specialised "up-market" species. Heavy investment in "modern" physical infrastructure and management techniques.	Same as C1 (Also many location-specific problems)	Same as C2

Source: After ICLARM, 1991.
Note: (a) raceways, silos, tanks, etc.

Pond fisheries and integrated agriculture-aquaculture systems will dominate discussion in this thesis. Pond fisheries will be considered in more detail here, and integrated systems later in the chapter. Pen and cage categories will appear mainly in passing in the thesis, while reservoir stocking, sewage-fish culture and "others" will not be discussed as they are not found in Tabasco.

Inland pond farming is the oldest form of aquaculture and continues to be the commonest dominant system (Pillay, 1994). It is largely confined to agro-ecosystems, utilising local supplies of surface or ground water. Ponds enhance habitat and landscape diversity within agro-ecosystems and, by and large, pond culture remains integrated with other aspects of the rural social, economic and natural environments (Beveridge and Phillips, 1993; Edwards, 1993). All farming intensities can be practiced in inland pond aquaculture.

Lazard and Weigel (1996) presented a different typology based on the conditions of African aquaculture that seems applicable to other tropical regions. In this case aquaculture is divided according to development criteria rather than intensification.

1) *Subsistence[1] aquaculture*
2) *Artisanal fish culture* as a small-scale commercial undertaking;

[1] Definitions of 'subsistence' will b explored in chapter 6

3) *"Segmented" fish culture*, and

4) *Industrial aquaculture.*

Subsistence-level fishpond culture was probably the earliest form of aquatic farming practised in many countries of Asia and Europe. The main objective was to raise enough fish for consumption of the farmer and his family. Any excess production was shared among friends and neighbours. In some areas it was considered socially prestigious for a family to own a fishpond, where the owners and their guests could enjoy recreational fishing (Pillay, 1997). These small-scale or subsistence farmers do not adopt aquaculture only for the sake of fish as a commodity to be eaten and marketed. Prestige, leisure and aesthetics have all also figured in adoption behaviour in Asia (Lightfoot and Pullin, 1995).

Subsistence aquaculture is characterised by low-input and low-management. Ofori and Prein (1996) analysed aquaculture farms in Ghana that fit well into subsistence management (although they did not include them into this category, as ponds were owned by the wealthiest farmers). They concluded that generally fishponds were a matter of status as often customs and social hierarchy requires that fish are given to family and community members as gifts, and the size of the fish can be of importance. Ponds were mechanically dug at high cost but without drainage facilities, proper water supplies or dike construction. In most cases the ponds are not adequately managed and production is much lower than potentially achievable. Most ponds are fished less than once a year, are not drainable and therefore require the loan or purchase of a net. Further they are not dried or restocked and very few nutrient inputs such as fertiliser, manures or feedstuff are provided.

In the view of Lazard and Weigel (1996), despite being the recipient of most aid from NGOs, the results of subsistence aquaculture can be considered globally negative because for farmers, the satisfaction of their basic needs does not constitute a sufficiently attractive motivation for the necessary effort, given the technical efforts required by this activity. Thus the social and technical constraints on the development of this kind of system, together with the expansion of modern production systems, may endanger subsistence production. This was noted by Pullin and Prein (1995) who believe that the small-scale farms with, or without ponds, may not survive long as industrial development proceeds. There is no clear management difference between subsistence and _artisanal fish culture_. Artisanal fish culture also implies production for subsistence through the use of on-farm nutritional inputs, in systems which have been developed through local technical knowledge without the influence of science, following in practice a holistic approach (Edwards *et al.,* 1997). The difference is that artisanal or small scale enterprises are managed as a business with a keener eye for financial gains (Pillay, 1994) and this mostly develops in periurban areas due to the existence of both the inputs and a market likely to absorb the production at a more attractive price for the producer (Lazard and Weigel, 1996). In addition, small-scale aquaculture depends on outside sources for many of the required inputs, and may depend on established marketing channels for the sale of produce. Generally subsistence and artisanal systems are considered basic stages of development which should ideally lead in a major commercial orientation (Edwards *et al.*, 1997).

Both subsistence and artisanal aquaculture are characterised by reduced environmental impact on the surrounding area compared to industrial aquaculture, nevertheless their introduction into new communities may have some negative effects. Harrison (1994, 1996a) based on a case study in Zambia argues that smallholder aquaculture may cause problems associated with changes in internal household dynamics and community relationships resulting from activities of rural development practitioners who are unaware of the local social structures.

Segmented fish culture is characterised by the structural division of the different farming cycles (fry production, feed production, nursing and production of marketable fish). It is particularly well-adapted to certain environments (lakes, lagoons and rivers) and to certain populations: fishermen for whom fish culture can constitute an alternative activity when earnings from capture fisheries become insufficient; it is also well-suited for city dwellers and entrepreneurs who see opportunities to invest capital and earn profits (Lazard and Weigel, 1996).

Industrial aquaculture is characterised by large production units that can engage in economies of scale. The objective is strictly economic or financial. Once the biotechnological parameters are controlled, the objective is to produce fish at the least possible cost (Lazard and Weigel, 1996).

In summary these 4 subdivisions of aquaculture should be grouped into two major groups based on the production purpose of on-farm consumption and commercialisation. Subsistence and family farming, crop/animal integrated farming and farming for recreational purposes are largely oriented to social benefits, whereas small-scale and cooperative farming enterprises, segmented fish farming and industrial aquaculture are run mainly for economic gain (Pillay, 1997).

2.3 The social and environmental failure of commercial aquaculture in the tropics and subtropics[2].

Extensive, semi-intensive and integrated fish farming systems seem to result in fewer environmental and social problems in the tropics compared to the most intensive cultures. This can be observed in the review of freshwater aquaculture systems in Africa presented by ICLARM (1991), where the possible environmental impact and benefit of each aquacultural system was calculated (table 2.1).

The way that environment and human communities have been impacted negatively by commercial aquaculture has been the focus of much research[3]. For example, Gopal (1991) describes how intensive fish farming methods in India are replacing the age-old practices of local people and Lo (1996)

[2] This review focuses mostly on socio-economic and environmental research and not technical aspects that are beyond the scope of this section.
[3] A more detailed analysis of social and environmental impacts and their relationship with sustainability is presented in chapter 4, section 4.14

reported that the careless application of new aquacultural technologies tended to have harmful effects on the environment in China.

Shrimp farming is the aquaculture industry most reported as causing environmental and social problems in poor countries and has therefore been the subject of much research and used to illustrate the negative impact of aquaculture in many academic papers. In Bangladesh, for example, its socio-economic structure (history, trade, organisation, economics, employment, etc.) has been evaluated, and its relation to environmental impact. The conclusion is in that shrimp culture has generated considerable resource flows to Southwest Bangladesh, in particular to its rural areas, but those resources accrue to the traditional rich to be used in the traditional ways which lead not to sustainable development, but to increased landlessness, exploitation, stagnation and major environmental damage (Guimaraes, 1989). It has been reported that more than 70 percent of the farms are small and resource-poor and have no capacity to become involved in the semi-intensive and intensive fish culture, as most of the modern aquaculture practices involve very high input costs, are not cost-effective and involve higher risk (Hoque, 1995). The poorest people (landless) thus do not have access to fish culture and their role in fish culture is by collecting fry, selling fry and harvesting ponds (Lewis *et al.*, 1996).

The ways in which commercial shrimp farming has changed both the environmental conditions of coastal lagoons and the socio-economic situation in tropical villages have been widely studied. Shrimp farming has been considered one of the most important causes of environmental degradation on tropical coastlines. In Honduras for instance, shrimp farming has led to destruction of mangrove forest, depletion of fishing stocks, disappearance of seasonal lagoons, and deteriorating water quality. These effects have caused reduction of catches by fishermen and deterioration of standards of living in coastal communities and have provoked conflicts between fishermen and shrimp farmers (Dewalt *et al.*, 1996).

It has been reported that semi-intensive shrimp farms need a spatial ecosystem support (the ecological footprint) 35 to 190 times the surface area of the pond, the very opposite to traditional pond culture of tilapia, which survives on offal from fisheries, agriculture and households, thus depending very little on external ecosystem areas (Kautsky *et al.*, 1997). Similar results were reported by Larson *et al.* (1994), who estimated that in 1990 an area of 874-2300 km^2 of mangrove was required to supply shrimp postlarvae to farms in Colombia, corresponding to a total area equivalent to some 20-50% of the country's total mangrove area. Reports on important environmental problems caused by shrimp farming have appeared in several countries.

In Thailand water quality impacts are substantial, as between 16 and 32% of the total mangrove area was destroyed between 1979 and 1993 causing problems to the coastal communities (Dierberg, and Kiattisimkul, 1996). Bhatta and Bhat (1998) explain how in recent years, under economic and political pressures, landowners leased their lands to commercial shrimp-producers in India, and conclude that rapid growth in the production of commercial shrimp, employment of unsustainable technologies, and laxity in environmental regulation have caused negative ecological and economic impacts on communities dependent on estuarine resources. Flaherty and Karnjanakesorn (1995) reviewing the development of Thailand's marine shrimp culture industry, examined the nature of the environmental impacts that are emerging and discussed the implications these have for the rural poor and the long-term viability of the industry, concluding that the effects have been very negative.

Stonich (1995) focusing on the expansion of shrimp mariculture in coastal zones along the Gulf of Fonseca, Honduras, documented how succeeding waves of export expansion have displaced small farmers from their lands, often initiating cycles of repression and violence while also generating or intensifying environmental destruction. At the same time, she makes use of political-ecological analysis to examine the interconnections among the dominant export-led development model, the policies and actions of the state, the competition among various classes and interest groups, and the survival strategies of an increasingly impoverished population. Stonich suggests that problems of social justice and environmental quality cannot be separated from the underlying social structure of the region. In the same way, negative effects of shrimp culture on poor coastal communities have been reported in the Philippines. Kelly (1996) examined the effects of mangrove removal and fishpond development on people's entitlements in three coastal communities in the Philippines. Aquacultural development here has detrimental effects on the integrity of the coastal ecosystem and the livelihoods of certain groups of local residents as a rich common property resource is converted into a privately-owned system of cultivation. The same study reveals that while benefits again accrue to those with access to the capital necessary for the construction of fishponds, the costs of development are borne largely by mangrove gatherers and artisanal fisherfolk, whose share of a diminishing resource base is steadily declining. Furthermore, he found that for these marginal groups, aquaculture is shown to provide few compensating economic benefits. He also supports, through concrete local evidence, the criticisms made of orthodox approaches to development, and the need to construct attitudes and strategies that are more attuned to local sustainability and equity.

Reports suggest that the intensive competition between resource users has led to violence. There is thought to be a link between the expansion of shrimp farms, enhanced social conflict and the emergence of local resistance movements of the poor. Stonich *et al* (1997) describe the globalization of shrimp mariculture, discuss its repercussions in Asia and Latin America, and explore its recent expansion in Central America, revealing a number of factors that affect rural livelihoods, impinge on small farmers, and hurt the rural poor. They suggest that the industry may be intensifying the social and ecological crises associated with commodities promoted earlier such as bananas. They raise serious concerns regarding equity, increased marginalization of the rural poor, and the further destruction of Central America's biophysical environment and natural resource base. Finally, they propose changes in policy to bring about more equitable and sustainable development. In summary, all these reports indicate the unsustainability of commercial shrimp farming. In spite of all the problems it causes, shrimp aquaculture enjoys strong comparative advantage in the use of labour and capital.

Environmental and social impact is not a prerogative of shrimp farming alone or the tropics and subtropics alone. Ridler (1997), for instance, reports similar problems for salmon cage culture in the Bay of Fundy in Atlantic North America. He again argues that aquaculture may produce conflicting rights and cause damage to other interests, and suggests that mutual economic and environmental interactions should be identified.

2.4 Aquaculture in low and middle-income countries

Aquaculture presently plays two roles in low-income and middle-income countries: commercial development and rural development. Commercial enterprises are based on an agribusiness approach and usually culture high value species fed on prepared diets. Both investment and profit are measured only in cash. Aquaculture provides jobs, earns or saves foreign exchange and creates wealth for the investors who tend to focus on export or local luxury markets (Brummett and Williams, 2000). On the other hand subsistence aquaculture is seen as a potential contributor to the livelihoods of the rural poor by promoting food security in rural areas (Bailey and Skladany, 1991).

Aquaculture has been used as the primary means of achieving the incremental growth in aquatic food supply necessary to meet continued increases of commercial demand. Intensive, high external input, "commercial" aquaculture activities dominate because, it is said, it is these that can produce the amounts of fish required (Lightfoot *et al.*, 1996a). This development has in practice been led by the high value luxury species that can justify the production costs (Coull, 1993), which weakens the justification of food production to satisfy population growth. This system in fact, prevails in low-income countries, although it is beyond the average farmer in both low and middle-income countries[4]. In Ghana, for example, Prein and Ofori (1996) conclude that such businesses are an option for very few, since in Ghana most farmers are small-scale and resource-poor. Hence, they say, the solution for improving their livelihood should be found by applying suitable technologies already available in which aquaculture is only one component within an integrated farming system. This seems also to be appropriate in other tropical areas with similar resource availability. Experience in the poor countries suggests that the development of commercial fish farming has the unavoidable complication of necessitating a level of investment which requires entrepreneurs of some substance, and it is in danger of helping mainly those who are already relatively well off (Coull, 1993).

Aquaculture for rural development in Africa involves production systems operated by smallholding farmers and based on locally available pond inputs and species that are easily grown and reproduced. Investment is in the form of land, water and labour. Impact is measured in food security, poverty alleviation, an improved rural environment and greater farm output and stability. The main production system is the small pond of 200-500 m^2, fed with unprocessed agricultural by-products. Fish are produced for home consumption or for the local barter economy. Little or no cash is involved (Brummett and Williams, 2000). It has been claimed that after promoting some hundreds of projects and after the expenditure of some millions of dollars, small- scale aquaculture in low and middle-income countries stagnates at a low economic level, and very often, at a subsistence level (Rau, 1980) of mere self-provisioning.

Edwards (2000) summarises the potential benefit that the rural poor can obtain from aquaculture, both in its commercial and its rural development form. The rural poor can gain from aquaculture because it generates:

[4] There are some exceptions. In Vietnam, for example cage culture of marine lobsters and finfish proved to be profitable on a small scale and has potential for the generation of increased income by poor local people (Hambrey, *et al*, 1999)

- Food of high nutritional value, especially for vulnerable groups such as pregnant and lactating women, infants and pre-school children, and the elderly.
- 'Own enterprise' employment for women and children too.
- Income through sale of relatively high value produce.
- Increased availability of fish in local rural and urban markets.
- Employment on larger farms, in seed supply networks, market chains and manufacture/repair functions.
- Benefit from common pool resources, particularly for the landless, through cage culture, culture of molluscs and seaweeds and enhanced fisheries in communal water bodies.
- Increased farm sustainability through: a) construction of ponds which also serve as small-scale, on-farm reservoirs, and b) rice/fish cultures as a component of integrated pest management.

These two main sectors of aquaculture are not sharply differentiated and a continuum of systems exists. Characterizing the various stages within the continuum helps the formulation of policies and development interventions (Brummett and Williams, 2000). For example, a third, intermediate, type of aquaculture enterprise can be identified in some countries. These enterprises are often referred to as `small-scale commercial'. Farmers in this group may represent a step in the transition from the rural development sector to more commercial aquaculture. Compared to those in the rural development sector, these farmers purchase a greater proportion of inputs and sell more of their products for cash. They differ from purely commercial systems by retaining their social connections to the local community. Maintaining this balance is extremely difficult in poor African communities and, consequently, success stories are scarce (Brummett and Williams, 2000).

Aquaculture production is dominated by Asian countries (Tacon, 1997). In this region fish have traditionally been the main source of animal protein in a context of dense populations with rice-based diets. The region has a long established practice of fish farming, especially of carp in fresh water, and milkfish in coastal lagoons and ponds (Coull, 1993). In Southeast Asia and Latin America shrimp farming for export has developed in the last 20 years.

The tilapias are the group of freshwater fish which have rapidly become the major cultured species worldwide due to their widespread acceptance among consumers (Smith, 1985). In Africa most modern aquaculture is based on extensive freshwater pond systems, dominated mostly by tilapia farming (Brummett and Williams, 2000). Egypt is the largest producer of tilapia (ICLARM, 1991).

Aquaculture in Latin America will be reviewed at the end of this chapter, with that in Tabasco.

2.5 Socio-economic research in aquaculture in middle and low-income countries

Research related to socio-economic aspects of aquaculture is not abundant. From a review of tilapia aquaculture, which is the major farmed species in the tropics, 94% of the research proved to be biotechnological, 5% interdisciplinary and only 1.4% was social science (mainly economics) (Pullin, 1996). This research scarcity is more severe in geography as noted by Barton and Staniford (1998). They reflected on the lack of importance that geographers have given to aquaculture, argued that geography should expand its traditional boundaries to include aquaculture in the research agenda and proposed that socio-economic, environmental and sustainability aspects be included in the main objectives.

2.5.1 Factors constraining aquaculture development

In addition to the environmental impact of commercial aquaculture, much social science research has been focused on specific local problems. Evaluation of policies and programmes, extension and adoption of new technology, descriptions of the socio-economic structure of the activity and communities, and economic evaluation of subsistence and commercial farming, have all begun to be explored (see below). An analysis of how sociology, political economy, and anthropology have approached aquaculture was presented by Weeks (1992). He found these disciplines to have studied this activity from two perspectives. The first explores the impact of aquaculture on rural communities, treating aquaculture like agriculture and focusing on issues of equity, labour patterns, nutrition, and health. The second stresses what aquaculture has in common with fisheries and is concerned with the use of shared resources such as bays and estuaries and with the possibility of turning fishermen into aquaculturists.

Most academics in aquaculture arguably overvalue technical constraints and tend to reduce social limitations to "farmers' backwardness", basing their proposals on improving technologies and setting out to change the farmer's ways of life. Rau (1980) for example limits the socio-economic problem in Southeast Asia to the following: lack of purchasing power and of infrastructure, resistance to changing a cherished way of life, religious belief, taboos and superstitions, or to sheer physical and mental lethargy from disease or inadequacy of diet. For him these are the most serious obstacles, greater than any technological or biological problem. The same is apparent in some institutional views where the role of sociological research in aquaculture is focused more on understanding farmers mentality in order to make them change rather than to provide them with alternatives according to their local conditions. For example, the World Bank (1991) reports that sociological analysis investigates the rationale of producers' motivations, the acceptability of innovations, or the relationship between production systems and social organisations. The document establishes three major scientific concerns that sociological research should address: i) The understanding of the function played by aquaculture in the allocation of production factors depending on social goals, ii) A better understanding of production systems and their dynamics to enable identification of "entry points" for technological and organisational improvements (and not simply transfer) of farming systems, and iii) social impact assessment as a critical component of any sociological research programme in aquaculture.

Some scholars point out that it is precisely the lack of understanding of socio-economic factors in aquaculture that has caused failure when development projects have been implemented in low-income countries (Smith and Paterson, 1982). Yet no changes in practice have followed and the same results are being found today. Thomas' findings (1994) in Nigeria support this view, after finding that an improved technology to raise fish yield was not adopted by the community due to a poor understanding of socio-economic and cultural factors. He suggests that the nature of the society should be a key determinant for any programme's approach to project organization, stressing that any management not compatible with local organisation, customs and economics is likely to fail. Lewis (1997), who analysed and critiqued conventional development projects of aquaculture in Bangladesh and suggested that current approaches are unlikely to benefit those with low incomes, highlighted this.

Lee (1997) identified six principal socio-economic constraints in low-income countries: shortage of infrastructure, variability of prices, ageing and poor training of aqua-farmers, inefficiency of extension services, lack of good organisation of producers and shortage of rural cash. He considers that strategies for the development of aquaculture will need not only to overcome the constraints that hinder development, but also to search for development opportunities and incentives. Some constraints, he thinks, could be overcome by structural adjustment, better market management and effective institutional programmes implemented by the government. From his point of view, development opportunities and incentives in aquaculture could be created by the expansion of foreign markets and increased demand for aquatic products. For him the answer lies in commercial aquaculture.

Major constraints in Africa were reported by Ballarin (1984a, 1984b, 1984c, 1984d, 1984e, 1985a, 1985b, 1985c, 1986a, 1986b, 1986d), and Deceoninck (1985) in a series of reports including most African countries. A summary of their findings in Liberia, Egypt, Central Africa Republic, Uganda, Tanzania, Kenya, Zimbabwe, Sierra Leone, Ethiopia, Benin, Togo and Cameroon indicates similar problems. Most important problems identified varied with the local context but most were linked to poor economic resources for extension, management and infrastructure, limited farmers' knowledge, bureaucracy and cultural barriers. Problems in extension institutions were: insufficiently trained technical staff and inadequate training facilities, inadequate budget and manpower for extension, insufficient supply of fry, absence of accurate statistics, disorganization of extension institutions, low wages of extension staff, no transport facilities for extension officers, inadequate equipment for extension officials, poorly maintained hatcheries, unsatisfactory advice from development experts, unclear development policy, lack of demonstration centres, inappropriate management of genetics, no linkage between research and extension, poor project planning, discontinued programmes resulting from instability of staff due to frequent rotations and fish culture research of little practical importance. The technical problems detected in fish farms were: lack of technical assistance, poor management by farmers, poor growth rates of stocked fish, farmers' lack of experience, inadequate ponds, inadequate pond management, uncontrolled polyculture, most ponds having large numbers of stunted fish (used as fingerlings), ponds have not been drained or manured for years, the lack of a proper record of fish production makes it difficult to assess pond productivity, poor feeding management, wrong species selection, bad site selection for ponds and bad farm design. And the socio-economic constraints were: rural ponds scattered over large areas and of difficult access, high capital cost, competition for land and water for agriculture, lack of credit, fish culture is a part time activity, vandalism and theft. Non-economic satisfactions were seen as merely constraints: *"fish farming generally adopted as hobby or a sideline to other farming activities rather than as a business; consequently, managerial input has been less than desirable"* (Ballarin, 1984a p53)

Although socio-economic and environmental constraints in aquaculture have been studied at local levels, some problems look common to many regions in the South.[5] For example, Kigeya (1995) gives a more detailed list for Uganda which identifies inadequate fish pond construction, fish farmers' lack of proper knowledge; fry supply shortages, pollution of water, the spread of pathogenic microbes, parasites and other health hazards, lack of proper communication and interaction among farmers; little fish eating culture; few opportunities for farmers' participation, lack of understanding of local traditions, slow transportation systems, lack of qualified aquaculture staff, ineffective extension services; and lack of access to technical information (books, journals, video) by fish farmers as the most important constraints affecting aquaculture. In reality some of these constraints are applicable to many regions in the South where aquaculture has been introduced.

Other researchers stress the importance of specific factors. For Edwards (1998), poor promotion of aquaculture to farmers is the most important constraint facing aquaculture at low-income countries. He thinks that the limited ability to assimilate existing technology and limited local capacity in education, research and development are the major factors maintaining aquaculture in low levels. He considers that a conceptual framework for the promotion of integrated aquaculture comprising theory and practice interrelated with human resources or capacity would facilitate the activities of those who promote or execute aquaculture. He thinks that national institutes should promote aquaculture in their areas of influence following a farming systems research and extension methodology, and that financial and technical assistance would be more effective if it were better co-ordinated.

Kalinga (1993) studied the evolution of the policy governing the initial introduction of fish farming in Malawi. His study, based on interviews with farmers and on archival sources, concludes that lack of practical support such as the provision of extension workers contributed to the failure of that project. All the same, Harrison (1996a), based on research conducted in Luapula

[5] Countries receiving 'Overseas Development Assistance'.

Province, Zambia, analysed why the promotion of small-scale fish farming in Africa has had only limited success, finding that although on many occasions there is apparently no difficulty in getting people to dig ponds, subsequent management and maintenance tend to be poor and ponds are often abandoned. He thinks that because of the legacy of past development interventions, many farmers dig fish ponds in anticipation of benefit or to associate themselves with a "culture of development" rather than because of any locally known merit in the technology itself. His article argues that part of the problem lies in the approach to farmer motivation taken by development projects and determines that three assumptions are unfounded: that all members of fish farming households are equal; that the decision making process of farmers is an informed weighing of costs, benefits and risk; and that the production of fish is the most important outcome.

Harrison (1996b) also studied motivations for fish farming in Zambia. Again her findings suggest that motivation of each member of the household is not equal, and that the decision-making process of individual farmers are not always an informed weighing of cost, benefits and risks as there are many occasions when action is more part of a continuing process of response and adaptation to new information. She reports that for most farmers in Luapula, fish farming was at most a secondary activity, supplementing other agricultural economic activities. Fish ponds were generally small (less than 300 m^2), production levels were low, based on clear water conditions, sporadic feeding, and incomplete harvesting. She explains such low intensity management by the reasons that induced people to dig their ponds. Although the main reason reported by farmers was household food consumption, her study revealed that fish farming was a way to gain social status, and an asset or security which may be greater than its immediate usefulness as a source of food or cash. The exchange value of farmed fish thus is very complex with no clear boundaries between commodity and gift. She argues that fish farmers are participants in networks of obligation and reciprocity, but such participation is not calculated or quantified. For that reason the term income should be broadened to encompass more than cash earnings but it is difficult to quantify what this means to farmers as the meanings which they attach to their actions vary accord to the social environment. Finally she concludes that maximum production of fish may not be the strategy for these farmers and wonders whether or not it is appropriate to suggest that low or non-production of fish constitutes a failure for people who dig ponds not just for food production. "*For whom is the failure? Is it principally for the technologists who want to see their technology working?* (Harrison, 1996b: p277). Similarly, Mills (1994) based on his results from Malawi, stresses that economic success in fish farming should not be measured solely in cash terms to be understood as profit, as subsistence fish farmers considered home-based consumption as the most economically beneficial utilization of the produce. His results indicate that farmers see their community as a ready cash market and an immediate source of reciprocal exchanges, which often surpassed cash transactions in terms of profitability. Fish farming is involved in non-material reciprocities through the exchange of fish for social status and other symbolic returns such as social indebtedness or altruistic reputation, and self-esteem. Lightfoot *et al* (1993) also argue that reasons for farmers to feel satisfaction when farming fish are far more diverse and complex than money or food, as leisure and social relationships drive adoption of the system by households, as do provision of inputs for other enterprises and the rapid growth of fish for quick returns. The same was noted by Thomas (1994) who reported that for many farmers in Nigeria, fishing the pond was not just a question of economic profit but also related to the festival nature of fishing, as it is a social activity in which many people participate. The limits of quantitative methods for evaluating aquaculture were noted also by Lightfoot *et al* (1993) who reflect on the need for a change in our views of aquaculture, to go beyond fish production and cash income to evaluating the many social, cultural and ecological services that pond water and pond biota, including farmed fish, can perform on an integrated farm that has some aquaculture.

Economic evaluations of diverse aquacultural practices and systems are more common in the literature than those of subsistence, but most studies are focused on commercial species and systems. There are few examples of profitable small-scale aquaculture systems. It may be that negative results occur when evaluations consider aquaculture as a single economic activity instead of part of the farm system. That is they cost all inputs produced on the farm at market prices. One example is the study of Hishamunda *et al* (1998a), which compared small-scale fish culture with agriculture to determine the best use of land. Fish culture was compared with sweet potato, Irish potato, cassava, tare, sorghum, maize, red beans, soybeans, and cabbage production. Results indicated that small-scale aquaculture was the most expensive way of producing protein (after cassava) whether it was carried out by co-operatives or by individual farmers. The same figure is found in a small-scale fish farming evaluation in Rwanda (Hishamunda *et al.*, 1998b), where results showed economic potential when evaluated as positive income above variable costs. The event `income above variable costs is at least zero' occurred with a 100% probability for both co-operatives' and individual farms. Nevertheless, when evaluation was based on net returns to land and management, economic failure became virtually certain, occurring with 99.8% and 95.5% probabilities for co-operatives and individual farms, respectively. Although the level of success was sensitive to higher stocking rates, and higher fish producer prices, the amount of labour used in the production-marketing process was the major determinant of economic success. The upper limit of the efficient level of labour was estimated at 20 person-days per 100 m^2 per growing cycle (Hishamunda *et al.*, 1998b).

The roles and limitations of international research in aquaculture in low-income countries have also been analysed. Two case studies in Rwanda reported by Egna (1998) illustrate how policy and practice were linked in international research. A complex picture emerged of resource allocation issues within the Rwandan household and the need to integrate aquaculture projects into the fabric of society. In such case studies, data show that dietary preferences were not static. Thus, technologies offered through donor-driven international aquaculture projects had the possibility of acting as powerful agents of change in Rwanda. The responsibility that accompanies this type of change, however, was not fully considered by the Collaborative Research Support Programs (CRSP). Even with these problems, CRSP efforts in Rwanda produced some indications of institutional sustainability--not from careful planning, but through informal activities of actors in Rwanda and the

US. A change in organisational culture eventually resulted, with the reluctant acceptance of social sciences into the traditional biotechnological agenda and the participation of women in the research programme.

Similarly Lazard (1996) from research in Sub-Saharan Africa, concluded that research should explore two avenues in the future: the economic and the biotechnological optimisation of the research already done, and the developing of new, efficient farming systems adapted to the rural environment where there is an important vacuum to be filled. He thinks that small-scale, commercial production systems in rural environments need to be developed but this cannot be done without farmer participation. He concludes that aquaculture should develop according to the type of environment, the target population, and the type of market targeted.

2.5.2 Successful, small-scale aquaculture projects in developing countries

All studies in section 2.4.1 focus on constraints not successes. Except from the research carried out by ICLARM in Southeast Asia, positive experiences in aquaculture by poor farmers in southern countries have been rarely recorded. This could reflect the magnitude of failure, the inappropriateness of evaluation and implementation of projects, or the reduced research conducted in rural small-scale aquaculture today.

There are reports in which positive adoption of adequate technology by poor farmers is described. That is the case of fish culture in rainfed rice fields of Northeast Thailand (Little *et al.*,1996), in which farmers adapted rice fields for fish culture as part of their whole farm strategy. It was found that benefits to rice, vegetable, fruit and livestock may be considered more important than fish yields by farmers and that the high value attached to even small quantities of fresh fish is a major incentive for rice-fish culture. The problem is that women who are decision makers in terms of changes to rice fields and household consumption have often not been fully considered during promotion of rice-fish cultures. This study suggests that stocking fish in rice fields in areas with poor access to wild fish supplies from community water bodies would have more impact and that although rice-fish culture can contribute to subsistence requirements, the high labour demand often means that the intensified capture of wild fish or pond-based culture of fish are more attractive for poorer and better off farmers, respectively. Good results were also reported in Malawi where a case study demonstrated successful diffusion of fish farming in communities with inherent barriers to development of fish farming, particularly in those based upon agricultural economic reciprocity and matrilineal land tenure system (Mills 1994). It is considered that one important reason for the successful diffusion resulted from the abandonment of top-down extension strategies and the promotion of community development strategies which encourage autonomous activities such as Clubs of Farmers, employment of traditional forms of communication such as village meetings, and utilisation of these to implement an appropriate pedagogy through the knowledge and experience of local farmers (Mills, 1994). Similarly Lightfoot (1991), based on successful projects in Vietnam, recognises the value of farmer participation and its role in accelerating recruitment of new entrants into integrated aquaculture-agriculture farming systems. For him, Farmer-first systems of research are the most effective means of extension, and that farmers' diagrams can improve field methods in on-farm research (Lightfoot and Mannic, 1991).

Fish-rice systems in Vietnam were evaluated and considered a feasible solution (Rothuis *et al.*, 1998). These systems differed from rice monoculture not in total farm cash or net return but in a higher fertiliser/water requirement and less pesticide use. Thus the main beneficial effects of rice-fish culture are thought to be related to environmental sustainability, system biodiversity, farm diversification and household nutrition (Rothuis *et al.*, 1998). Rajasekaran and Whiteford (1993) also reported similar results. They described the socio-economic aspects of crab-rice culture in India and highlighted the importance of local knowledge, which they fear may be lost.

Some authors argue that collective or group work is an important way to get success because co-operative fish farming not only insures a wider distribution of land and fish farming technology to larger segments of the population, but also makes possible the integration of limited individual resources into sizeable and economically more viable production and marketing units (Rubagumya, 1993). In Rwanda, Rubagumya (1993) identified organisational attributes and practices associated with effectiveness of fish farming co-operatives and found that the variables that affected production levels were the length of time groups had been together doing fish farming business; democratic leadership style; the extent to which each member does all pond management operations on a rotational basis; the frequency of reports made by the control and supervision boards; the number of members; the degree of family ties among members; membership size; and the extent to which groups implement arrangements designed to compensate for failure to provide labour contributions. At the same time he found that there were variables influencing sustainability such as the extent to which each member does all pond management operations on a rotational basis; the frequency of general assembly meetings; the length of time members have been together in fish farming business; the number of 25-46 year old members; membership size; and the extent of friendship among members.

As seen before there are a number of papers indicating constraints for aquaculture development in poor countries, but very few go further proposing ways to overcome such limitations. Edwards (2001) presented some ideas suggesting that aquaculture could make greater contributions to rural development, if policy implications are recognised.

- Social, economic and institutional issues limit the contributions that aquaculture might make as generic technologies already exist. Land-based culture systems in inland areas have the greatest potential as aquaculture can be integrated with existing small-scale farming.

- A new professionalism is needed, involving changes in values among development professionals and increased use of participatory farming systems approaches to empower the poor and local communities.

- The poor need to be targeted and provided, at least initially, with public sector support, although aquaculture has to function on a self-financing basis within the private sector.
- Government needs to address both the design and implementation of policy, with feedback mechanisms allowing the poor to influence development.

Many International Agricultural[6] Research Councils, like the national counterparts involved in agricultural research, may still find themselves constrained by two sets of tendencies: i) Approaches which tend to take 'world-ordering' knowledge and assert the basic superiority of formal scientific approaches over those of farmers, instead of complementing them; and ii) Top-down bureaucratic view which assumes that government should control, regulate and educate those with whom it comes into contact (Lewis ,1998). A clearer recognition by policy makers of two crucial sets of issues may offer a way out of current impasses. i) An understanding of social and quality issues must go hand in hand with existing research on improving aquaculture technology and its delivery; and ii) the priority is for strengthening in country and international institutional capacity to undertake such research in a more participatory manner (Lewis, 1997).

2.5.3 Gender in aquaculture research

Generally little research has focused on gender divisions of work in aquaculture or women's participation in aquaculture.

Studies in Africa indicate an apparent very low participation of women as actual farmers in aquaculture. Nevertheless in West Africa women participate extensively and actively in all phases of work performed on fish farms. In Zaire, it was recorded that the participation of women and children was important for success because of their work collecting and transporting materials for composting. In the Central African Republic 70-80% of the women interviewed in one survey said that they had participated in construction, 70% helped with feeding and over 90% in emptying ponds and selling fish. Only the women of Benin appear to be barred from the production side of fish farming, where fish farming is traditionally seen as man's work (Trottier, 1989).

In Zambia (Harrison, 1996a) few women were found to own ponds in their own right, due partly to constraints in access to land and labour but also because fish farming has been promoted as a technology for men by men. Nevertheless in cases of households of lower income, women and children play an important role in pond management.

Major constraints on promoting fish farming amongst women have been listed by Trottie (1989). The main constraints seems to be time to allocate to a new activity, lack of access to land ownership, credit and labour, extension and training, and the failure to make explicit provision for them in the target group.

Debashis *et al* (2001) report success pursuing family approach to integrate women into aquaculture in Bangladesh. Female participants in an aquaculture project perceived an improvement in their status within the family. Income earned from sales of fish was used to meet family needs and a large proportion of fish was often used to meet family consumption needs. Women were found to prefer fish culture activities to other interventions promoted by that project. Similar results were reported by Rahman (2001) indicating high fish yield, 3.55t $ha^{-1}a^{-1}$ on farms managed by women compared to the national average of 0.77t ha^{-1}-a^{-1}

There is evidence to show that directly raising women's incomes can be instrumental in strengthening their status and bargaining power, which in turn positively affects children's nutrition and education. As men and women have different work roles and access to resources, they are likely to be affected differently by the development of aquaculture technologies (Lewis, 1997).

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[6] These may include aquaculture

Despite its importance, gender is only one part of a farmer's identity. Age, class, skill are also significant factors and may combine with gender to create certain specific user profiles that may influence the selection of appropriate technologies (Lewis, 1997).

2.6 Integrated aquaculture systems.

There are two ways in which subsistence aquaculture could change to become more productive: to more intensive commercially oriented systems or to integrated aquaculture-agriculture systems (IAAS). As will be analysed later in the text, the first does not look the best option if sustainability is being considered[7]. Change to more intensified systems implies changes from diversified or mixed farming to a single production activity. Stand-alone fish farms can be risky ventures, especially for resource-poor farmers, because of the environmental effects and economic factors such as the price volatility of some aquatic produce (Lightfoot *et al.*, 1993).

For that reason and due to its similarities to subsistence fish farming, IAAS is now described in detail. In the chapters 4 and 6 it will be referred as the model which subsistence aquaculture should follow in order to become a more sustainable option for the poor. Pillay (1997) who considers IAAS to be progress in family farming has noted this.

Integrated aquaculture can be defined within the general definition of integrated farming on the basis of diversification of agriculture towards linkages between sub-systems (Prein, 2002). These lead to synergies in which an output from one sub-system in an integrated farming system, which might otherwise have been wasted, becomes an input to another sub-system resulting in a greater efficiency of output of the desired products from the land/water area under the farmer's control (Edwards, 1998). This implies a reliance on on-farm resources for recycling. A broader definition of integrated

[7] Issues of sustainability will be explored in chapter 4

farming also includes the use of off-farm resources, such as agro-industrial products and by-products (Little and Muir, 1987) Another definition (Edwards, 1998) adopts a livelihood approach and potential expansion in peri-urban areas, increasing linkages among farms and agro-industries. Integrated farming involving aquaculture is defined as concurrent or sequential linkages between two or more human activity systems (one or more of which is aquaculture), directly on-site, or indirectly through off-site needs and opportunities, or both (Prein, 2002).

The principal ecological attributes of integrated systems as presented by Ruddle and Zhong (1988) are:

a) A polycultural mimicry of a natural state, with a variety of intercropped species.
b) The maintenance of the natural ecological system, retaining systemic congruity between the cultural and ecological systems.
c) The maintenance of the whole structure of the natural community while changing selected items of its content.
d) The recycling and minimising of losses of energy and materials via the utilization of wastes.
e) A multilayered structure which reduces the requirements for energy subsidies and labour inputs
f) Integration permits a fuller utilisation of heat, light, moisture and nutrients by species with different habits and nutritional requirements than is possible in non-integrated systems.

The fundamental concept underlying any integrated system is that many outputs, sometimes called wastes or by-products, of subsystems become basic inputs for other subsystems, rather than just additive components of the overall farm economy. A synergy thereby created such that the total productivity of the system exceeds the sum of the individual subsystems. This results in higher yields for all commodities produced and a wider range of products than could otherwise be obtained per unit area. In addition to producing subsistence and commercial commodities, among other benefits the farm family is assured a regular and balanced diet and a high degree of self-reliance in a range of foodstuffs and raw materials, while risks inherent in more specialized farming are spread (Edwards *et al.*, 1988).

Integrated systems, both at large and small-scale, may depend in part on the use of agro-industrial products such as commercial inorganic fertilisers and nutritionally complete or formulated pelleted feed (Edwards, 1998). Indeed, in the most highly integrated systems, fishponds play a pivotal role in supporting other activities and in water conservation and wastewater treatment, for example (Pullin and Prein, 1995). Production is relatively efficient being based on the use of organic and inorganic agricultural fertilisers, crop and/or animal production by-products and fish feeds, produced locally, within the system, and at either a low monetary cost or at an opportunity cost (Beveridge *et al.*, 1997a, Ruddle and Zhong, 1988)

Compared to monoculture and intensive commercial aquacultural systems, integrated farming systems that include semi-extensive aquaculture imply less risk to the farmer because of the efficiency derived from synergy among enterprises, their diversity of produce and their environmental soundness (Lightfoot *et al.*, 1993).

Integrated farming has also been defined more broadly to link aquaculture with human activities other than agriculture, such as management of water resources, industry and sanitation (Little and Muir, 1987). Edwards (1998) argues that social and economic dimensions of integrated systems must also be addressed by considering people's livelihoods, as farmers are likely to be motivated primarily by what they perceive as improvements to their welfare.

Sustainability indicators have been suggested for integrated aquaculture-agriculture systems. Lightfoot *et al* (1996b) consider diversity (the number of species cultivated), recycling (number of bioresource flows), the capacity of the natural resource systems (the total output from each system including internal and external flows expressed in monetary terms divided by the number of resource systems) and economic efficiency (profit or net income which is gross return minus total cost). They conclude that integration offers a potential for a greater performance in all sustainability indicators as integrated farms have more species diversity, more materials recycled, greater capacity from their resource systems and higher economic efficiency. Efficiency differences, however, are very small because of the higher labour and material inputs on integrated farms. Benefits of putting into practice the concept of integration in subsistence farms have been reported by Ruddle (1996). He found that the addition of a vegetable field and a pond to 14 modelled systems could directly improve household nutrition in Ghana, whilst household cash incomes improved between 229 and 679%.

2.7.1 Aquaculture in Latin America

This chapter now concludes with an overall introduction to aquaculture in Latin America, Mexico and the site of the fieldwork, Tabasco. Aquaculture production in Latin America is very small, compared to world production (Saint-Paul, 1992), contributing only 2.3% in volume to the total fish production in this region from capture and culture (Martínez and Pedini, 1997). A specific characteristic of aquaculture in Latin America is that it is mainly export oriented, with shrimp and salmonids as the main export products. Shrimp culture in Ecuador, the main producing country, showed rapid growth during 1984-1989 followed by moderate growth during 1990-1995 (Martínez and Pedini, 1997). Most income from aquaculture in the region comes from shrimp farms (Saint-Paul, 1986), but tilapia production is also very important and some progress has been achieved with salmonids. In temperate zones of Latin America the most important cultured species are various species of salmon and rainbow trout. Chile is the largest producer of these in the region, but trout is also farmed in Mexico, Panama, Bolivia, Venezuela, Brazil and Argentina (Saint-Paul, 1992). In spite of its great richness of native species (in the Amazon region alone more than 2000 species are found), exotic species were introduced without restriction so that exotics dominate aquaculture production (Saint Paul, 1986). For this reason tilapia culture still dominates Latin American fish culture. Tilapia has been introduced virtually throughout the continent, mainly in Brazil, Haiti, Jamaica, St. Lucia, Grenada, Costa Rica, Mexico, Nicaragua, El Salvador, Panama, Ecuador, Colombia, Venezuela, Peru and Bolivia. The second most important non-indigenous fish species is the mirror carp, introduced in Latin America at the end of the 19th century, but later other carp species were also introduced. Among the native species the culture of *Colossoma macropomun* and *Piaractus mesopotamicus* are gaining more importance. Mollusc culture is also practiced in the area; Mexico is by far the biggest producer (Saint-Paul, 1992).

Due to low levels of fish products in the region (compared with Asia), it seems that an increase of fish consumption in Latin America is a prerequisite for aquaculture development (Huisman, 1987), but the greatest incentive for introduction of commercial aquaculture has been the high prices on export markets. For this reason shrimp culture has achieved great importance, especially in Mexico and Ecuador but it is also farmed in Venezuela, Peru, Colombia, Brazil and Central America (Saint-Paul, 1992).

Problems for aquaculture development in the Latin America were grouped by Martinez and Pedini (1997) in the following categories:

- *Environmental.* Problems mostly related to industrial-scale aquaculture are beginning to arise. Mangrove cutting in Ecuador, and conflicts with capture fishery activities in several countries.
- *Climatic.* Events such as El Niño, which has had impacts on the shrimp culture industry on the Pacific coast of the region through floods and undesirable changes of temperature, and hurricanes in the Caribbean area.
- *Biological/technical.* Diseases are affecting not only shrimp culture (viral) but also oyster culture (parasites). The reproductive cycles of several aquaculture species are also not fully understood. Seed supply is a serious limiting factor in many areas, affecting industrial, semi-commercial and rural aquaculture.
- *Institutional and legal framework.* There has been delayed reaction to developments in the aquaculture sector.

- *Social.* Land tenure, conflicts on the use of certain resources, and access to aquaculture products by the poor.
- *Economic.* Instability, frequent currency changes, high inflation rates, high commodity prices and competition with capture fisheries.

Subsistence fish farming is important in the Latin American tropics. Nevertheless there are few publications describing the farming conditions and farmers' motivations that go into this activity. A study in Guatemala (Popma *et al.*, 1995) indicates that farmers' motivations, socio-economic and technical constraints are similar to those of African and Mexican farmers (see below), and will be briefly reviewed.

In Guatemala subsistence fish farming (mainly tilapia), which was the most common system, reports average yields of 2291 kg ha^{-1} in 6 months compared to 2300 kg ha^{-1} $year^{-1}$ reported by Lovshin *et al.,* (1986) in manured ponds in Panama with production cycles of 15 to 26 months. In Guatemala, a typical integrated pond of 120 m^2 yielded 48 kg, of which 20 kg were sold and 23 kg were consumed by the producer family. Fish production cycles were usually 4 to 9 months. The most common fish production enterprise was a single pond owned and operated by one family. The study indicates that average per capita annual fish consumption among producer families increased from 0.5 kg to 3.3 kg after the introduction of fish farming. On an average farm the pond occupied only 2% of the land, but the market value of all fish harvested increased on-farm income by 18% (Popma *et al.*, 1995). For rural Guatemalans animal husbandry was not a new concept, but fish were traditionally considered wild creatures, needing no special care. For that reason in the view of the authors, investing scarce resources to tend and feed fish required a radical change in thinking for most subsistence farmers (Popma *et al.*, 1995). In this study improved nutrition was the primary motivating factors for most of the 8000 participant family members (Popma *et al.*, 1995). Nevertheless another survey in the same country suggests that about 30% of farmers thought that income generation was an equally motivating factor (Gonzalez, 1990).

2.7.2 Aquaculture in Mexico

There are few studies of the history of aquaculture in Mexico. Ramirez-Granados' review of aquaculture in Mexico (1977) found that the Aztecs before the conquest already practised fish farming in 1521. Similarly there are records form late 19th century indicating that at the beginning of that century Catholic monks were already practicing rainbow trout farming (an imported fish). Fish farming was also practised on the '*haciendas*'[8] before the beginning of the Mexican Revolution in 1910 when largemouth bass was also introduced into Chapala Lake. Modern aquaculture started between 1930-1950 when the first rainbow trout and stream trout hatchery was built in Almoloya del Rio. Later the El Zarco Carp Hatchery was established, but it was in the period between 1960 and 1970 when real promotion of aquaculture began with the introduction in different areas of the country of several species of carp and tilapia and the firsts study of native species of fish (Ramirez-Granados, 1977).

Nowadays aquaculture is a growing activity in Mexico, the leading producer in Latin America. The most cultured species are shrimps on the Pacific North western cost, tilapia in most warm areas and carp on the high plateau; but other species such as abalone, rainbow trout and channel catfish are also farmed.

In Tabasco aquaculture is more recent, starting in 1966 with a project to build the first hatchery, initially for fry production of native species such as turtles, Mayan cichlid and tropical gar, and introduced species such as bull frog, catfish and several species of tilapia. The scope was reduced in 1974 to tilapias and native turtles when the hatchery started operations, within the National Plan of Rural Pisciculture (Aleman, 1992). Studies of aquaculture in Tabasco are scarce. In 1991, Mendoza *et al* carried out an evaluation of the aquaculture situation in the Zanapa Tonala Region, finding an average tilapia yield of 679 kg. Aleman (1992) carried out a study of fish farmers and

[8] Large estates, which were very common in Mexico before the land reform.

fishermen in Chontal indigenous regions finding that in spite of technical and organizational limitations both subsistence and commercial aquaculture were good production alternatives. She considered subsistence as a basic stage that should evolve with fishermen entering commercial activities. In 1992 Aguilar-Manjarres identified suitable areas for aquaculture development using Geographical Information Systems (GIS). The work of Chavez *et al* (1988), established the basis for the study of native fish species with potential for aquaculture. Later research focused in the study of the Mayan Cichlid *Cichlasoma urophthalmus* with the work of Mendoza *et al* (1989), Mendoza *et al* (1995), Galmiche and Sanchez (1995), Mendoza and Navarro (1995) and Meseguer and Rios (1995), etc. reporting fair farming feasibility but financial non-feasibility for commercial production. Pierard *et al* (1993), evaluated the Camellones agro-piscicultural system[9] in Nacajuca, Tabasco, finding that it had high potential to enable peasants to improve their standard of living. Ross and Beveridge (1995) used a case study in Tabasco to stress the value of GIS and the necessary cooperation of commercial developers, governments and international agencies in the developing of new native species farming systems. Finally, Pérez-Sánchez (1998) evaluated social, environmental and economic constraints for the development of aquaculture, finding that poorly developed infrastructure, inadequate market and distribution conditions, poor availability of inputs (feed and fry), few credit facilities, low yields, high pollution due to the oil industry, the loss of aquatic habitats, soil erosion, limited access to groundwater, extreme water variation in the hydrologic system, population growth, migration, limited job opportunities, low motivation of fish farmers and thefts, all mitigated against development.

2.8. Concluding remarks

Aquaculture has been divided into different systems according to its farming intensity or its development stage, for the purposes of this thesis. Subsistence systems are commonly so defined according to some notion of stages of development and considered a primary stage but could easily fall into extensive or semi-intensive systems according to the farming intensity.

[9] A diversified system with high potentiality for integration.

Aquaculture in poor countries has many technical and socio-economic limitations and most of the growth has been in commercial aquaculture systems for export, especially shrimp farms, even though these have been a source of environmental and social problems. Nevertheless certain scientific research has focused on the study of the old integrated agriculture-aquaculture systems and presented these as a more sustainable option for small farmers. These then seem to be the systems into which subsistence could change in order to become more efficient without losing its positive qualities. These possibilities will be explored here for Tabasco.

Aquaculture in Latin America has developed under two main systems. Commercial aquaculture, producing mainly salmonids and shrimps and oriented to export markets, and subsistence aquaculture, intended to improve the protein intake of the "rural poor" throughout the small-scale culture of tilapia and carps. Studies in Guatemala indicate that subsistence fish farming generally results in low yields, but this is enough to improve the nutrition of poor rural households which seems to be also the case in Tabasco. Environmental, climatic, institutional, social and economic constraints on aquaculture in Latin America have been identified but these studies are mostly focused on industrial aquaculture, leaving subsistence aquaculture problems unexplored. Aquaculture expansion in Mexico started in the second half of 20th century with the culture of carp, tilapia and shrimps. Commercial aquaculture has been mainly developed in North and Central Mexico, while subsistence aquaculture is more often found in the South and South East, including Tabasco. This thesis will explore how this has come about in Tabasco, and what the options now are.

CHAPTER 3
METHODOLOGY

3.1 Selected theoretical considerations important to this research

The aim of the research is to use the case study of Tabasco to explore possibilities for achieving more sustainable change through aquaculture. The research has developed through a range of theoretical influences, including critical development, alternative development, eco-feminist, and post-modern thinking.

The research questions seek to identify both the socio-economic and physical factors important in the development of fish farming in the area and to explore connections with the formulation and application of programmes and projects by the official institutions. The methods have been chosen to establish local answers. Theoretically, there are relevant considerations from postmodernist theory and alternative development such as the belief that knowledge is both local and contingent and that there are no standards beyond particular contexts by which we may judge truth or falsity (May, 1998).

Gender has been absent from the understanding and explanation of aquaculture in Mexico. I have therefore sought to study the roles not only of men but of women and children in aquaculture, which make an important contribution to income generation in many Mexican families. For this reason, interviews were undertaken with different members of the family. The intention has been to avoid unexamined assumptions about women that would be reproduced later in the results. This can be avoided by recognising that research is a two way process and that objectivism "(according to feminists) *...is not only a mythical aim, but also an undesirable one which disguises the myriad of ways in which the researcher is affected by the context of the research or the people that are part of it*" (May, 1998 p20).

I agree with what Escobar (1995) calls 'The system knowledge approach' and I see 'Development' as just one option for human change (among many other forms of social life). Development is a cultural practice and in this respect development as a category is no different from culture in that they are both elusive concepts (Nederveen Pieterse, 2001). Development, in the critical development approach, is a dominant culture, a product of power relationships, which has erected itself as the only viable choice for change and has achieved the status of certainty in the social imaginary:

"Certain conditions in Asia, Africa and Latin America were perceived as poverty and backwardness by western experts and politicians" (Escobar, 1995 p10).

Elevating such individual perception to 'certainty' justified 'the moral right' to intervene, or simply the extermination of other ways of life different to urban, consumerist, materialistic development. 'Development' thus became a knowledge system, used in many cases to perpetuate unequal power relationships. Consequently other forms of knowledge need to be explored.

"*Development has relied exclusively on one knowledge system, namely, the modern Western one. The dominance of this knowledge system has dictated the marginalization and disqualification of non-western knowledge systems. In these latter knowledge systems, the authors conclude, researchers and activists might find alternative rationalities to guide social action from economistic and reductionistic way of thinking*" (Escobar, 1995, p3).

This knowledge system thus excludes people's knowledge of non-monetary matters, which have major importance for those in the margins of the market economy.

"It is also about disallowing anything that is outside the market economy, specially the activities of subsistence and local reciprocity and exchange, so many times crucial to peasants, women, and indigenous people; it is, finally about a definition of progress that is taken as universally valid, not as marked by culture and history" (Escobar, 1995, p59).

Thus in this study 'development' is seen as just one knowledge system, never the only one and not different to others, considering that it is also product of a particular culture.

"However, the dominant system is also a local system, with its social basis in a particular culture, class and gender. It is not universal in an epistemological sense. It is merely the globalized version of a very local and parochial tradition. Emerging from a dominating and colonising culture, modern knowledge systems are themselves colonising" (Shiva, 1993 p9).

Nevertheless I must argue that the pervasive effects of development (referring to a process of change based on consumerism) must not be reduced to the non-industrialised societies. To me, 'development' is neither the most appropriate nor the most sensible way to think of human groups in nature. For this reason I think that no solutions can be found by separating the problems North[1] and South[2] because at this point in time local problems are linked one to another whether as part of the cause or in suffering the effects.

I conceive of this research as knowledge-inclusive; my work is informed by the view that there should be *"an acceptance of the pluralistic character of social experiences, identities, and standards of truths, moral rightness and beauty"* and that *"In place of a unitary concept of reason and uniform cultural standards, in a post-modern culture we speak of traditions of reason and a plurality of cultural standards that express different tradition and communities"* (Seidman, 1998, p 347).

Similarly, taking into consideration the feminist approach (Harding, 1990), this research seeks to reduce stereotypes and ethnocentric approaches for this is not only an inaccurate representation of the social world, but also ignores important differences between people's experiences. To avoid the dangers of homogenisation, the diversity of people's histories, cultures and experiences must be represented (Williams, 1989). In accordance with the ecofeminist

[1] Countries which are sources of 'Overseas Development Assistance'
[2] Countries in receipt of 'Overseas Development Assistance.

approach, the information that this research seeks to generate is influenced by subjectivity, as it will focus on the meanings that people give to the environment, not the environment itself.

*"The postulate of **value free research**, of neutrality and indifference toward the research object, has to be replaced by **conscious partiality**, which is achieved through partial identification with the research object.... conscious partiality, however, not only conceives of the research objects as parts of a bigger social whole but also of the research subjects, that is, the researchers themselves"* (Mies and Shiva, 1993, p38) (stressed in original).

I agree that, as a researcher, I cannot know this independently of people's interpretations of it. For that reason, what can be presented is my interpretation of people's understanding and interpretation of the social and physical environment.

This research takes from the eco-feminist approach the conviction that the vertical relationship between researcher and research object, the *view from above* must be replaced by the *view from below* (Mies and Shiva, 1993). Thus the results of this research express my interpretation of farmers' views rather than my personal beliefs.

This work stresses the role of the environment while providing ideas to facilitate the life of the poor. Leaving environment out of the discussion or misinterpreting its value would lead to false solutions, perhaps preserving the environmental crisis in the name of equity and poverty alleviation. Environment must be at the core of any sustainability debate. Shiva (1991) argues that poor and the marginalized groups suffer because the natural resource basis of their survival economy is eroded, while lack of income prevents them from entering the market economy. As the entrance of the poor into the market economy could worsen the environmental crisis, I seek (and that is the intention of this thesis) to look for alternative forms of development which fulfil the expectations of the poor and the simplicity which could be an alternative for those disappointed with the consumerist way of life.

The neglect of the role of the natural resources in ecological processes and in people's sustenance economy, and the division and destruction of these resources for commodity production and capital accumulation, are the main reason for the crisis, and the crisis of survival in the third world. (Shiva, 1991, p342).

I agree (Chapter 4) with those who argue that the solution seems to lie in giving local communities more control over local resources so that they have the right and responsibility to rebuild nature's economy and through it their sustenance (Shiva, 1991), which some call endogenous development, the duty of each society to find its own strategy.

In an analysis of alternative development, Nederveen Pieterse, (2001, p86) argues that:

"The notion of 'endogenous' refers to social, cultural and symbiotic space. Endogenous development implies a refutation of the view that development = modernization = Westernisation. Self-reliance, then does not imply concern with the means but the ends of development: the goals and values of development are to be generated from within...Modernization then is not a matter of importing foreign models but also the 'modernization of tradition'. Imported modernization means the destruction of existing social and cultural capital... by contrast, modernization-from-within means the revalorisation and adaptation of existing social and cultural capital."

Although the approach of this research coincides considerably with the endogenous development concept, I do not consider all external knowledge invasive but complementary (when appropriate) to local people's knowledge. No society or community is perfect, real co-operation (instead of imposition) between communities, regions and countries may be the engine to bring positive change to poor communities and to get closer to a more sustainable world. I am aware that local culture is not an uncontaminated space but a field criss-crossed by traces of migrants, travellers, traders, missionaries, colonizers, anthropologists, etc., but dysfunction starts when changes are the product of imposition rather than the community choice. This is because "*the western systems of knowledge have generally been viewed as universal and local knowledge is made disappear by simply not seeing it, by negating its very existence*" (Shiva, 1993; p9). It is therefore necessary to challenge such dominant knowledge with well-structured, functional arguments because *"by declaring it* (local knowledge) *non existent or illegitimate, the dominant system also makes alternatives disappear by erasing and destroying the reality which they attempt to represent...* (and) *destroying the very conditions for alternatives to exist.*" (Shiva ,1993; p12)

Like Vandana Shiva and some contemporary ecology movements, I think that steadiness and stability are not stagnation, respecting nature's essential ecological processes is not scientific and technological backwardness, but scientific and technological sophistication towards which the world must strive if the planet earth is to survive (Shiva, 1991). Here I agree with some alternative development literature for which the agency of development is local and which the local knowledge is the keynote epistemology (Nederveen Pieterse, 2001). Alternative development tends to be practice oriented rather than theoretically inclined, its logic is that genuine development knowledge is also people's knowledge and what counts is local rather than abstract expert knowledge. It emphasizes agency in the sense of people's capacity to effect social change, it is development *from below* (Nederveen Pieterse, 2001).

The problem is how to arrive at global solutions through local solutions. Post-developmentalists think that the magnitude of today's institutions makes people powerless to undertake global action and, precisely for that reason, any action has to be local to make some difference. In the end, acting locally would result in the inter-connection of those dissenting with the global unsustainable economic system, in order to take political action (Esteva and Prakash, 1997). Eco-feminists such as Bennholdt-Thomsen and Mies (1999) believe that subsistence is the solution to development, where subsistence means to favour local markets at all scales, community, regional, national etc. so that the addition of local solutions would help in solving the global problems. Politicisation of subsistence, the re-definition of 'good life', 'quality of life' and 'fundamental human needs' and the extension of these new concepts to consumers could be the way to reach such change. Although I consider the post-development position and the feminist alternatives for change valid, I think that global change would take much time under such strategies (even if they can resist the opposition of the economic elite). Environmental and poverty problems call for immediate action. So in my view, instead of eliminating any trace of the development experience, I think that it is more practical to learn from past experiences, keeping the good and transforming the bad features of development through political action. Like Peet and Hartwick (1999) I think that the existence of world and people depends on breaking the styles of mainstream development thought. But that needs more protagonistic academic action. Like them, I believe that *"democracy, emancipation, development, and progress are fine principles corrupted by the social form taken by modernity, that is, capitalism as a patriarchal class system, a type of society operated in the interest of a male elite, based on the profit motive to the exclusion of everything else*...and that *the main problem with democracy is that it has never been achieved."* (Peet and Hartwick, 1999; p197). For that reason I take on, for the purposes of this research, their redefinition of development as:

"*Development for us primarily means building 'economic capacity' so that material life can be improved. Yet 'economic' is broadly interpreted to mean all activities employing labour organised through social relations, whether productive in the existing, restricted sense, or socially reproductive in the feminist and radical democratic senses. The model of labour comes not from the globetrotting executives, forever scheming how to make more money, but from mothers, peasants, and artisans whose work is connected with the direct reproduction of immediate life... 'Capacity' means... reproductive resources, that is land, infrastructure, machines, fertilizers, and the like, devoted to increasing the production of food, housing, useful goods, and basic services like clinics, hospitals, schools...*" (Peet and Hartwick, 1999; p208-9)

But as such change remains very difficult to implement while few people sensitive of environmental and community issues achieve "decision making positions". New practical alternatives for the poor should be searched out and ways to insert such ideas into the current institutions should be explored. In other words, global changes should be looked for while locally based answers are explored and implemented. Local problems cannot wait until consensus is achieved around a new development model and how to reach it. Subsistence and food security approaches, for example, could be valid answers with potential to be introduced into the development agendas presented as alternative ways to reach current development goals such as levels of nutrition or opportunities for self-employment. This is the ground on which this research was conceived, so that is my intention to present both radical solutions arising from the analysis of what in my view is the cause of the problem and also more practical answers with more likelihood of implementation under present conditions.

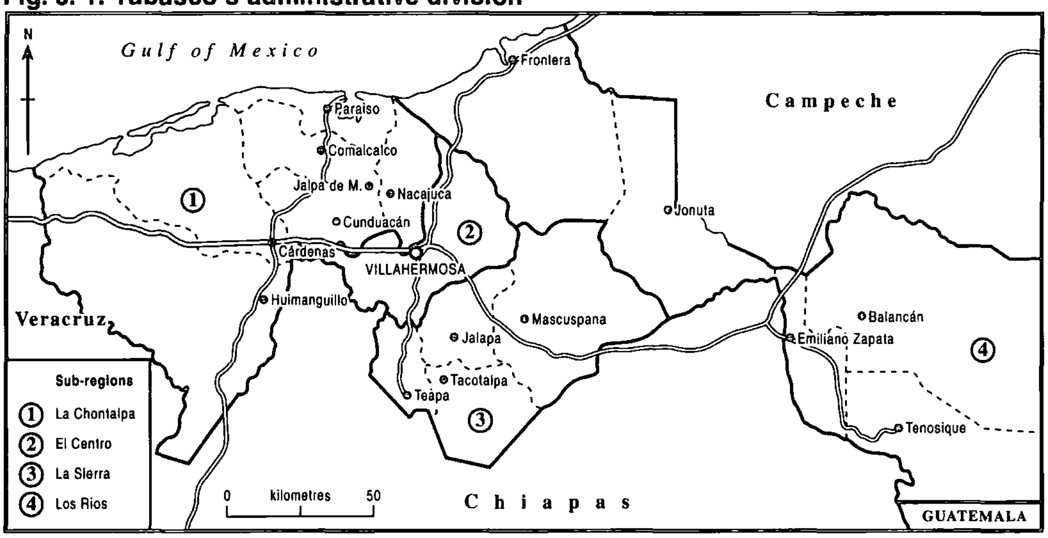
The findings of this study will clearly reflect my interpretation of a phenomenon at a particular time and place. It is not my intention to look for a paradigm for human change, but to look simply for local answers to local problems, to look in the environmental and cultural diversity for solutions, which under no circumstances should be considered messianic but just an option among many others in that place and time. Nevertheless, although this research has been carried out in a localised physical and social environment, such boundaries are arbitrary, for environmental and social boundaries are never discrete but a gradient in which different natural and social environments interconnect. In this sense the people, according to the degree to which they feel that the results apply to their everyday life, will establish the boundaries of this research. Yet I believe in the validity of considering culture, place and time through the recognition of the existence of local people's knowledge and adaptation for generations to a localised environment, which gives them an authority to define local problems. I prefer to talk about local or people's knowledge, rather than indigenous knowledge, because knowledge does not necessarily have to be endogenous to be adopted and adapted.

In spite of the local focus of this research, given the political context of Mexico, it is expected that a number of outcomes may resonate with other areas of the country and outside it. Nevertheless, although these findings could be useful, they should never be used as general or universal.

3.2 Area of Study

This research was conducted in four municipalities in the state of Tabasco, Mexico (fig. 3.1). Initially this research was planned in Márquez de Comillas, Chiapas; but, due to political instability there, the area of study was changed to Tabasco.

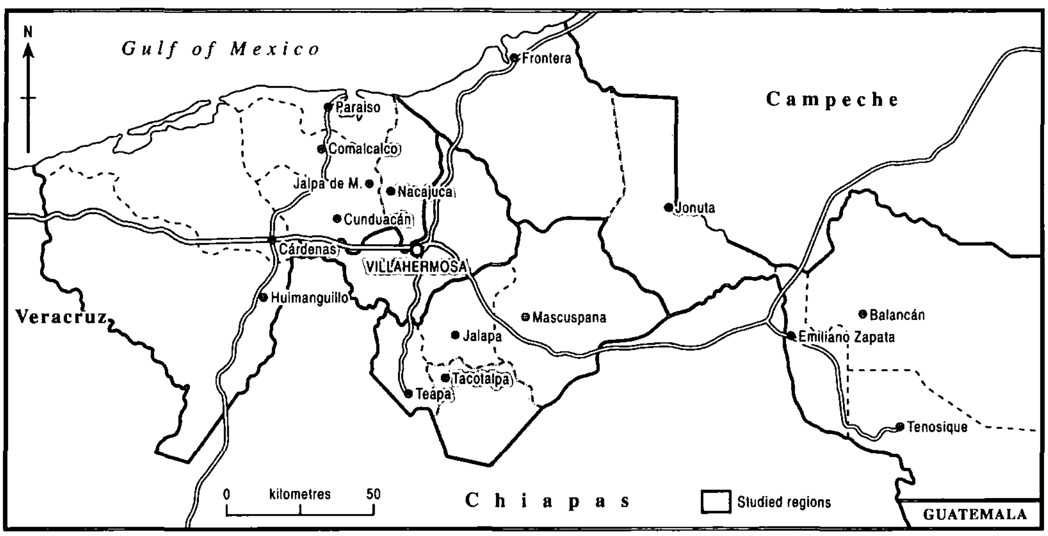
Fig. 3. 1. Tabasco's administrative division[3]



State of Tabasco: Administrative structure

Tabasco was chosen because it has a variety of environmental and socio-economic conditions in relatively close proximity, convenient for the exploration of environmental and socio-economic differences. The state can be divided into four physical regions, each with a distinct topography and environment (fig 3.1). "La Sierra" is a hilly area of 4351 km2 comprising 4 municipalities with average altitude of 15 m over sea level, and its maximum elevation is "Sierra Nava" with 1500 m above sea level. "La Chontalpa" is a flat area of 8567 km^2, which extends from the Gulf Mexico to the centre of the state and has 7 municipalities. Its average altitude is 13 m and its maximum 560 m (Cerro la Ventana). "Los Rios" ($9945m^2$) reaches from the frontier with Guatemala to the Gulf of Mexico. It is relatively flat with a great number of annually flooded depressions and rivers. Mexico's two most important rivers, the Grijalva and the Usumacinta cross Los Rios, which has 5 municipalities. It has an average altitude of 14 m but its maximum just reaches 200 m. The fourth region is El Centro (1612 m^2), which is in the centre of Tabasco, surrounded by the other three regions and has an average altitude of 10 m. All the environments of Tabasco (except the coastal) can be found in El Centro, a single municipality that includes Villahermosa (350,000 people) the capital city of the state.

Fig. 3.2 Regions studied[4]



State of Tabasco: Administrative structure

3.3 Selection of sites

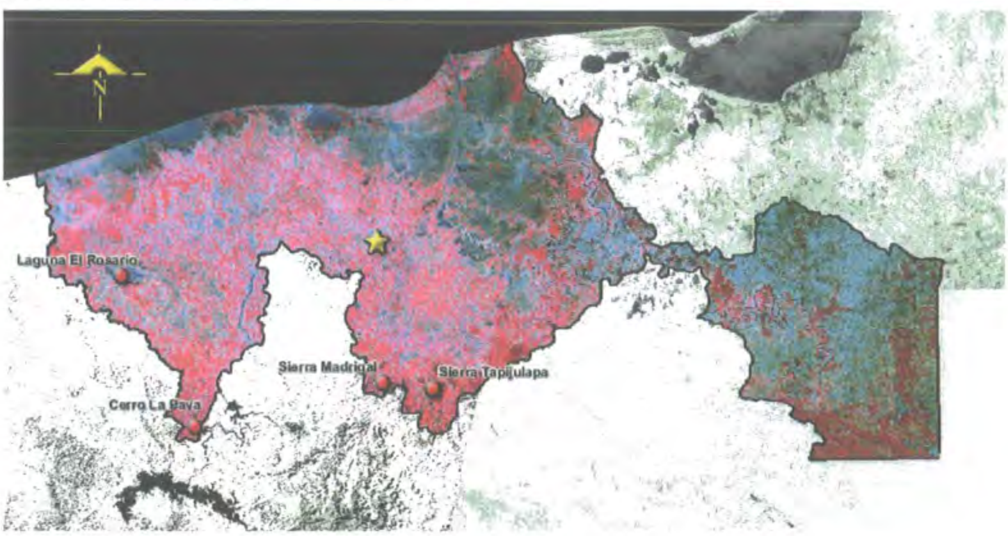
Firstly, four municipalities were chosen, one from each region: Nacajuca (La Chontalpa), Centro (El Centro), Tacotalpa (La Sierra), and Jonuta (Los Rios) (fig 3.2). These were chosen as having environments representative of each region (fig. 3.3) and different socio-economic conditions, and for their relative proximity to Villahermosa, the base for this research. Social parameters such

[3] Modified by the Design and Imaging Office, Geography, Durham, from SEDESPA (1997a)

as literacy and nutrition were also taken into consideration and two municipalities with lower living standards were chosen, for comparison with El Centro, which has the highest living standards and greatest economic resources.

La Chontalpa is considered the best area for agriculture in Tabasco, being mainly flat with swamps in the east. Coconuts, cacao, sugarcane, pineapples, oranges, offshore fishing and cattle (for meat) are the most important products. Oil extraction is however the most important primary economic activity. Los Rios is also relatively flat with many annually flooded depressions that overflow seasonally from September to December when the rivers rise. Los Rios is the leading cattle provider (milk and meat) in the state but inland fishing is also important.

Fig. 3.3 Satellite image of Tabasco



Source: INEGI[5,6]

La Sierra is a hilly area with some tropical rainforests. The main farming activities are cattle (milk and meat) and banana plantations. Oil and cement are the most important economic activities.

[4] Modified by the Design and Imaging Office, Geography, Durham, from SEDESPA (1997a)
[5] http://www.inegi.gob.mx/
[6] National Institute of Geography and Computing Science.

Villahermosa has the state congress and all the regional head offices. The local government of El Centro thus has more resources because the most important economic activities take place there. El Centro enjoys good communications and services compared to the other three municipalities, as well as some industry. Commerce is the most important activity.

3.4 Methods

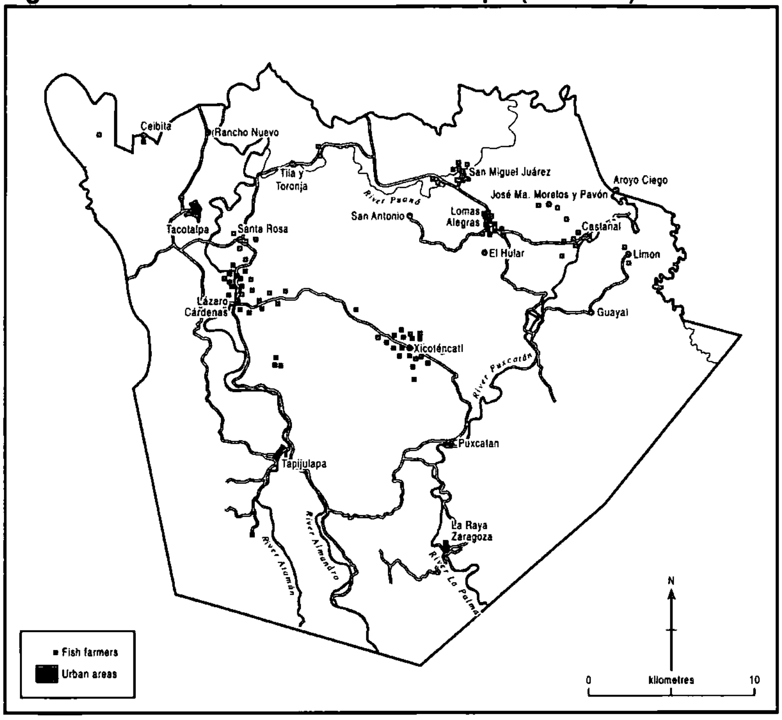
The fieldwork was conducted from October 1999 to May 2000, with a return visit in December 2001, employing quantitative and qualitative methods.

I was born and brought up in the region, on a small farm. I qualified in biology at Universidad Autonoma Metropolitana in Mexico City and in aquaculture at the Institute of Aquaculture at Stirling (UK). I had 13 years professional experience in the study area, as an extension officer in the State Government and as a researcher and lecturer in aquaculture in the Colegio de Postgraduados en Ciencias Agrícolas y Forestales in Cardenas, Tabasco. At Durham, I worked to develop some understanding of the social sciences and particularly of cultural approaches. All this had a great influence on the research design and the fieldwork. Access to official information was easier for me through my connections in government's institutions. My familiarity with local terrains and climate helped in the planning of the fieldwork. In the same way, communication and rapport with farmers was facilitated by my knowledge of the local culture and of the regional Spanish dialect.

Above all, my whole understanding of aquaculture changed during the course of the research. I came to Durham specifically to explore the role of political, social and economic life in aquaculture in my PhD, but the approaches I adopted meant that for the first time in this fieldwork the farmers were able to educate me in the meanings that guide their lives.

3.4.1 Quantitative methods

Fig 3.4 Fish farm distribution in Tacotalpa (la Sierra)[7].



Tacotalpa fish farmers

1) Pilot Questionnaire

First, 30 preliminary questionnaires (Wilson and McClean, 1994) of 40 questions were tested across the four regions, in October 1999. The base for the research was in Villahermosa, and transport to the villages was by car. Farmers were selected by random sampling[8] at this stage from a list provided by the Fisheries Development Directorate at the Economic Development Secretariat (SEFOE[9]), the Development office of the Municipal Administration of El Centro and the Regional office of the Secretariat of Environment, Natural

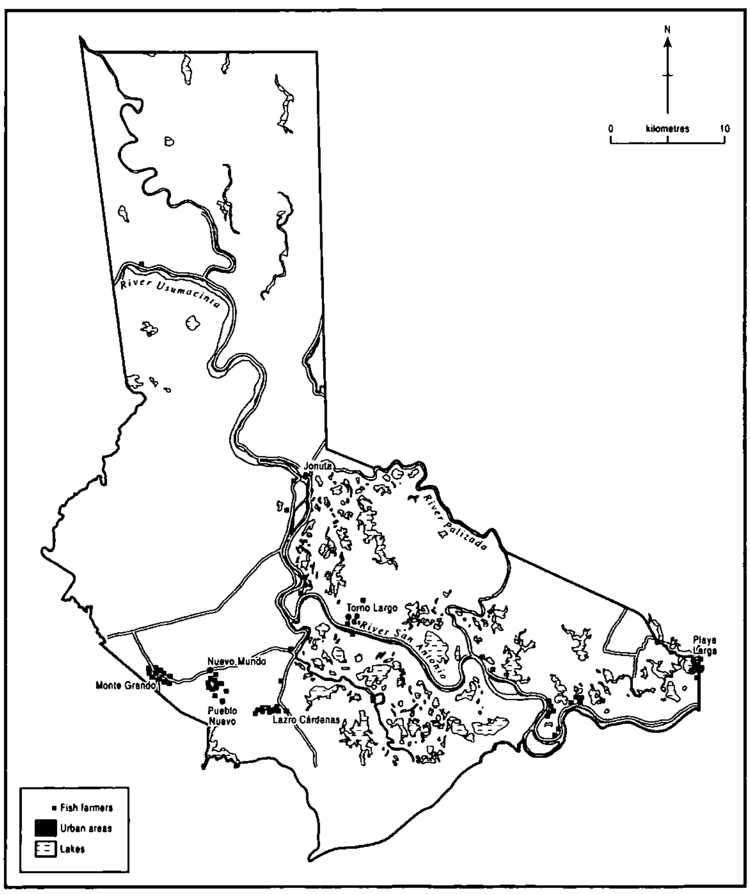
[7] Modified by the Design and Imaging Office, Geography, Durham, from SEDESPA (1997a)
[8] This method makes possible to express the mathematical probability of sample characteristics being reproduced in the population. Each person in the population of interest has an equal chance of being part of the sample. What is vital for random sampling is that a complete list of the population exists (sampling frame). In the sampling frame each individual is given a unique number starting at one and a mathematically random selection of the sample is then made (May, 1998).
[9] In 2002 the Fisheries Development Directorate was moved to new secretariat: Secretaría de Desarrollo Agropecuario Forestal y Pesca (SEDAFOP) (Agriculture, Livestock, Forest and Fisheries Development Secretariat); while SEFOE changed its name to Secretaría de Fomento Econ0́mico y Turismo del Estado de Tabasco (SEDET) (Economic Development and Tourism of Tabasco).

Resources and Fisheries (SEMARNAT) (For fish farm distribution see figs. 3.4, 3.5, 3.6 and 3.7). This preliminary questionnaire was a tool for selecting and arranging the questions for the survey.

2) Questionnaire

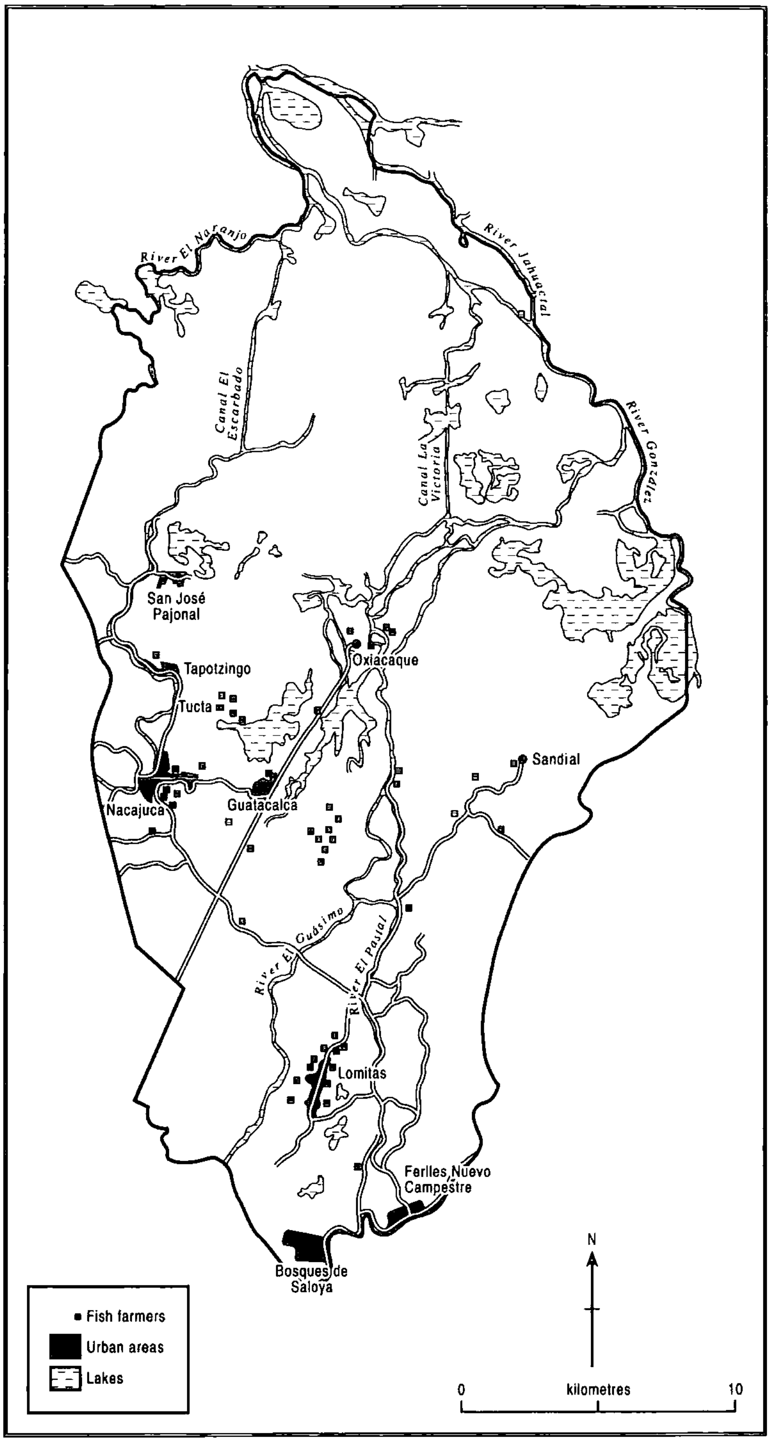
From this initial face-to-face questionnaire, some questions were omitted when the respondent was not positive, others were re-formulated to avoid misunderstandings and yet others were added when field experience established the importance of new topics (see appendix 1 for distribution of questionnaires). As a significant number of people were illiterate, all questions were asked orally for consistency. (The conditions were wholly inappropriate for a self-completion or telephone survey).

Fig 3.5 Fish farm distribution in Jonuta (Los Rios)[10]



Jonuta fish farmers

Fig 3.6 Fish farm distribution in Nacajuca (La Chontalpa)[11].



Nacajuca Fish Farmers

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[10] Modified by the Design and Imaging Office, Geography, Durham, from SEDESPA (1997c)
[11] Modified by the Design and Imaging Office, Geography, Durham, from SEDESPA, (1997d)

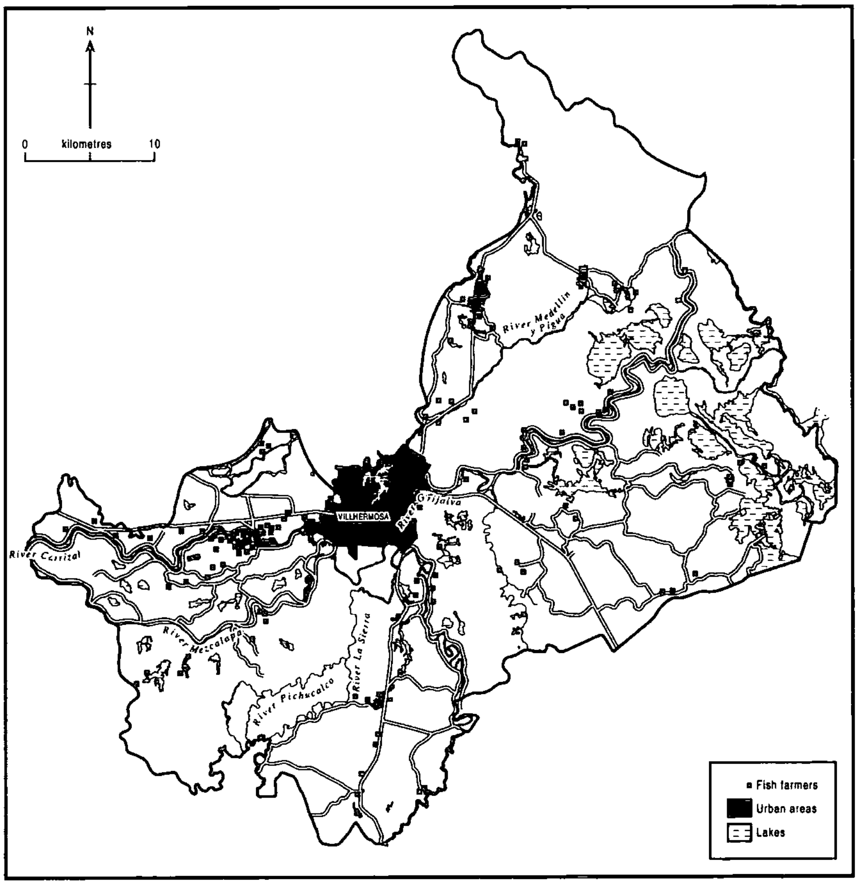
The objective of the questionnaires was to establish the present situation of aquaculture in the area of study. Questions were designed to establish the history of the local development of aquaculture and the current practices of fish farmers, their use of resources, labour division, and technical parameters (such as pond area, stock density, yield, cycle duration etc); to identify individuals and groups who belonged to group projects or enterprises and to locate successful individuals, families and groups.

The survey was carried out from November 1999 to January 2000. 159 face-to-face questionnaires were completed, 46 in El Centro, 34 in Jonuta, 30 in Nacajuca and 49 in Tacotalpa. The number of respondents was decided according to the number of fish farmers registered in each municipality. The determination of optimum sample size was not appropriate because the number of farmers in the lists was small, so that in some cases a majority of farmers were interviewed (Table 3. 1). Three lists of fish farmers were employed, two for the four areas and one more for El Centro. One was from the Fisheries Development Directorate from SEFOE, one from the Regional Aquaculture Office of the relevant National Ministry: Secretaría de Medio Ambiente Recursos Naturales y Pesca (SEMARNAT) and the last from the Development Department of the Local Government in El Centro (See Chapter 5 for their organisation). The three lists were brought together, and the new overall list was modified when information from the official lists was erroneous (see appendix 2). In this phase, 76 villages were visited across the four municipalities. The selection of farmers was random in areas where the overall list proved accurate, but had to be changed to snowball[12] when farmers included in the list (and chosen by the sampling method) either did not exist or had never practised fish farming. 17 farmers in Jonuta, 3 in Tacotalpa, 5 in Nacajuca and 5 in El Centro not included in any list were also identified and included in the final list.

[12] "*This approach involves using a small group of informants who are asked to put the researcher in touch with their friends who are subsequently interviewed, then asking them about their friends and interviewing them* "(Burgess, 1990: p55 cited by May 1998 p119)

Once this survey was completed, a preliminary analysis of questionnaires was made to select 62 farms for the site surveys. This number of farms was chosen in order to have a significant sample size covering the greatest possible range of diversity. Parameters used in selecting the farms were: Socio-economic level, yield, pond size, kind of management, organization type, gender of farmers and the physical characteristics of the farms. Twelve site surveys were located in Jonuta (35%), 13 in Nacajuca (43% of all questionnaires), 16 in Tacotalpa (33%) and 21 (45%)[13] in El Centro. The number of site surveys was defined in accordance to the number of fish farmers in each municipality. This round covered: a technical site survey and semi-structured interview at each site, carried out between February and April 2000.

Fig. 3.7 Fish farmer distribution in El Centro (El Centro)[14]



Centro fish farmers

[13] Percentages are in relation to the number of questionnaires in the previous survey.
[14] Modified by the Design and Imaging Office, Geography, Durham, from SEDESPA (1997b)

Table 3.1 Number of farmers visited in the survey

Municipality	Total Number of known Fish Farmers[15]	Number of Farmers Sampled
El Centro	127	46
Jonuta	80	34
Nacajuca	46	30
Tacotalpa	84	49

3) The site survey

The site surveys included water quality and soil analysis, technical survey and semi-structured interviews.

Fig 3.8 Dissolved Oxygen determinations *in situ*.

Water quality

The technical site surveys were designed to establish the suitability of the farms for fish farming. Water quality parameters in the ponds were measured on site to record the physico-chemical conditions and productivity indicators, including oxygen, pH, water and ambient air temperatures, and transparency (Sechi disk) (figs 3.8 and 3.9).

Table 3.2 Water quality parameters determined

Parameter	Method	Place of analysis
Dissolved Oxygen	Winkler	*In situ*
pH	Potentiometer (Corning 350)	*In situ*
Temperature	Thermometer	*In situ*
Transparency	Sechi Disk	*In situ*
Suspended solids	Gravimetric	Ecology Lab
Nitrates	Brucina	Ecology Lab
Total Ammonia	Nessler	Ecology Lab
Orthophosphates	Stannous Chloride	Ecology Lab
Iron	Phenolphthalein method	Ecology Lab
Turbidity	UTN	Ecology Lab
Total alkalinity	Potentiometric method	Ecology Lab
Phenolphthalein alkalinity	Potentiometric method	Ecology Lab
Total hardness	Titration with Erichrome black 'T'.	Ecology Lab
Calcium Hardness	Titration with murexide	Ecology Lab

One water sample was collected per pond, near the outlet (if any) or from the area where, from experience the poorest water quality was likely (generally at the edge of the pond exposed to the prevailing wind, where a layer of suspended material was detected). Samples were collected at medium depth[16] in 5 l plastic containers, stored in an ice tray below 10ºC and transferred to the Ecology Lab in Villahermosa (Laboratorio de Ecología, SEDESPA[17]) the same evening, to be analysed the same day or, if the samples arrived too late, the morning after. The time for samples to reach the lab depended on the distance, road conditions, the weather and when farmers were available to be present at the site survey. The time at which samples were collected varied for the same reasons, between 08:00 hrs and 17:00 hrs. Weather conditions during the sampling period varied from heavy rain to sunshine, as this was a season of varied weather. In the laboratory the

[15] Number calculated according to the official lists of farmers provided by the three Aquaculture Extension Institutions

[16] Depth depended on the pond depth. Generally ponds were between 2 and 3 m deep, so the sample was collected between 50 cm to 75 cm from the surface.

[17] Secretaría de Desarrollo Social y Protección Ambiental (Secretariat of Social Development and Environmental Protection).

samples were analysed for nitrates, ammonia, orthophosphates, iron, and turbidity, total and phenolphthalein alkalinity and total and calcium hardness. The list of water quality parameters is presented in table 3.2.

Oxygen and transparency were used as indicators of primary productivity; nitrates, ammonia, turbidity, hardness, and alkalinity were measured to evaluate whether conditions in the pond were acceptable for fish growth and orthophosphates to determine the availability of nutrients in the water for primary productivity. Water colour, as an indicator of algae occurrence, was recorded by simple observation on site. Similarly, notes were taken about visible organic layers, odour, and floating matter, as indicators of pollution. Water sources and the presence of inlet and outlet structures were recorded as were the presence of clouds and rain during the sampling (which would influence the results of water quality), by simple observation.

Fig. 3.9 Recording water temperature *in situ*.

Soil analysis

At the same time as the water sample, a 100 g soil sample was taken from the bottom of the pond, stored in a black plastic bag and transferred to Villahermosa where they were air-dried. Samples were transferred to the soil analysis laboratory at Durham University to determine particle size and iron.

Methods for soil analysis are presented in table 3.3. Particle size was determined as an indicator of soil permeability, and Iron as an indicator of pH in the water, which is related to primary productivity and the efficiency of fertilization. Manual determination of soil texture was carried out on site and observations about colour, odour of soil and topography were recorded.

Table 3.3. Soil Parameters

Parameter	Method	Place of Analysis
Soil colour	Direct observation	In situ
Soil odour	Direct	In situ
Soil Texture	Conter Coulter	Geography Lab, Durham
Iron	Atomic absorption spectrometer[18]	Geography Lab, Durham

4) Technical evaluation

Every pond was measured (with a 100m tape) and information on pond morphology, slope, embankment and depth was recorded. The nature of the water body (natural or artificial, phreatic or elevated, permanent or seasonal), the vegetation surrounding the pond, the species farmed, the natural fauna in the pond and the pond location were also recorded.

3.4.2 Qualitative methods

1) Site survey

Conditions on the farms were recorded from direct observation. These included: domestic animals, field crops, housing conditions, machinery, access to roads, distance from village, type and condition of roads and other relevant information.

2) Interviews with farmers

At the same sites, semi-structured Interviews (Silverman, 1993) were carried out with the household member most involved in fish farming. The main themes for the interviews resulted from key topics emerging from a preliminary analysis of the questionnaires. Generally the interviews were used

[18] 220 Expectr AA 220FS

to establish attitudes to fish farming, fish consumption and environmental concerns by farmers, gender division of labour, the use of resources for farming fish, the problems faced by farmers related to the activity, the government role in fish farming development, and their expectations and perception of aquaculture staff and government support. Differences in culture, dialect and level of education in the area were recorded. Interviews were recorded with a portable tape recorder (with some technical failures) and notes were taken. In some cases interviews took place at the fish farmer's home, but usually at the pond (fig 3.10). Interviews lasted between 20 and 60 minutes, depending on the respondent's attitude, detail of answers and tendency to sidetrack.

Semi-structured interviews were selected to enable the interviewee to answer questions within their own frame of reference (May, 1998). Interviews would bring out relevant information that was not possible to record in the questionnaire survey, go into more qualitative details of selected topics and check information from the survey.

Direct observations (McCracken *et al.*, 1998) were also used at each site to check the information from the interviews, including notes on the daily activities of the family, resource availability, access etc.

Fig. 3.10 Interviewing a farmer

3) Interviews with aquaculture staff

Interviews were conducted with a total of 20 staff from three institutions dedicated to the promotion and development of fish farming: the Office of Municipal Development of Local Government in El Centro, the Aquaculture Department of SEFOE, part of Government of the State of Tabasco and the Aquaculture Department of the Regional Office SEMARNAT, part of the Federal government (see chapter 5). These semi-structured interviews with a range of senior staff and field workers explored topics such as motivation, working conditions, personal views about the development of aquaculture in the state, goals and objectives. Five interviews took place with the heads of the three main public hatcheries in the state: Teapa, Puerto Ceiba and El Centro; and two private: Chable and Zapata. The goal was to explore the problems related to the management of the hatcheries and find out how the managers see the development of this activity. As with the farmers, the conversations were taped and notes were made during the interview.

3.5 Statistical Analysis

The analysis of the questionnaires and the physical parameters were carried out with the software SPSS. The analysis for the questionnaires used frequencies, student t test and crosstabulation. Multivariate analysis was used for the water quality and soil information, together with the other technical parameters. These were subjected to a factor test using the principal components method and to a multiple correlation. This would allow detecting linkages between parameters and specific factors or combination of factors affecting yield. The interviews were transcribed and more frequent and relevant topics were subjected to translation from Spanish and interpretation, trying to maintain the meaning of the original version as far as possible.

3.9 Limitations of this research

The fieldwork started in autumn 1999, when the study area suffered a flood of great magnitude. A significant number of farmers lost all their fish production and many ponds were destroyed. This event will have affected farmers' attitudes, reducing optimism about fish farming, and could affect the information they provided. Floods came up several times in each interview, so that the flood problem could have been over-estimated.

Another problem was the unreliability of the lists of fish farmer obtained from the aquaculture institutions in Tabasco. In many cases, many farmers on the existing lists had never practised fish farming, while a significant number of fish farmers (especially those farming native species) were found who were not included on any list. The aquaculture institutions only have records of farmers to whom they provide fry, but many, very often the poorest, obtain the fry from natural water bodies. It was therefore not possible to determine the total number of fish farmers which affected sampling.

The political environment also affected the fieldwork. 2000 was election year. Many politicians were on political campaigns since autumn 1999, visiting the villages and offering support to farmers. As a result villagers often identified strangers as government envoys who were collecting information in order to provide support. For that reason, although I stressed my independence from the government many interviewees continued to assume some government affiliation on my part. This could have affected information obtained. The 1999 election, of course, let to the first change in the party in power in some 70 years, but the interviews took place under the old political system.

3.5 Concluding remarks

This thesis studied fish farming in four municipalities of Tabasco, Mexico, belonging to four different regions. Qualitative and quantitative methods, including measurement of physical and technical parameters were used. Although it is both usual and attractive to situate the theoretical approach of this research in a particular school of thinking, this thesis has been much influenced by a number of outlooks but accords with no single one. In its criticism of mainstream approaches, critical development offers the strongest and most reflexive arguments, demonstrating that 'development' has been used as a form of cultural imperialism, perpetuating existing power relations, so that radical change is urgently needed. Nevertheless critical development fails to propose ways to achieve such a change. This research adopts the pragmatism of some alternative development literature, recognising the need to work for small-scale, specific changes even though global change is not achieved. Ecofeminist criticisms of 'objective' research are accepted, as is the urgency of changing our view of nature from a storage of goods for production of capital to a reservoir for the reproduction of life. At the same time it is necessary to disagree with the feminist view that the present situation is merely the result of the prevailing patriarchal societies. In summary, this research accepts certain arguments from different and conflicting schools of thought. The immediate focus here is the search for practical solutions as the problems of the rural poor call for immediate action. It remains important to recognise that such actions will never solve the root problem because a global solution requires radical change in the economic system, which under existing power structures is difficult to achieve.

CHAPTER 4
AQUACULTURE IN SOUTHERN MEXICO: AN APPROACH TO SUSTAINABILITY

4.1 Introduction

Like any human activity, aquaculture has played both a positive and negative role in different areas depending on its local process of development and on the nature of the technology in use. That is why it is important to analyse its characteristics in Tabasco, in order to compare it to other aquaculture systems and to learn from the comparisons. Pond aquaculture in Tabasco can be considered as part of a larger 'semi-subsistence' system, since the subsystems are interrelated by inputs received and outputs into other subsystems in the farm enterprise, such as livestock and agriculture. Two key questions arise from this: 1) are these subsistence systems environmentally friendly? 2) what is the likelihood of their long-term survival? It is difficult to find a term which would take us to criteria for environmentally friendly human change to answer these questions. 'Sustainability'? What actually is sustainability? Does it exist? These questions make it necessary an analysis not only of sustainability but also of the critique. Then this thesis is able to ask, can subsistence aquaculture be considered a sustainable activity in Tabasco?

In the field, 'non-sustainability' is a more practical concept to apply than 'sustainability'. To predict that a given human-environment system will be sustainable would be rash. There are very complex systems in which crucial relationships may be very small but far-reaching; on top of this there is the unpredictability of human behaviour. For that reason, some considerations of the effects that modern industrial societies have had on the earth will first be presented. This will provide some light for the search for a suitable definition of 'sustainability' for the purposes of this research. Second, given the polemic related to this concept, a number of approaches will be explored. Third, an analysis of such polemic will follow and identification of some approaches that are particularly appropriate for the purposes of this thesis. Insights into sustainability in aquaculture follow. Finally, there will be an examination of sustainability indicators which could be applied in the evaluation of aquaculture in the context of Tabasco and its people.

4.2 Environmental crises and the search for a new development.

Academic and social concern about the environmental problems caused by accelerated economic growth, first in Northern countries and later at a global scale, led scientific elites to question the direction in which human civilization was changing. There was awareness among scientists that many ecosystems upon which we depend for our future well-being were changing rapidly in response to new technological interventions (Berryman, 1991a). This concern reached public opinion and the debate over the effects of industrial development acquired political and economic dimensions. In the late 1960s it was judged that the world was near to reaching an environmental crisis (Adams, 1990). Species extinction, erosion, pollution, ozone depletion, deforestation of the tropics and later global warming were seen as possible factors in system disequilibria (Berryman 1991b). The ecological effects of the 'technosphere' are not limited to waste products, for every material input has an ecological damage potential *per se* (Hinterberger *et al*, 1997). Degradation may be recognised by a diversity of symptoms. Another complication is that it may take several decades to identify the effects of a single activity. In the same way, the outcomes of different attempts to solve a problem are also very mixed and difficult to analyse. For example, a new and apparently 'environmentally friendly' technology might be less sustainable if it implies increased energy loss or waste products. In other words, we cannot continue solving problems by creating new ones. Most of the time, science is seen as the main tool in solving the problem, but this position is not unquestioned as science is often seen as much as the cause of environmental problems as the solution (Yearley, 1992). Social scientists have challenged the status of scientific knowledge, often on the basis of detailed studies of how it is produced (see

Latour and Woolgar, 1979; Latour, 1993; Law, 1994). All this illustrates the fragility of our planet, and the difficulty of addressing its present problems in the presence of a dynamic, globalised and consumption-based economy. Robert (2000) proposes a change to attacking the problems by removing their underlying causes rather than 'fixing' problems once they have occurred. What he calls 'upstream' thinking seems attractive but the problem is to put it into practice.

There currently seems to be substantial agreement in certain groups that economic development has been non-sustainable. Non-sustainability implies a systematic degradation of the ecosphere's ability to sustain its productivity and biodiversity, and thereby to sustain human societies with their demands for services and resources from other parts of the ecosphere. This ability depends on very complex interactions between the various species within the ecosystems (including humans) and the surrounding geophysical world (Robert, 2000). The environmental crisis includes the economic, social, political, and cultural crisis within the human universe, alongside the ecological crisis between humans and the natural universe (Mebratu, 1998).

To recognise an environmental crisis is to admit not only that the future is uncertain, but that future outputs of goods and services from managed ecosystems cannot be assured at the levels desired. Meanwhile the number of threatened species in nearly all countries, whether industrialised or not (World Resources Institute, 1993) is but one sign of ecosystems in stress. In addition to genetic losses, commodities such as timber, fuelwood, ocean fish stocks, or clean water often appear more likely to be depleted than to be sustained (Ludwig *et al*, 1993).

Whether or not there is a causal connection, we face also the gap between rich and poor countries and even between rich and poor regions within the same country. We are profligate with energy. Some studies suggest that at least four times more wealth could be produced with the energy used today (Von

Weizacker *et al*, 1997 cited by Robert, 2000). Because impoverishment has been identified as one of the root causes for environmental degradation (Srinath *et al*, 2000), poverty reduction could be an important factor in solving this environmental crisis. In many cases, for example, poverty leads to deforestation of areas which are becoming progressively more important to the biosphere's equilibrium. It is not likely that the whole earth can sustain a global *per capita* energy expenditure like that in the North. Today some 20% of the world's population induces more than 80% of the anthropogenic material flow (Hinterberger *et al*, 1997), so the earth systems may not be able to support bringing the poor to a similar standards of living as the prosperous if our inefficient use of energy continues. *"If equity is to prevail in the future, and to allow the economies of the southern hemisphere a sustainable development of their economies, the industrialized countries will therefore have to dematerialise their economies by much more than 50 %, so that a cut in half of global anthropogenic material flows can be achieved"* (Hinterberger *et al*, 1997 p8). Thus, a more efficient use of energy could be an acceptable solution because it is seen as unlikely that governments will show the political will to implement policies to reduce consumption. Energy efficiency is clearly important to greater sustainability.

At present the North can deal with the problem because it can transfer the ecological and social impact to the south. Even though people in the North are progressively more concerned about the environment, there is still no generalized awareness of the degradation and ecological impact that their consumption is creating in the South. A time could come when the ecological problems (such as global warming) would reach the rich countries and social pressure could then lead to radical change. Will there be enough time then to change the direction of development? Meanwhile non-industrialised countries are deprived, particularly in rural areas.

4.3 Lexicography of sustain, sustainability

Because of the awareness of the possible environmental crises, a change of direction in development has been urged both by the academic community and by public opinion. That concern leads to the search for a term to guide a new development. At first, the term 'Sustainability' seemed to fulfil such concern, but later it was the target of considerable critiques.

First, the literal meaning of the word. In the Oxford English Dictionary (1991), the verb 'to sustain' is defined as: to keep from failing or giving way; to cause to continue in a certain state; to maintain at a proper level or standard; to maintain or keep going continuously (action, or process); to support life in; to provide for the life needs of; to support the efforts of; to preserve the status of; to support life (nature with necessaries); to hold up; to stand by (one's own action or conduct); to endure without failing or giving way; to withstand, to bear up, to hold out. In the same way, 'sustainable' is defined as: supportable, bearable, able to be maintained at a certain level, while a 'sustainer' is a person who or thing which sustains, upholds or maintains something, a supporting structure. 'Sustained' is kept up without intermission, maintained through successive stages or over a long period, kept up or maintained at a uniform pitch or level. Thus sustainability is the quality of being sustained.

Traditionally, among environmentalists, the expression 'sustainable' has been used as synonymous with 'long term', 'durable', 'sound' or 'systematic'. Indeed, out of the context of the English language, sustainable development is very often referred as 'durable development' in French, while literal translations are found in the German (nachhaltige entwicklung), and Portuguese (desenvolvimento sustentável) (Leal-Filho, 2000). In Spanish there is still no agreement on a correct translation. *'Desarrollo sosteníble'* and *'desarrollo sustentable'*, *'sostenibilidad'* and *'sustentabilidad'*, are used indiscriminately to refer to 'sustainable development' and 'sustainability'. Literally '*sustentar*' and *'sostener'* have similar meanings but are used in different contexts to have slightly different meanings and neither was used in the context of development or environmental protection before the USA ecology literature of the 1970s. Given the exact meaning of 'sustaining', the term implies an anthropocentric and even ethnocentric view of reality. In the first place somebody has to sustain something, and there is a purpose for such sustenance. Questions emerge. Who is going to sustain? The earth itself? Or are humans still to keep manipulating to change it at their convenience? The earth has the capability to sustain itself, but because of human action imbalances have occurred. Is it the whole of humanity, who will sustain it? Is it Western societies? And then, preserve for whom? For human kind? (what about other living beings?) For the people of the West? (What about other societies on the planet?) And what is to be sustained, the whole planet? The capitalist system? The well-being of Western societies? Biological and cultural diversity? The demand for 'sustainability' seems to obey the Western historical process of development, to solve the problems the West has created. This makes it more difficult to generalize about the term because the concept differs between languages slightly or radically. Then again, who is participating in the debate? Save for a few scholars, like Vandana Shiva, often considered radical, most of the relevant literature is produced in English by academics from the North. (At least, that is the literature most often cited). But what about people? A worker in Mexico City suffering from air pollution, or a landless person in Brazil, having to cut down the rainforest to secure a piece of land, for example? Is it that the South has nothing to say? Is it that sustainability is not an issue there? If that is the case, why?

4.4 Origin of sustainability

Critiques of this concept question the origins of the word and the political or ideological discourses hidden behind it. Adams (1990) and Mebratu (1998) undertook historical reviews of sustainable development and sustainability. Adams (1990) asserts that the concept originated from environmentalism which emerged in the USA and Europe, with roots in nature preservation, colonial science and the internationalisation of scientific concerns in the 1960s and 1970s. In the same way Mebratu (1998) argues that the concept evolved from three historical periods: Pre-Stockholm, before the Stockholm conference on Environment and Development (-1972); from Stockholm to WCED[1] (1972-1987, see below) and Post-WCED (1987-1997).

Malthusian theory and anarchism, and the two famous books of Schumacher, *The crucial problems of modern living* (1959) and *Small is beautiful* (1979) are cited by Mabratu (1998) as precursors to the concept of sustainable development. Redclift (1987) states that the term 'sustainable development' was already used in the 'Cocoyoc Declaration[2] on Environment and Development' in Mexico in October 1974, an international meeting of experts in which the environmental problems were looked at from the perspective of poor countries (Adams, 1990).

The 1972 UN Conference on Human Environment in Stockholm recognized the importance of environmental management and the use of environmental assessment as a management tool (DuBose *et al*, 1995). The report of the Club of Rome claimed that industrial society was going to exceed most ecological limits within a matter of decades, if it continued to promote the kind of economic growth witnessed in the 1960s and the 1970s. These are considered major steps forward in the evolution of the concept of sustainable development (Mabratu, 1998). Subsequently, the terminology evolved into terms like 'environment and development,' 'development without destruction,' 'environmentally sound development' and finally 'eco-development'. It was not until 1980, through the World Conservation Strategy, that the term 'sustainability' was highlighted in the subtitle 'Living Resources Conservation for Sustainable Development' but it was

[1] UN World Commission on Environment and Development

[2] The 'Cocoyoc Declaration' resulted from the UN conference held at Cocoyoc, Mexico, on "Patterns of Resource Use, Environment and Development Strategies". It pointed to the problem of maldistribution of resources and to the inner limits of human needs as well as the other limits of resource depletion. It pointed to basic needs, and called for a redefinition of development goals and global lifestyles (Adams, 1990).

brought into debate after the WCED report (known as the Brundtland Report) in 1987. The Commission underlined strong linkages between poverty alleviation, environmental improvement, and social equity through sustainable economic growth.

4.5 Sustainable development and sustainability

In academic debates 'sustainable development' is progressively falling into disuse[3] and being replaced with 'sustainability'. According to Sneddon (2000), both 'sustainable development' and 'sustainability' are at root normative concepts, describing versions of how human activities and ecological processes might be reconciled for the 'good of both'. Although the two terms are not synonymous, the second having a broader connotation, both still have similar connotations so an analysis of the whole idea seems more appropriate than discussing each concept separately.

In the Brundtland Report *Our Common Future*, sustainable development is defined as *"development that meets the needs of the present without compromising the ability of the future generations to meet their own needs"* (WCED 1987, p43). Since then, the concept of sustainability has taken off with a definition driven by political consensus, which offers sustainable growth as a solution. It is based on satisfaction of needs. Derived from this is the IIED[4] definition in which sustainable development *"is based on the identification of three systems as basic to any process of development: the biological or ecological resource system, the economic system, and the social system"* (Mebratu, 1998 p505). The objective is to maximize achievement of goals across these three systems at one and the same time, through an adaptive process of trade-off. This solution is notionally based on the increasing empowerment of people to take charge of their own development, combined with a clear

[3] Sneddon (2000) for example, argues that sustainable development has reached a conceptual and political dead-end.
[4] International Institute of Environment and Development

knowledge of environmental constraints and a commitment to meet basic needs. Similarly WBCSD[5] asserts: *"business leaders are committed to sustainable development, to meeting the needs of the present without compromising the welfare of future generations"* (Mebratu, 1998 p505). This position recognizes that economic growth and environmental protection are inextricably linked, and that the quality of present and future life rests on meeting basic needs without destroying the environment upon which all life depends (Schimidheiny 1992 cited by Mabratu 1998). In this approach economic growth in all parts of the world is seen as essential to improving the livelihoods of the poor, to sustain a growing population and eventually to stabilizing it. Eco-efficiency is seen as a way in which industry can reach such growth while minimizing resource and energy use. This definition was well interpreted by Svirezhev and Svirejeva-Hopkins (1998 p56) as: *'the development of the world's industry and technology while saving its natural environment'*.

4. 6 Critiques of the Brundtland Commission Definition

Academic discussions have both analysed the meaning and questioned the coherence of and even the intentions behind the concept. Adams (1990) asserts that sustainable development is an eclectic and often confused term of overlapping meanings, because 'development' itself is left conceptually ambiguous and elusive. He argues that the term is essentially reformist and owes little to radical ideas despite claiming a green or Marxist heritage. Adams concludes that green development must be about political economy and the distribution of power, rather than environmental quality. In the same vein Redclift (1987) argues that sustainable development is a concept which draws on two frequently opposed intellectual traditions: one concerned with the limits which nature presents to human beings, the other with the potential for human material development which is locked up in nature. For Redclift the problem in achieving sustainable development is related to the overriding structures of the

[5] World Business Council for Sustainable Development

international economic system, which arise out of the exploitation of environmental resources, and which frequently operate as constraints on the achievement of long-term sustainable practices. Carrying on the criticism, Daly (1996) states that sustainable development is dangerously vague and Goldin and Winters (1995) describe it as elusive. Although the term has been upheld by a number of scholars and decision-makers as the goal for human development, it also has been deconstructed and in not a few cases reduced to mere 'rhetoric'. Despite the claims that this concept has failed in addressing the challenges of human change, sustainability has been widely used in development projects around the world and has become a goal for fair and environmentally-friendly development.

Due to the vagueness of the concept, and to an attractiveness which it would be difficult for any other term to project today, there is an enormous number of definitions, quite as large as the number of approaches to development. The extent of the criticism is similar so it is impossible to discuss all the positions here. What all approaches seem to have in common is an acceptance that the world is faced with an environmental crisis, and an awareness of the limits of reductionist thinking in understanding and addressing this crisis. All apparently seek the same goal, but there are great differences in the identification of the source of the crisis, in the core approach and in the basis of and key instruments for a solution.

The Brundtland Commission's definition is frequently interpreted as endorsing a business-as-usual scenario, within the broad logic of capitalism, with some limited disquiet over the environmental impact of modern systems of production and consumption. It is viewed as requiring no more than a minor adjustment to the current pattern of technological advance, largely directed by the forces of the market place (Munton, 1997). Yanerella and Levine (1992) claim that sustainable development alone does not lead to sustainability, on the contrary, the concept supports the unsustainable path. By the same token it is being used as a new standard by those who do not really wish to change the current pattern of development (Gligo, 1995; cited by Fricker, 1998).

Brundtland's definition of sustainable development is ambiguous. First, 'development' is a concept questioned by some academics for its ethnocentric content and the dominant discourse behind it. Esteva (1993) argues that development is just one cultural expression of human change (chapter 6), not the only one, as humanity is rich in cultural values and ways to express change are the products of each particular way of life. He argues that 'sustainable development' has been explicitly conceived as a strategy for sustaining 'development'. According to Illich (1993, p88) "development' is near its end: *'earth was the wrong place for this kind of construction... the right place for supporting the flourishing and enduring of highly diverse natural and social life".* Secondly, because it involves the concept of needs, which is arguably subjective and ambiguous.

4.6.1 Sustainability, human needs and well-being

The inclusion of human needs in the concept makes it even more debatable. For Illich (1993) the historical movement of the West, under the flag of evolution, progress, growth and development, discovered and then prescribed 'needs' which are different from immutable necessities, the newest need being that which must be met. To me, it is clear that needs depend on the individual life history and the cultural context in which anybody has lived. How can we know what human needs are? The needs of an urban British citizen are different from those of a rural compatriot and even more different from those of a Mexican *'Campesino'*, for whom a society in transition to modernity creates a specific mixture of necessities, needs and desires. Even in the Mexican context, what a farmer in Tabasco perceives as a 'need' is very different to that of a farmer on the central high plateau. In other words, what is perceived as 'needs' by a person included in 'modernity', who perceives consumers goods and money as basic needs, may not be perceived in the same way by a subsistence farmer from Tabasco whose main priority is to produce his/her own food, rather than to earn cash. Wisner (1988) in his interpretation of the 'basic needs approach' argues that those who should define their needs are the poor themselves. He claims that as 'needs' are very often used by political authorities to justify policies imposed from above on people, a change is needed in which meeting basic needs becomes a means to empower people to become agents in creating a more just society.

Verburg and Wiegel (1997) conclude that sustainability challenges the dominant conceptions of 'needs', 'freedom', and 'growth'. There are many arguments to support this perception for *"people see life through diverse prisms. What some consider as high priority may be trivial for others, and each individual's ability to imagine a positive future is constrained by his or her perspective"* (Mebratu, 1998 p516). If it is difficult to agree what we can call 'needs' today, it is even more difficult to predict what will be the needs of future generations. Looking at the problem in retrospect, for example, everybody agrees on the importance fossil fuels have had in the technological progress of the last 200 years, and today modern societies still depend on petroleum to function. In other words, we need petroleum to satisfy the needs of modern societies; but for a European scientist living in the XVIII century, it would have been very difficult to conceive of the importance this resource would have in the future. So, how could the societies of that time protect this resource? Is the present generation better prepared, or do we have the right to establish what the needs for future generations will be? The answer to this question is likely to be 'no' and that is why the Brundtland Commission's definition of sustainable development seems vague.

The same happens when we extend the term needs into well-being. Pearce and Turner (1990), say that it is human society that should be sustained. In other words, that human well-being should not decline over time. This vision is arguably rather naïve because it apparently suggests the existence of a definite "human society", but in the end, the Brundtland Commission's definition seems to look for the same outcomes. To what human society do they refer? Based on previous experiences of 'development' (Esteva 1993) and the prevalence of capitalism and globalisation as the only option for human change in current political discourse, the generalisation 'human society' rather than 'societies' could be interpreted as an assumption of the existence of only one society or at least only one society worth sustaining.

But the reality is that there is not only one but many societies with different views of well-being. What well-being do they want to preserve? If they refer to the now widely accepted view of well-being, that is, the materialistic view which measures the number of products to which a person has access, then again we perceive the tendency to take it for granted that the urban western view of reality is universal. This argument refers to capitalism instead of human societies and consumption instead of well-being. This view does not seem reasonable for sustainability; first because it does not say much about the use that we obtain from a product in order to satisfy human needs and desires. In other words, as desires and needs change over time so consumption would increase instead of being kept at the same rate and so would energy expenditure and waste. Second, to maintain the view of well-being as defined above, as consumption, while at the same time preserving the environment for future generations goes beyond common sense. It could be argued that human well-being in the form of life expectancy, health, nutrition, low infant mortality has never been so good as under capitalism. But we have to calculate the ecological cost of such improvement. If well-being is a product of consumption, raising well-being could threaten the ecosphere. A balance should be found as well-being can be achieved not only by augmenting global consumption but through redistribution of goods and services.

There is some evidence that the increased consumption (of course after we have satisfied our basic requirements) does not make people happier or healthier[2]. Hinterberger *et al*, (1997) assert that it is possible to maintain well-being with minimum effect over the biosphere by de-linking it from services so that more and more people find that well-being is not necessarily connected to consumption, for example by increasing leisure and having more time to contemplate, to communicate with their friends and families etc. In that case sustainability can be achieved with fewer services as long as well-being is maintained over time. This seems a rational view, but de-linking well-being from consumption implies human societies different from that proposed by eco-economists. Yet a fast change of attitude seems unlikely. For decades people heard from the mass media and political discourse that more income means greater well-being. I think that the majority of people at a given moment could accept that well-being could be found through a simpler way of life with more human and spiritual values in place of material goods; but it would not necessarily make them change their consumer behaviour much, if external pressure to buy remains part of every day life. It is one thing to be aware of a problem, another to change. It is necessary here to 'think the unthinkable', to imagine changes which seem possible.

This seems a vicious circle. If the purpose is to achieve consensus, the process is problematic because each culture and even individual has a particular view of well-being. It may not be possible to agree about how we should sustain well-being. With this perspective, instead of generalizing the concept, it would in theory be better if every human group defined it for themselves. The result could include societies opting for less sustainable or unsustainable systems, but at the same time there could be an opportunity for others to adopt a large variety of more sustainable ways. Logically the unsustainable ones could collapse but the

[2] Whereas the GDP per head in the United States has continued to increase since 1950, the Genuine Progress Indicator (GPI) shows a steady decline which mirrors people's experiences and perceptions of their well-being. For instance, 50% of Americans considers themselves to be overweight, 50 % consider they consume alcohol in excess of 'moderation', etc. (Fricker, 1998).

effect being more local the probabilities of spreading the negative outcomes to broad portions of the earth would be reduced. There could also be more opportunity for societies to learn sustainability from each other. Having more options can lead to more knowledge, so I think that, like biodiversity, cultural diversity should be included in the concept of sustainability.

It could be argued that criticism is sterile if there is no proposal of an alternative model. The problem is that any alternative seems utopian when it is not consumption-based. Over-consumption is a part of everyday life for the prosperous, people feel good consuming and a different approach looks like a return to a primitive age. We expect a saviour model granting equity without pollution while preserving the over-consumption culture. To me that is not possible, environmental problems are to a great extent the result of over-consumption so that sustainability is antagonistic to the present economic model. There may be alternatives. Bennholdt-Thomsen and Mies (1999) for example, argue that the answer is to return to subsistence at all levels: local, regional and national. Giving preference to local natural and human resources for satisfying needs is seen as a way to reduce energy expenditure and waste at the same time that more employment opportunities for local people are promoted. At the same time they suggest a change in people's perception of needs. But this would not be capitalism. Bennholdt-Thomsen and Mies's (1999) position seems rational, naturally and humanly possible, but for those wanting to preserve over-consumption it is utopia and at present there is no better way to disqualify alternatives than labelling them utopian.

Thus it seems that there is no choice but capitalism. I believe that humanity is still culture-rich to produce alternatives for change. Thinking about only one form of change looks intellectually defeatist and a pessimistic view of the future. The solution does not necessarily have to be the same for every region of the world as there could be many ways to achieve sustainability according to each local culture: capitalism itself is highly flexible. In my view, every society may want to secure the right to be different and that cannot be achieved without political action and people's participation. Many lower income countries argue that, as rich countries achieved their level of well-being by unsustainable practices and by passing much of the environmental cost to poor nations, it is not ethical to impose an economic model and at the same time to force only poor countries to adopt more sustainable practices because that would perpetuate the gap between the North and the South. Daly and Cobb (1989, p7 cited by Bridger and Luloff, 1999, p380) assert that *"Given the extent to which the belief system associated with capitalism has penetrated nations of the south, it may be politically impossible for the north to demand that their less fortunate neighbours pursue policies which strictly adhere to the idea that the development involves … the qualitative change of a physically non growing economic system in dynamic equilibrium with the environment".* In fact, it would be desirable for the North to stop growing while the South grew fast, but would northern economic interest and public opinion let it happen? The problem is how to make the transformation, and surely it is not within the present mainstream approach.

There are studies which suggest that our concern for the environment decreases as we become more affluent (Dunlap *et* al, 1993; Dunlap and Mertig, 1995). Fricker (1998) argues that the few examples of sustainability are found where there is no affluence, in Amish communities for example, and that this is because of the greater equity, justice and social cohesion found there. In South America, the presence of 'islands of sustainability' in the Andes show how some rural communities engage in fairly intensive form of resource use in ways that are ecologically sustainable and socially inclusive (Bebbington, 1997) The challenge to the affluent world is therefore to strive for equity and justice, whilst at the same time creating the conditions for appropriate qualitative development. In my view, the problem is rooted in the permanence of the present consumer, industrial, urban and capitalist economic system, which enhances consumption to produce wealth. The search for simple life styles to achieve happiness, seems impossible under capitalism because in essence it is contrary to its basic principles.

4.6.2 Sustainability and economic growth

According to WCED (1987, quoted in Korten, 1992, p161) sustainability depends on continued growth *"if large parts of the developing world are to avert economic, social, and environmental catastrophes, it is essential that global economic growth be revitalized"*. This, according to Korten is a contradiction of the Commission's own analysis, which concludes that *"growth and over consumption are root causes of the problem"* (Korten, 1992 p161). Continued growth, even if planned with ecological concern, ignores the evidence indicating that present demands now exceed ecosystem capacity (Korten, 1992). This contradiction is well explained by Lele (1991 p609) who states that "*when development is taken to be synonymous with growth in material consumption* –which it is often even today- sustainable development would be *-sustaining the growth in material consumption' (presumably indefinitely). But such an idea contradicts the now general recognition that ultimate limits...exist"*.

We can see in the Brundtland definition and the environmental economics approach (see below) that it is taken for granted that maintaining the western way of life and the dominant economic system is possible without affecting the environment by augmenting the efficiency of industrial processes. Thus the leading financial institutions such as the World Bank legitimise the imposition of the modern way of life on poor communities in the South under the names of 'empowerment' or 'poverty alleviation', using 'participation' to legitimise such imposition. Can this change to cultural values of poor communities under the name of sustainable development be called sustainability? Were such sustainable development to be possible (and according to the previous discussion it seems that it is not), the question is whether or not the earth can withstand sustainable development for all the poor of the planet. Do we know the earth's limits for certain? Do we know how much energy expenditure the earth can resist?

Following the WECD line, there is the approach of those environmental economists who see the environment as a commodity which can be analysed just like other commodities. They assert that the only way to protect the environment is by giving it a proper economic value. The impacts which ecosystems have suffered are thus the result of their lack of value which causes them to be over-used (Redclift and Benton 1994). But these arguments are not sufficiently convincing. How do we set the value of natural resources? In the present market driven economy, we cannot guarantee the preservation of ecosystems just by giving value to nature, no matter how high the value might be. If global ecological stability were to depend on the Amazonian rainforest, for example, the common benefit it provides should be enough to guarantee its preservation through international cooperation without establishing arbitrary values which could be surpassed if rare or precious natural resources were detected.

This debate has led to the definition of two categories of sustainability in ecological economics which involves describing the relationship between *"dynamic human economic systems and larger dynamic, but normally slower-changing ecological systems*[6]*"* (Costanza *et al*, 1991 p8-9): 'weak sustainability' and 'strong sustainability'. Conceptually, weak sustainability is based on the savings role of nature and substitutability between capital and natural resources. It assumes that total capital stock should be constant and that natural capital (the contributions of the non-human world to economic production) and the contribution of human manufactured capital are substitutable (Gowdy and O'Hara, 1997). It is the total stock of humanly created and natural capital which must be maintained. In practice, this means that as natural capital is depleted, it must be offset by gains in human capital (Daly and Cobb, 1989). On the other

[6] In its normative meaning, this relationship visualizes a sociological context in which: 1) human life continues indefinitely, 2) human individuals can flourish, and 3) human cultures can develop; but in which effects of human activities remain within bounds, so as not to destroy the diversity complexity, and function of the ecological life support system (Costanza, *et al*, 1991).

hand, a 'strong sustainability' focuses on maintaining the stock of natural resources over time, including the capacity of nature to assimilate wastes (El Serafy, 1997). Natural capital must be kept constant, this is advocated on the argument that natural resources are essential for many purposes, including the continuation of economic activities, as natural resources provide the ingredients to which value may be added by labour and capital (El Serafy, 1997). If environmental resources diminish, economic activity will decline, if not immediately, then inevitably later (El Serafy, 1997). Strong sustainability rejects the idea that humanly created growth can offset the continual loss of natural resources. It argues that human and natural capital must be maintained separately, since *"...they are complements rather than substitutes in most production functions"* (Daly and Cobb, 1989, p72).

Hinterberger *et al.*(1997) argue against using 'natural capital' to refer to nature. To them, natural capital is not an adequate description of dynamic ecological systems that should be sustained. This is because basic definitions of 'capital' in economic theory often exclude nature, capital being rather a factor of production used by humans in order to extract useful goods from nature or, along another sense, *"capital is not physical at all, but a fund (of money)"* (Hinterberger *et al*, 1997 p6). They say that the notion of natural capital faces the problem of 'valuation' because this criterion cannot be satisfied with physical or monetary measures. Hence, there is no way to know what value future generations would place on the components of the stock. Another critique of 'natural capital' is the implication that nature can be reproduced by humans, and can therefore be substituted, which is clearly a wrong perspective as one ecosystem cannot replace another. As an alternative they suggest the use of material input per unit of service (MIPS) as a measure for sustainable development. MIPS is based on the first law of thermodynamics: every waste flow is the result of material inputs into the ecosystem, so that reducing material input means waste reduction. MIPS implies a change in perspective from stock to flow. 'Material input' is a non-monetary indicator which counts the material input of economic systems in kilograms. The material inputs are grouped into five categories: movements of biotic and abiotic materials, earth, water and air. Nevertheless, Hinterberger *et al.*(1997) recognise that this approach can only affect real economic development if the principles are both understood and accepted by most individuals and political decision makers. In the same way, the concept needs a socio-economic development that re-considers the present generalized nature of production, lifestyle and the politico-economic systems.

Free market environmentalists such as Simon (1996), argue that there is no contradiction between continued growth and sustainability. For them consumption causes shortages, so that prices rise; this leads to finding new ways to satisfy shortages, and in the end we end up better off than if the original shortage problem had never arisen. In other words, depletion of resources erosion, pollution etc. provides the impetus needed for the continuous improvement of the human condition.

Can sustainability be reached while preserving high rates of consumption? Some say yes. Agenda 21 requires higher income countries to reduce their use of natural resources and production of wastes whilst simultaneously improving human amenities and the environment. But Moir and Mowrer (1995) think that to achieve a precarious balance between consumers and environmentalists may merely defer problems to the future, when they become even more intractable. What may be 'cautious' action to one group is outrageous to another. Here a new question emerges. What is meant by human amenities? Does this imply the western view of standard of living defined as material consumption? Fricker (1998) argues that it is possible to maintain the standard of living through greater efficiencies but simultaneously improving the quality of life. He suggests that quality of life could be improved even at a lower 'standard of living', because just as human needs are not absolutes, neither is the 'standard of living' nor the 'quality of life'. But if quality of life could be improved even at the expense of the standard of living, which today is measured as a function of consumption, then that implies that a reduction of consumption would be required which contradicts the capitalist approach. An example of the impossibility of sustainability in a consumer society is cacao processing in Tabasco. In economic terms it is cheaper to send raw cacao to the fermentation and drying plant even though it uses more fossil energy than selling it already dried by solar energy, as that requires more labour. The system is ruled by economic laws which do not obey natural or physical laws but human laws which are artificially created or conceived.

4.7 The problem of achieving a universally accepted definition of sustainability

In the absence of a common point of departure, such as a common definition on sustainability, well-being, needs, etc. it would be impossible to get visionary directions that would lead to achieving a sustainable world. It is difficult to conceive of a concept of sustainability that satisfies and reflects all views, because everybody has a different ideal for the earth. But which human groups are looking for an ideal for the earth? There are societies which are not so ambitious, whose visions are only for their own environments (see below). There are others, even humbler, which do not have a vision, but just live respecting nature as they have done for generations. What is important for one person depends on the context in which he or she is living or has lived; so that needs, problems, visions, expectations, freedom, growth and life, in general have different meanings in every social and natural context. It is complicated to agree on a plan for the planet because it is impossible in a diverse world. If every society was to look at their own mistakes and seek for solutions to the crisis each has created in their own environment without trying to impose their views on other societies, maybe there would be no need for consensus about sustainability. I argue that a single definition of sustainability is not possible, and that the concept would be better defined locally. Every human group wants to sustain different things.

4.8 Other approaches to sustainability

As a result of the diverse criticisms, the debate has shifted from sustainable development to sustainability. Definitions of sustainability have been presented, sometimes eliminating 'human needs' from the context. But the removal of consumerism, and economic growth does not itself solve the problem because there is still great disagreement as to the root of environmental problems, the way to address them and the solution. In summary, there is no agreement about what sustainability is or should be. Some approaches call for alternative changes (Shallow ecology), others for the respect of local perceptions of reality as a central element for diversity and richness of knowledge (eco-theology, community sustainability), others for new paradigms (Political ecology, Deep ecology, Social sustainability), etc. But no approach is either strong enough to resist criticism or explicit enough about how to make the change.

4.8.1 Ecology related approaches

In ecology, nature is seen as a self organizing system that changes, responds, and evolves over time through a highly variable set of quasi-stable conditions and is sustainable in the sense that it has no discernible goals or purpose and is self-controlled within larger scale constraints. Shallow ecology treats the environmental problems without tackling the underlying causes and without confronting the philosophical assumptions that underlie our current political and ecological thinking (Clark, 1993). Deep ecology identifies the root of the environmental problems as cultural and in particular as those cultural values legitimising the domination of nature, so that reforms of social-economic systems are not enough to solve the crisis. Deep ecologists propose replacing anthropocentric hierarchies with biocentric egalitarianism and see richness and diversity of life as values in themselves. They assume that human beings have no right to reduce these, except perhaps to satisfy their most basic needs. They also stress the need for cultural and social diversity as necessary preconditions for the survival of life on earth (Braidotti *et al*, 1994). Political ecology offers an interdisciplinary approach in diversity because it address four key challenges: holism, empowerment, social justice and sustainable production and reproduction (Pezzoli, 1997). Bryant (1997), for instance, argues that sustainable development cannot be translated into effective policy programmes in poor countries unless research is informed more by power relations. For political ecologists a factor 10 reduction seems a reasonable 'ball park number' for the necessary reduction in energy expenditure in the North and argues that a sharp increase in resource productivity of industrialized economies is needed to avoid severe reductions in wealth and well-being (Hinterberger *et al.*1997). They see an average tenfold reduction of the resource intensity of services delivered as technically possible, without reducing convenience, safety, health care and the like. But appropriate political signs are crucial (Hinterberger *et al.*1997).

The resource maintenance approach emphasizes the maintenance of existing and future resources rather than continued growth. In this view, efforts are focused on minimising the impact on the environment through limiting the use of natural resources while simultaneously meeting the material needs of people (Batie, 1989 cited by Bridger and Luloff, 1999). The protection of natural resources is an explicit goal and is placed on an equal footing with economic considerations (Bridger and Luloff, 1999). This approach *"requires a fundamental rethinking of our relationship to the environment, consumption patterns and standard of living*" (Bridger and Luloff, 1999, p379), and is characterised by an appreciation of nature, satisfaction of vital needs rather than desires; anti-consumerism and minimisation of personal property; and the use of simple and appropriate technology whenever possible (Naess, 1995 cited by Bridger and Luloff, 1999). This approach calls for affluent countries to reduce their consumption (Bridger and Luloff, 1999). For example, the factor 10 concept focuses on materials, and assumes that sustainable material turnovers will not be reached unless and until the material intensity of the OECD countries is reduced by a factor of ten (Scmidt-Bleek, 1994; Scmidt-Bleek 1997 cited by Robert 2000).

Some eco-feminist literature identifies the destruction of natural resources and over-consumption as the two most immediate threats to our survival. In this perspective, the male system is the source of the threat and the only way to change this is by the feminisation of the power (Mies and Shiva, 1993). Eco-socialism states that sustainable development is a contradiction in terms that can never be realized. The ecological crisis is the result of a crisis within the capitalist system which can be overcome only through ecologically oriented socialist development. They argue that humans are not a pollutant, neither are they guilty of hubris, greed, aggression, over-competitiveness, or other savageries except under the present capitalist socio-economic system. The alienation from nature is a separation from a part of us which can be overcome by re-appropriating collective control over our relationship with nature, via common ownership of the means of production. Changing the mode of production means changing many needs, and the resources to fulfil them, and also the set of ecological problems to be solved (Pepper, 1993). Conversely, eco-theology states that the main source of the problem is human greed and the solution lies in a renewed commitment to humility, to the virtue of detachment, and to the central religious posture of gratitude by which we accept the natural world as God's gift and treat it accordingly (Hought, 1996).

There is clearly a varying degree of validity in both the criticisms and the solutions offered by these approaches. I believe that the problem is that scholars adopt a narrow position and for that reason it is difficult to adopt one of those approaches in this research.

Political ecology is entirely convincing in saying that increasing efficiency is necessary, but that it is not enough to solve the problem. Even if technology is able to produce environmentally friendly products and to augment energy efficiency, as consumption is the basis of growth in capitalism, new needs will still be continually created so the consumption of environmentally friendly goods will increase and the problem will remain the same.

Although eco-feminism, eco-socialism and eco-theology seem to be discrepant approaches they are arguably complementary. Patriarchal culture is a source of many environmental problems, but there are non-capitalistic patriarchal subsistence societies in which people have different (more respectful) relationships with nature (as there are those which are exploitative). It is difficult to believe that in a capitalist society the mere transfer of power to women would end the threats to the environment. Similarly, capitalism has not been the only cause of the environmental crisis as the industrial societies of the ex-socialist countries were also a source of much environmental damage. The communal use of resources can help but *per se* does not guarantee sustainability. By the same token to judge greed or 'unlimited want' as universal traits of humans is debatable. There are small human societies in which people establish limits to their desires and greed, Mennonites in USA, Mexico and Central America and many subsistence hunter-gathering groups in the tropics (see Sahlins, 1974, for examples). The same is found in northern Pakistan where local pastoralists practice a kind of community[7] and resource-use sustainability centred on the relationship between the symbolic meanings attached to ecological resources and the instrumental uses of those resources (Butz, 1996). Although it would help, finding the solution to the environmental crisis only by religious virtue does not seem very probable. First of all we need to change the Judeo-Christian perception of humans as a superior entity provided with the divine grace to dominate other creatures in nature and therefore to transform the environment at their will. To me, over-consumption is a key factor of the problem which can exist in any economic system or regime, run by men or women, individualist or collective, religious or agnostic. This will continue whilst there is no

[7] It must be repeated that 'communities' in this thesis refer to local groups, recognising that these are in no sense an ideal, but highly subject to internal conflict, hierarchy and social exclusion.

transformation of our view of 'needs', 'standard of living', 'wealth', 'quality of life', etc. Another similar problem is universalisation, the tendency is for most approaches to set themselves up as paradigms. Human societies are diverse and so should ways be to address sustainability. Every society could be able to seek its own way according to local conditions, culture, religion and beliefs. All attempts to define a sustainable world where human groups do not have the possibility of defining their ways of change seem questionable. This, in fact is considered in the article 8(j) of the Conservation on Biological Diversity on *in situ* conservation calling for signatories to *"respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity"* (UNEP, 1994). It could be argued that such cultural fragmentation could give rise to negative practices such as slavery, minority oppression, environmental disturbances, etc. But that is a risk we have to face. The west had its time in history to change to more inclusive societies, women have been emancipated, differently abled people have gained rights, people are thought to have more ecological awareness[8]. These changes were the product of internal political activism rather than of external imposition. In the same way I believe that, this is a process every society has to follow and be the result of their own history. Nevertheless, we are still far from reaching such a goal, because in practice the recognition of indigenous rights by the dominant industrial societies may often not include rights of indigenous people to manage resources in their own way. This is because resource management is considered to be based on scientific principles that are not culturally related. The recognition of this right, however, might be achieved by demonstrating local people's knowledge and sustainable management of their environments and showing that their

[8] Nevertheless Martinez-Alier (1995) argues that the assumption that only rich countries exhibit environmental awareness ignores an 'environmentalism of the poor' which seeks to maintain access to communal resources under threat from state development programmes and market processes. This 'environmentalism of the poor' seems to be expressed in Dunlap, *et al.*(1993) whose results from a survey in 24 rich and poor countries surprisingly suggest that people in poor countries have more environmental concerns.

conservation of local environments and biological diversity is a vital part of a global effort on behalf of all humanity (Cleaveland and Murray, 1997).

4.8.2 'Social sustainability' and 'Community sustainability'

Based on the idea that 'sustainable development' fails to acknowledge the importance of social, cultural and political processes in the emergence, definition and development of policies, other approaches to sustainability related to the scale of organization have been proposed. Social and community sustainability differ at the levels in which sustainability can be reached. Social sustainability claims to be achievable by the implementation of global policies (Scott *et al.*, 2000) whilst community sustainability maintains that the only way sustainability is possible is at the local level (Berry, 1993).

Social sustainability is a broad concept which embraces the social, cultural, political and economic resources necessary for livelihood, social participation, identity and a sense of worth, without invoking a politics of nostalgia, or 'traditional' values. Economic and environmental sustainability are intrinsic to the concept but with a local and historical content including elements of livelihood, social participation, justice and equity. The search for social sustainability involves fostering processes which allow people who form different communities of interest to engage with the issue and each other in new ways in an effort to get things done. It becomes a global struggle, but experienced in locally specific ways (Scott *et al*,.2000).

The top-down approach of the supporters of social sustainability is contested by those following community sustainability. They argue that because each local culture has its particularities which create difficulties in achieving sustainability at a global level because, in practice, at the macro-level solutions for unsustainability tend to be given by those who have created it. In other words talk of sustainability at a global scale strengthens the social and economic conditions which support unsustainable practices (Munton, 1997; Bridger and Luloff, 1999; Yanerella and Levine, 1992a). Instead, they propose a bottom-up perspective, as the locality is the level of social organisation where the consequences of environmental degradation are most keenly felt and where successful intervention is most noticeable. Sustainable community development may be the most effective means of achieving sustainability on a broader scale (the adoption by each community of sustainable practices would lead to global sustainability in the future) (Bridger and Luloff 1999, Yanerella and Levine 1992a,). Barton (1998) explores how eco-neighbourhoods in different countries can fulfil the 'sustainability trinity' of environmental, socio-cultural and economic long-term viability. Protagonists of social sustainability assert that the weakness of community sustainability is that confusion exists in discussion about sustainability and about how people conceive of themselves as part of a group, as not all members share the same interests and so divisions are present. This confusion, they say could contribute to the re-entrenchment of the dominant discourse.

The sustainable community development approach is local. It stresses the importance of striking a balance between environmental concerns and development objectives whilst simultaneously enhancing local social relationships. Sustainable communities meet the economic needs of their residents, enhance and protect the environment, and promote more humane local societies (Bridger and Luloff, 1999). Berry (1993, p14) defines a sustainable community' as *"a neighbourhood of humans in a place, plus the place itself: its soils, its water, its air, and all the families and tribes of non human creatures that belong to it... we are speaking of a complex connection not only among human beings and their homeland but also between the human economy and nature, between forests and field or orchard, and between troublesome creatures and pleasant ones. All neighbours are included"*. Similarly Kline (1995, p4) sees sustainable community development as *"the ability of a community to utilize its natural, human, and technological resources to ensure that all members of present and future generations can attain a high degree of health and well-being,* *economic security, and a say in shaping their future while maintaining the integrity of the ecological systems on which all life and production depends".* Although both definitions sound attractive they are also debatable. If all neighbours are included, how can the exploitation of nature for human purposes fulfil desires that are not basic requirements? It seems clear that conflicts can be produced by the competition for resources between communities and even between individuals within the community. For instance, Heiman (1997) reviewed innovative community-based attempts to make toxic waste producers accountable, but found that these are still unable to challenge the basic incompatibility between capitalism and sustainability and thus to restrain locally deleterious decisions made by powerful (often global) corporations.

In spite of the difference in the level in which the change could be achieved, social and community sustainability share more similarities than differences and it could be fruitful to make them complementary. Probably the main contribution of community sustainability is the valuation of the local and diverse as reservoirs of knowledge and as dynamic units for social change. Nevertheless this approach still carries with the 'ideological baggage' of institutional definitions such as intergenerational equity and natural capital. Thus, the concept is not challenging the causes of unsustainability rooted in excessive consumerism but it tries to adjust the same economic rationality to a more environmentally friendly and socially equitable development. Social sustainability, on the other hand, seems to cover most of the elements necessary for a change, however some apparent contradictions need to be clarified. Is it possible to reconcile economic and environmental sustainability, taking into consideration the ways in which economic success is evaluated today? How can complexity be managed well enough to evaluate sustainability if so many social, cultural, economic and environmental factors are included? How is it possible to face the resistance of the economic, cultural and social elites on one side and the community and individuals on the other?

Two questions arise. Are social and community sustainability suitable in this globalized world? Is there enough time and do the political conditions exist to implement this gradual change? There are forces competing with each other for resources, communities against each other and economic elites against communities. The most powerful more often wins. When resources in a community are valuable, the interest of large corporations can turn political decisions against the community. This suggests that changes should reinforce democracy, making it more participative. Such a change however, is beyond community action; it would be a national achievement which required a community network organization to achieve national goals. Resistance from the establishment could also be faced, and be even worse in southern countries where democratic institutions are even less strong. The problem is clear in the words of a fish farmer in Jonuta, Tabasco:

"The government is always interested in developing the community if they keep control of us; once they realise that one is independent, they will look for ways to destroy our organisation"

Fish farmer, Boca de San Geronimo, Jonuta

In my view, there is no doubt that changes at macro and micro level need to be simultaneous to guarantee even relative individual freedom. To me, the critiques of both approaches are sound, nevertheless neither offers a complete solution to the problem and it would be desirable to look at them as complementary rather than opposed.

4.8.3 Non-materialistic approaches to sustainability

Fricker (1998) looks at sustainability beyond material matters. *"Sustainability is more than just the interconnectedness of the economy, society and the environment. Important though these are, they are largely only the external* *manifestations of sustainability. The internal fundamental, and existential dimensions are neglected. Sustainability, therefore, may be something more grand and noble, a dynamic, a state of collective grace, a facet of Gaia, even of spirit"* (Ficker, 1998 p367)...(sustainability)*"is ...the non material side of life – the intuitive, the emotional, the creative and the spiritual, for which we need to engage all our ways of learning... Perhaps there are indeed some fundamental and universal truths if meaning and spirituality are components of sustainability. Morals and Values, however, are not necessarily absolutes, and can be very difficult to define."* (Ficker, 1998 p368). Similarly for Viederman (1995) sustainability is a vision of the future that provides us with a road map and helps us focus our attention on a set of values and ethical and moral principles by which to guide our actions.

Although it could be considered a romantic position, the strength of these views is in the emphasis on the need to change moral values to achieve sustainability. The problem is how to change these and more importantly how to make it a general practice. Societies seem to have enough good moral values to reach sustainability, but few people follow them.

Mebratu (1998) argues that an essential source for the havoc wreaked by western societies upon the earth is the Judeo-Christian view about *"Man"s right to master the earth"* (Genesis, 1:28). His reflection seems appropriate considering that the technological civilization was developed in Christian nations. Although this could be part of the problem but not necessarily the main cause as not all Christian societies have a similar attitude to nature. There are many Christian societies in which people's relation with nature is more harmonious such as some peasant communities in the tropics in Latin America for example. Traditional peasants in Tabasco sometimes work less than 8 hours a day as land is fertile so that there is no need to exploit it more. To the Northern Mexican peasant mentality, where the land is dry and poor, and where they have to exploit it to its limit, Southern farmers are lazy because they are satisfied with the products the land gives to them, which is enough for a simple way of life. Both groups are Christians, but differ in the way they see nature. Probably, the Tabasco view is rooted in local pre-Hispanic knowledge but it is mixed with Christian beliefs:

"I do not kill the birds who come to eat the fry in my pond. God provides for everybody; all of us have the right to eat, my family have the right and so do the birds".

Fish farmer, Vainilla, Nacajuca.

In Asia, Africa and America there are indigenous beliefs conceiving of humans not as masters of the universe but part of it. Although these beliefs have different contexts and structures, the core element is the importance of living in harmony with nature (Mebratu, 1998). In other words these beliefs have a holistic vision as against to the reductionist vision of the dominant contemporary culture. Thus the concept 'sustainability' (according to the origin of the concept, section 4.4) is purely western but the idea is not new. Living by respecting the environment was (and still is, in some cases) for many indigenous societies part of everyday life. Although this less anthropocentric view has been marginalized and reduced to 'primitive' by the western industrial perspective, I see it as advanced knowledge product of centuries of intergenerational experience, being devalued by the short-term view of industrial societies which have not been able to comprehend it.

Thus in the last 40 years industrial societies have been discovering what was perceptible to many cultures thousands of years before: the need to live in balance with nature for preserving our species. Now Cleaveland and Murray (1997, p495) describe *"the increasing acceptance of the need for more sustainable agriculture and for reducing the impact of other human activities on the environment is challenging not only assumptions about sustainability of industrial and indigenous resource management but the concept of national sovereignty over natural resources"'.*

4.9 Putting sustainability into practice

Most governments are ready to challenge the argument that economic growth and environmental protection are necessarily in conflict. Myers and Macnaghten (1998, p351) concluded that *"the rhetoric of environmental organisations and the rhetoric of everyday talk about the environment are seriously out of joint, with the result that the public are not influenced by environmental persuasion to change their behaviour in straightforward or predictable ways".* For example, the 1995 edition of the UK White Paper *This Common Inheritance* concludes that *"Ultimately, sustainable development requires a response by every member of the society, by millions of individuals' choices about their lifestyle"* (H.M Government, 1995a). To change attitudes to sustainability is difficult, because many members of the UK public still remain confused about the idea of sustainability, so attitudes could change against certain unsustainable practices, but that would need the cooperation of the mass media and local and national governments. For a period in 1989, environmental pollution was regarded as a more serious matter than any other social, economic or political issue in the UK, but since 1991 it has lagged far behind anxieties over unemployment, the economy and the health service (Munton, 1997). Over-consumption has to be reduced, and it is necessary to find values and to re-defining 'well-being' and 'quality of life'. But to reduce consumption is to constrain economic growth which no present government would wish.

4.10 Principles and guidelines for sustainability

There is wide conceptual disagreement around sustainability. But what should be done? Is it necessary to abandon the concept? Is it necessary to wait for an agreement to start putting it into practice? Perhaps at least some ethical principles should guide development in the new century. Ludwig (1993) argues that the best judgement underlain by social or ethical imperatives may have to substitute for scientific certainty.

There are numerous papers proposing principles to guide and parameters to measure sustainability (see below), analysis of which is beyond the scope of this research. Although some examples are presented they are not necessarily the best, and their language is obscure.

Nattrass and Altomare (1999) listed basic principles for a sustainable future:

a) The funnel – a metaphor for the awareness of the overall problem of non-sustainability: the decline of the ecosphere's capacity to support present day economies, and even life itself. They argue that the walls of the funnel will appear as higher and higher costs for waste management, taxes, insurance, resources, loans, loss of credibility in the market, and market shares lost to those who are planning ahead by skilfully taking those aspects into account.
b) Their four system conditions or basic principles for sustainability in an 'ecosphere/society' system:
    1) Not increasing concentration of substances extracted from the earth's crust.
    2) Not increasing concentrations of substances produced by societies.
    3) No physical impoverishment by over-harvesting or by other forms of ecosystem manipulation.
    4) The use of resources fairly and efficiently in order to meet human needs worldwide. It is essential that the system conditions are applied to guide our decisions by focusing attention upstream on the cause-effect chains.

Robert (2000) presented a strategy to comply with these system conditions:

1) a step-by-step approach, systematically to replace activities that are not compatible with the system conditions, by activities that are, or can be elaborated in that direction, 'the principle of substitution'
2) flexible platforms. To link the short term technically with the long term, and
3) 'low hanging fruit'. To link the short term economically with the long term. In combination all these are strategic principles that can allow substitution to link short term steps with long term technical and economic solutions and
4) the precautionary principle, particularly when there is doubt whether activities contemplated comply with the system conditions or not, and when such activities would consume large amounts of resources.

Afgan *et al.*(2000) defined the sustainability criteria for the energy system as follows:

1) The system should reflect sustainability.
2) It should be defined with indicators which can be measured as physical parameters and are available in quantitative or qualitative data.
3) It should be based on timely information. This means that the energy system and its subsystems have to meet sustainability through every stage of the life cycle.
4) It should be based on reliable information.
5) It should reflect a strategic view, since sustainability is not a quick fix of current problems but a way of choosing actions today that will cause fewer problems tomorrow. The energy system may be interpreted as: a mixed energy concept with optimisation of local resources, urban and industrial planning with transport optimisation and use of renewable energy.
6) It should give opportunity to optimise the system to *minimise* energy cost, the use of materials, government regulations and financial

resources; while *maximising* protection of the environment, together with safety, reliability, availability and maintainability of the system.

7) It should reflect longevity of design. The life of the elements and subsystems is not equal.

Moir and Mowrer (1995) propose five itemized guidelines which may be helpful when difficult and often controversial decisions are to be made.

1) Be explicit about responsibilities to future generations and discount present values of the resources accordingly, which usually means curtailing demand.
2) Analyse the effect of a proposed activity at all important space-time scales. A decision to set aside resources without reducing high consumption of that resource in a global economy may increase the burden on other countries to provide that resource.
3) When the stakes at any scale are high, be cautious. The precautionary principle states that an action or non-action should be made before harm to the environment becomes visible. High levels of natural variability and reductionism of ecological models can hide overexploitation, surprises, and possible irreversible changes in non-equilibrium systems.
4) When environmental risks are high or when there is possibility of irreversible damage, then spread the effect unevenly over the land and maintain a high level of spatial diversity. Providing spatial redundancy is a good tactic when management results are uncertain. And finally
5) To help reduce possibilities of instability or chaos, by taking actions that avoid long time lags, large growth rates, and introduction of highly efficient predators or parasites.

Similarly three principles have been proposed by Viederman (1995, cited by Fricker, 1998) to inspire the discourse on sustainability.

1) The recognition of the limitation of human knowledge. The humility principle;
2) The precautionary principle, which advocates caution when in doubt; and
3) The reversibility principle, which requires us not to make any irreversible changes.

The problem with these views is that they are generally short on the social aspects. Can environmental problems be addressed only with ecological and economic logic? Generally most principles are very difficult to accomplish under the present competitive economic system, and putting them into practice would depend on the political will of industrial countries and emerging economies. Most scholars invoke the precautionary principle but strict application would slow down innovation and economic growth.

If such recommendations are well-founded or at least based in reason, the problem is how to put them into practice. Definition of indicators of sustainability then becomes necessary.

4.11 Measuring Sustainability

Even though discussion of sustainable development and sustainability is not complete, an extensive literature continues to look for indicators and ways to measure sustainability. Developing a set of objective, universal indicators has been problematic both ideologically and in practice. Measures of sustainability at present tend to be an amalgam of economic, environmental and social indicators but these are not widely accepted indicators as each factor and method reflects specific approaches, sometimes divergent.

Although there is no approach which could simply fit into this research, the following two could be useful for evaluating semi-subsistence aquaculture systems. Environmental and social problems have grown until there is no time to wait for a conclusion of the debate on sustainability permits consensus on parameters and methods. The decision to do nothing may be inappropriate.

Fricker (1998) analysed indicators applied to closed physical systems and discusses their application in sustainability. He found that many are limiting measures reflecting unsustainability, and survival[9] rather than sustainability and their main value is in indicating the direction of change rather than identifying a desired state. Nevertheless he argues that many social (e.g. standard of living, quality of life etc.), environmental (related to the environmental sphere closest to the human activity) and ecological (related to ecosystems, where the human impact is not so evident) indicators are in fact also sustainability measures. For him, economic indicators are not useful as measures of sustainability (Redclift, 1987): *"it is difficult to conceive how any index which has consumption as its base can be a measure of sustainability"* (Fricker, 1998 p371).

Hart (1995) suggests seven criteria as indicators for sustainability:

1. Multidimensional, linking two or more categories.
2. Forward looking.
3. Emphasis on the local.
4. Emphasis on appropriate levels and types of consumption.
5. Measures that are easy to understand and display changes.
6. Reliable, accurate, frequently reported data that are readily available.
7. Reflects local sustainability that enhances global sustainability.

The problem with these criteria is that they lack social indicators such as quality of life, possibly because quality of life is a subjective condition, and remains difficult to measure.

[9] In Fricker's view survival is merely not dying, whereas sustainability is more about *"justice, interdependence, sufficiency, choice and above all, the meaning of life"* (Fricker, 1998, p368).

The sustainable community approach looks more appropriate. The ideal typical sustainable community can be defined by five dimensions (Bridger, 1997 quoted in Bridger and Luloff 1999) (see also chapter 8).

1. An emphasis on increasing local economic diversity.
2. Self-reliance.
3. A reduction in the use of energy coupled to the careful management and recycling of waste products.
4. The protection and enhancement of biological diversity and careful stewardship of natural resources.
5. Social justice and efforts to create an empowered citizenry.

4.11.1 Methods for measuring sustainability

A number of methods for measuring sustainability have been developed in recent years. Some yield good indicators but they are not comparable. Environmental management systems (EMS) are administrative tools for environmental work within firms. The Factor 10 concept (Schmidt-Bleek, 1994) is a very direct way of using metrics on various activities that can reduce the throughput of resources and energy in relation to the utility, in other words 'by what factor can – or should – a particular flow be reduced?' Life cycle assessment (LCA) (Heijungs *et al*, 1992, cited in Robert *et al*, 2000; Carlsson-Kanyama, 1998) is a way of evaluating all processes involved with a certain product or service, 'from the cradle to the grave' i.e. from resource extraction, through transport, processing, maintenance and disposal of the product. LCA is a way of creating an overview of the total complexity of interactions between different processes in industrial societies and the ecosystems. It permits planning ahead, because we can simulate new conditions for the future, when various things like transport systems, etc. have changed.

Other methods have been developed more recently like ISO 14031 (Veleva *et al*, 2001), Factor 4 (von Weizsäcker *et al*, 1997), Sustainable Technology

Development (Weaver *et al*, 2000), Natural Capitalism (Lovins and Lovins, 2000) and The Natural Step Framework (Robert, 2000). These have been supported by a number of organizations and programs. Nevertheless this variety has led to some confusion regarding the qualities, differences and linkages between the various tools, and, consequently, questions on how best to apply them (Robert *et al*, 2002).

Ecological Footprint (Rees and Wackernagel, 1994) is a way of 'bench-marking" all dematerialisations[10] under the system conditions[11] (Robert *et al.*, 2002). In this concept the outcomes of various activities in societies are measured and aggregated into units of area, i.e. as a reduction or an increase in the ecological area needed to support the activities. All the accumulated 'footprints' from various local activities are related to the total carrying capacity of the ecosphere. This provides a tangible way of describing the relevance of smarter technologies and more subtle lifestyles, sensitive to demands on the environment, as means to reduce 'footprints' of affluent societies in line with the system condition (Robert, 2000).

4. 12 Sustainability and aquaculture

Like other commercially oriented activities, commercial aquaculture has been a cause of environmental degradation and social problems throughout its development. Problems associated with aquaculture production have more to do with the kinds of systems (level of intensity, the physical area where the farm is located and the management provided) than to the region in which the development is carried out. In fact, most environmental and social problems are provoked by commercial systems, usually with an intensive or large-scale operation (Beveridge *et al*, 1997a). Artisanal or subsistence aquaculture, on the other hand, causes minimum environmental impact (Muir *et al*, 1999), and in

[10] For dematerialisations the author refers to substitutions (see section 4.12)
[11] The system conditions are listed in section 4.12

many cases promotes biodiversity and enhances social relationships in the villages (Beveridge *et al*, 1997a). The best known impacts of aquaculture on the environment worldwide are:

- It facilitates the spreading of diseases in natural water bodies. Especially in intensive cage cultures, the stress conditions produced by the high densities make fish more susceptible to disease and parasites. These can be transferred to natural fish populations when cultured fish escape and when the farm is in direct or indirect contact with natural water bodies (Beveridge, 1996).
- Organic and chemical pollution of natural water bodies follow (Beveridge, 1996).
- Overfishing of wild fry is common (Deb, 1998).
- It can create problems for neighbouring agriculture farms such as salinization, and environmental costs are sometimes imposed on neighbours, such as the need to build dikes or raise their land height to reduce salt intrusion from nearby shrimp polders (Tisdell, 1999).
- Habitat destruction to create ponds is common (Beardmore *et al*, 1997a).
- Disappearance of seasonal lagoons occurs (Dewalt *et al*, 1996).
- Competition with endemic fauna by escaped exotics can be serious (Beardmore *et al*, 1997).
- Genetic introgression with local fauna by selected populations, species and transgenics can occur (Beardmore *et al* 1997).

Sometimes aquaculture alters aquatic environments irreversibly and destroys or diminishes the natural resource-base on which it depends for its productivity, and sometimes the external consequences are much larger (Tisdell, 1999). Aquaculture's impacts on the environment stems from the consumption of environmental goods, the transformation (i.e. farming) process itself and from the production and release of wastes, the overall relationship ranging from the positive (i.e. enhancement of environmental quality) through the relatively neutral, to that which results in environmental degradation (Beveridge *et al*, 1997a).

Of all environmental problems in aquaculture, organic pollution is the most apparent. For example, in Chile, despite the use of low pollution diets, the waste (nitrogen and phosphorus) produced by the salmon industry in 1994 was comparable to that of a population of 1.7 – 2.5 million people; which is three times the current population of the Chilean salmon cultivation area (Buschman *et al*, 1996). Major attempts to reduce organic pollution have been made not only because of adverse public opinion, but because aquaculture itself depends upon the environment for essential services such as the replenishment of oxygen and the dispersal and assimilation of wastes which otherwise would accumulate in the production system, exerting negative feedback on fish growth and survival (Beveridge *et al*, 1997a). Nevertheless genetic contamination of wild species could be the most serious impact, due to its irreversibility, but as it is less perceptible, the problem has not yet reached the attention of the public.

Of the socio-economic problems, intensive and large-scale aquaculture has been reported as producing conflict with and damage to other users. For example cages can restrict access to traditional fishing areas and also may interfere with navigation, while residential property values may decline due to eyesores and smells and tourist income lost, etc. (Ridler, 1997).

In Chile it has been reported that aquaculture of mollusc, seaweed and fish causes organic pollution, massive occurrence of plague organisms in the fjords, while increasing sedimentation, bio-deposition, etc. affect the habitat heterogeneity for other fauna. Similarly, introduced species are vectors for transmitting diseases to wild organisms (Buschmann *et al*, 1996). In Bangladesh the shrimp farming industry has been held responsible for overfishing of fry and juvenile shrimps, massive destruction of wild fauna, destruction of mangroves, increased soil acidity, intrusion of salinity into agricultural and wild areas, increased organic pollution, chemical pollution (due to indiscriminate use of antibiotics, fertilizers, disinfectants, piscicides and molluscides); genetic pollution and diseases introduction to wild shrimp populations etc. The socio-economic implications of industrial shrimp farming were also found to be acute. Deprivation of coastal communities of their traditional common resources, labour utility disequilibrium, disruption of traditional safety nets and rising violence are all acute (Deb, 1998).

In spite of all these disturbances, little attention is paid by the public to forcing a change to a more sustainable aquaculture, especially in low and middle income countries. The problem is that most consumers still do not perceive aquaculture products as possessing significant negative environmental attributes or as being unsafe for consumption, as they do in some places for some agricultural products (Tisdell, 1999).

4.12.1The concept of sustainable aquaculture

Increased concern about the environmental consequences of aquaculture, including public opinion, as well as new, stricter environmental regulations have led to the search for more sustainable practices.

At present there is no satisfactory definition of sustainability in aquaculture. One is needed to facilitate the study of sustainability in aquaculture and to justify the mainstream aquaculture studies based on the production of technology for intensive and large-scale farming. Authors tend to distance themselves from the sustainability debate, often ignoring the socio-economic and political dimensions of the problem.

The FAO definition of sustainable development (1990, cited in Branckaert, 1995 p110) is one of the most frequently used definitions of sustainability in aquaculture, and is merely a rewording of the Brundtland Commission's definition (above). *Sustainable development is the management and conservation of basic natural resources and the orientation of technological and institutional change in such a way as to ensure the continued supply and satisfaction of human needs of present and future generations.* Such sustainable development should protect land, water, genetic, vegetable and animal resources, not harm the environment and be economically viable and socially acceptable (Branckaert, 1995).

Sometimes approaches from mainstream agriculture are considered and used in the aquaculture context. The World Bank definition of sustainable agriculture states that it should involve the successful management of resources to satisfy changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources (TAC/CGIAR, 1989). Nevertheless, like the Bruntdland Commission's definition, this is ambiguous in meaning and subject to the same criticisms.

Despite the recurrent call in most aquaculture research for sustainable aquaculture, the reality is that there is little debate on sustainability in aquaculture. Views are dominated by ecological economists, probably because of the entrepreneurial orientation of most literature generated since the global spread of aquaculture in the late 1960s.

There are many definitions of sustainability in aquaculture. Thus Lightfoot *et al.* (1993) see the utilization of the economic, social, nutritional, and ecological services offered by managed water resources and fish as a basis for sustainable farming systems. For Folke and Kautsky (1992, quoted in Srinath *et al*, 2000 p559), sustainable aquaculture is defined as *"the balanced use of resources and ecosystem to satisfy human needs, conserve rural resources, and maintain and enhance the quality of the environment"*. For Pullin (1993), the sustainability of the systems are best considered with reference to their 'evolvability[12]' or scope for future change. Shang *et al*, (1998) conceive of sustainable development in

[12] Referring to the potential of a system to evolve.

the case of shrimp farming as an activity which is in harmony with other economic activities in using natural resources. For them, the activity should produce a reasonable and relatively stable net income and benefit to producers/society on a long-term basis without degrading the environment. Its development has to be balanced among production, marketing and other supporting services. Therefore it has to be bio-technically feasible, environmentally sound and socio-economically viable (Shang *et al*, 1998).

Boyd and Schmittou (1999) make a whole series of important statements. They suggest that the FAO definition of sustainable development ignores the debates and lacks criteria for sustainable development, so its adoption in aquaculture is not suitable. They emphasize that most aquaculture environments have not been properly studied, have been modified without clear understanding of total impact, and are not viewed holistically in an ecosystem concept. In their vision, *"an adaptable production technology system whose ecological and economic viability can persist indefinitely is a sustainable aquaculture system"* (Boyd and Schmittou, 1999 p62). To me the weakness of this definition lies in problems stressed by the authors, *"the criteria for sustainable aquaculture are based exclusively on ecological and economic viability of farming technological and business practices and not on psychological, social and political factors"* (Boyd and Schmittou, 1999 p62). On one side, as we have seen earlier in this chapter, the infallibility of existing scientific knowledge has been contested, and on the other, simplifying reality by ignoring factors that are difficult to measure such as the social and political does not solve the problem but merely postpones it. Although social factors have sometimes been taken into account in analysing aquaculture, the reductionist vision still dominates aquaculture research. This must, I think, be overcome to move closer to a more sustainable practice. This definition does not bring anything new, Governments remain responsible for establishing standards and passing the cost of ecological impact evaluations to the private sector, and government action is seen as subject to national public opinion. Government is to regulate aquaculture enterprises, as over effluents, importation of non-native species, drugs and chemical use, feed etc., the implementation of environment impact assessments, the restriction of certain practices such as discharging brackish-water into fresh-water bodies and the banning of the establishment of farms in mangrove areas (Boyd and Schmittou, 1999). All this is already practised in many rich countries and emerging economies but has been insufficient to make aquaculture more sustainable (in the broad sense). Despite notable exceptions, national and regional public policies have generally supported industrial development of aquaculture. But if aquaculture is to continue its strong growth, it will need to become compatible with other environmental and economic uses of aquatic resources. The problem is that at present government policies do not seem adequate to regulate unsustainable practices (Sylvia, 1997). Similarly, the reliability of environmental impact assessment cannot be guaranteed. Because impact assessment methods in aquaculture are not well established, some scholars such as Pillay (1997), recommend following a flexible approach: *"if initial evaluations based on existing local information and experience elsewhere show prima facie acceptability, the project should be considered suitable for implementation, provided the monitoring of impacts and correction of adverse impacts are accepted as integral parts of project activity. This approach is justified in aquaculture by the observation that 'in most cases the negative effects have not been as severe as scientists anticipated, the media reported or the public observed'"* (Rosenthal, 1994; quoted by Pillay, 1997, p11). Clearly, in spite of public concern, planners, project managers and authorities are still eager to take environmental risks in order to bring economic development. I think that especially in the case of aquaculture, where we work with fragile ecosystems which have particularly ill-defined boundaries, we should look at the global dimensions of sustainability, physical and socio-economic, and make the precautionary principle the core of sustainability. Sadly, the precise content of the precautionary principle remains largely unclear. In particular, the ways in which the precautionary principle relates to science are contested, and at the moment there is no single precautionary principle strategy (Kaiser, 1997).

Sustainability is also considered through systems approach (Edwards, 1998). In this perspective, sustainability may be expressed in terms of three interrelated aspects:

- Production technology which is subdivided into three main aspects: cultured species, culture system, and husbandry.
- Social and economic aspects, considered at the macro level (international, national and regional) and the micro level (community and farm household).
- Environmental aspects. The environment is here defined as being external to the aquaculture system and includes the natural resources used for aquaculture development such as land, water, nutrients and biological diversity.

Other authors provide a wide range of ideas for sustainable aquaculture which do not strictly constitute a definition but raise important elements. For Altieri and Anderson (1986) sustainability can only be approached when farmers manage their natural resources ecologically, while Lonegran (1993), sees community awareness and education as very important elements of sustainability. Alternatively Srinath *et al*, (2000) suggest that in sustainability of aquaculture the issue is not the concept but the methodology for implementation. In their view, sustainable national and international strategies should pay attention to land use practices, debt relief and environmental promotion and should involve sound economics and environmental accounting and assessment as well as the use of operational guidelines. For them, the impact of a particular technology depends on its nature, the size of the population deploying it, and the population's level of affluence.

4.12.2 The search for sustainable aquaculture

Most writing on improving sustainability focuses on new technologies designed to minimise environmental impact without diminishing the yield or economic profitability of large-scale, commercially oriented systems. The exceptions are a few groups working on small-scale integrated aquaculture systems.

Muir *et al.* (1999), believe that environmental economics is an adequate tool to assess aquacultural activities such as commercial salmon and shrimp enterprises or when public or common assets and resources are involved. Nevertheless, they find it has many limitations for evaluating subsistence aquaculture because a number of non-market issues may affect local and community level decisions and it may be so difficult to specify and separate social and environmental issues that it may be necessary to develop a composite approach. *"In the rural aquaculture case, inputs and yields are low and of relatively small financial consequence. Environmental impacts may be negligible and environmental goods and services are unlikely to be highly valued. With the possible exception of biodiversity issues, extending the valuation constituency would neither be very justifiable nor effective in changing the perspective. Here social issues are likely to be more critical in determining choice and the practical sustainability of development, and may need to be captured through other approaches, including RRA or PRA"* (Muir *et al.*, 1999, p55).

The solution of eco-economists to unsustainablility in aquaculture is to apply techniques involving total economic valuation and so take into account the non-marketed components, including environmental and amenity components of economic activity. For example, it is generally suggested that shrimp producers should be expected to pay charges to make them take their external environmental costs into account (waste treatment, pollution prevention, or taxes on discharging effluents). Currently such charges are not established in the current regulations of most countries (Shang *et al*, 1998). The quandary remains because even where such taxes are established they allow for few environmental costs. For example, they ignore the environmental cost of non-local input and the loss of nursery areas (which impacts on capture fisheries) and they tend to disregard irreversible impacts such as genetic contamination of wild fish populations.

Generally, solutions to nonsustainability in aquaculture are seen to lie in science and technology through new pond designs (Sandifer and Hopkins 1996), implementation of new kinds of feeds (Bolliet *et al*, 2000) and new management practices (Berg *et al*, 1996). Nevertheless, the search for answers to nonsustainability only in science and technology is widely criticised. Aquaculture relies on many resources and must be viewed in the broad context and not as an isolated sector (Pullin, 1993).

Recent research has been responsible for a range of technological and management innovations. Novel self-feeding systems, lower stocking densities, vaccines, waste treatment facilities, etc. have helped reduce demands on the environment. However, such measures are unlikely to be widely adopted unless either imposed on the industry or shown to increase profits (Beveridge *et al*, 1997a). To a greater or lesser degree, solutions to nonsustainability in aquaculture are almost always limited by the dominant economic system, which tends to deregulate economic activity and leave problems to be solved by the market. But what can we expect if consumers generally ignore the extent of environmental and social impacts, especially when the consumers are in places physically very distant from the farms, as in the case of aquaculture?

Often, technological solutions do not solve the problem but transfer it to other areas. For example, aquaculture environmentalists see reductions in food-conversion ratios as a way of reducing the adverse environmental consequences of wasted food, such as water eutrophication, which can directly increase a farmer's profit by reducing the outlays on inputs. Following this approach, low pollution diets or high energy diets[13] have been developed (Beveridge *et al*, 1997b; Bolliet *et al*, 2000; Cho and Bureau,1998). This does not in fact solve the problem but merely transfers it to other, usually marine areas, by indirectly increasing fishing effort as more fishmeal and energy (transport, manufacture, etc) are required to produce the fish feeds, and competition and conflict among marine fishermen may also follow. In other words, to put aquaculture in its ecological context, one must expand the perspective and action far beyond the locality (Kautsky *et al*, 1997). The resulting situation is beyond the simple ecology and economics approach. Even ecology and economics together are arguably an insufficient approach to sustainability, so that it is misguided to reduce the problem to such a narrow focus merely to facilitate comprehension.

All types of aquaculture have to receive energy, food and other natural resource inputs from outside the water body, and for their daily survival are usually dependent on large and often non-local ecosystems for production of feed, and for processing the wastes. The area affected increases with the intensity of the cultivation and to some degree varies with the method of farming and the species being cultured. The main limiting factor for intensive cultivation will often be the supply of feed, and availability of large enough areas for processing the wastes (Kautsky *et al*, 1997). Life cycle analysis (LCA) could offer more information to evaluate the real dimensions of environmental impact and energy expenditure of aquacultural activities so that we could determine which systems are the more sustainable.

4.12.3 Indicators for sustainable aquaculture

The literature on indicators and methods to measure sustainability in aquaculture is sparse. A number of indicators have been defined for subsistence aquaculture, generally specific to particular systems and goals. In the case of integrated rice-

[13] Diets with high and good quality protein content are used more efficiently by the fish, reducing the excretion and consequently the wastes discharges. This reduces pollution in the water bodies where the cages are located.

shrimp farming in Vietnam for example, efficiency (net income), diversity (number of enterprises), recycling (number of bioresource flows) and resource systems capacity (biomass output in t ha^{-1}) have all been listed as indicators of performance related to sustainability (Van Sanh *et al*, 1993).

Pretto (1996), in FAO's *Report of the Expert Consultation on Small-scale Rural Aquaculture* lists indicators of sustainability as Farmers' capacity for producing their own fry requirements, species diversity for ensuring food supply all year, bioresources recycling, productive capacity of the natural resource base, economic efficiency and food security (quantity and quality).

Solutions are presented at local, regional and national level, and universal solutions are very rarely offered. This is arguably correct as physical and socio-economic variation impedes wide-ranging answers. An example of this is provided by Lee (1999), suggesting that in order to enhance sustainable aquaculture development in the US-affiliated Pacific islands, the following are needed:

- Careful selection of species for culture ensuring that they are socially and economically acceptable.
- The establishment of an appropriate technology base in the region.
- Use of cultural practices that are environmentally friendly.
- Establishment of regional networks to take advantage of possible benefits from cooperation.

As it is not always possible to conduct this kind of study at national or regional level, especially in poor countries, the challenge for would-be developers of aquaculture is to be wise enough to identify solutions that could be applied in other, specific places.

On the socio-economic side, the community involvement in conservation and management of resources should arguably be more important than any other indicator so that community awareness and education should be elements of sustainability (Srinath *et al*, 2000). Thus in the search for sustainability both an integrating decision making process and participation are needed (Deb, 1998).

On the ecological side, the role of the state as protector of the environment is widely agreed to be of primary importance. In the case of Chilean salmon industry, Barton (1997) argues that if the state does not make itself directly responsible for the maintenance of environmental quality, the long-term sustainability of the industry may be threatened. Undoubtedly that is also true for commercial aquaculture in most southern countries.

Ecological footprint is the tool most used to evaluate environmental sustainability of aquaculture in its commercial and large-scale form (Folke *et al*, 1998, Berg *et al*, 1996; Kautsky ,*et al*, 1997). With this method it has been possible to display the extent of the nonsustainability of commercial farming of salmon, shrimp and tilapia among others. The ecological footprint of a defined population is the total area of biologically productive land and water used to produce all the resources consumed, and capable of assimilating all the wastes generated by that population, using prevailing technology (Hansson and Wackernagel, 1999). One example of the extent of the ecological impact of aquaculture is provided by Kautsky *et al*, (1997) who found that semi-intensive shrimp farms in Colombia needs a spatial ecosystem support (the ecological footprint) of 35 to 190 times the surface area of the pond. Similarly in intensive tilapia cage farming, in Zimbabwe, the ecological footprint for feed production is 10 000 larger than the area of the cages. Nevertheless the footprint has been criticised because the original result cannot be easily replicated or meaningfully compared across time or between populations (Bicknell *et al*,1998). The problem is that the method establishes the absolute biophysical constraints for human economic activities but does not indicate how much should be produced or in what way (Roth *et al*, 2000). These authors argue that the ecological footprint in itself does not indicate whether the production is sustainable, and that the literature dealing with ecological footprints and aquaculture suggests very strict and radical solutions for aquaculture. These, they say, would mean nothing less than a fundamental change in social values, including moves from optimising to minimising the use of 'ecological services'. In their view, this implies that we should combine the ecological footprint tool with a strategy of re-embedding the human economy into a life-support context by localisation of ecological changes brought about by human consumption. To me, although the ecological footprint could be considered unrealistic, in fact a change of that kind is needed if we really want to achieve sustainability, but the outcome would not be capitalism.

4.12.4 Subsistence aquaculture and sustainability

Fish culture in small water bodies has received little research or extension support and the operations rely largely on farmers' experience and intuition. With the exception of ICLARM in Southeast Asia and other minor institutions, the study of these systems and the search to make them more efficient and productive has been sparse. This may be because the owners small-scale farming systems rarely have high economic power, so that the funding of such research and/or extension depends on the will of governments and national and international NGOs.

A number of reports imply the greater sustainability of small-scale fish ponds as compared to commercial systems. In Malawi, Brummett (1999), found the integrated pond-vegetable gardens to generate almost three times the annual net income from the staple maize crop in small farms, and that the ecological footprint of integrated aquaculture is approximately 4 m^2 per kg of fish produced compared to 170 m^2 for more intensive systems. Pullin and Prein (1995) based on research in Africa concluded that farm ponds, through their contribution to other farm enterprises and household needs, can be important social and environmental assets in addition to their role in fish production. Studying integrated agriculture-aquaculture systems in Ghana, Prein *et al* (1994) found an increase in both economic (gross income, total cost and net cash income) and ecological (enterprise diversity, number of cycling flows on farm and total farm production) indicators and in economic efficiency when compared to non-integrated ponds. For example, through the addition of the fishpond, seven new flows recycled available nutrients (six to the pond, one from the pond). Similarly Branckaert (1995) praises the sustainability of such systems in general because of their diversification of resource use, low risk, more effective utilisation of labour and of biological and chemical energy in the system, high efficiency in resource use, low dependence on external inputs, non-polluting status and their increased profitability and stabilisation of agricultural activities which may even reduce rural emigration. In addition they produce direct benefits to the households by increasing household nutrition and income and fish availability for other villagers (Prein, 2002). Examples of these kinds of systems can be found in the integrated Chinese agriculture-aquaculture systems (Gomiero *et al*, 1999) and rice-fish farming systems (Kamp *et al*, 1996, Velarde, 1996, Nandeesha *et al*, 1996). But no sustainability can be achieved without people's participation. In the study of small scale, integrated aquaculture systems in general, Lightfoot *et al*, (1993) recommend a broad view of integrated farming, encompassing a fully integrated management of all the natural resources available to farm households. In order for aquaculture to be integrated at this level of complexity, farmers must participate in system design (Lightfoot *et al*, 1993).

I argue that in looking for appropriate ways to evaluate sustainability in small-scale aquacultural systems it is of primary importance to set new values on the benefits and sophistication of these systems.

There are already some new methods proposed to measure sustainability in such systems. Dalsgaard and Oficial (1997) present an analytical framework which can help operationalise the sustainability concept. The models form the basis for quantifying a series of agroecological system attributes (species richness, agricultural diversity, efficiency, harvest index, productivity, nutrient cycling, throughput, standing biomass, production/biomass, biomass/throughput, and agroecosystem nutrient balance) and economic properties (gross margin and returns to labour) for each farm. Comparative analysis suggests that what we perceive as ecologically sound farming, i.e. diverse and integrated natural resources management, can indeed be productive, profitable, and manageable, given access to labour and secure tenure (Dalsgaard and Oficial, 1997).

The problem is that at present there is still the tendency to measure small-scale aquaculture with inadequate methods providing too much weight to financial aspects and wrongly evaluating environmental and social factors.

Evaluating sustainability of subsistence aquaculture using inappropriate methods can lead to wrong conclusions like in the case of Pillay (1997 p4), who states that because the promotion of subsistence aquaculture in most low and middle-income countries and in certain underdeveloped areas of industrial countries *"was largely focused on the social uplift of rural communities and gave only marginal consideration to the economics of the activity undertaken; ...the sustainability of subsistence aquaculture could not be ensured, except when the farming made a measurable contribution to the income of the farmer and his family..."*. The fact that environmental and social sustainability of small-scale aquaculture is likely to be very high (Muir *et al*,1999, Beveridge *et al,* 1997a) does not seem be considered to have any value by those such as Pillay who have purely materialistic mentalities so typically in aquaculture science. For that reason, when speaking about sustainability other than in its broad sense, it is desirable to specify if it is integrated, or merely economic, social or environmental, and to enumerate the criteria used to reach such a conclusion.

4.12.5 Sustainability indicators for subsistence aquaculture in Tabasco

Although not wholly compatible, community sustainability and deep ecology arguably offer the most satisfactory approach to sustainability for this research. Nevertheless the utility of these concepts for promoting global change is limited because it is not clear how local changes could be generalised. Yet it is useful as a departure point. It is difficult to assess to what extent this concept could be accepted by or adapted to local rural people in the 4 regions researched because each is culturally hybrid, varying with the distance from urban centres and the influence of electronic media both promoting more individualistic and materialistic ways of life. Based on the above discussion, the following list summarises the idea of sustainability when used to describe the aquaculture systems of this research:

1) Given the conceptual problems implied in the term 'sustainability' and the more general agreement as to what could be called 'nonsustainability', this thesis will refer to more-sustainable or less-sustainable practices.
2) Sustainability at a global level is difficult to conceive of, given the cultural, economic and environmental heterogeneity around the planet. It will be therefore implicit that any reference to sustainability is focused at the local level.
3) Community is used in this text as a parallel to a village because in Mexico community is the word most often used in rural development. In a broader sense, few or none of the villages researched can be considered communities in the conceptual sense.
4) When referring to a more sustainable practice, environmental and social values have more weight in this research than economic values, since on some occasions monetary measurements blur other positive traits such as the consumption of products produced on-farm or collected in the countryside which provide nutritional and labour benefits which are very often omitted from cost-benefit evaluations.

5) In this sense yield will not be considered a criterion of sustainability on subsistence farms since in many cases farmers opt to choose the enjoyment of consuming a better quality product rather than produce high yields for the market. Similarly, given the lack of commercial structures geared to fair prices for small farms, the benefits of high yields (through more sustainable practices) are limited and do not necessarily lead to economic sustainability.
6) Given the ideological content implied in the use of human needs (section 4.6.1), this concept is avoided in this use of sustainability. Production of necessities (see Illich, 1993) for farmers and families is considered instead.
7) The cultural aspect is also evaluated. An activity that can be accepted and adapted to the local culture and cultural practices is seen as more sustainable.
8) Similarly an activity will be considered more sustainable when its introduction into communities and households has less impact on social relations.
9) It is not possible to predict the performance for long periods. Aquaculture is an activity that can be practised for relatively long periods of time, so its continuation will be affected by external influences. It could therefore be abandoned if other practices came to fulfil expectations better.

4.12.6 Can semi-subsistence aquaculture systems in Tabasco be considered a sustainable option?

It will be argued that subsistence fish farming in Tabasco is a semi-closed system with little opportunity to affect the surrounding environment. It uses low levels of inputs, does not depend on external sources of energy, contributes to the recycling of nutrients on the farm, does not interfere with the traditional farming practices in the countryside, does not seem to disrupt social relations in the community or household, has been adapted to the local culture and contributes to environmental protection.

4.13 Subsistence in "sustainable rural livelihoods"

The sustainable rural livelihoods approach (SRL) points to the resources on which rural people depend, and explores, for instance, how different patterns of asset holding (land, stock, food stores, savings etc.) can help families to withstand shocks (Allison and Ellis 2001). This is linked to "vulnerability", which is defined as a high degree of exposure to risk, shocks and stress, and to proneness to food insecurity (whether as a result of climate, markets or sudden disaster); both may be offset by internal coping capability determined by features such as assets, food stores, support from kin or community, or government safety net policies) (Allison and Ellis 2001). SRL is influenced by ecological literature concerned with the "sustainability of ecosystems" defined as *"the ability of a system to maintain productivity in spite of a major disturbance, such as is caused by intensive stress or a large perturbation"* (Conway, 1985; quoted by Allison and Ellis, 2001, p378). In the study of sustainable livelihoods, "resilience" refers to the ability of an ecological or livelihood system to "bounce back" from stress or shocks; while "sensitivity" refers to the magnitude of a system's response to an external disturbance. It follows from these ideas that the most robust livelihood system displays high resilience and low sensitivity, while the most vulnerable displays low resilience and high sensitivity (Allison and Ellis 2001).

A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets, while not undermining its natural resource base (Scoones, 1998, quoted in Mwale, 2001 p1327).

According to Mwale (2001) livelihood strategies may be categorized into three broad groups: a) Agricultural intensification/extensification (strategies based on the exploitation of natural resources, including off-farm income derived from agrarian activities); b) Livelihood diversification (the diversification of activities and social support capabilities for survival including non-agricultural activities and income transfers); and c) Migration (whether seasonal, circular or permanent).

The study and application of SRL is broad and has resulted in a great volume of literature, which it is impossible to explore here as the focus of this research is subsistence and sustainability (detailed reviews can be found in Ellis 1998, Bebbington 1999 and Scoones, 1998, for example). It remains important for this thesis to place subsistence aquaculture in Tabasco in the context of SRL because subsistence production meets the basic criteria to be a valuable component of SRL.

In Tabasco, first, as will be explored in chapter 5, fish farming cannot be studied separately from the other activities on the farm as all elements, agriculture, aquaculture, livestock and off-farm income are interconnected in the interests of farm sustainability.

Second, in regions like Tabasco which are not subject to extreme environmental variations, subsistence production is often a key factor for the survival of households when poor employment opportunities and wages prevail. This is the case of rural Tabasco which, despite certain environmental hazards (mainly floods, now occurring more often, according to most farmers interviewed), has fairly stable temperatures, fair soil fertility and rainfall during most of the year. As will be explained in chapter 6, subsistence is here a way to reduce risks because it ensures food supply for the year and is the only way to obtain high quality, locally valued and in many cases organic foods. Subsistence food production in turn reduces household vulnerability to the variation of prices in the markets for agricultural products, because the basic food supply is secured.

In rural Tabasco, given the prevalence of low wages, which can by no means fulfil the average household's basic material needs, a heavy dependence on off-farm income can involve inserting most members of the household into the wage market in urban centres. This may lead to family disintegration and permanent out-migration. Conversely, subsistence production may empower farmers to decide how far they wish to engage in off-farm waged activities.

Third, most households studied had highly diversified strategies of food production and income generation. In the three regions studied, farmers were often involved in a variety of economic activities in response to environmental changes, market fluctuations, crop cycles and job opportunities. Thus in a good crop year (with good crop prices) a farmer's labour can be mostly farm-oriented, while in a year of bad crops, livestock disease or poor prices, the same farmers can diversify the farm produce more or sell more of their labour off-farm. Thus one year a farmer can practice agriculture, aquaculture, livestock and fishing seasonally or simultaneously while reducing off-farm work, and another year the on-farm effort can be reduced to subsistence production while most cash is obtained from off-farm work. This bears out the findings of Allison and Ellis (2001) who report, after analysing small-scale fisheries literature in poor countries in the last 25 years, that diversified livelihoods were a feature of household strategies in small-scale fishing households, which were often involved in different economic sectors to smooth the effects of resource variations. They found a variety of intra-household responses such as allocation of family labour in time of need, or acceptance of income variation and modification of consumption patterns.

Subsistence can be an important element to augment resilience and to reduce sensitivity in rural livelihoods in Tabasco. The elements which particularly augment the vulnerability of the semi-subsistence farms studied seem to be as follows:

- fluctuation in market prices of agricultural outputs (mainly livestock, cacao and bananas), and inputs (fertilisers and pesticides),

- frequent changes in subsidies (usually reductions) and rural development programmes,

- periodic floods, and (although less frequent) droughts.

Thus, producing basic goods like maize, fruits, vegetables, chicken, pigs, ducks, turkeys and pigs for subsistence becomes vital to ease hardships, either as a store of food or as a personal bank of goods that can be sold in emergencies. The social side of subsistence can also increase resilience as the non-monetary transactions in the villages reinforce food and labour supplies in times of hardship. All this, although indirectly, can be an element reducing migration to urban centres as household nutrition tends to be guaranteed. Although migration still occurs, this tends to be of young people who leave the villages in the search of further or higher education and later for specialised jobs, but generally at least one child in the household will stay to be take charge of the farm, should the head of household die or become too disabled to manage it.

Allison and Ellis (2001) conclude that diversified livelihoods and geographical mobility may both be beneficial to resource conservation and may both need policy support rather than restriction. The recognition and support of `occupational pluralism', by careful analysis of the factors that currently constrain it, would seem to be one productive direction for future fisheries management and development. This runs counter to an approach that seeks to `professionalise' artisanal fishers. The same argument can be used to support subsistence as it is often both an important part of economic pluralism in rural households and beneficial to resource conservation (chapter 5). A sensitive approach in rural development including SRL should imply the recognition of the virtues of subsistence, instead of directing effort to transform farmers into specialists in a single activity, such as aquaculture.

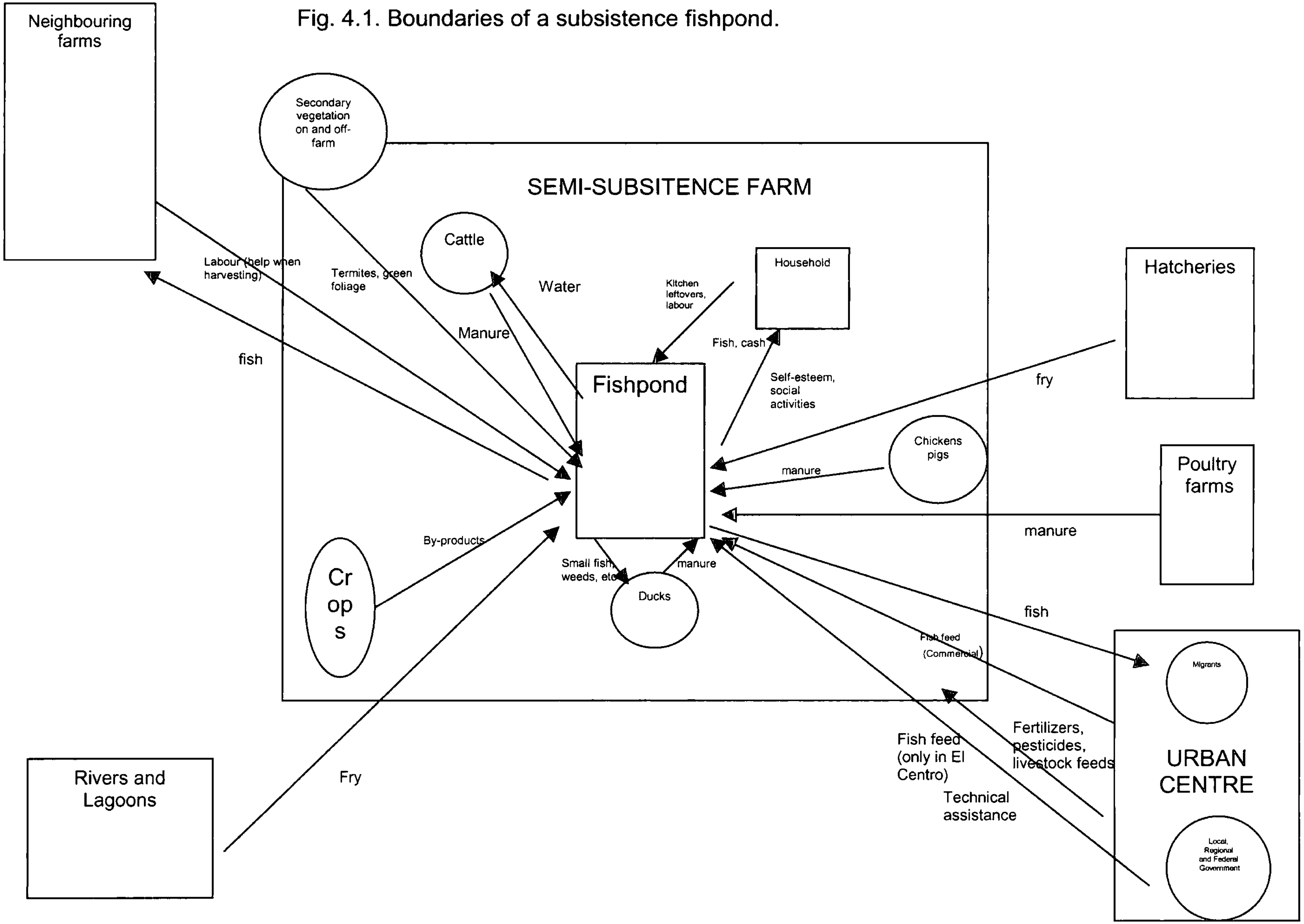
Nevertheless, despite its benefits, subsistence production tends to be unrecognised and sometimes even ignored in SRL as most research and application, even here, is biased to cash income generation. I argue that subsistence production can be a valuable component in rural livelihoods, so that it is desirable to re-examine carefully its role in SRL. Promoting subsistence, where appropriate, could be an important element to reduce poverty but first, research must be carried out.

4.14 System boundaries.

As seen in fig. 4.1, most material flows linked to the fishponds originate on-farm. There are some external inputs, but their importance is low whether in volume or value. High dependence on external inputs is rare and when it occurs it is temporary.

Fishponds receive animal manures as fertilisers and the by-products of maize and other agriculture (such as cassava leaves), as fish feeds. These are produced on-farm and their transport and preparation generally imply manual work rather than mechanical power. The pond can also receive kitchen leftovers produced in the household, although not all of them, as the small livestock also compete in their use. Foliage and termites acting as fish feeds can be obtained from the household's or neighbouring farms and also from areas with secondary vegetation.

Fig. 4.1. Boundaries of a subsistence fishpond.



Although important, off-farm inputs are limited in terms of volume. They include: 1) fry, brought from either hatcheries or natural water bodies such as rivers, lagoons, or seasonal flooded areas, 2) fish feeds, purchased in urban centres either in private shops or, in El Centro, from the council fish feed plant and, in some cases, 3) technical advice from the fish farming extension institutions. 4) Non–paid labour from other farmers is an important input in the harvesting season, and is provided in exchange for a portion of the harvest.

The fish for household consumption and the social satisfactions linked to fish farming (see chapter 6) act as a stimulus to self-esteem and leisure activity. Along with farmers' pride in their provision to other farmers of a valued commodity which is difficult to access in the villages, through non-monetary transactions, these are the most important outputs of the fish ponds. Thus the fish is not only consumed by the household but also by neighbours and relatives and often by members of the household who have migrated to urban centres.

Although household migrants can act as cash providers, regularly or in hardship periods (health or education emergencies), the external source of cash does not subsidise the fishpond because the current fish farming management does not require significant amounts of cash. In the case of fishponds managed more intensively (generally when a migrant takes a special interest) the cash provided by household migrants may be used to obtain fish feed.

So, most flows of materials (in volume) and of labour involved in the management of the fishponds occur on-farm, making these systems more sustainable. The low energy requirements, with the low dependence of fishponds on external materials (feeds and fertilisers) or on external economic resources, make these subsistence aquaculture systems have low impacts on other ecosystems, and low vulnerability to changes in aquaculture input prices.

The well-defined boundaries and the low external dependence together suggest that well managed semi-subsistence aquaculture systems are a sustainable option for improving livelihoods in rural Tabasco.

4.15 Concluding remarks

The concepts of sustainable development and sustainability are highly contested subjects of academic debate. Nevertheless at present there is no other concept able to substitute for sustainability as it embraces a set of ideals difficult for any other term to match.

It is hard to place this thesis clearly within any one of the approaches to sustainability mentioned above, because all tend to have mono-causal postures and consequently to offer partial solutions. This thesis argues that the problem of unsustainability is multi-causal and will therefore never be solved by attacking just one cause. Thus the solutions must be given in all areas, which is only possible by seeing some approaches as complementary rather than opposed. For example, this thesis concurs with eco-feminism in arguing that the destruction of nature is rooted in excessively consumerist cultures but differs about attributing all the responsibility to the patriarchal way of life and on judging the mere feminization of power to be the solution to the environmental crises.

This thesis also agrees with deep ecologists in pointing to certain cultural values which legitimize the domination of nature as originators of unsustainability. Nevertheless, I believe that this is just one piece of the whole puzzle because the spread of the dominant economic system has also accelerated the destruction of nature, as the political ecologists point out. The position of this thesis does not hold only capitalism responsible for unsustainability as eco-socialism does, but also any other system based on consumption and unlimited growth.

It is more difficult to reflect on the proposed solutions because save for a few local case studies reported in some alternative development literature, at present none of the proposed solutions have been implemented. Although a factor of 10 reduction on energy expenditure in the North, as political ecologists suggest, looks theoretically possible to reduce the depletion of natural resources, this seems to have been impossible to implement in practice, perhaps because the engine of capitalism is continuous growth. Thus capitalism would have to be replaced by a new system based on the satisfaction of social and spiritual requirements, in which material values play a secondary role. Social sustainability seeks a world in which social justice and solidarity are linked with participation to build opportunities for everyone to improve their quality of life and to create livelihood security and safety from physical threats. Such a world, as eco-socialists argue, cannot be achieved under the present capitalist regimes. This does not mean that, in view of the evident difficulty of replacing capitalism by a more just system, nothing must be done. As the community sustainability approach maintains, this thesis argues that, while we have not found a new paradigm or the mechanisms to achieve global change, some changes can be achieved through local action. The atomisation of efforts, although it could run counter to achieving rapid change, could also bring the opportunity to assess a diversity of strategies to achieve sustainability at local level and to select those able to yield the best results.

Because of the extent of the impacts created by commercial aquaculture, agreement on sustainability is necessary to define its development and control the impacts of commercial production. There is not much study on sustainability of subsistence aquaculture, nevertheless the available information indicates that it is an activity likely to be sustainable. Despite its limitations, the sustainable community approach seems to be the most appropriate for this thesis, nevertheless indicators to evaluate the sustainability of subsistence aquaculture within this approach remain to be established.

CHAPTER 5

CONDITIONS FOR AQUACULTURE IN RURAL TABASCO

5.1 Introduction

Aquaculture systems need to be described from both the physical-environmental and socio-economic perspectives in order to understand the present conditions for aquaculture in rural Tabasco. This Chapter presents an account of results of both quantitative and qualitative research (see chapter 3 for methods) in which quantitative methods provided data to evaluate the farms technically, whilst mainly qualitative methods were used to explain results and understand the human aspect of fish farming. The technical and physical conditions are presented first as key elements to problems that can be solved through technical and scientific approaches. Next a fictional, compound, household that would be typical of the overall findings is described and analysed. A description of the fish farmers in the study and their current management is then given, followed by an account of the regional differences. The aquaculture extension institutions working in Tabasco are explained, as they will be mentioned recurrently in this and the next chapter. Finally some conclusions are drawn.

5.2 Technical and physical conditions for aquaculture in Tabasco

5.2.1 Impact on yield

There is surprisingly little overall relationship between the technical and physical conditions established in the research and the yields of fish. Each pond was subject to different technical management and level of intensification (density, feeding, fertilising, etc). It is probable that the yield was affected more by management differences than by physicochemical variation or other technical indicators included in the technical evaluation.

The physico-chemical data do nevertheless produce points of interest. For instance, the results of water quality analysis on the 62 farms are presented in Table 5.1. There is data uniformity. Although some values surpassed the tolerance levels for fish growth (Pullin and McConnell, 1982), generally water quality parameters were acceptable. Taking into account the limitations of using yield as a dependent variable[1], and that there was no strong variation of water quality among the 62 ponds, the lack of correlation found between the 12 parameters and yield is a reasonable result.

5.2.2 Technical Evaluation of 62 Fish Farms in Tabasco.

Table 5.1 summarises water quality and pond technical characteristics of the 61 fish farms (62 ponds) included in this study. Numbers in bold indicate values *above the upper limit of tolerance* for fish (water quality parameters) and undesirable characteristics of the ponds for efficient management. As can be seen, only one pond (C21) had all the optimal physical and technical conditions for fish farming. The other ponds all had at least one problem related to pond design or water quality.

Although 27 ponds showed at least one problem of water quality, in general values above the limits of tolerance appeared isolated from each other, so that each farm had different problems. As most farms had few water quality problems, the solution appears not to be problematic. Most common problems were related to design and management. These are problems that can be solved by modifying both the pond and/or the management practices. Only 15 ponds showed a combination of several problems of water quality, where improvement seems to be possible but would involve significant effort and money.

[1] Details can be found in chapter 3.

Table 5.1. Physico-Chemical [2]

Code	pH	S/s[3]	Fe in water (ppm)	Total Hardness	Fe in Soil (ppm)	Turbidity	Alc. Total	Alc. Phenol	NO_3	PO_4	O_2	Transp	Toxic Ammonia	Odour	Colour	Bubbles	Floating Matter	Soil Texture	Dike	Pond Shape	Pond Area (m^2)	Fence	Yield Kg ha^{-1} a^{-1}
T1	7.3	22	.22	170	702.9	24	129	0	.130	.020	6.0	40	.00234	No	**Brown**	**Yes**	No	Silty Clay Loam	Fair	**Irregular**	776	**No**	5470
T7	7.1	34	.15	290	367.6	16	261	0	.040	.020	5.0	25	.00020	No	**Transparent**	No	No	Silt Loam	Fair	Rectangular	**160**	Yes	N/a
T9	7.3	12	.20	80	533.0	28	65	0	.020	.010	9.0	25	.00085	No	**Brown**	No	No	Silt Clay loam	Fair	Rectangular	**125**	**No**	**110**
T11	7.1	18	.27	100	490.6	38	76	0	.100	.030	**11.0**	20	.00060	**Yes**	**Brown**	**Yes**	No	Silt Clay Loam	**Bad**	**Irregular**	2128	**No**	**0**
T12	7.7	26	.25	100	476.5	40	83	0	.130	.030	8.0	25	.00596	No	**Brown**	No	No	Silt loam	**No**	**Irregular**	5031	**No**	**456**
T18	6.9	22	.31	**44**	398.6	45	45	0	.040	.080	**17.0**	**15**	.00133	No	**Brown**	No	No	Loam	**No**	**Irregular**	**380**	**No**	5000
T22	**5.9**	8	.25	**16**	271.4	13	**14**	0	.020	.010	4.0	**50**	.00000	**Yes**	**Transparent**	No	No	Loam	**No**	**Irregular**	600	**No**	**0**
T23	**6.2**	14	.09	**18**	331.0	5	**16**	0	.020	.010	7.0	**65**	.00000	No	**Transparent**	No	No	Silt loam	**No**	**Irregular**	4664	**No**	8570
T27	8.6	**234**	.11	130	278.7	35	128	5	.010	.040	9.0	28	.01090	No	Green/yellow	No	No	Loam	Fair	**Round**	**325**	Yes	**400**
T30	8.8	80	.40	12	368.3	270	**15**	2	.060	.260	**14.0**	**5**	.01308	No	Green/soft	No	No	Silt Loam	Fair	**Irregular**	**350**	**No**	**420**
T32	7.0	10	.30	70	601.2	40	**45**	0	.080	.020	10.0	30	.00700	No	**Brown**	No	No	Silt Loam	**No**	**Irregular**	3440	**No**	5000
T33	8.6	50	.10	**14**	949.9	46	**8**	1	.010	.030	**12.0**	**18**	**.02770**	No	Green/soft	No	No	Loam	**Bad**	**Irregular**	9000	Yes	**145**
T37	**5.6**	4	.17	**12**	151.0	16	**4**	0	.020	.010	10.0	**50**	.00000	No	Green	No	No	Silt Loam	**No**	**Irregular**	**420**	**No**	**860**
T40	**6.2**	**92**	.40	**6**	376.1	160	**44**	0	.040	.170	**11.0**	**5**	.00000	No	**Brown**	No	No	Loam	**No**	**Irregular**	630	**No**	**300**
T41	**4.9**	46	.34	**8**	495.4	120	**5**	0	.080	.070	8.0	**9**	.00000	No	**Brown/red**	No	**Yes**	Silt Loam	Fair	**Round**	**190**	**No**	N/a
T47	8.2	26	.14	200	465.9	25	167	0	.010	.030	**11.0**	28	.00528	No	Green/yellow	No	No	Silt Loam	**Bad**	Rectangular	**176**	**No**	DNA
N1	8.2	12	.03	170	256.1	7	169	0	.010	.010	8.0	**80**	.00660	No	**Brown**	No	No	Silt Loam	Fair	Rectangular	25600	**No**	3
N2	7.3	18	.14	150	209.6	22	144	0	.060	.390	**1.0**	25	.00299	No	Green/dark	**Yes**	No	**Sandy Loam**	**No**	**Round**	765	Yes	N/a
N4	7.2	56	.01	390	317.2	32	305	0	.080	.450	**.6**	**N/a**	.00611	**Yes**	**Transparent**	No	No	Silt Clay Loam	Good	Rectangular	3000	**No**	8833
N8	7.6	22	.15	410	303.8	12	330	0	.050	1.050	**1.7**	**50**	**.02496**	No	Green/yellow	No	No	Silt Loam	Fair	Rectangular	**72**	**No**	**0**
N9	7.8	28	.05	220	281.5	11	160	0	.010	.005	5.0	**90**	.00200	No	Green	No	No	Silt Loam	**Bad**	Rectangular	**60**	**No**	1380
N14	8.1	4	.03	170	253.2	5	107	0	.010	.010	**11.0**	**90**	.01080	No	Green/dark	No	No	**Sandy Loam**	**No**	**Irregular**	5276	Yes	**110**
N16	7.9	8	.01	220	291.7	16	226	0	.020	.090	8.0	30	.00252	No	**Grey**	No	No	Silt loam	**No**	**Oval**	**234**	Yes	1250
N17	8.3	80	.16	200	270.3	45	204	0	.020	.110	10.0	**18**	.00720	**Yes**	Green/dark	No	**Yes**	**Sandy Loam**	**Bad**	**Oval**	532	Yes	1500

[2] Source: Author's field work. Numbers in bold indicate values *above the upper limit of tolerance* for fish (water quality parameters) and undesirable characteristics of the ponds for efficient management.
[3] Suspended solids

Table 5.1. Cont.

Code	pH	S/s[4]	Fe in water (ppm)	Total Hardness	Fe in Soil (ppm)	Turbidity	Alc. Total	Alc. Phenol	NO_3	PO_4	O_2	Transp	Toxic Ammonia	Odour	Colour	Bubbles	Floating Matter	Soil Texture	Dike	Pond Shape	Pond Area (m^2)	Fence	Yield Kg ha^{-1} a^{-1}
N20	8.2	6	.06	160	298.5	8	143	0	.020	.340	10.0	**50**	.01080	No	Green/yellow	No	No	Silt Loam	**Bad**	Square	832	Yes	4400
N21	7.6	16	.04	160	291.1	4	142	0	.010	.020	10.0	**60**	.00144	No	**Transparent**	No	**Yes**	Silt Loam	Good	Rectangular	540	Yes	13330
N24	7.3	74	.16	70	126.5	25	57	0	.040	.030	6.0	40	.00065	No	Green	No	No	**Sandy Loam**	**Bad**	Square	1462	Yes	**100**
N27	7.3	18	.10	80	543.4	10	69	0	.010	.005	**3.5**	**80**	.00068	No	**Transparent**	No	No	Silty Clay Loam	Fair	**Irregular**	6728	Yes	**250**
N29	7.9	18	.04	140	1465.0	13	154	0	.030	.030	8.0	40	.00462	No	Green	No	**Yes**	Silty Loam Clay	**Bad**	**Irregular**	7600	**No**	5330
J1	8.3	18	.10	170	296.2	21	168	0	.020	.030	10.0	25	.00924	No	Green/yellow	No	No	Silt Loam	Fair	**Oval**	660	Yes	**400**
J3	7.5	6	.04	130	345.1	3	136	0	.010	.070	6.0	**115**	.00085	No	Green/dark	No	No	Silty Clay loam	**No**	**Irregular**	**500000**	**No**	**300**
J7	8.6	**124**	.32	210	152.2	100	201	5	.010	.530	9.0	**8**	**.02398**	No	Green/yellow	No	No	**Sandy Loam**	Fair	**Irregular**	3000	**No**	**0**
J8	8.5	20	.06	150	313.8	17	128	2	.040	.010	12.0	38	.01662	No	Green/yellow	No	No	Silt Loam	Fair	Rectangular	4261	**No**	1540
J10	8.5	30	.06	380	232.2	12	211	4	.010	.010	10.0	**70**	.01526	No	**Brown/red**	No	No	Silt Loam	Good	**Oval**	5700	**No**	**786**
J13	7.6	60	.21	64	69.6	28	79	0	.020	.110	10.0	25	.00221	No	**Brown**	No	No	Loam	Fair	**Irregular**	3045	Yes	2000
J17	8.1	56	.16	100	184.5	40	83	0	.050	.040	8.0	30	.00770	No	**Brown**	No	No	Silt Loam	Fair	Rectangular	960	**No**	**150**
J24	7.3	46	.15	120	255.3	30	86	0	.040	.030	5.0	30	.00221	No	Green/yellow	No	No	Silt Clay Loam	**No**	**Irregular**	544	Yes	**0**
J25	8.7	58	.10	170	78.3	23	113	3	.020	.020	9.0	**55**	.01260	No	Green/yellow	No	No	Loam	**Bad**	Rectangular	3136	**No**	**186**
J26	7.1	24	.12	**44**	205.4	20	**38**	0	.010	.010	9.5	40	.00056	No	Green/yellow	No	No	Loam	**No**	**Oval**	800	**No**	8330
J29	7.3	70	**.56**	70	255.7	20	**31**	0	.001	.120	10.0	**14**	.00153	No	**Brown**	No	No	Silt Loam	Fair	Rectangular	1125	Yes	**830**
J31	8.4	24	.07	240	302.3	16	170	2	.010	.010	7.0	**45**	.01038	No	Green/yellow	No	No	Silt Loam	Fair	**Irregular**	2609	Yes	3430
C5	7.7	18	.06	110	248.3	12	73	0	.020	.010	9.0	**50**	.00128	No	Green	No	No	Loam	**Bad**	Rectangular	2346	Yes	**N/a**
C7	7.8	28	.10	64	45.7	18	63	0	.030	.120	9.0	28	.00384	No	Green/yellow	No	No	**Loamy Sand**	**Bad**	**Irregular**	3734	Yes	1600
C8	7.3	18	.10	**20**	281.8	19	**34**	0	.030	.005	10.0	**45**	.00065	No	**Brown**	No	**Yes**	Silt Loam	**No**	**Irregular**	989	Yes	12500
C11	7.0	30	.25	**26**	171.9	50	**23**	0	.050	.020	**11.0**	20	.00091	No	**Brown**	No	No	Loam	**Bad**	Square	1600	**No**	**0**
C12	6.7	4	.17	50	939.1	9	**11**	0	.030	.020	**11.0**	28	.00049	No	Green/yellow	No	No	Silt Loam	Fair	Rectangular	9040	Yes	DNA
C14	8.3	22	.04	210	359.2	31	174	0	.010	.005	8.0	**55**	.00330	No	Green	No	No	Silt Loam	**No**	**Irregular**	**750000**	**No**	50
C15	8.5	16	.03	110	344.5	8	103	3	.010	.020	10.0	**50**	.01211	No	Green	No	No	Silt Loam	Fair	**Irregular**	**120000**	**No**	**125**
C16	7.7	50	.03	110	179.6	17	75	0	.010	.010	8.0	**70**	.00128	No	Green	No	No	**Loamy Sand**	Fair	Rectangular	5750	Yes	7800
C21	8.2	44	.13	140	259.9	27	144	0	.030	.100	9.0	35	.00462	No	Green/yellow	No	No	Loam	Fair	Rectangular	1980	Yes	**950**

[4] Suspended solids

Table 5.1 Cont.

Code	pH	S/s[5]	Fe in water (ppm)	Total Hardness	Fe in Soil (ppm)	Turbidity	Alc. Total	Alc. Phenol	NO_3	PO_4	O_2	Transp	Toxic Ammonia	Odour	Colour	Bubbles	Floating Matter	Soil Texture	Dike	Pond Shape	Pond Area (m^2)	Fence	Yield $Kg\ ha^{-1}\ a^{-1}$
C24	7.4	22	.06	180	298.7	8	182	0	.020	.410	**4.0**	**110**	.01156	No	**Transparent**	No	**Yes**	Silt Loam	Good	Rectangular	3528	Yes	7500
'C25	7.5	14	.09	190	487.3	9	172	0	.030	.080	6.0	**70**	.00091	No	**Transparent**	No	No	Silt Clay Loam	**Bad**	Rectangular	546	**No**	0
C28	8.4	24	.05	190	317.5	17	182	2	.020	.170	**11.0**	**45**	.00872	No	Green/soft	No	No	Silt Clay Loam	Good	Rectangular	1230	Yes	**644**
C29	8.1	20	.08	150	257.5	20	124	0	.010	.060	8.0	**42**	.00440	No	Green/dark	No	No	Silt Loam	Good	Rectangular	**308**	Yes	**35**
C32	7.6	42	.06	150	335.3	11	169	0	.020	.010	**2.6**	40	.00325	No	Green/soft	No	No	Silt Loam	**Bad**	Rectangular	539	Yes	DNA
C35	8.2	26	.08	190	288.3	18	174	0	.020	.030	**11.0**	35	.00440	No	Green/yellow	Yes	No	**Sandy Loam**	Fair	Rectangular	4480	**No**	1500
C40	7.9	62	.01	190	347.1	14	150	0	.020	.010	7.0	**42**	.00630	No	**Grey**	No	**Yes**	Silt Loam	Fair	Rectangular	949	Yes	1200
C41	7.1	**292**	.02	270	298.4	95	280	0	.020	.270	5.0	**200**	.00295	**Yes**	**Transparent**	**Yes**	**Yes**	Silt Loam	**Bad**	Rectangular	19000	Yes	DNA
C43	7.9	24	.03	200	265.7	16	197	0	.030	.010	7.0	**45**	.00546	No	**Grey**	No	**Yes**	Silt Loam	**No**	**Irregular**	1350	**No**	48000
C44a	**6.5**	52	.30	**16**	16.4	75	**17**	0	.050	.100	9.0	40	.00000	No	**Brown**	No	No	**Loamy Sand**	**Bad**	Rectangular	1110	Yes	**382**
C44b	**6.4**	20	.11	**20**	110.9	17	**20**	0	.020	.020	7.0	**55**	.00000	No	Green	No	No	Loam	**Bad**	Rectangular	**442**	Yes	**382**
C45	8.4	32	.12	120	83.3	45	51	1	.010	.110	10.0	30	.01188	No	Green	No	No	Silt Loam	**Bad**	Rectangular	2592	**No**	11500
C47	8.0	52	.01	200	307.6	8	170	0	.010	.005	6.0	**65**	.00378	No	**Grey**	No	No	Silt Loam	Fair	**Irregular**	**50000**	Yes	1000

[5] Suspended solids

The most common problems were low pH, low total hardness, low total alkalinity and O_2 content above saturation[6]. Acidic water causes stress in fish, which increases aggression and susceptibility to disease, thus reducing growth as fish energy is expended in processes other than growth. At the same time, low pH inhibits primary productivity, reducing the availability of natural feed for the fish. The acceptable range for fish culture is 6.5 to 9.0. Higher and lower values of this range could even be lethal for the fish. Eight ponds in the sample had acidic pH (table 5.1). As in all but one instance the acidity is not related to high iron content in either the soil or the water, adding quicklime to the water can easily raise pH. In the one case where high iron content is responsible for the low pH, then the management practice of adding lime will not work.

Alkalinity is the capacity of water to neutralize acids without increasing the pH. Total alkalinity is the sum of the carbonate and bicarbonate alkalinity. The carbonate buffering system is important to the fish farmer because as photosynthesis is the primary source of oxygen, carbonates and bicarbonates are storage area for surplus carbon dioxide. When carbon dioxide is restored in the buffering system, it ceases to be a limiting factor that could reduce photosynthesis and so reduce oxygen production. Also, by storing carbon dioxide, the buffering system prevents wide daily pH fluctuations. 50 to 400ppm of carbonates is acceptable for warm water fish. 11 ponds yielded total alkalinity values below 50. In most cases the addition of quicklime to the water would solve this problem, and also increases pH.

Water hardness is similar to alkalinity, in that values of at least 20ppm should be maintained for fish growth, but the optimum levels are from 50 to 400ppm in warm water. As in the case of alkalinity, adding agricultural lime can raise low hardness levels. Thirteen ponds were found with low hardness levels.

Three ponds showed high levels of toxic ammonia, a by-product of fish metabolism, which can be a problem in highly intensive aquaculture systems.

[6] O_2 above saturation is an indicator of eutrophication (excess primary productivity) and is related to oxygen depletion by respiration at night.

Levels below 0.02ppm are acceptable for fish growth. Higher levels can reduce growth and prolonged exposure can cause fish death. Generally toxic ammonia does not occur at high levels in natural water bodies or earth ponds because most of the time fish stock densities are low. The occurrence of these three cases could be a consequence of the semi-closed nature of the system, which does not allow excess nutrients to be released, causing over-concentration.

Data for transparency and dissolved oxygen indicate euthrophication in at least two of the three cases with high levels of toxic ammonia. This could be caused by wrong fertilizer management or by some source of organic matter. The fact that this problem was detected in three cases indicates that although phreatic ponds present many advantages related to sustainability, such as low energy input, some major water quality problems could appear, as elimination of wastes is difficult due to the lack of drainage. Satisfactory management must therefore be an object of research. The design of a tool suitable for the removal of accumulated sediment without having to drain the pond, or the construction of inlets and outlets at the natural soil level covered with a mesh could be appropriate lines to explore. These would promote water exchange during the flood season while preventing fish escape.

In spite of the limitations of using dissolved oxygen in water as an indicator for water quality (because only one test was done on each farm, on different days at different times), some interesting observations can be reported. Six ponds had very low levels while four had levels above the saturation point. These extreme numbers (depending on the time when the sample was taken) may be indicative of pond euthrophication. Euthrophic ponds tend to have extremely high levels of O_2 in the afternoons due to excess primary productivity and very low levels at night or early in the morning due to the respiration of the large phytoplankton population. As oxygen is essential for respiration, it is the most important parameter for fish husbandry so that optimum levels for fish growth must be procured. Low levels of oxygen reduce fish growth considerably and can cause the mass death of fish when fish density is high and O_2 is depleted. It seems that at least five ponds had problems with euthrophication, having both low and above saturation levels of O_2 and low transparency[7]. Another four ponds also had water with very low O_2 concentration but their high transparency suggests that the low O_2 levels could be the result of other factors such as chemical pollution.

The transparency findings imply deficient management of fertilisation. Nearly 50% of ponds had very high transparency (above 40 cm), indicating very low primary productivity, i.e. the ponds had little natural food (phytoplankton, zooplankton, etc) available for the fish. When natural food is not sufficient fish have low growth, feed costs are high because fish must be fed with complete feeds containing all essential nutrients. When primary productivity is optimal the fish can obtain all vitamins, amino acids and other micronutrients from the natural environment, so that supplementary feeds do not need to include all essential amino acids and micronutrients. Well-balanced fish feeds are rarely available locally and the cost is beyond the farmers' budget, so in ponds with low primary productivity the yield tends to be very low. Proper management of fertilisation is therefore the best choice to increase yields without raising the production costs. Fertilisation thus becomes one of the most important management factors in the search for an optimal and sustainable semi-subsistence fish system.

Most farmers own some form of livestock the manure of which could be used as organic fertilizer at very little extra cost. Although organic fertilisation has great potential, given the achievements of Chinese integrated agriculture-aquaculture systems (Prein, 2002), local research is necessary to identify the best fertilisation rates which do not lead to large accumulation of organic materials in the bottom of the pond. Nevertheless, applying manure at about 50% of the current rate used in commercial semi-intensive fishponds[8] could significantly improve primary productivity without causing problems of

[7] Although transparency can be affected by other factors such as turbidity caused by suspended clay in the water, it is used as an indicator for primary productivity, assuming that most of the suspended solids in water are phytoplankton. A transparency of 30 cm is a good indicator of primary productivity but a range between 25 to 40 cm is acceptable. Low transparency indicates excess primary productivity while high transparency indicates poor primary productivity.

[8] Schroeder *et al* (1980) reported a rate of 100 kg (dry base) ha^{-1} day^{-1} in Israel

euthrophication. That means a rate of 50kg ha^{-1} $day^{-1}$of cow manure[9]. It remains important to know whether farmers would be willing to spend more time fertilising every day. If not, augmenting the quantity of manure but applying it once a week could be a good way to balance labour, time and the benefits of a well-managed pond.

The same pattern was found in the colour of the water. A well-managed pond tends to have green water indicating the presence of phytoplankton. As can be observed in table 5.1, almost half the ponds did not have the right colour. Many ponds had brown water, indicating an abundance of suspended clay, which limits primary productivity because sunlight cannot reach the whole water column and is therefore not available for phytoplankton growth. In other ponds the water was transparent, showing very low primary productivity. A few ponds had a very dark green colour, indicating euthrophication problems.

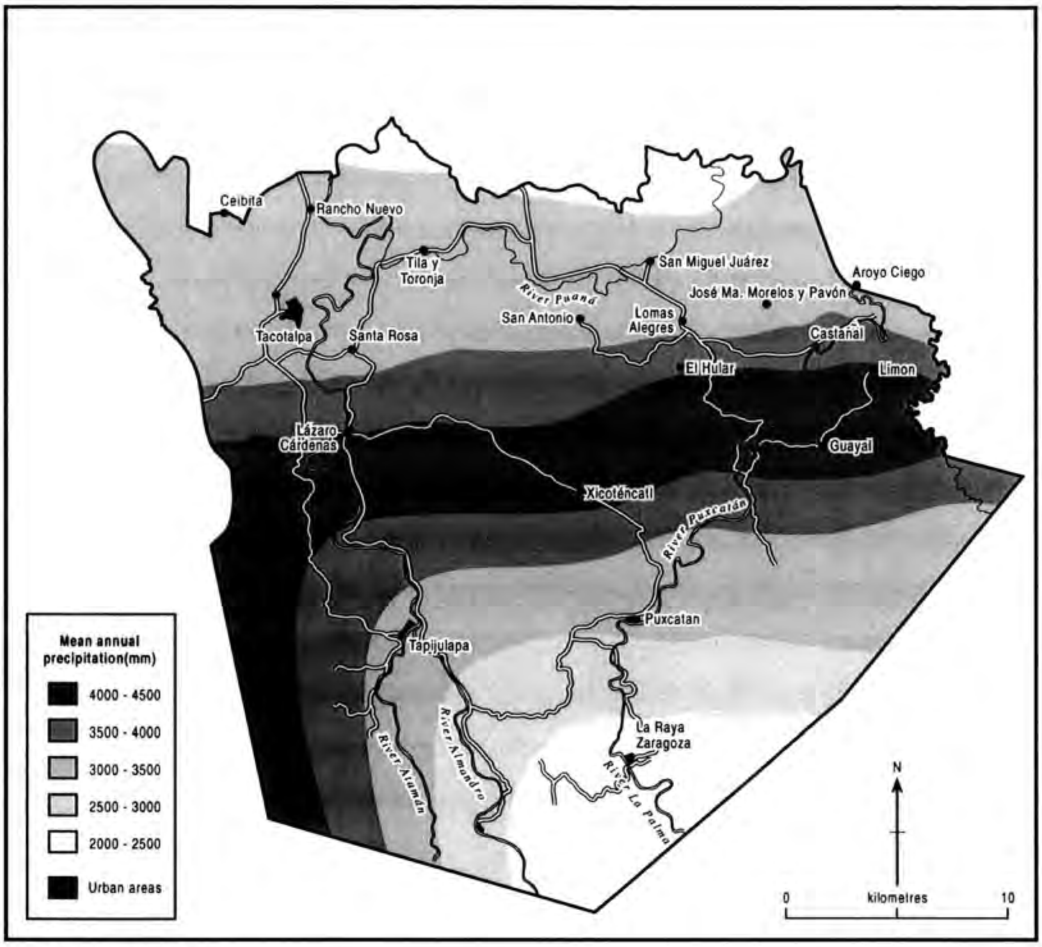
Although it is technically possible to reach high yields under the local physical conditions by delivering rigid technical directions to the farmer, flexibility could be the best way to increase yield. The ideal would be for farmers to have a good enough basic grasp of the possibilities to adapt their ponds to serve their needs better. Otherwise, it will be necessary to identify the socio-cultural limit for fish farming by knowing how much of their cash, time and labour farmers are able to devote to improving their systems. Probably the best answer lies in finding a balance between all these aspects.

5.2.3 Regional differences

Looking at the water quality data by region, it was found that water quality was poorest in Tacotalpa. Tacotalpa is mainly hilly and the precipitation is greater than in the other two regions (fig 5.1, 5.2, 5.3 and 5.4). As this region is higher, it was anticipated that, because stream water in the hills tends to be poorer in carbonates than in areas closer to the coast where the water has accumulated more materials. A factor more likely to be affecting both water

[9] This is a general recommendation based on my own experience and must be taken with reservations. The proper strategy is to conduct local based research to find optimal rates.

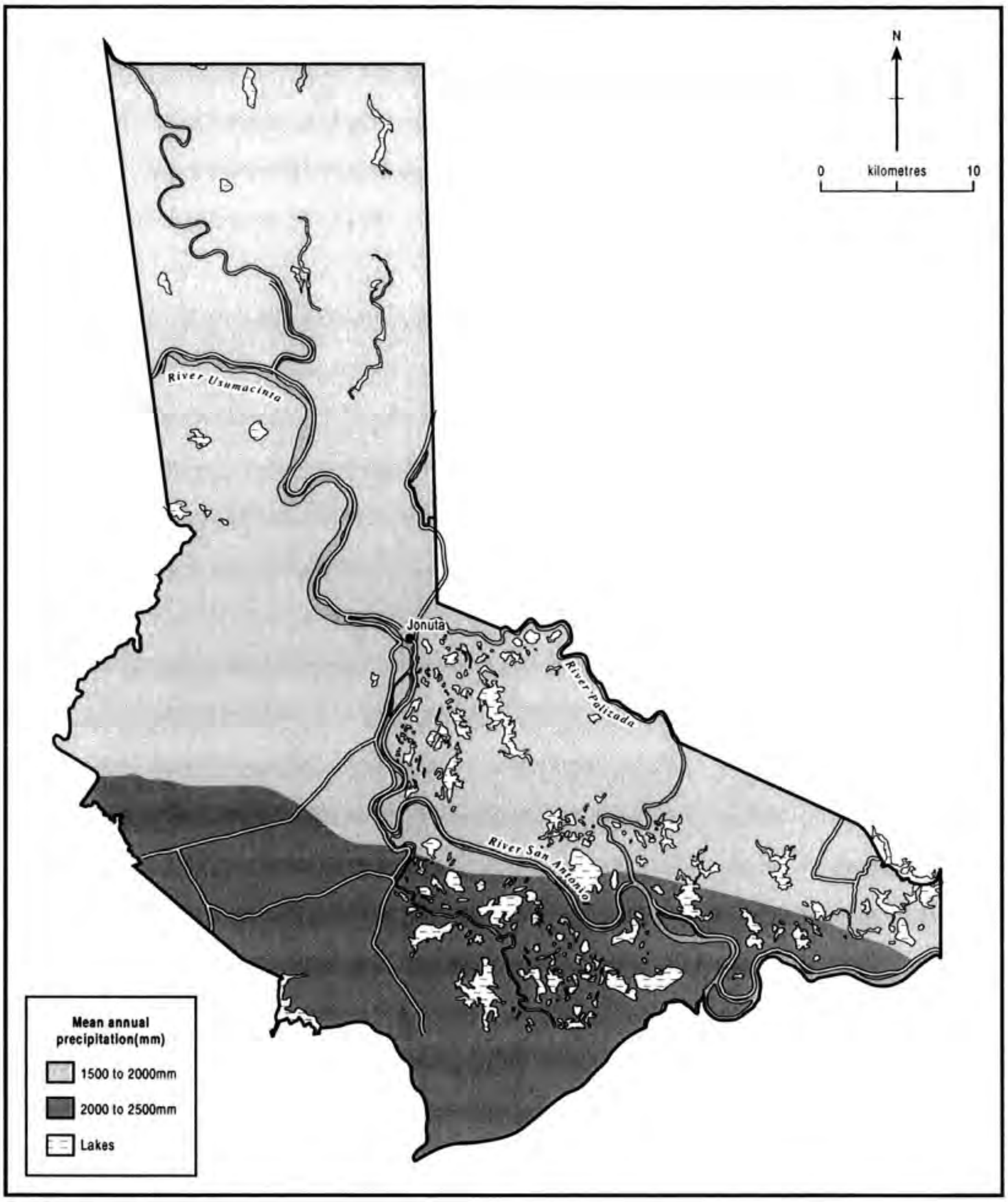
quality and technical parameters may be management, as farmers in Tacotalpa tended not to manage well.



Tacotalpa rainfall

Fig 5.1 Rainfall differences in Tacotalpa [10]

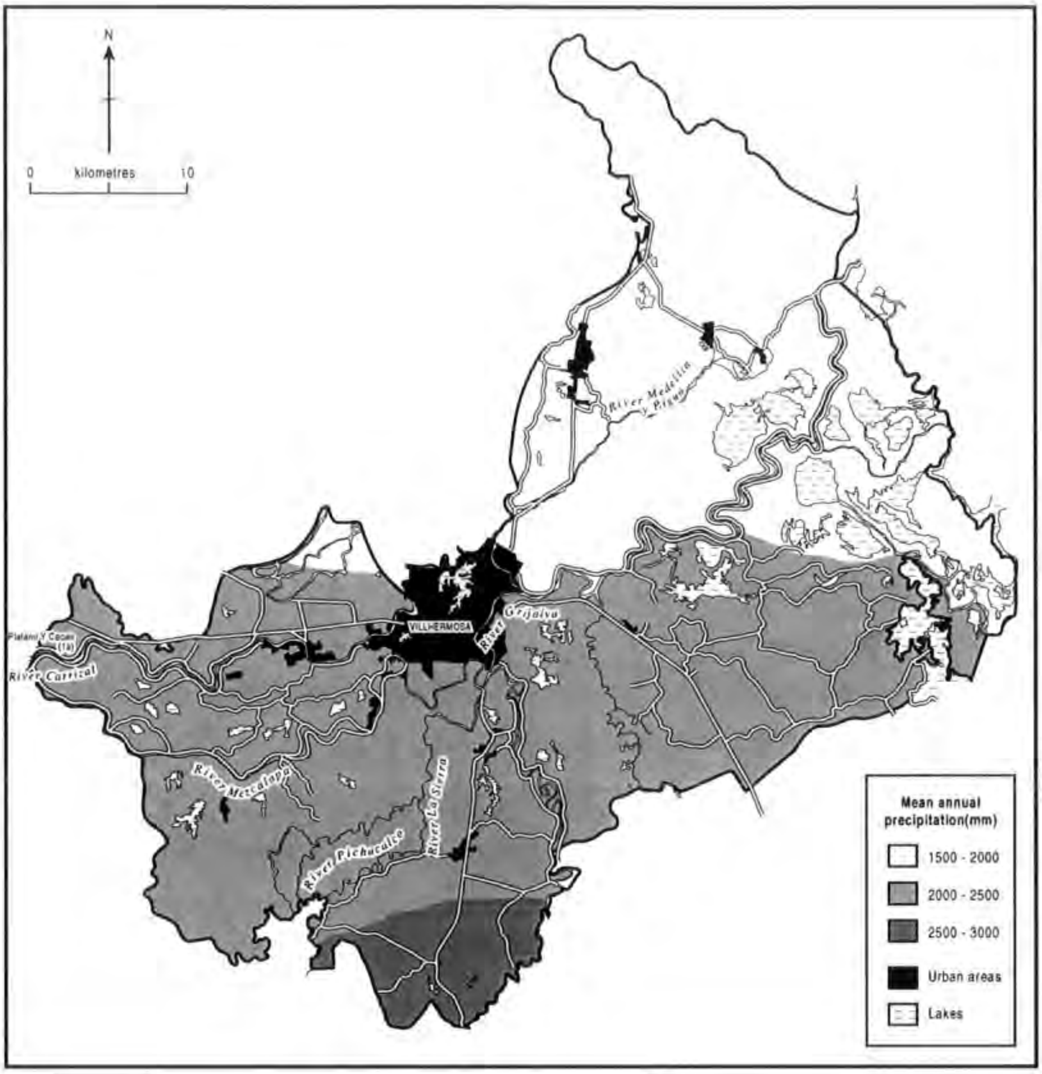
[10] Modified by the Design and Imaging Office, Geography, Durham, from SEDESPA, (1997a)



Jonuta rainfall

Fig 5.2 Rainfall differences in Jonuta[11]

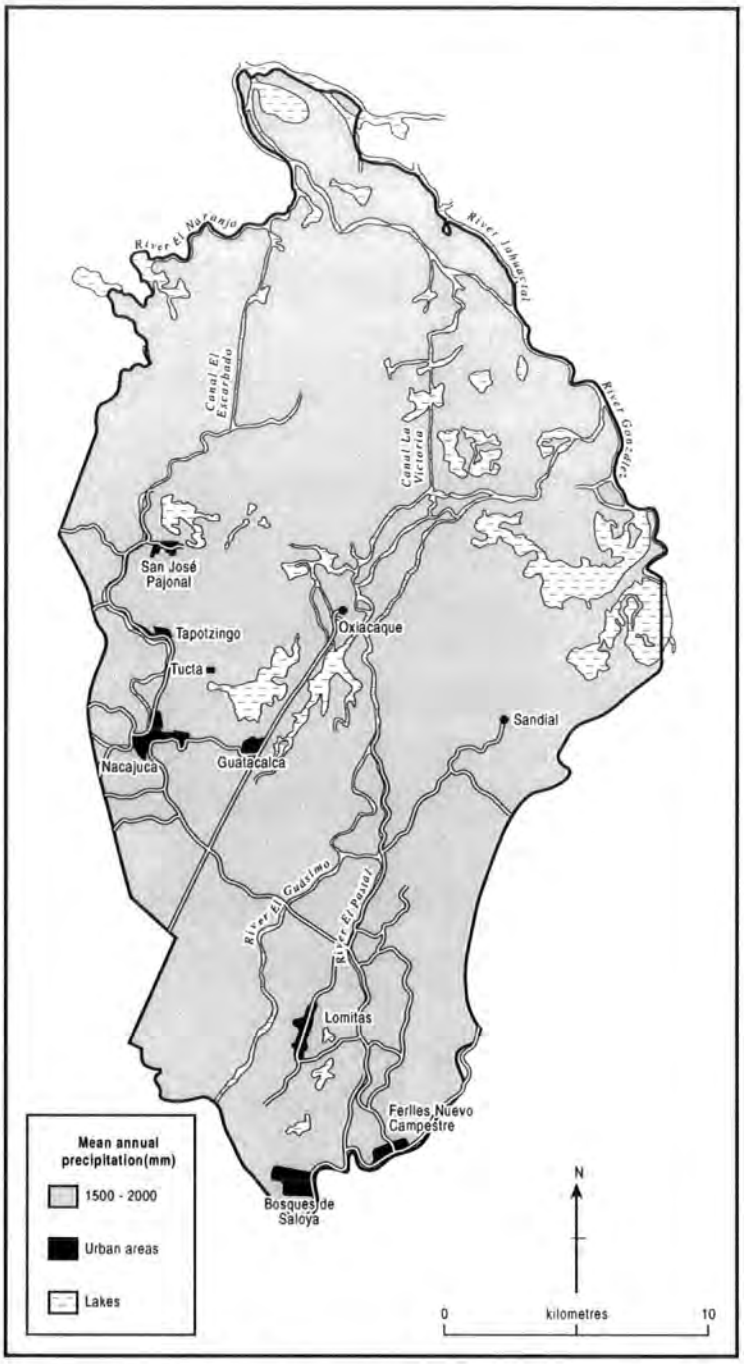
[11] Modified by the Design and Imaging Office, Geography, Durham, from SEDESPA, (1997c)



Centro rainfall

Fig 5.3 Rainfall differences in El Centro[12]

[12] Modified by the Design and Imaging Office, Geography, Durham, from SEDESPA, (1997b)



Nacajuca Rainfall

Fig 5.4 Rainfall differences in Nacajuca[13]

5.2.4 Pond design

As aquaculture is not still widespread in the region, people's idea of fish farming is that it can be carried out in any water body. Because of local

[13] Modified by the Design and Imaging Office, Geography, Durham, from SEDESPA, (1997d)

topographic and climatic conditions, most ponds visited were inadequate. Generally ponds are rudimentary: the soil is taken off, but not put on the banks to build a dike but transferred to a different place, leaving a kind of hole which may overflow (mainly in the lowlands).

Soil texture in most ponds was loamy, with varying contents of clay or/and silt. These textures are fair for earth ponds as they are impermeable enough to avoid significant water filtration. Only 9 ponds had sandy loam or loamy sandy soils which could favour water filtration and so the drying of the pond in the dry season; only 3 of those ponds were reported ever to have dried. This may mean that depth rather than soil texture is the more limiting factor for pond drought. If the pond is deep enough to reach the phreatic stratum in the dry season, the soil texture on the bottom loses importance, as there is a permanent water supply from the ground. If, on the contrary, the pond has the proper soil texture, rich in clay in the bottom but is too shallow, it is likely to dry up in an extreme dry season because of the intense evaporation and lack of rainfall. In any case, good soil texture is of great help in shallow ponds when the dry season is not too long.

One of the most common problems of ponds was the dike. 18 ponds had the dike in bad condition while 16 had none. A dike is necessary to prevent the pond overflowing as it retains the water above ground level when floods occur. Dikes must be at least 50 cm above the natural soil level and uniform around the pond should have a slope of 2:1[14], and have at least one mesh covered outlet to let the excess water out but preventing fish escape. A dike in bad condition or absent reduces yields severely because of the high probability of fish escaping during the rainy season. Sometimes one heavy storm can cause the pond to overflow so rapidly that the farmer does not have time to implement some temporary solution. For this reason, if farmers want to increase yield, special care must be taken to repair or build the dikes.

[14] For every two metres in a horizontal line, the slope decreases one metre down.

Even though pond shape and depth have almost no direct influence on fish yield, they are important factors, which have practical effects on total production. When fish are harvested with a net, pond shape is a very important factor in the total catch and therefore the cost of production. Rectangular and square ponds are easier to harvest as the possibility of leaving big fish and predators in the pond after the harvest is reduced. Irregularly shaped ponds present many problems during harvesting, because the net cannot cover all the pond area, thus, when the net is being dragged, the fish escape easily. Pond shape was one of the most common problems found on the farms as 28 ponds had irregular or circular shapes. Modifying the pond shape to a rectangle can significantly increase production. Unfortunately, although it is technically possible, in practice most farmers cannot afford such work.

Similar problems were found with pond depth. Ponds with a depth of more than 4m in the dry season are very difficult to harvest, because current nets are not large enough to reach the bottom so that most fish escape. On the other hand, shallow ponds tend to dry out resulting in the death of all the fish or a premature harvest of small fish. Research is needed to find the best pond depth for each locality. Available data on the fluctuations of the phreatic mantle could be studied, in order to identify critical levels and establish a pond depth able to maintain water in extreme droughts but at the same time able to be harvested every year. Similarly, a credit programme directed at pond improvement (depth, dike, and shape) could be one way to help farmers increase the yield without increasing labour and time.

The size of pond was another limiting factor. Ponds measuring less than $500m^2$ are too small to provide enough fish to supply one household regularly. A well-managed $500m^2$ pond, assuming a yield of 5000 kg ha^{-1} $year^{-1}$, can provide about 5 kg of fish per week. This is enough for one or two meals so that cash saving can be perceptible to the farmer and make it more probable that the farmer will have a positive attitude to fish farming and more interest in managing the pond. Managing a smaller pond requires similar effort but the benefit is less perceptible. Larger ponds (more than 1ha) require more labour and the management is more difficult, so the yield tends to be lower. Groups can work well in large ponds but as discussed in section 5.3.2 they are subject to many internal problems.

5.2.5 Multiple correlation

Multiple correlation between water quality, soil and selected technical parameters gives no important associations with yield. This indicates that there is no individual factor (physicochemical or technical) having a major effect over yield but a mix of parameters that cannot be distinguished using the data collected in this research. Furthermore, the differences in the means of yield under different management conditions (see above), indicates that effects on yield are highly related to management.

Some associations between variables already expected (table 5.2) were found, as in the case of toxic ammonia – pH. The combination of higher pH and high temperature causes more ammonia to be transformed into its toxic form (Francis-Floyd and Watson, 1990). Similarly, other high correlations were found among parameters that are physically or biologically linked. That is the case for suspended solids with turbidity, iron in water and total and calcium hardness (negative), turbidity with transparency (negative), pH with alkalinity to phenolphthalein, alkalinity with Calcium hardness, and calcium hardness with total hardness. Nevertheless these links are irrelevant to factors influencing fish yields.

Table 5.2 Multiple Correlation of physical and management parameters in 62 fishponds

		Yield	Turbidity	Suspended Solids	Orthophosphates	Nitrates	Transparency	Pond Area	pH	Alkalinity	Alkalinity to Phenolphthalein	Total Hardness	Hardness to Ca	Fe in water	Fe in Soil	Toxic Ammonia	Fish Density	Feeding Rate	O_2 in water
Yield	Pearson Correlation	1.000	-.165	-.083	.108	.139	.099	.211	-.285	.077	-.164	.080	.053	-.091	.051	-.104	.324*	.189	-.053
	Sig. (2-tailed)	.	.274	.585	.475	.356	.519	.191	.055	.612	.277	.596	.728	.548	.736	.491	.030	.255	.727
	N	46	46	46	46	46	45	40	46	46	46	46	46	46	46	46	45	38	46
Turbidity	Pearson Correlation	-.165	1.000	.624**	.380**	.379**	-.710**	-.062	.090	-.251*	.187	-.312*	-.312*	.606**	-.076	.058	.106	.081	.285*
	Sig. (2-tailed)	.274	.	.000	.002	.002	.000	.657	.482	.047	.142	.013	.013	.000	.555	.650	.412	.566	.023
	N	46	63	63	63	63	62	54	63	63	63	63	63	63	63	63	62	53	63
Suspended solids	Pearson Correlation	-.083	.624**	1.000	.298*	-.014	-.313*	.097	.248*	.159	.309*	.086	.067	.177	-.235	.195	.177	.160	-.055
	Sig. (2-tailed)	.585	.000	.	.018	.912	.013	.487	.050	.215	.014	.505	.604	.165	.063	.125	.168	.253	.667
	N	46	63	63	63	63	62	54	63	63	63	63	63	63	63	63	62	53	63
Orthophosphates	Pearson Correlation	.108	.380**	.298*	1.000	.212	-.340**	-.074	.057	.226	.079	.144	.148	.269*	-.144	.292*	.112	.404**	-.078
	Sig. (2-tailed)	.475	.002	.018	.	.096	.007	.595	.656	.074	.540	.259	.248	.033	.262	.020	.387	.003	.545
	N	46	63	63	63	63	62	54	63	63	63	63	63	63	63	63	62	53	63
Nitrates	Pearson Correlation	.139	.379**	-.014	.212	1.000	-.274*	-.053	-.308*	-.070	-.222	-.130	-.090	.261*	.153	-.137	.131	.084	-.104
	Sig. (2-tailed)	.356	.002	.912	.096	.	.031	.703	.014	.583	.081	.308	.485	.039	.230	.284	.309	.550	.416
	N	46	63	63	63	63	62	54	63	63	63	63	63	63	63	63	62	53	63
Transparency	Pearson Correlation	.099	-.710**	-.313*	-.340**	-.274*	1.000	.299*	-.099	.356**	-.168	.415**	.426**	-.738**	-.095	-.041	-.200	.044	-.456**
	Sig. (2-tailed)	.519	.000	.013	.007	.031	.	.028	.445	.005	.193	.001	.001	.000	.463	.750	.122	.752	.000
	N	45	62	62	62	62	62	54	62	62	62	62	62	62	62	62	61	53	62
Pod area	Pearson Correlation	.211	-.062	.097	-.074	-.053	.299*	1.000	.132	.000	.165	.030	-.005	-.208	-.044	.172	-.348*	.144	.096
	Sig. (2-tailed)	.191	.657	.487	.595	.703	.028	.	.341	.999	.232	.830	.971	.131	.752	.213	.011	.340	.489
	N	40	54	54	54	54	54	54	54	54	54	54	54	54	54	54	53	46	54
pH	Pearson Correlation	-.285	.090	.248*	.057	-.308*	-.099	.132	1.000	.325**	.745**	.356**	.323**	-.242	-.046	.812**	.028	-.260	.330**
	Sig. (2-tailed)	.055	.482	.050	.656	.014	.445	.341	.	.009	.000	.004	.010	.056	.721	.000	.827	.061	.008
	N	46	63	63	63	63	62	54	63	63	63	63	63	63	63	63	62	53	63
Alkalinity	Pearson Correlation	.077	-.251*	.159	.226	-.070	.356**	.000	.325**	1.000	.091	.951**	.943**	-.561**	.023	.433**	.091	-.023	-.413**
	Sig. (2-tailed)	.612	.047	.215	.074	.583	.005	.999	.009	.	.478	.000	.000	.000	.857	.000	.484	.871	.001
	N	46	63	63	63	63	62	54	63	63	63	63	63	63	63	63	62	53	63
Alkalinity to Pheolphtalein	Pearson Correlation	-.164	.187	.309*	.079	-.222	-.168	.165	.745**	.091	1.000	.148	.099	-.002	-.105	.621**	.035	-.053	.274*
	Sig. (2-tailed)	.277	.142	.014	.540	.081	.193	.232	.000	.478	.	.247	.439	.986	.415	.000	.786	.706	.030
	N	46	63	63	63	63	62	54	63	63	63	63	63	63	63	63	62	53	63
Total Hardness	Pearson Correlation	.080	-.312*	.086	.144	-.130	.415**	.030	.356**	.951**	.148	1.000	.980**	-.563**	.023	.484**	.055	-.078	-.399**
	Sig. (2-tailed)	.596	.013	.505	.259	.308	.001	.830	.004	.000	.247	.	.000	.000	.857	.000	.673	.576	.001
	N	46	63	63	63	63	62	54	63	63	63	63	63	63	63	63	62	53	63
Hardness to Ca	Pearson Correlation	.053	-.312*	.067	.148	-.090	.426**	-.005	.323**	.943**	.099	.980**	1.000	-.590**	.046	.462**	.029	-.065	-.416**
	Sig. (2-tailed)	.728	.013	.604	.248	.485	.001	.971	.010	.000	.439	.000	.	.000	.720	.000	.820	.642	.001
	N	46	63	63	63	63	62	54	63	63	63	63	63	63	63	63	62	53	63
Fe in water	Pearson Correlation	-.091	.606**	.177	.269*	.261*	-.738**	-.208	-.242	-.561**	-.002	-.563**	-.590**	1.000	-.020	-.217	.044	.224	.319*
	Sig. (2-tailed)	.548	.000	.165	.033	.039	.000	.131	.056	.000	.986	.000	.000	.	.875	.088	.732	.106	.011
	N	46	63	63	63	63	62	54	63	63	63	63	63	63	63	63	62	53	63
Fe in soil	Pearson Correlation	.051	-.076	-.235	-.144	.153	-.095	-.044	-.046	.023	-.105	.023	.046	-.020	1.000	.050	-.174	-.074	.041
	Sig. (2-tailed)	.736	.555	.063	.262	.230	.463	.752	.721	.857	.415	.857	.720	.875	.	.698	.176	.598	.750
	N	46	63	63	63	63	62	54	63	63	63	63	63	63	63	63	62	53	63
Toxic ammonia	Pearson Correlation	-.104	.058	.195	.292*	-.137	-.041	.172	.812**	.433**	.621**	.484**	.462**	-.217	.050	1.000	-.067	-.019	.116
	Sig. (2-tailed)	.491	.650	.125	.020	.284	.750	.213	.000	.000	.000	.000	.000	.088	.698	.	.604	.890	.366
	N	46	63	63	63	63	62	54	63	63	63	63	63	63	63	63	62	53	63

Table 5.2 cont.

		Yield	Turbidity	Suspended Solids	Orthophosphates	Nitrates	Transparency	Pond Area	pH	Alkalinity	Alkalinity to Phenolphthalein	Total Hardness	Hardness to Ca	Fe in water	Fe in Soil	Toxic Ammonia	Fish Density	Feeding Rate	O_2 in water
Fish density	Pearson Correlation	.324*	.106	.177	.112	.131	-.200	-.348*	.028	.091	.035	.055	.029	.044	-.174	-.067	1.000	-.185	-.042
	Sig. (2-tailed)	.030	.412	.168	.387	.309	.122	.011	.827	.484	.786	.673	.820	.732	.176	.604	.	.188	.748
	N	45	62	62	62	62	61	53	62	62	62	62	62	62	62	62	62	52	62
Feeding Rate	Pearson Correlation	.189	.081	.160	.404**	.084	.044	.144	-.260	-.023	-.053	-.078	-.065	.224	-.074	-.019	-.185	1.000	-.159
	Sig. (2-tailed)	.255	.566	.253	.003	.550	.752	.340	.061	.871	.706	.576	.642	.106	.598	.890	.188	.	.254
	N	38	53	53	53	53	53	46	53	53	53	53	53	53	53	53	52	53	53
0_2 in water	Pearson Correlation	-.053	.285*	-.055	-.078	-.104	-.456**	.096	.330**	-.413**	.274*	-.399**	-.416**	.3198	.041	.116	-.042	-.159	1.000
	Sig. (2-tailed)	.727	.023	.667	.545	.416	.000	.489	.008	.001	.030	.001	.001	.011	.750	.366	.748	.254	.
	N	46	63	63	63	63	62	54	63	63	63	63	63	63	63	63	62	53	63

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

5.3 The socio-economic dimensions of aquaculture in Tabasco.

The socio-economic dimension of aquaculture, and the problems which constrain its development in Tabasco, would be difficult to understand by just analysing technical data, which may produce useful information but lacks the nuances necessary to comprehend the human element of the problem. For that reason, the case of Juan Hernandez is used in this chapter to exemplify the present status of aquaculture in Tabasco and what aquaculture means for the rural poor. This case is fictional, having been compounded from other farms to give us a "typical" fish farm.

5.3.1 The farm of Juan Hernandez

Married with 4 children between 12 and 28 years, Juan Hernandez is a 48-year-old farmer who lives in a village of 500 people where he has a house and yard. He also owns a 12ha plot located about 1 km from the village. The plot he owns today is not the same he received from the government 30 years ago through the agrarian reform. He has sold and bought new plots a couple of times in the search of a better and more accessible one. Juan and his wife, Maria studied at primary school while their children have secondary education. At present two of his children are married and the two youngest live with him and help him on the farm. Every day, Juan and his wife wake up at 4:30 a.m. She gives him coffee and bread and cooks some food, generally beans, eggs and tortillas, to take with him. He starts work on the plot at 5:30, takes a break at 8:30 and finishes at one in the afternoon every day when he returns home for a meal and rest. He also works around the house, perhaps repairing tools or cleaning the yard, or meets up with friends in the afternoon. On about 10 days a month, Juan earns some extra cash as a farm labourer, for 38 pesos (£2.14) per day. He knows this is very little but he must do it to get cash to buy goods that cannot be produced on-farm, e.g. school materials, clothes, medicines and tools. Maria, his wife, works as a housewife, carrying out the usual domestic duties such as: cleaning, washing clothes, cooking, watering green vegetables on the house yard, grinding maize for the animals, (two pigs, 10 chickens, and 8 ducks) and preparing pozol[15]. Two or three times a day, Maria feeds the animals and the fish in the pond. They have two dogs, which guard the house at night. The house (fig. 5.5) is of brick with a roof of zinc sheets, like others in the village. It has one big living-dining room and two bedrooms.

Fig. 5.5 Typical fish farm in Jonuta

There is little furniture in the house: an old wooden table and chairs, two beds, some little tables and some hammocks, radio and T.V. They also own a bicycle that the children ride to school and to the plot. The kitchen is of palm leaves and is outside the main building, as are the toilet and bathroom in the big yard. They built the house in 1988 through a programme that then provided cheap building materials. Younger families in the village have no such programme. Recently the Hernandez dug a 300-m2 pond behind the house. At first they farmed fish at the pond in the plot but Juan thought that, as nobody could guard it at night, most fish were stolen. They obtained the new pond when the company building the new road asked the villagers for sand; the company got the sand and they got the pond. Juan farms fish to procure fresh, clean food for his family and also because he wants his grandchildren to know the local species, which are now scarce. Maria says

[15] Local fresh drink made of blended maize and cocoa

that the fish brought by traders to the village are small and perhaps contaminated, so it is better to farm their own.

Now they farm tilapia because that is what the state government distributes, but they also stock native fish such as *mojarra castarrica* (mayan cichlid), *pejelagarto* (tropical gar) and turtles because they prefer the taste and because they want to preserve the native species. They know that turtle consumption is banned but say that eating turtles is a tradition. The price of turtles is very high, about 500 mxp each (£38), but they cannot sell them because trading turtles is banned. The Hernandez say it is good to have shade for the fish because the water gets hot in the dry season, so they have planted some bananas and coconut palms around the pond. In the yard managed by the women they grow a variety of tropical fruit trees and a vegetable garden (tomatoes, sweet chillies, coriander, parsley, spring onions, chillies, shallots, chayote, chaya[16], cassava, pumpkins, radish, sweet potatoes, etc.).

The men, Juan and the boys, work on the plot (weeding, harvesting, handling the cattle etc). They have planted 2ha with maize, 0.5ha with black beans and 0.25ha with cassava and bananas. Most land is in pasture where they have five cows. Generally they breed calves and sell them every year. Sometimes there are few cows, as they have to sell them to meet health or education contingencies. Sometimes they rent the land to other farmers or profit-share: they provide land and labour, and another farmer provides the animals. The plot also has a pond. It is around 500m^2 and was constructed in 1990 through a government programme, which let them hire the machinery at a low price (just paying for the petrol and the machinery operator allowances).

Juan built the pond to store water for the livestock, later he got the idea of farming fish from the village representative who said the government was providing free fry. He paid to transport the fry, which was expensive given his income, but he was very enthusiastic. But the fish were stolen at night and in

[16] Green leaves used as cooked vegetable.

1994 they escaped when there was a large flood after the hurricanes Roxanne and Opal. Juan lost interest and left fish farming, but later he decided to dig another pond at the house lot and try again. Now he would like a new pond at the plot, but the pond-digging programme is over and he lacks the money to build his own. He wants the new pond at the plot because one of his children got married and will build a house there so there will be somebody to look after the fish. The house pond was stocked with 4000 tilapia fry three years ago. The density was very high but they thought that if they stocked more fry they would harvest more fish. Juan would like to stock more fry this year but now he has to pay 10 cents per fry plus transport, and does not have enough money.

The Hernandez manage the pond simply, feeding the fish with ground boiled maize, cassava leaves and bananas leftovers, and add termites when they find them. When the fish are small, they give them commercial chicken feed, because they think that, like chicks, small fish require more food and attention. They fertilise the pond but not on a regular basis. In fact they do not know how the manure works so they add small quantities but are afraid of polluting the water. They are aware of their ignorance of fish farming, as their management resulted from trial and error. Nobody has told them how to manage the pond or what local resources they can use. They remember only that the extension officer came once to check the water and said that it was okay; but they have not seen him again. Like all the goods they produce, fish is farmed to be consumed on-farm. They may sell some, but only the surplus.

Generally they fish with a *tarraya*, which is a circular net for throwing to catch a small number of fish. They catch only fish bigger than 500g because they say it is a pity to catch smaller ones full of bones. There are bigger harvests once or twice a year, on special occasions such as Fridays in Lent, Holy Week or when they have guests. The harvest becomes a kind of party and usually their relatives and neighbours are invited to help and to share in the produce. They also send fish to their friends as presents, just as on other occasions they receive other products from them. The Hernandez do not like to harvest all the fish, they say that the fish must breed because otherwise the species will die out. They are happy with the pond but they had expected harvests 10 times as big. They say that they could harvest more with more knowledge.

With some local variations, the case of Juan and Maria Hernandez summarises a typical fish farm of the four regions studied. Quantitative and qualitative information now follows.

5.4 General characteristics of semi-subsistence fish farms in rural Tabasco.

Fig. 5.6 Fish farmer in Nacajuca during an interview

5.4.1 The Fish Farmer

Most fish farmers in the study were more than 40 years old (fig 5.6). Young farmers were few because land reform has ceased in 1991 and thus they can only obtain land either by inheritance or by purchase. Very few farmers can afford to purchase land. Thus inheritance is the way the majority of young farmers get plots, but this generally takes a long time and sometimes the plot is smaller, the original plot being divided between those descendants who decide to continue farming[17]. Most families here have members living in cities. Farmers' age has both positive and negative effects on aquaculture. Older farmers tend to be difficult to convince of proper management practices but this is not necessarily bad because extension officers did not always recommend satisfactory alternatives. For example, most farmers cultivate native species in spite of officers' opposition, which is good, but farmers also frequently refuse to keep fish density low or to make recurrent applications of organic fertilizers as suggested by extension officers, so limiting the yield.

5.4.2 The fish farming unit

Like all other activities on the farm, fish farming is a family activity. Even though group work has been widely promoted by aquaculture institutions, most farmers prefer to work in the family or groups of relatives (table 5.3). 73% of farmers avoid working in Farmers' Groups (FGs)[18], although they recognise that group work can provide more efficiency and higher yield. Organizational and interpersonal problems were the main reasons given e.g.: difficulty in getting agreement, corruption, inequality in workloads, the irresponsibility and lack of commitment of some members, disagreement over management practices or profit management, and injustice in profit distribution etc.

Table 5.3 Organisation for farming fish

	Frequency	Percent
Family-Relatives	116	73
Groups of farmers	43	27
Total	159	100

Family work is preferred because then nobody expects everybody to work equally. Work is distributed in accordance with members' time availability, because the family is a collaboration unit often extended to some relatives. Most households had between two and eight members. A typical household included a couple with children and often one or more grandparents, uncles or

[17] This is becoming rarer as most young rural people migrate to the cities and the householder only ensures that at least one of his/her children stay to run the farm.
[18] Groups of farmers doing fish farming communally, usually with commercial aims.

aunts, brothers or sisters in law and sometimes non-relatives who had been accepted as family members. The physical space and the working structure is similar to the House gardens in the rainforest, in Los Tuxtlas, Mexico, described by Townsend *et al.* (1995, p62) as highly sustainable systems, *"unlike most forms of production in the Mexican tropics".*

Although 80% farmers interviewed did not believe that group work succeeded, aquaculture institutions still provide more support to FGs than to family units. As a result, many groups are established with members who do not believe in communal work. Farmers go into the groups because they see them as the only way to get support, even when they know there are few opportunities for success or that the group will not survive for long.

From interviews, even though FGs face many problems, there are possibilities of success but much effort is necessary to keep the groups united. It is also desirable to select members better to make smaller groups and to find ways to avoid the mismanagement of those in charge of the FGs' administration.

Fig. 5.7 Swamp before transformation into aquaculture in Colonia San José, El Centro.

5.4.3 The Aquaculture Production Societies (APSs)

The Economic Development office in El Centro works mainly with groups of farmers organized to work communally as APSs, which are organized either by the aquaculture officials or on farmers' initiative. At the beginning these societies may have more than 30 members but the number always falls in the following years, usually to less than 8 members, frequently all relatives. Thus APSs have to recruit new members, as 12 partners are required to receive official support.

Most of the time APSs manage big ponds, which were previously swamps (figs. 5.7 and 5.8). The transformation involves long, hard work. Many disappointments follow and the number of partners declines because no wage is provided at this stage. Promise of profit in the future is not a sufficient motivation to maintain membership because members need to procure cash for family support.

Fig. 5.8 Swamp transformed into aquaculture. APS La Majagua in El Centro.

In previous years APSs practised cage culture with poor results. Low growth, poaching, vandalism, high cost of fish feed and organic pollution in flood seasons were some causes of the failure, which made APSs change to extensive culture[19]. At the time of the survey, none of the 42 APSs in the four municipalities were practising cage culture.

APSs in El Centro enjoy a number of benefits. The policy of the Centro Municipal Aquaculture Department (see below) is to provide free fry and regular advice and training. The municipal administration provides and/or facilitates loans to run the farms and to acquire infrastructure and equipment for marketing the fish. They have built '*Palapas*'[20] in which to establish restaurants in which fish farmers can sell cooked fish, at a better price (fig 5.9). For APSs that still do not have a restaurant, the municipality may provide transport to sell the fish in other villages or to supermarkets in the capital city, where the municipal extension officers have previously looked for a market. These APSs have the option of continuing training not about fish farming but also in group organization, gastronomy, customer service, restaurant management, etc. Thus, the programme focuses on building up an entrepreneurial mentality among rural fish farmers.

Fig. 5.9 Rural Fish Restaurant in Guapinol, El Centro

[19] Low stocking densities, low or non- feeding and fertilizer management, etc.
[20] Open wooden structures with palm leaf roofs for shade in tourist coastal areas, very popular on hotel beaches.

The change from the subsistence way of life to an entrepreneurial mentality does not always work. Many farmers still give priority to their farm work and only use part of their time for aquaculture.

Even though these micro-enterprises have sometimes had good results and may be financially sustainable, some are not environmentally sustainable. APSs were advised to farm fish in cages at the beginning as that was the only intensive system that could be adopted under local conditions to provide enough yield to ensure profit for all members of the group. But cage culture has been proven to be environmentally unsustainable, creating severe environmental impacts (Beveridge, 1996) and being energy-intensive. For example, fish cage culture requires a high protein feed[21] and much labour input, while the wastes (uneaten food) pollute the water body leading to euthrophication, etc. Nevertheless, at present most groups have abandoned cage culture, not for environmental concerns but because of management problems and financial non-feasibility. This is a good move toward a more sustainable activity, but as the change was not seeking sustainability but only for financial reasons, the possibility remains of going back to cage culture when local conditions make it profitable. For that reason, it is important to provide environmental education to the groups to keep fish farming as environmentally sustainable as possible.

APSs could be a good solution in areas near cities, where people can afford to eat out, or in areas with good marketing channels for large volumes of raw fish, conditions that local governments could create. But as people owning land in such areas are generally not the poorest, it would be good to promote groups of landless people in areas like Jonuta, Nacajuca and Tacotalpa, where there are no such groups. It would be necessary however, to provide economic support and training, and money is what poor municipalities do not have. In remote areas with poor access, no funding and no marketing

[21]These feeds require a high quantity of fishmeal, which is made of fish which could be used for human consumption. Between 2 or 3 kg of fresh fish, converted into fishmeal is required to produce one kg of fish in intensive systems. Taking into account the energy spent in the process of fishmeal manufacture, fish feed production and transport for distribution, commercial fish feeds are considered to be 'very unsustainable'.

infrastructure the solution may be rather different, and improving subsistence systems at family level may be a better option for success.

5.5 Fish farming management in rural Tabasco

5.5.1 Yield

Although the results of student t test in many cases resulted in perceptible differences of means when yield was tested against different management conditions; generally the differences were not significant. This was because of the high data dispersion, in which yield reported ranged between 30 and 20,000 Kg ha^{-1} a^{-1}(in the case of cage culture). This makes it difficult to report which management factors influenced yield in the fish farms.

Due to management problems (see below) yields reported by farmers tend to be low. Although this study indicates a low mean yield of 2175kg $ha^{-1}year^{-1}$ (tables 5.4 and 5.5) this can be considered an improvement compared with the mean of 679 $ha^{-1}year^{-1}$ reported by Mendoza *et al.,* (1991) for the Zanapa-Tonala region, also in Tabasco. Nevertheless the mean is derived from highly variable data and cannot be considered a good indicator of the local farm productivity. For example, 53% farmers said they produced less than 500 $ha^{-1}year^{-1}$ (table 5.5). This is extremely low compared to that reported in other rural areas of Central America (Lovshin, 1986[22]). Nevertheless 14% of reported yields were between 5,000 and 20,000 kg $ha^{-1}year^{-1}$, which is comparable to yields reported in carp polyculture in Asia, where China, the most advanced country in integrated agriculture-aquaculture systems, has a national yield average of 4000 kg $ha^{-1}year^{-1}$ in ponds (Zhao, 1997 cited by Rana, 1997), and comparable to some regions of India, where farmers produce 15000 kg $ha^{-1}year^{-1}$ (Tripathi *et al.*, 2000). The data from this study, however, have to be treated with caution as yield information was recorded

[22] These studies by Lovshin, however, had more reliable data as detailed records of fish harvests were made. In addition, such farmers had good and intensive advice on pond management, and these reports are for monoculture of tilapia, for which there is a large amount of management information.

from farmers' recollections. Farmers have no written record of catches so that yield reports are subject to errors and are therefore approximations.

Table 5.4 Average yield (ha^{-1}year^{-1}) at fishponds in Tabasco

	Number	Minimum	Maximum	Mean	Arithmetic Mean	Std. Deviation
Yield at last crop	101	35	15488	2174	796	4.62
Valid number	101					

58 missing values[23]

Table 5.5 Yield at last crop (ha^{-1}year^{-1})

	Frequency	Percent
0*	28	20.6
<100	9	6.6
100-499	35	25.7
500-999	13	9.6
1000-2499	21	15.4
2500-4999	10	7.4
5000-9999	12	8.8
10000-19999	4	2.9
20000-29999	1	0.7
>30000	3	2.2
Total	136	100.0
Harvest has not occurred	13	
The respondent does not know	10	
Total	23	
Grand total	159	

* 0 represents ponds not possible to harvest because they were too deep, fish were poached, fishing equipment was not available, the fish did not grow or died etc., not the actual fish production in the pond.

5.5.2 Stocking

The farmers' understanding of fish farming cycles varies greatly and affect the way they evaluate results. Typically farmers stock fry once only, expecting them to grow and breed to establish a stable population in the pond so that they can repeatedly catch the largest in small quantities without the resource diminishing. For Tabasco's fish farmers, aquaculture is similar to chicken and duck rearing so they expect to have fish available for the household for many years encouraging the population stocked to recover.

In general, first timers and inexperienced farmers stock the fry at any time of the year. More experienced farmers prefer to do it just after the flood season

[23] Mostly farmers who were farming fish by first time, and had not harvested when the survey was being carried out.

in December or January, which gives them more opportunities to catch big fish in Lent (March-April) and the rest before the flood season starts, in middle- late September.

5.5.3 Stocking densities

There was wide variation in stocking density, from less than 1 fry m^{-2} to more than 80 fry m^{-2}. A direct relationship between yield and stock density was therefore expected, because fish grow slower when density exceeds the carrying capacity of the pond[24] (Fig. 5.10). Nevertheless that was not the case. It is possible that results are distorted by other factors. If there is inadequate control of predators (fish, birds and thieves) and no proper management (feeding, fertilising, control of floods etc.) it is likely that fish density declines during the cycle. Higher stock densities could then be adjusted to lower and more appropriate ones by the natural community dynamics in the pond, specific managements practices such as incomplete harvests and management faults. The lack of correlation indicates a waste of effort, money and energy when densities are above 2 fry m^{-2} as many farmers could obtain higher yields stocking fewer fish. The solution seems simple at first sight but the mere adoption of a simple management strategy is complicated given the fish farmers' current ideas of farming fish. Generally, farmers have the idea that ponds can support unlimited amounts of fish, the only limitations being feed and time. Others think carrying capacity depends on the depth of the pond, not the area, so farmers sometimes stock higher densities against the advice of the extension officer.

In semi-intensive aquaculture, stocking densities are calculated in numbers of fish per square metre. This is because primary productivity takes place mainly in the top metre of the water, so that ponds deeper than 1.5m do not increase the carrying capacity. On the contrary, deeper ponds tend to be less productive. Nevertheless it is difficult to change farmers' ideas just with advice. If farmers insist in stocking high densities, probably a good strategy is

[24] Expressed in fish biomass (kg)

to agree to try both high and low densities in different cycles and compare results.

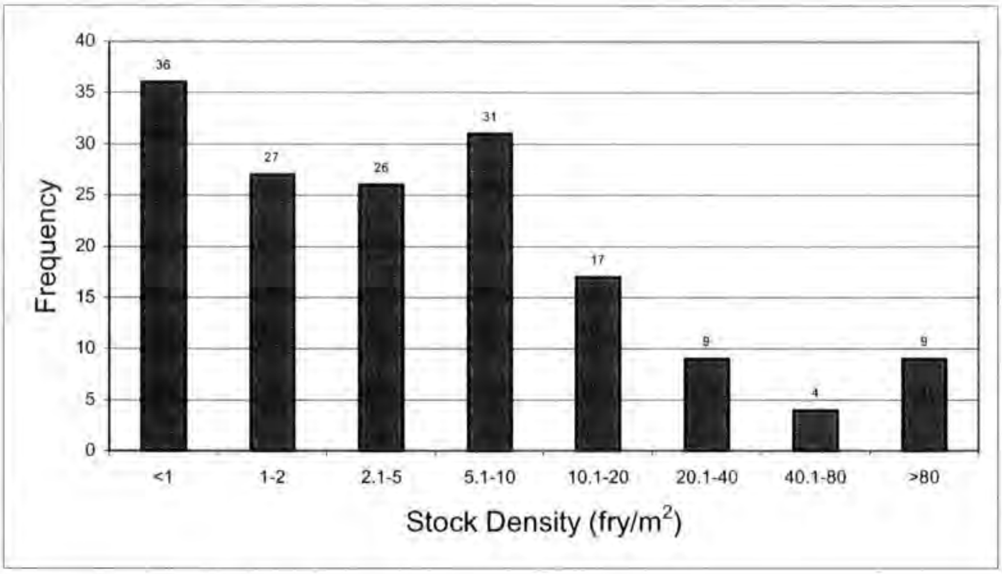


Fig 5.10 Stock Density in phreatic ponds

5.5.4 Farming system

Most farms had one fishpond, between 100 to 2500m^2 (Figures 5.11 and 5.12), either next to the house or in the pastures where cattle graze.

Ponds near the house have many advantages (fig 5.13) as they can be better managed: it is possible to provide feed more often, they can be integrated with other livestock such as ducks or chickens, they are more likely to be kept clean, farmers can do more work with less effort, all the family can participate in the management, etc. On the other hand, manuring takes more effort as the cattle are generally in the fields, and pollution with detergents could be a problem as neighbours and even the actual farmer may not care where the laundry wastes discharge.

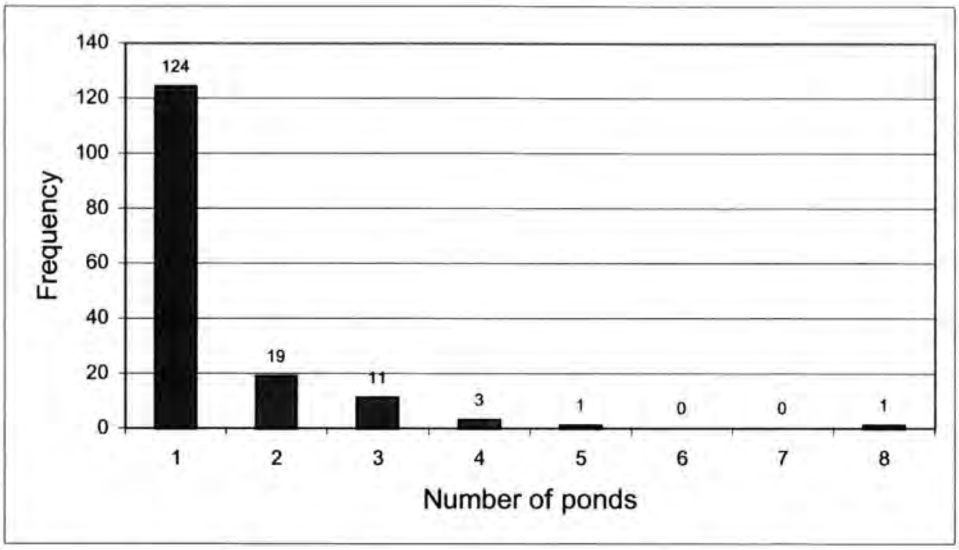


Figure 5.11 Number of ponds per farm

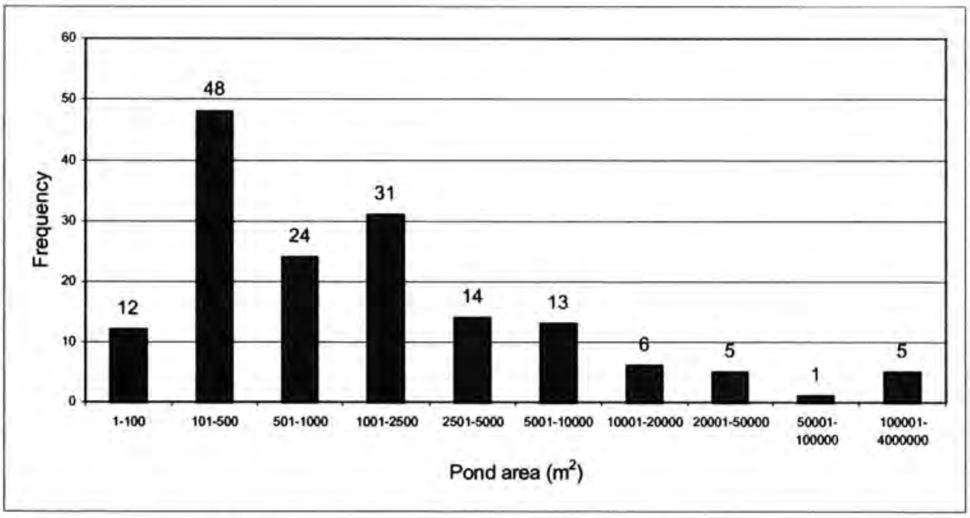


Fig. 5.12 Pond area (m^2)

Fig 5.13 Fish Pond in a house lot, Sandial, Nacajuca.

Fig. 5.14 Tilapias caught in a phreatic pond

5.5.5 Species cultivated

Except for one, all the fish farms farm tilapia, because most farms depend on hatcheries where tilapia is the only species provided. Although many farms utilize only wild fry, tilapia is the most abundant fish in natural water bodies, having been released both deliberately and accidentally during the 1970s and 1980s. Tilapia in Tabasco are a mixture of *Oreochromis niloticus*, *O. aureus* and *O. mossambicus* (fig 5.14). Pure species were introduced to Mexico, but later a number of hybrids were created in the search for all-male populations[25]. The new hybrids could breed with pure lines of the three species and adapted well to the natural environment.

Fig 5.15 Girl showing some *mojarras castarrica* from the latest catch.

This is one reason why a significant number of farmers farm native species (table 5.6). The native species most cultured are: *mojarra castarrica* (*Cichlasoma urophthatlmus*) (fig 5.15), *tenguayaca* (bay snook) (*Petenia splandida*), *paleta* (redhead cichlid) (*Cichlasoma synspilum*) and pejelagarto (*Astractosteus tropicus*). Some farmers also include common snook (*Centropomus undecimalis*), fat snook (*Centropomus parallelus*), *pargo*

[25] During the 1970s and 1980s it was believed that breeding species with opposite sex determination systems would result in all male offspring as in the case of salmonids , but this did not happen as the sex determination system of tilapia is more complicated.

(*Lutjanus sp*), and herbivorous carp (*Ctenopharingodon idella*) which is known locally as bobo escama, introduced in the neighbouring state of Chiapas to control the blooms of aquatic hyacinth (*Eichornia grassipes*) and spread naturally into Tabasco. Generally native fish are collected in rivers, lagoons and puddles when lowlands dry out. Fry captured in natural water bodies is varied, including tilapia. Generally farmers do not select any ratio between species but stock what is collected. In the opinion of some farmers, the quality of wild fry is comparable to and even better than that produced in hatcheries.

28% of respondents farmed turtles. Red-lined turtle (*Trachemys scripta callirostris*), is more often found but white turtle (*Dermathemis mawii*) and musk turtle (*Staurotypus triporcatus*) were also reported. Capturing, trading and farming turtle is illegal as they are protected species. For that reason they are consumed on-farm in spite of the high price they can reach (up to 500mxp (£38) per turtle).

Table 5.6 Most common species farmed in phreatic ponds in Tabasco

Species	Frequency	Percent
Tilapia	157	99
Native Cichlids	52	33
Turtles	45	28
Pejelagarto	25	16
Common Snook	7	4
Herbivorous Carp	2	1
Pargo	2	1
Total number of farmers	159	100

Farmers farm native species with no scientific knowledge but their own experience. This reflects the fact that there are no developed management standards such as stock densities and size, ratio between species, feeds, etc. available for native species. There have been some isolated attempts to produce a monoculture model for the *mojarra castarrica* (Mendoza *et al.*, 1989, Galmiche and Sanchez, 1995), and *pejelagarto* (Contreras *et al*, 1989), but they were all conducted under commercial conditions. These experiments were not economically successful so the technology was never transferred to farmers. Basic studies of the biology of *tenguayaca* and *paleta* have also been made but not for farming purposes.

Native species are captured as fry, juvenile and broodstock from rivers, lagoons and lowlands that dry out during February, March, April, and May. Despite all the mistakes involved in farming native species, the existing management information about rural ponds in the literature could be of great help in improving the management and increasing yields.

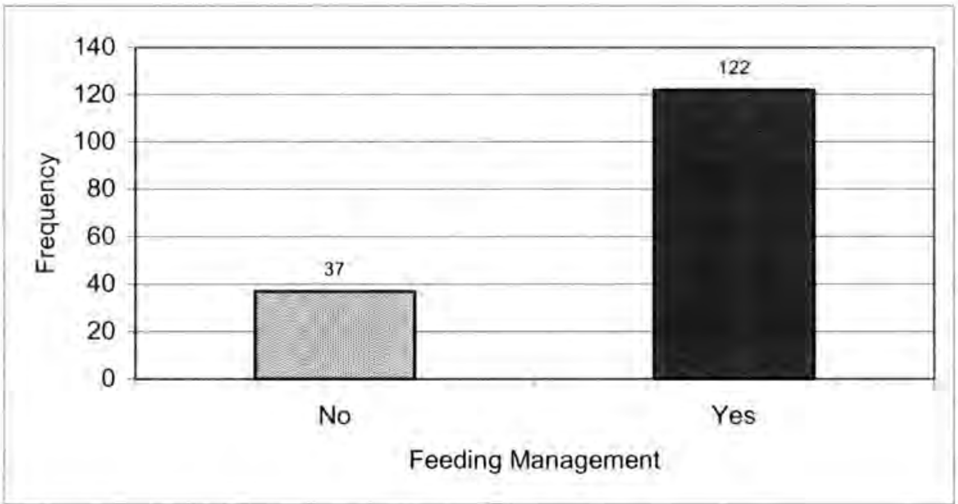


Fig. 5.16. Number of farms providing feeding management

5.5.6 Feeding

77% of farmers fed their fish, but there is no standard feed management (fig 5.16). Farmers mostly use what is available on the farm or nearby. Ground maize, kitchen wastes, termites, cassava leaves (*Manniot esculenta*), *amate* leaves[26], stale bread, insects (attracted by light, deliberately), commercial feeds for other livestock, fruit, live fish, etc (table 5.7), are used as fish feeds. Most of the time farmers use a limited number of feeds, due to lack of knowledge and/or prejudices. A number of resources are under-utilized indicating that yield could be raised with better use of on-farm resources, for example using surplus fruit, which is neither consumed nor sold.

[26]Kind of tree

Table 5.7 Feed types

	Frequency	Percent
Kitchen waste	54	44.3
Blended maize boiled or raw	49	40.2
Fish feed	45	36.9
Other livestock feed[27]	34	27.9
Agriculture by-products[28]	35	28.5
Stale bread	9	7.4
Alive fish and/or shrimp	5	4.1
Not using feeds	36	
Total	159	

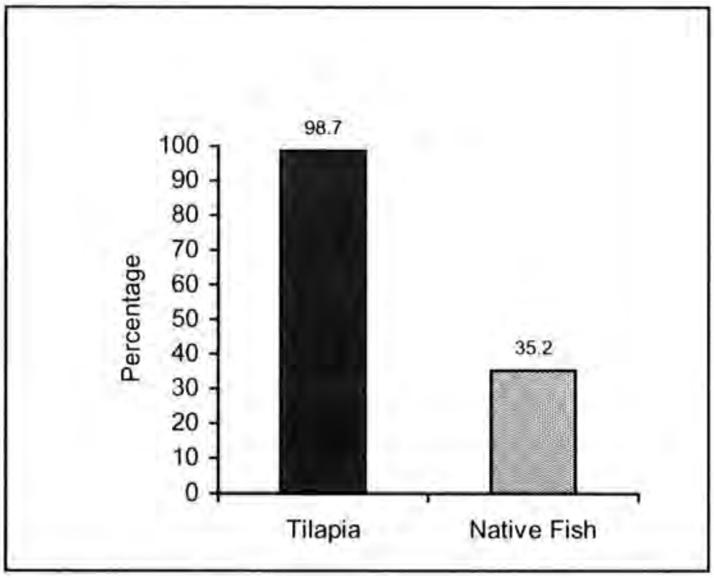


Fig 5.17 Species cultivated on semi-subsistence farms

There is a belief that fish, especially the native species, have enough nutrition from the grass and small insects at the edge of the pond, so in the farmers' view there was no need to add anything else. Farmers thought that *tenguayacas*, *mojarras castarrica* and *paletas* grow well without extra food. Native fish were often compared to the unimproved (*criollo*) chickens, which grow slower than improved races but do not depend on formulated, protein-rich feeds to grow. That is why more people farming native species tended not to add feeds compared to those farmers only farming tilapia (fig 5.17 and 5.18). Similarly most believe that tilapia can only grow well with commercial formulated feeds.

[27] Other livestock feed: pig, chicken or cattle (one or more kinds)

[28] Agriculture by products and other materials: termites, macro algae, grass, bananas, rice byproducts, insects, *amate*, cassava leaves, etc.

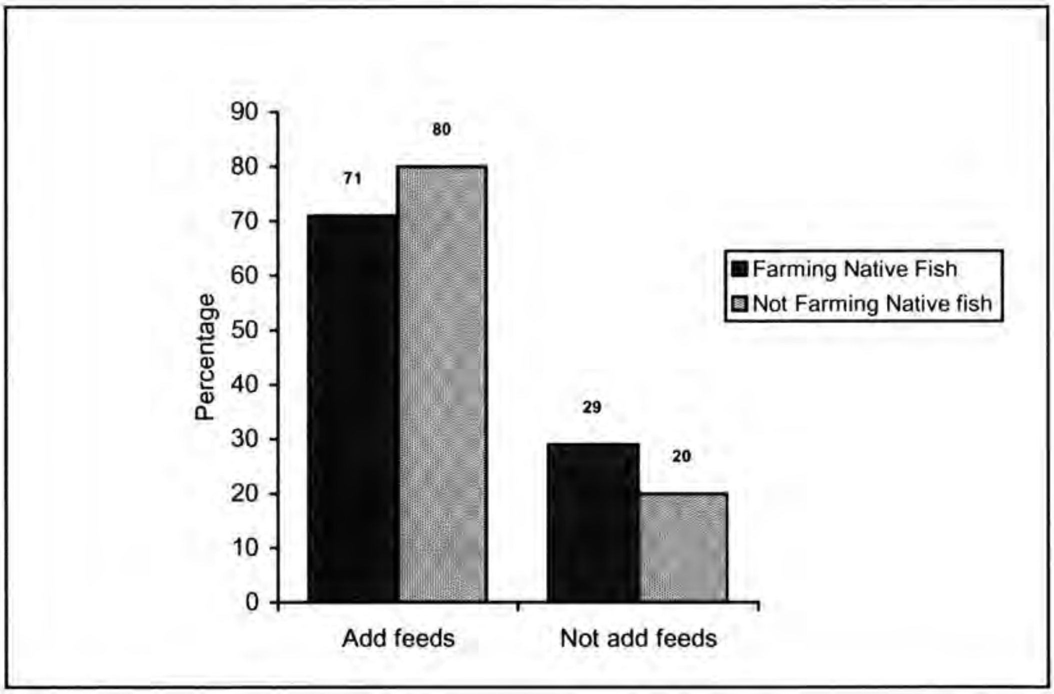


Fig 5.18 Differences in feeding management in ponds containing native species.

Despite a difference of 974 kg between the yield of those farms which provided feed to the fish and those which do not, no significant differences were found at the 95% interval confidence in the t-test (Table 5.8) This lack of significance was a result of the very high variances resulting from the physical and management conditions for fish farming in Tabasco. Nevertheless the value (0.076) is almost significant, indicating a pattern in which ponds provided with feeds resulted in higher yields. Similarly, no significant difference appears between the different types of feed provided to the fish. Moreover, there was no significant difference in yield between the group providing commercial fish feeds and those who used other feeds.

Table 5.8 Yield at last crop in ponds supplied with and without feeds.

	N	Mean	Arithmetic Mean	Std. Deviation	Std. Error Mean
With feeds	75	2502	931	.6737	7.780E-02
Without feeds	26	1528	505	.6072	.1191

T-test not significant .076 assuming equal variances and .0698 when equal variances are not assumed. 95% confidence interval.

This result indicates that the use of on-farm by-products and commercial feeds produces similar results. Yields of 1 t ha^{-1} a^{-1} can be obtained using local and on-farm by-products and thus commercial feeds are not necessary. The lack of difference between the use of formulated commercial feeds and on-farm by-products is because a considerable number of farmers use commercial feeds not formulated for fish (table 5.7). In general these feeds are inappropriate because they have low stability in water letting vitamins and other nutrients dissolve or mix with the water before the fish take advantage of them. Commercial pig, chicken or cattle feeds act more as expensive fertilizer. Another reason is that most farmers using fish feeds utilized feed from the fish feed plant managed by the local government of El Centro, which contains high levels of grains and chicken manure and lacks agglutinant[29]. This feed is provided at subsidised prices to fish farmers while commercial feeds are expensive and inaccessible. Although this service is potentially of great help, the quality of the feed is low and most is wasted in the pond.

The lack of effectiveness of fish feeds is also a result of inappropriate feeding management, as seems clear when data about feeding rates are observed (table 5.9).

Table 5.9 Feed quantity kg d^{-1}.

Feed quantity (kg/day)	Frequency	Valid Percent
0.1-2	31	42.5
2.1-5	16	21.9
5.1-10	14	19.2
10.1-20	4	5.5
20.1-40	5	6.8
40.1-50	2	2.7
200	1	1.4
Total	73	100.0
Not applicable (no feed added)	62	
The respondent does not know	23	
Information not available	1	
Total	86	
Total number of farmers	159	

[29] Agglutinant is necessary to keep the pellet form of the feed to ensure the fish ingest all ingredients.

The feeding management is very diverse, and in most cases has no technical or practical foundation. Most farmers have no proper feeding management. The majority add the same quantity of feed throughout the cycle and others add feed only when the fish are small (table 5.10).

Table 5.10 Feed strategy.

	Frequency	Valid Percent
According to biomass	21	17.8
Fixed quantity or non programmed	97	82.2
Total feeding	118	100.0
Not applicable (no feed added)	37	
The respondent does not know	3	
Information not available	1	
Total	41	
Total number of farmers	159	

Most farmers add fixed quantities of food throughout the growth cycle. This means that fish have an excess of food during the first stages when the natural productivity is enough to satisfy their needs and suffer scarcity during the fattening period when the fish exert more pressure on the natural flora and fauna in the pond. In other words, feed is wasted at some stages and limited in others, causing low growth and higher mortality. Generally the feed provided seems to be insufficient. Taking into consideration that the modal area of ponds was between 100 and 500 m^{-2} and fish density varied mainly between <1 to 20 fish m^{-2}, adding 2 kg of feed every day (as by 43% of farmers) is a very poor diet.

Table 5.11 Feeding frequencies.

	Frequency	Valid Percent
3 times a day	15	12.5
2 times a day	33	27.5
Once a day	30	25.0
3times per week	13	10.8
2 times per week	15	12.5
Once a week	10	8.3
Once every two weeks	2	1.7
When possible	2	1.7
Total	120	100.0
Do not feed	37	
Information not available	2	
Total	39	
Total	159	

Timing of feeding is important to maintain a good growth rate. In general feeding three times per day is the most appropriate, but once a day is still acceptable. As can be observed in table 5.11, timing for feeding is very diverse, and the number of cases when farmers do not feed at least once a day is high although they are advised to feed three times a day. This mismanagement also helps explain the lack of difference in yield between ponds supplemented with commercial fish feed and other kinds of feeds.

5.5.7 Fertilising

Fertilising is the simplest and cheapest way to stimulate the natural food production in the pond. The addition of nutrients promotes primary productivity (phytoplankton), secondary production (zooplankton) and the heterotrophic chain (bacteria). Omnivorous fish, such as tilapia and *mojarra castarrica*, can take advantage of all levels of the trophic chain, but others such as the carnivores *tenguayaca* and *pejelagarto* are specialized in only one level. Good fertilizer management is therefore necessary to increase yields and reduce expense.

Fertilisation was on a non-technical basis. Mostly ponds' primary production was poor because of inadequate rates of fertilization. The main reason given was the farmers' fear of polluting the water and contaminating the fish or affecting the cattle, but farmers were aware of their own ignorance and acknowledged their need for qualified advice.

Table 5.12 Regional differences in the use of chicken manure as fertilizer in fishponds.

Municipality	Not using chicken manure	Using chicken manure	Total
Tacotalpa	20	7	27
Jonuta	15	2	17
Nacajuca	11	7	18
Centro	12	23	35
Total number of farmers	58	38	96

Throughout the areas studied there was under-utilization of fertilizer resources. Of the 159 farmers only 95 used some kind of fertilizer (Fig. 5.19). Cow manure was the most utilized, followed by chicken manure. Inorganic fertilizers were very rarely used, mainly because of the high cost and lack of information. Aquaculture staff rarely recommend addition of inorganic fertilizers because cow manure is abundant and can provide good results. This is available almost everywhere and implies no monetary cost but some extra labour. Chicken manure is more effective than cow manure in ponds, but using it involves costs and transportation and it is not always available. The use of chicken manure seems to result from the advice of extension officers (mainly in El Centro) who recommend a standard management generally not adapted to local conditions (table 5.12). As a result, farmers spend money on something that could be replaced by a free, more abundant and almost equally effective resource. Even though pig manure was available on many farms (Table 5.13), it was only used on one. Pig manure is known to be one of the most effective fertilizers, superior to cattle manure, but people do not use it due to the bad reputation of pigs regarding cleanliness. Probably because of this, extension officers rarely recommend it.

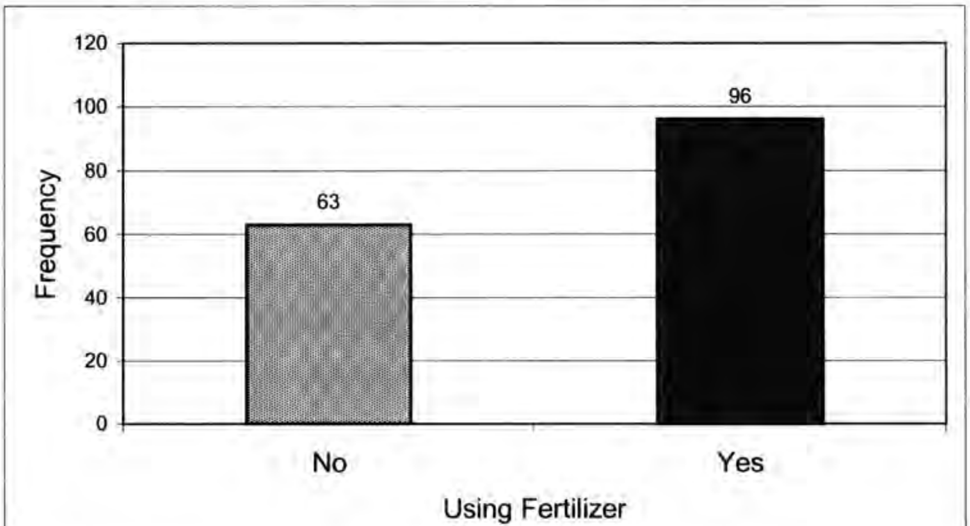


Fig 5.19 Farms using (organic and inorganic) fertilizers.

Table 5.13 Kinds of fertilizer used in fishponds in Tabasco

Fertilizer	Number of farmers
Number of farmers using fertilizers	96
Inorganic (urea or superphosphate)	7
Organic	89
Cow manure	63
Chicken manure	39
Horse manure	1
Pig manure	1
Grass	2

Farmers' distrust of pig manure comes in part from the mistaken belief that manures act as feeds, not fertilizers in the pond. But the process in which manures are utilised in the pond is rather different. Although fish can directly ingest small portions of manure[30], most nutrients pass into the food chain by the heterotrophic action that transforms the manure into bacterial colonies that are eaten by the zooplankton, which are consumed by the fish (Delmendo, 1980). Bacteria transform another part into simple nutrients allowing them to be used by the phytoplankton. Phytoplankton is consumed by zooplankton and also directly by fish. It seems that the use of manures is limited by the farmer's knowledge of the pond system, so that visual tools (video, diagrams, etc) could be valuable in convincing farmers to make better use of local sources of organic fertilizers.

Fertilization is mainly by filling punctured plastic bags with manure, tying the bags to sticks and putting them into the pond so that they stay near the surface where the nutrients can be released slowly. This technique is common when applying inorganic fertilizers such as triple super-phosphate. This is because inorganic fertilisers are fast acting and this technique permits control of optimum levels of nutrients by the simple removal of the bag when the desired water transparency is reached[31]. The adaptation of this strategy seems to be the result of the aquaculture extension officers' advice but there is no evidence whether this technique was developed empirically, under local conditions, or comes from an incorrect interpretation. Applying manures in this way could be inappropriate, because manures are long-term fertilizers which could be used to the full by fish if simply spread into the pond. Manures are animal wastes or agricultural by-products which, when applied to ponds, may serve as direct sources of food for invertebrate fish food organisms and fish, or they may decompose slowly to release inorganic nutrients that stimulate phytoplankton growth (Boyd and Massaut, 1999). This has led to fish being

[30] Nearly 20%, but this depends on the kind of manure, the feed the animal ingests, the animal's age, etc. In fact fish only consume directly those materials which were not digested by the livestock (Delmendo, 1980).

[31] Transparency is an indirect measure for primary productivity. 25-35 cm is considered the optimum range. Transparency higher than 35 cm indicates that the pond is not very productive so that more fertilizer should be added. On the contrary less than 25 cm indicates that the pond is too productive and can create problems of 0_2 depletion.

the cheapest source of animal protein in large parts of the Far East, obtaining best results with frequent applications (Wohlfarth and Schroeder, 1979). Applying manures in bags reduces this advantage as the nutrients released are used only by the phytoplankton, whilst the potential use by zooplankton and direct consumption by the fish are eliminated. It has been suggested that the reason for adopting this practice is to prevent over fertilisation of the pond, but as this would require very high inputs the problem is unlikely to occur (table 5.14). For example, depending on the pond conditions, 100 kg-$ha^{-1}d^{-1}$ of dry cow manure[32] has been suggested as an appropriate rate, (Schroeder, 1980). Only 37 farmers applied manure through spreading (table 5.15). This indicates that a potential increase in average yield is possible by improving fertilizer management.

Table 5.14 Fertilizer rates (Kg ha^{-1} $month^{-1}$) managed for fishponds

	Frequency	Valid Percent
< 50	27	37.5
50 - 100	12	16.7
101 - 250	18	25.0
251 - 500	9	12.5
> 500	6	8.3
Total	72	100.0
Not fertilising	63	
Data not available	24	
Total number of farmers	159	

Table 5.15 Methods of fertilisation in fishponds

Fertilizer method	Number of farmers
Number of farmers using fertilizers	96
Bags	53
Spreading	37
Dissolved in water	4
Trays	8
Added to an enclosure inside the pond	1
Left to decompose in water, then added	1

Other problems detected in manure management are quantity and quality. Generally farmers use dry manure rather than fresh manure. Fresh manure is more suitable because it contains more micronutrients and dissolves better in water. Management however is harder, as more volume is required and it is

[32] Based on dry matter

more difficult and less pleasant to handle, thus possibly limiting its use. Nevertheless many farmers were ignorant of the advantages, suggesting that some change could be achieved by informing the farmers of the advantages.

A general problem was also the quantity and frequency of manure applications (tables 5.14 and 5.16). The literature (Delmendo, 1980) recommends the addition of manures daily at noon, on sunny days only, so that phytoplankton can use the nutrients released through heterotrophic action. The addition of manures on dull and rainy days leads to the accumulation of organic matter which, when the sun returns, decomposes quickly provoking excessive nutrient release and, giving rise to eutrophication. This can reduce O_2 levels in the water to the minimum, provoking growth suppression or even the massive death of the fish population (Boyd and Massaut, 1999).

Table 5.16 Frequency of fertilization.

	Frequency	Valid Percent
Daily	12	12.6
Four times a week	1	1.1
Three times a week	6	6.3
Twice a week	9	9.5
Once a week	15	15.8
Every two weeks	9	9.5
Once a month	11	11.6
Every two months	1	1.1
Every three months	3	3.2
Every four months	2	2.1
Every six months	5	5.3
When required	6	6.3
When possible	2	2.1
Only once, before stocking	13	13.7
Total	95	100.0
Not fertilising	63	
Data not available	1	
Total	64	
Total number of farmers	159	

Probably farmers' fears of this problem have led them to a very limited and infrequent application of manures. For example, only 11 farmers applied manures every day, and only 41 did so at least once a week. Similarly 63 (67%) applied fixed quantities and only 3 in accordance with pond productivity (table 5.17). Table 5.14 shows extreme under-utilization of the manures. 54%

applied less than 3kg-$ha^{-1}day^{-1}$ (100kg-$ha^{-1}month^{-1}$), which is very low. Only 5 farmers applied between 33 and 133kg-$ha^{-1}day^{-1}$, which is a better rate. These figures indicate a very limited understanding of fertilizer management.

Table 5.17 Fertilizing strategy

	Frequency	Valid Percent
According to primary productivity	3	3.2
According to fish growth	1	1.1
Fixed quantity	64	67.4
Arbitrarily	27	28.4
Total	95	100.0
Not fertilising	63	
Data not available	1	
Total	64	
Total number of farmers	159	

Table 5.18 Motives for not fertilising in fishponds.

	Frequency	Valid Percent
No knowledge of benefits	33	52.4
No time	2	3.2
Laziness	3	4.8
Does not believe that it is useful	3	4.8
Advised by extension officer	5	7.9
The pond was used for livestock drinking, the manure pollutes	5	7.9
The livestock fertilizes naturally	2	3.2
Lack of cash	4	6.3
Manure changes the flavour of the fish	1	1.6
Water body is too large	3	4.8
Farming in cages[33]	2	3.2
Total	63	100.0
Farmers fertilizing	96	
Total number of farmers	159	

A large number of farmers applied no fertilizer (fig 5.19). 33 of them said that they knew nothing of the utility of manures. Other excuses were: cows fertilise the pond naturally when they go to drink, the manure pollutes the water, the manure changes the flavour of the fish etc. (table 5.18). Some claim to have been advised by extension officials not to add manure, implying inadequacy of pond evaluation and advice. For example, when a farmer applies for fry, technicians evaluate the suitability of the pond, sometimes by means of a water quality analysis (generally only dissolved 0_2 and pH) or direct

[33] Fertilisation is not necessary in cage culture because fish are enclosed in a limited space depending 100% on fish feed.

observation such as water colour and transparency. The technician then tells the farmer whether the pond is suitable and whether it needs fertilizer. The problem is that this recommendation is generally based on one visit, before the pond is stocked, as the extension official rarely returns during the fish farming cycle. But the fact that the pond did not need fertilizer on one occasion does not mean that there is never a need. Thus, the farmer gets the idea that not requiring fertilizer is a permanent trait. Such misunderstanding affects not only the yields but the attitude that the farmer may have when the farming cycle finishes.

5.5.8 Predators:

***Pejelagarto* (tropical gar)**

No significant difference was found in the yields in ponds with and without *pejelagarto*. Gar is an aggressive carnivorous fish so this was unexpected. Generally extension officers recommend clearing ponds of gar before stocking with fry. Farmers do not always follow the advice because gars are highly valued in cookery; they are a kind of symbol of Tabasco's identity. In the late 1980s there was some attempt to produce a monoculture model for *pejelagarto* (Contreras *et al.*, 1989), but the research was abandoned because gar can only ingest live fish meaning a low potential for commercial exploitation. Nearly 16% of ponds contained gar, indicating that the current advice to remove the gars is ignored in favour of the very strong dietary culture in which people prefer losing high yields in the hope of producing a valued fish (now reported as very scarce in the wild). The lack of significant difference in yield between ponds with/without gar could suggest that although gars are unsuitable for typical commercial fish monocultures, the conditions and purposes of subsistence farms permit including them in the system. Extension programmes, therefore, need to define the boundaries between subsistence and intensive commercial cultures and produce new management parameters.

Table 5.19. Farms reporting crocodiles in ponds, both as subject to farming and as a predator.

Farms	Tacotalpa	Jonuta	Nacajuca	Centro	Total
Not reporting crocodiles	30	15	23	33	101
Reporting crocodiles	19	19	7	13	58

Crocodiles

It is important to highlight that crocodiles were reported in 37 % of farms, a meaningful finding as they are considered a threatened species in Tabasco (table 5.19).

As with gar, there was no significant difference in fish yield between ponds with and without crocodiles (table 5.20). The difference of 809 kg in the mean could indicate some effect of crocodiles on yield. The lack of significance seems to be due to the high variances in both samples, nevertheless the means may suggest a tendency. Crocodiles were reported in ponds, both as products and as predators (fig. 5.20), without regard to administrative region or topography (table 5.20). Farmers' attitudes to crocodiles thus seem arbitrary, creating a problem when a standard technology for fish farming is sought. Is it best to recommend the removal of crocodiles to all farmers in order to raise fish yield? Or is it better to include it in the local polyculture system, given that crocodile meat and leather reach high prices in the market?

Table 5.20. Mean yields (kg ha^{-1}-day^{-1}) on fish farms reporting crocodiles and *pejelagarto* in ponds.

	Number	Mean	Arithmetic mean	Std. Deviation	Std. Error mean	Sig.*	Sig. **
Not reporting crocodiles	59	2511	929	4.76	1.23	0.228	0.224
Reporting crocodiles	42	1702	639	4.38	1.26		
Not Farming *pejelagarto*	79	2114	865	4.32	1.18	0.286	0.345
Farming *pejelagarto*	21	2404	578	5.85	1.47		

*(2-tailed) equal variances assumed
**. (2-tailed) equal variances not assumed

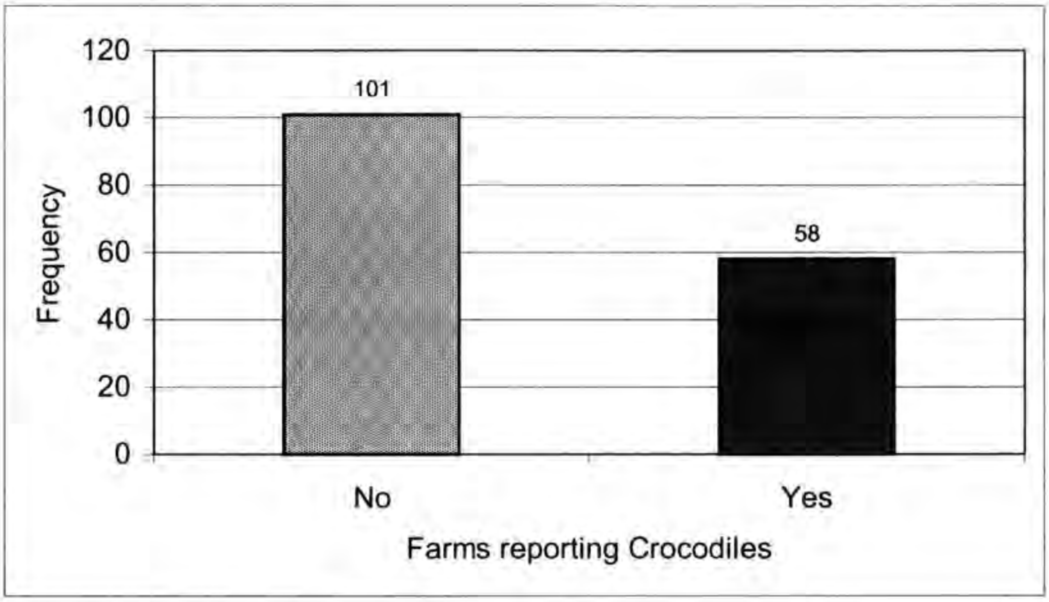


Fig 5.20. Reports of crocodiles in fish farms

Farmers had several reasons for including crocodiles in ponds, some seeming more reasonable than others. The most common explanation is that they see crocodiles as pets. Farmers often expressed joy observing the continuing growth and the behaviour of the crocodiles and disappointment when they escaped from the pond. Another important reason is 'species preservation', expressed as concerns of the right of their descendants to know the native species, and the belief that predators also have a right to exist. National campaigns for the protection of crocodiles seem to have reached the rural population.

Other less common reasons for stocking crocodiles were for food and commercial purposes, as the black market[34] can pay attractive prices for the leather. Other reasons seem more peculiar. Two farmers said that they had the crocodiles to avoid the pond drying up. This belief seems to come from the observation that in wilderness, crocodiles are found in perennial water in droughts. This of course results from the crocodiles' continual movement in search of cooler and deeper water bodies in order to survive the dry season.

[34] As protected species, the trade and consumption of crocodiles are banned. The environmental protection law allows high money penalties and even jail for offenders.

Advice is needed to correct such deductions as their presence affects production.

No accidents with crocodiles were mentioned in the 62 interviews. Either crocodiles have not threatened the security of people on the farms or the topic is so obvious that there was no need to mention it. If crocodiles are wanted in a local polyculture system based on scientific research, security should be analysed, especially on farms where children have easy access to the ponds.

Most crocodiles were reported in Jonuta and Tacotalpa, areas of low population density and few large urban centres. Nevertheless there were important occurrences in highly populated areas.

It could be tempting to recommend the elimination of crocodiles from the system. However, non-economic motivations appear to be very important for farmers (chapter 6) so that practices that sometimes diminish yield are not the result of pure ignorance. Farmers who deliberately introduce crocodiles into their ponds seem to be aware of the negative effect on the yield but still keep them. This could be because farmers mostly see the pond as a multiple-use resource and the production of fish as one but not the only satisfaction they can obtain from it. Renouncing some kilos of fish for the joy of observing wildlife on their farms may be appealing sometimes, because there is no commercial interest and the intention is to consume fish on a few occasions. The recommendation to eliminate crocodiles from the pond should be only and exclusively for those farmers who consider them as a problem e.g.: when farmers' motivation is exclusively yield or money; when there is danger to people living on the farm or when an intractable misconception exists of the effect crocodiles have on the pond.

Other predators

Difference close to significant was found in the student t analysis in the yield of ponds where fish predators and competitors are removed or not (table 5.19). Farmers who cleaned the pond before stocking doubled their yield, producing 744kg more, when the mean yield of farmers who did not remove predators was only 607kg. This result seems contradictory, when the inclusion of *pejelagarto* and other local carnivorous species in the pond did not result in significant differences in yield (table 5.21). As farmers carry out a diversity of management practices, this result could be the product of a sum of multiple factors. First, it is possible that those farmers cleaning the ponds had more access to advice, fish feed and other kinds of support. Then removing predators also implies other good practices. Second, it is possible that removing predators at the beginning of the cycle makes a real difference compared to stocking predator fish mixed with the fry. This is because *pejelagartos*, red *tenguayacas* or *pinta* (jaguar guapote) already existing in the ponds must be of different sizes and very probably the largest individuals consume large numbers of fry as soon as fry is stocked. Fish are more vulnerable when small, and need time to adapt to the new environment in order to have more opportunities of escaping the predators. If however the pond is cleaned, the size of both carnivorous and the omnivorous fish is similar at the stocking time. Then both the predator and the prey get time to adapt to the new environment. Thus, the predating ability of the predator increases together with the escaping capacity of the prey. Similarly if predators are stocked small, they require fewer prey to consume. Although the effect of predators at the beginning of the cycle is negative, their feeding behaviour could be transformed into positive at the latest stages. Cichlid fish are known for their high fecundity. In commercial farms this trait is seen as a disadvantage because ponds tend to overpopulate. Overpopulation creates competition for space and food, so growth rates diminish and so does yield. Thus predators may act as an effective population control by consuming large numbers of offspring, avoiding the overpopulation of the pond. It is clear therefore that there is room to increase yield by exploring appropriate ratios in this mixture of local species. Finally, netting before stocking reduces fish density as large numbers of competing species are eliminated. These species, mainly fish belonging to the families *Poecilidae* and *Cichlidae,* compete for food and space and are not consumed by the farmers because they are small. Their removal helps to optimise the fish's resource use and therefore the yield.

Table 5.21. Difference of yield in ponds subjected to elimination of predator fish before stocking the fry*

	Predators were eliminated	N	Mean	Std. Deviation	Std. Error Mean
Yield at last crop (kg ha^{-1} a^{-1})	No	92	1336.68	2463.86	256.87
	Yes	38	2402.32	3712.68	602.28

*Not Significant 0.057 assuming equal variances,
** 39 missing values

5.5.9 Support

The variable 'support' and 'advice' did not result in significant differences in yield. 'Support' in this study includes a range of assistance such as fry, technical advice, pond construction, feed, fertilizers, O_2 for fry transport, training, fry transport, etc. Many 'supports' had too few cases to analyse. Support was therefore kept as a general variable. Probably the diversity in the variable produced the absence of significant difference in the T test.

5.5.10 Harvest

One of the farmers' priorities in aquaculture in Tabasco is to have a sustainable fish population in their ponds. They therefore catch a limited number of fish at a frequency that, in their view, lets the fish population recover in order to ensure a continuous supply of fish all year (table 5.22, fig 5.21).

Table 5.22 Harvest type

	Frequency	Valid Percent
Total harvest	14	9.3
Partial harvest	137	90.7
Total	151	100.0
The harvest had not been carried out	7	
Data not available	1	
Total	8	
Total number of farmers	159	

Fig 5.21 Harvesting the pond.

This practice lets farmers have fish available when they wish. The annual number of harvests is established by the farmer on arbitrary grounds: when they want to eat fish, when they have guests, when there is no money to buy beef, when tradition dictates eating fish (Fridays in Lent or Holy Week), when the depth of the pond is suitable (when it is too deep, in the rainy season, the harvest is more difficult, if not impossible), when they are able to borrow a net from somebody and, most important, according to the farmer's own impression of the maximum number of fish to take in each harvest and the number of harvests possible without depleting the fish population in the pond. Sometimes this limit is established through experience but not always. Therefore limiting the harvest by the availability of nets, especially when they are difficult to get, could mean a considerable waste of fish (table 5.23).

Table 5.23 Harvest tools

	Frequency	Valid Percent
Different kinds of nets	139	93.3
Hook and simple tools	10	6.7
Total	149	100.0
The harvest had not been carried out	9	
Data not available	1	
Total	10	
	159	

Yields could be raised by making nets available in these farms (perhaps by farmers buying more shared nets), by researching the most suitable frequency for fish harvests, by defining a threshold for the biomass that should be maintained in the pond to permit its recovery and by developing simple methods for farmers to measure the fish biomass. Generally the harvest and dry season coincide, because it is then when the net can be used, as most ponds are very deep in the flood season, when farmers fish for small quantities with rods.

Of the fish caught in a netting session, only the largest are taken and the remainder returned to the pond. The size taken depends on the farmer's preference, 500g in most cases but there were many farmers preferring fish weighing 1kg at least. This practice helps to raise yields as the most competitive individuals, generally the biggest, are eliminated. This provides more space and less competition in the pond so that the smaller fish have more chance to grow faster.

5.6 Regional differences in fish farming in Rural Tabasco:

5.6.1 Topography

Differences between topographic regions are linked to the differences found when analysing administrative regions (municipalities) (fig. 5.22, 5.24, 5.26 and 5.27), because each municipality belongs to a region with a characteristic environment, and was chosen in order to explore the environmental differences (Figs 5.23, 5.25 and 5.28). As can be seen in Table 5.24, Nacajuca, and El Centro had more fish farms on plains, Tacotalpa in hilly areas and Jonuta on lowlands.

Attitudes to farming are affected by the physical environment. It is possible to perceive a clear difference between people living in hill areas and those living in flat and lowland zones. For the former, fish is less frequent in the diet because fish is naturally scarcer so there is less habit of eating fish. Marketing of fresh, non-local food items like fish reach these villages with difficulty, as distances are long, roads are not well maintained, and the purchasing power of villagers is too low to attract fish traders more often.

Difference in resource availability was observed between the three regions, so differences were expected in yield and type of management.

Table 5.24 Number of fish farms by administrative regions and topography.

Administrative region\ Topography	Hills	Lowland	plain
Tacotalpa	46	0	3
Jonuta	0	26	8
Nacajuca	0	6	24
El Centro	4	13	28

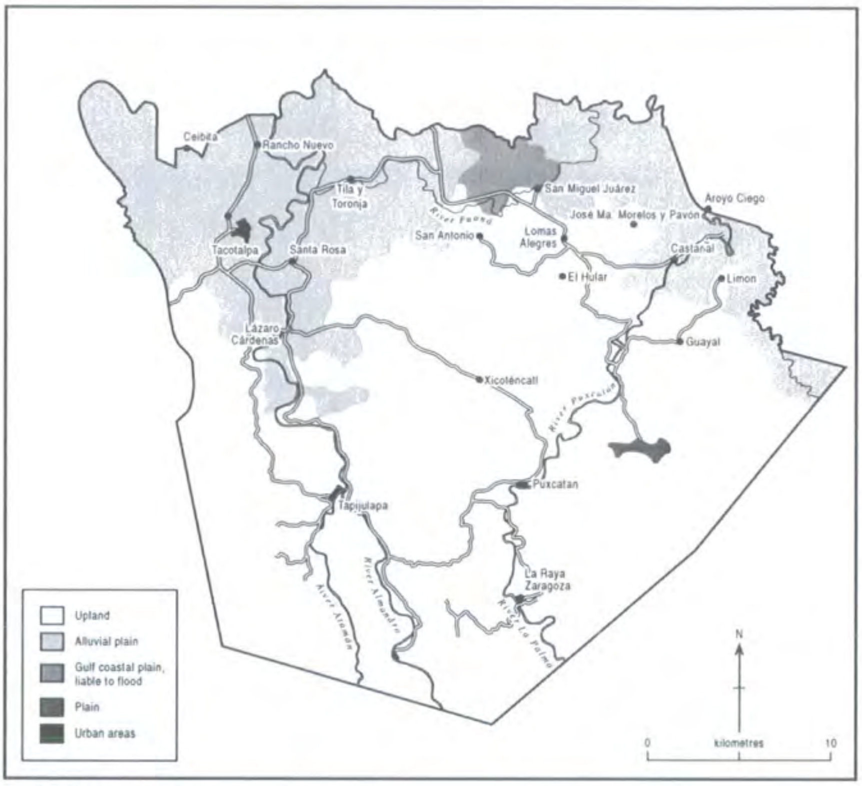
Fewer farmers interviewed were female (13%) in lowland areas than in plain and hilly areas where the percentage was around 25%. This could be because in these lowlands people generally conceive of fish farming as similar to fishing and fishermen are mainly men.

Farmers tended to be poorer in lowland areas. (Here, houses made of wood were more common, 30% compared to less than 14% in the other two environments; these houses are cheaper to build.) These zones tend to flood in the *'nortes'* season, so that the grass tends to have poorer quality for cattle; crop fields are subject to natural hazards such as floods and droughts and consequently agrarian activities are very problematic. This affects farmers' wealth and sometimes, as in the case of Jonuta, which is mostly lowland, affects the local budget to promote rural development[35]. For example, people from the lowlands reported considerably less support[36] for fish farming (table 5.25). More than 40% of lowland farmers said they had received no institutional support for fish farming, compared to less than 22% in the other two areas. For this reason, farmers cultivate more native species and obtain the fry from the wild. Their economic condition and the lack of public support

[35] Municipalities receive resources from state and federal governments, but as there is not an efficient system of resource re-distribution, poor regions receive little so an important fraction comes from local taxation (property taxes etc.).

[36] Support can be given as fry, fish feed (free or at subsidized prices), pond digging (free or at preferential prices), cages, transportation of the fry, O_2, advice on production, training, marketing advice, infrastructure, fishing equipment, etc.

means they cannot afford to pay for transporting the fry from the hatchery (table 5.25).

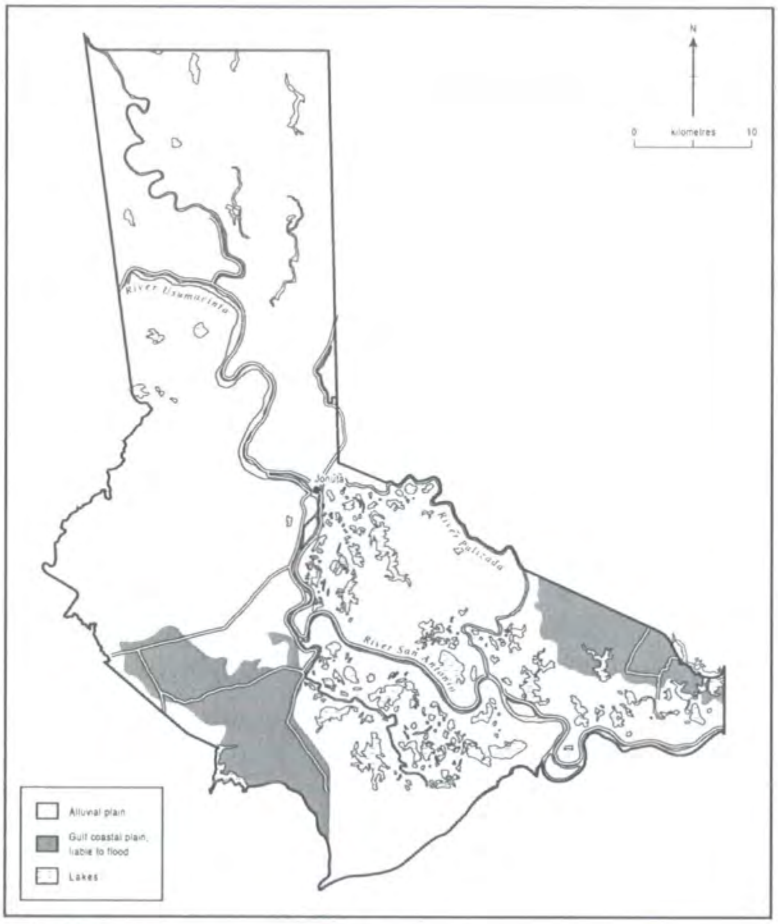


Tacotalpa topography

Fig. 5.22 Topography, Tacotalpa[37]

Fig.5.23. Fishpond in a hilly region

[37] Modified by the Design and Imaging Office, Geography, Durham, from SEDESPA (1997a)

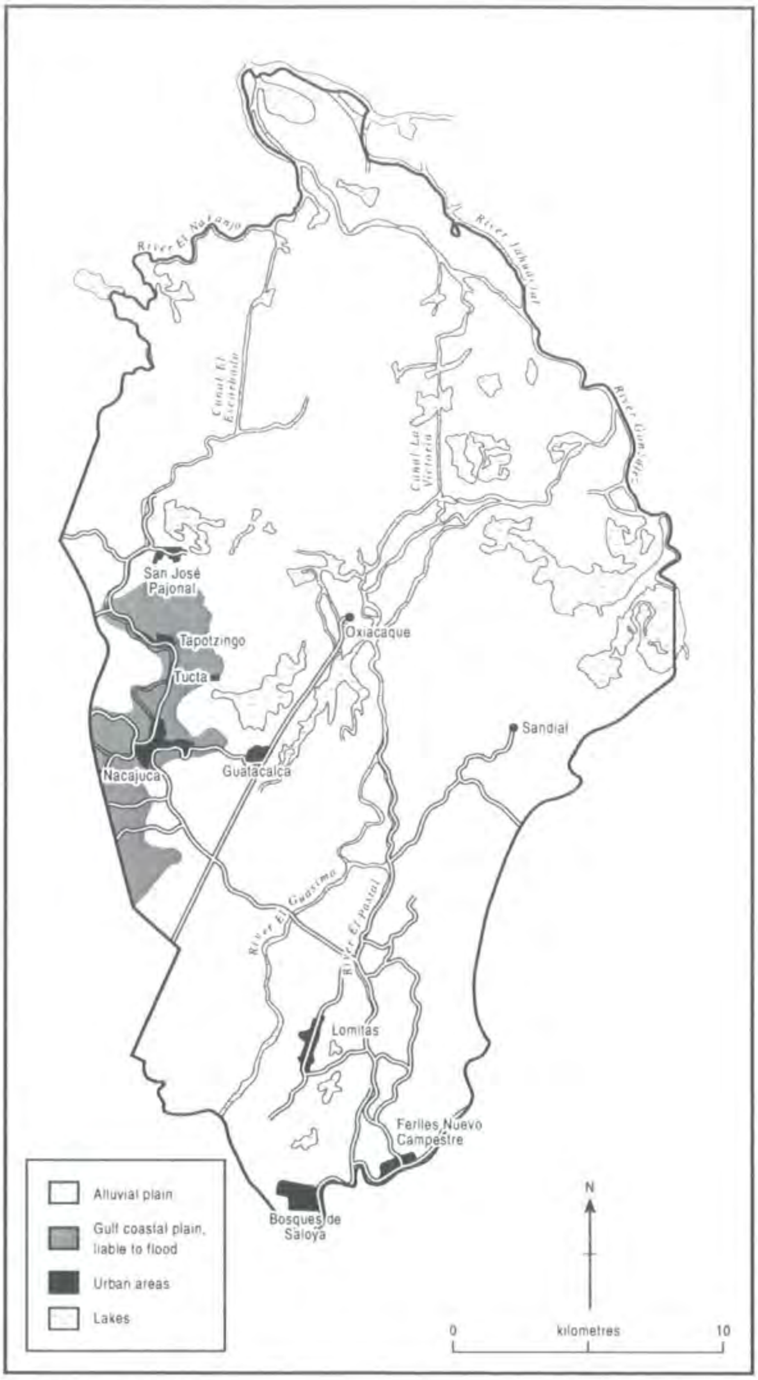


Jonuta topography

Fig. 5.24 Topography, Jonuta[38]

Fig 5.25 Fishpond in an area subject to floods.

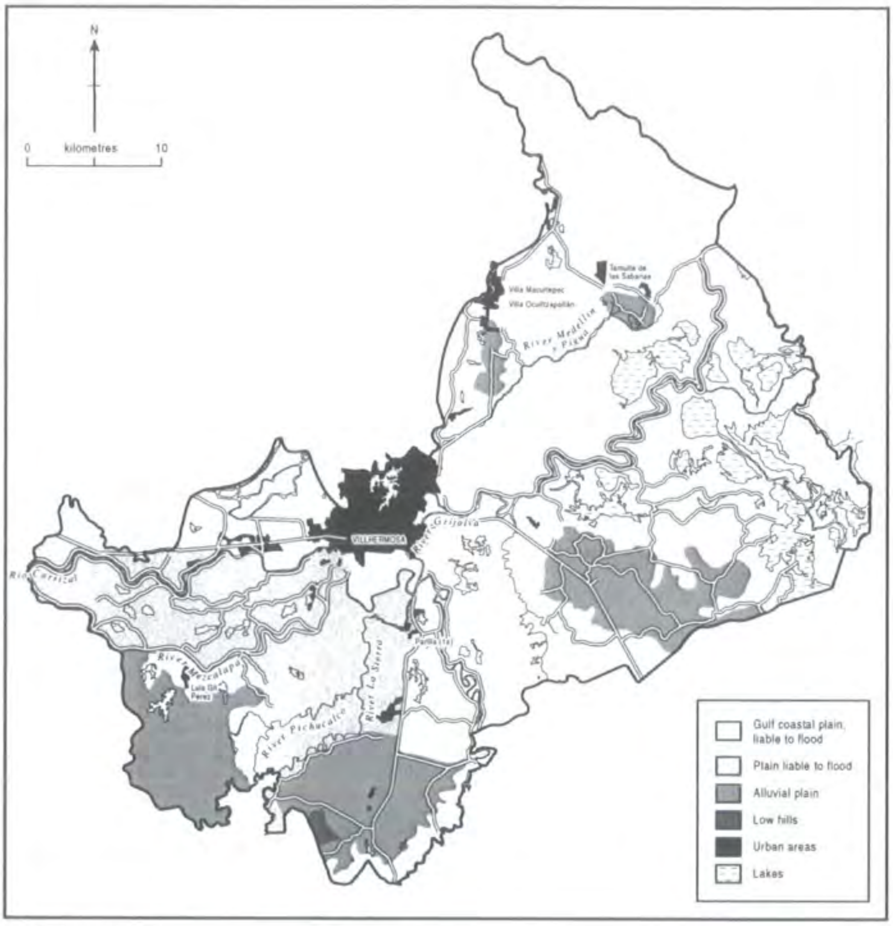
[38] Modified by the Design and Imaging Office, Geography, Durham, from SEDESPA (1997c)



Nacajuca Topography

Fig. 5.26 Topography, Nacajuca[39]

[39] Modified by the Design and Imaging Office, Geography, Durham, from SEDESPA (1997d)



Centro topography

Fig. 5.27 Topography, El Centro[40]

Fig. 5.28 Fishpond in a plain region

[40] Modified by the Design and Imaging Office, Geography, Durham, from SEDESPA (1997b)

Table 5.25 Species cultivated in 3 different topographies (number of farmers)

Species	Plain	Lowlands	Hills	Number of Farmers
Tilapia	63	44	50	157
Native cichlids	18	22	12	52
Pejelagarto	11	12	2	25
Snook	3	4	0	7
Turtles	17	17	11	45
Total	63	45	50	159

Now that the fry has also to be paid for, accessing hatchery fry is even more limited. SFOE provided free fry before 1997, but nowadays farmers have to pay 100 mxp per one thousand fry.

Most farmers in lowlands went into aquaculture out of personal interest, with the need to produce food, environmental concern, perception of fish scarcity in nature, and benevolence[41] being some of their commonest reasons. People in plain and hilly areas however were mostly motivated by someone else. In these regions most farmers went into aquaculture because they were offered a programme or because they copied someone else. It was clear that the poor tended to seek activities to secure food, like aquaculture, even when the environmental conditions were not appropriate. This is the case in the lowlands where, for generations, people have been accustomed to eating fish, as it was abundant during the flood season. If fish are now scarcer than before, fish farming is an option to maintain their food culture. It is precisely in these poor areas where less support is provided for aquaculture, that people tended to have more enthusiasm for and better attitudes to fish farming (table 5.26).

Table 5.26 Number of farmers saying they obtained some kind of support from any government institution.

	Plain	Lowland	Hills	Total
No	14	19	10	43
Yes	50	26	40	116
Total	64	45	50	159

[41] In some regions villagers spend part of their time saving fish which are dying in puddles when lowlands start drying in the dry season and stocking ponds or returning them to the streams.

Farmers in lowlands tended to restock fish more often. More than 50% of farmers had restocked more than three times compared to one or twice in the other two areas (Table 5.27). This is because farmers in lowlands can capture fry every year from the nearby rivers, lagoons and swamps so that they have less dependence on hatchery fry, an advantage that people in hilly areas do not have where farmers have to depend 100% on the fry produced in hatcheries (table 5.28). The only limitation on fry collecting in the wild is extra effort, but this is offset by the fact that they do not need to spend money on fry.

Table 5.27. Number of fish farming cycles in fish farms located in three different topographic areas.

Number of stockings	Plain	Lowland	Hill	Total
<2	41	22	48	111
3 - 4	15	11	2	28
> 5	8	12	0	20
Total	64	45	50	159

Table 5.28. Origin of fry stocked in fish farms in three topographic areas.

	Plain	Lowland	Hills	Total
Fry produced in hatcheries.	50	22	49	121
Fry caught in natural water bodies.	13	23	1	37
Total number of farms	63	45	50	158

The number of active farms is an important indicator of success in fish farming, and could be more appropriate than yield or pond condition. If people keep on farming fish in spite of low yields and management problems, it may be because fish farming produces some practical benefit or satisfaction. In this sense, lowland farms present the lowest rate of failure (29%) compared to almost 50% in plain areas. Thus the poorest zones, with more management and environmental problems and less support, tend to remain in fish farming. This could be due precisely to these adverse conditions. As mentioned before, farmers in lowlands in rural Tabasco are accustomed to surviving under very difficult conditions. They carry out agriculture and livestock production with fewer environmental advantages but are more prepared for natural hazards than people in hilly and plain areas where farmers are used to more stable conditions. Natural phenomena such as the Roxanne and Opal hurricanes in 1995 and the Great Flood of 1999 caught people unawares in the flat areas. Economic losses were thus high, and so was the disappointment of failure, which made many farmers quit productive activities, especially the less deeply rooted, like fish farming. For example, nearly 50% of those who had quit fish farming in plain sites (table 5.29) said that the main reason was their disappointment after fish escaped in the floods. In contrast, people in lowlands know that there is no guarantee of a good or bad year, they are used to have some losses and also to getting no help or compensation. They see climatic variations as a natural part of the production process and have strategies to deal with them, harvesting the pond before the flood season, for example. Just as they continue agriculture and cattle farming in spite of adverse conditions, they also continue fish farming.

Table 5.29. Present situation of fish farms in three different topographic areas.

	Plain	Lowland	Hills	Total
Working	32	32	31	95
Not working	32	13	19	64
Total	64	45	50	159

A learning process can be deduced from table 5.30[42]. If farmers adapt their management to the local environmental conditions, rising yield may be expected in the later cycles as they gain experience. This tendency is mostly observed in lowlands, probably because they give more importance to the pond, have larger fishing tradition or have adapted better to production under difficult conditions.

Table 5.30. Yield tendency in fish farms with more than one culture cycle in three different topographies.

	Plain	Lowland	Hills	Total
Up	15	25	5	45
Down	8	2	4	14
Variable	12	5	2	19
Total number of farms	35	32	11	78

In spite of less satisfactory conditions for aquaculture, and recognising that no differences in yield were found between the three topographies, there was

[42] Data set is small because most of the farmers were not able to provide this information.

less perception of failure in the lowlands where only 20% perceived their aquaculture experience negatively compared with 53% in plain areas and 29% in hilly sites. It is possible that the perception of success depends on wealth, as farmers studied in lowlands tended to be poorer, and had lower yield expectations (table 5.31). Many farmers perceiving their aquacultural experience negative still continue practicing it, indicating that motivations to fish farming are complex and that aquaculture can be seen as a challenge, able to provide personal satisfaction when success is achieved.

Table 5.31. Perception of success of fish farmers in three topographic areas.

	Plain	Lowland	Hills	Total
Positive	20	23	24	67
Fair	10	11	9	30
Negative	33	10	14	57
Total number of farms	63	44	47	154*

*5 missing values

These results are replicated in the motivation to continue in fish farming. More farmers in plain areas (16%) were not attempting fish farming anymore, compared to only 4% and 2% in lowlands and hills (table 5.32). Most people giving up had practised fish farming only once. Perhaps the results of the first experience define farmers' attitude to fish farming. If there is failure in the first try, there is less probability to undertake it again. On the other hand, a farmer who achieves a good first cycle but fails in the second seems to keep a more positive attitude. Aquaculture institutions should perhaps provide special attention for farmers attempting fish farming for the first time.

Table 5.32. Attitude to fish farming in three topographic areas

	Plain	Lowland	Hills	Total
Farmers who will not continue in fish farming	10	2	1	13
Farmers who will continue in fish farming	47	37	43	127
Farmers who will continue in fish farming but only if more support is provided	7	5	5	17
Total number of farms	64	44	49	157*

* two missing values

Difference was also perceived in availability of equipment for harvests. In lowlands 70% farmers owned nets as people regularly fish in natural water bodies compared to 37% in hilly areas where fishing is a marginal activity as there are fewer rivers.

Differences appear in the objective of producing fish. More farmers in hilly zones (84%) farmed fish exclusively for on-farm consumption compared to 48 % in the lowlands. Traditionally, farmers in the lowlands have practised seasonal inland fishing, mainly in the flood season when agriculture is not possible. Small-scale inland fishing in Tabasco is mainly a commercial activity so that lowland farmers are more used to selling fish than people from the hills where fishing is a minor occupation.

Feeding was related to the local availability of resources and access to advice. Maize, agriculture by-products, stale bread, feeds formulated for other livestock and kitchen wastes were more common in lowlands; maize, non-fish feeds and kitchen wastes in hilly areas and fish feed, feeds formulated for other livestock and stale bread in plain areas. Farmers in plain areas tended to have better feed management as a result of more access to technical advice. In contrast, about 50% of farmers in hilly areas only provided feed when fish were small, copying the management of free-range chickens. This indicates lack of experience and absence of advice. Although farmers in the lowlands were less often advised feed management seems to be better than in hilly areas, perhaps because of the experience of more years in fish farming (table 5.33).

Table 5.33. Feeding management on farms located in three topographic areas

	Plain	Lowland	Hills	Total
According to fish size	14	6	1	21
Fixed quantity during the whole cycle	26	24	17	67
Fixed quantity, only when fish is small	10	2	18	30
Total number of farms in which supplementary feed are used	50	32	36	118
Total number of farms	63	45	60	159

Slight differences could be detected in the management of fertilizer. Chicken manure and inorganic fertilizers were more often utilized in plain areas, all of them in El Centro, where more people also fertilize by putting bags of cattle manure into the water, apparently as a result of extension officers' advice.

5.6.1.1 Problems in pond management

Even though all three topographies showed similar management problems, in some cases there were important variations in occurrence (table 5.34). Drought (fig. 5.29) was less common in the lowlands as were floods in the hills. This is because the aquifer is less deep in the lowlands and natural drainage is better in hilly areas so the excess of water can from heavy showers be eliminated by putting a net at the outlet of the pond. Fish thieves were more numerous in the hills, possibly because the farms were larger and taking care of the pond was more difficult. In many cases farmers were living in the villages so the plots were unsupervised. Crocodiles were less reported as predators in plain areas, perhaps because the higher population density does not leave appropriate refuges for wildlife. In the lowlands there were fewer reports of poor fish growth, perhaps because more farmers farm wild fry the quality of which is more uniform. The quality of the fry from hatcheries on the other hand tends to vary in accordance with the quality of the broodstock, which is not always good. Farmers with no fishing equipment to harvest the pond were more numerous in hilly areas where fishing is not a primary activity. As a consequence it is difficult to find people owning nets, and thus farmers commonly harvest with nets only when they can get one. This could have major implications for fish yield[43] because unlike commercial farmers who catch all the fish and then restock, it is unlikely that with only irregular netting the farmers catch all the fish in the pond (Chapter 6). For example, if one farmer nets a $100m^2$ pond every two months, obtaining 20 kg each time, then the annual fish yield reported would be 1 ton ha^{-1} $year^{-1}$. But it does not mean that netting six times a year is the best frequency to exploit all the pond production. The possibility remains that a considerable, but unknown fish biomass is left unexploited.

[43] Fish yield in this study refers to total fish weight which farmers caught from their ponds, not to the actual biomass in the pond.

Fig 5.29 Dry pond in Torno Largo, Jonuta. In areas like this, ponds tend to overflow in the rainy season too.

Table 5.34.Regional differences in common problems in the fish farming cycle

	Plain	Lowlands	Hills	Total
Reporting any kind of problem	64	42	49	155
Birds	33	20	28	81
Slow growth	14	4	7	25
Drought	20	10	15	45
Floods	53	33	30	116
Lack of equipment	5	6	11	22
Thieves	19	13	23	55
Predators: fish and turtles	6	2	7	15
Predators: Crocodiles	15	14	18	47
Pollution	2	3	2	7
Mass deaths	3	2	2	7
Diseases	0	1	0	1
Lack of Advice	31	26	27	84

5.6.2 Municipality

Few differences were found between municipalities in terms of management, resource use, yield or physical-environmental problems. Striking differences were found in the support that farmers received for fish farming (fig 5.30).

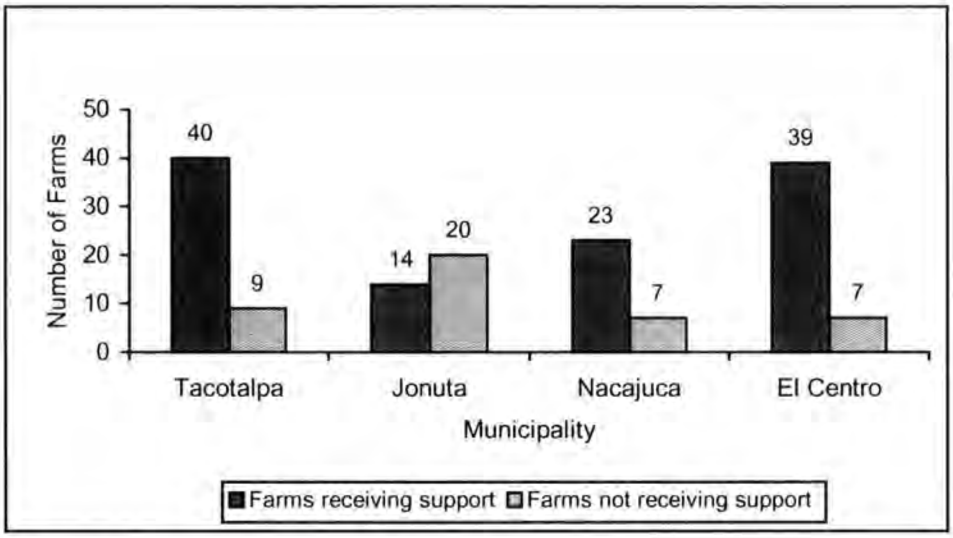


Fig 5.30 Regional differences in support received by farms

Excluding fry, which since 1997 is not provided free of charge anymore by the state government, farmers in Tacotalpa, Jonuta and Nacajuca receive little support for fish farming (fig 5.30). This seems to be because aquaculture is not considered a priority in any of these municipalities so there is apparently no specific budget for it. In addition, none have their own aquaculture extension officers, instead they depend exclusively on the SEFOE Aquaculture Department's extension officers. As SEFOE has only 12 extension officers to cover 17 municipalities, this is little obvious for farmers to receive regular advice.

Particularly in Jonuta, the poorest municipality of the 4 according to welfare level (fig 5.31) and the region with more environmental and physical constraints for fish farming, farmers received little support (41%), compared to El Centro, Nacajuca and Tacotalpa in which between 77% and 85% received at least one kind of support (table 5.35).

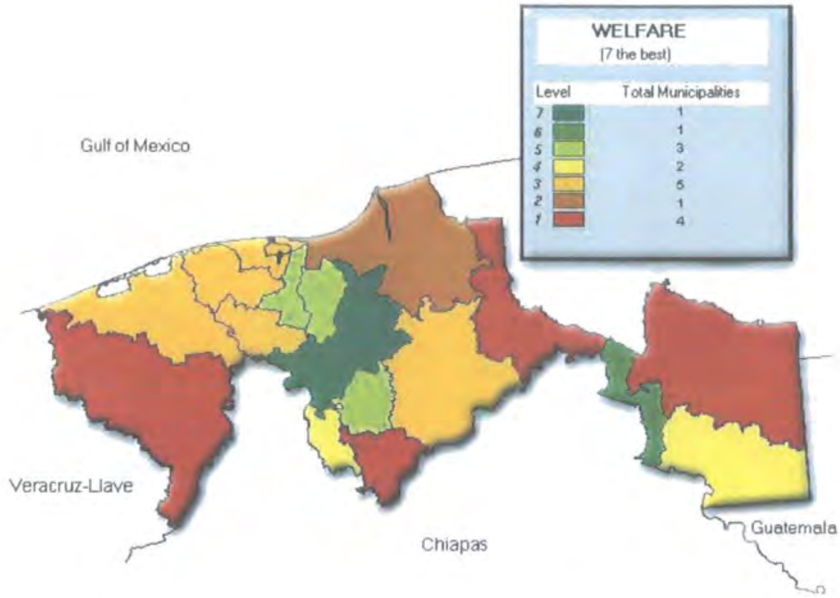


Fig 5.31 Regional Level of Welfare in Tabasco[44]

As Jonuta receives less support for aquaculture and the poorest farmers live in the most distant areas, often subject to floods, it is evident that 'the poor' are precisely those who do not receive support. If the purpose of fish farming is to raise the living standards of the rural poor by the production of high quality food (chapter 7), then it is clear that public resources are not reaching the target group.

Jonuta is a municipality with a low population density in a relatively large area. Most of the municipality is subject to seasonal floods so that access to most communities is limited for part of the year. In addition, the average distance between the farms and the state owned hatchery is further than from the other three municipalities, so that transporting the fry is more expensive, and some farmers said that the cost could exceed 600 mxp (£46). Most farmers cannot afford this.

[44] Source INEGI, http://www.inegi.gob.mx/

Table 5.35 Number of farms receiving any kind of support.

	Tacotalpa	Jonuta	Nacajuca	El Centro	Total
Loan to build the farm	1	0	0	6	1
Transport	13	7	10	30	60
Bags	3	5	11	24	43
Oxygen	21	11	17	31	80
Feed (free)	2	0	4	4	10
Feed (sold subsidised price)	1	0	2	11	14
Pond digging (free)	3	2	4	12	21
Pond digging (preferential price)	7	0	1	4	12
Pond digging (exchange for sand)	0	4	1	2	7
Fry	34	11	23	37	105
Training	3	1	7	13	24
Advice	4	1	11	18	34
Fishing equipment	1	0	4	15	20
Wage for first cycle	1	0	0	0	1
Marketing	1	0	1	8	10
Total farmers receiving support	40	15	23	39	117
Total number of surveyed farmers in the municipality	49	34	30	46	159

Fry supply makes a difference from those receiving support and those who do not since that is the assistance most often reported by farmers. Unlike the other three municipalities, Jonuta government does not subsidise fry transportation. This indicates that transportation is a major factor limiting the expansion of aquaculture among poor farmers and a key factor explaining why farmers do not take advantage of other supports such as free fry. In other words, it is useless to offer free fry, as in the past, if farmers do not have the means to bring the fry to their farms. This example shows that supports that on paper are planned for the poor, in practice may not reach the target for practical reasons (table 5.36). Practicability must be taken into account to ensure that the benefit reaches the target group. A link between federal, state and municipal programmes is necessary to guarantee better use of resources and more probability of reaching the poor. The practical constraints farmers face must not be overlooked.

El Centro is a very different case, where farmers received support in the form of fry, loans, subsided fish feed and advice. El Centro Municipal Administration owns two hatcheries and one small fish feed processing plant[45]. It also has three biologists in charge of the hatcheries and advisory service. The State's capital, Villahermosa, is located in this municipality, which has a larger budget, as most of the State's economic life is concentrated here. El Centro reaches level 7 for welfare (INEGI, 2000), the top level in Mexican standards (fig 5.31). Thus farmers from the most prosperous areas received more support.

Table 5.36 Municipalities, welfare and support

Municipality	Region	Welfare level[46]	Distance from the main hatcheries (km)[47]	% of farmers receiving at least one support
El Centro	El Centro	7	0 – 65	84
Jonuta	Los Rios	1	138	44
Nacajuca	La Chontalpa	5	93	77
Tacotalpa	La Sierra	1	25	81

Problems with thieves were more commonly reported in Tacotalpa (Table 5.37), which seems to be connected to house location rather than to administrative region. In Tacotalpa fewer farmers lived at the plots (table 5.38) so that farmers had less chance to guard their ponds.

Table 5.37 Reports of fish thefts in 4 administrative regions

	Reports of fish thefts		Total
	No	Yes	
Tacotalpa	26	23	49
Jonuta	26	8	34
Nacajuca	21	9	30
El Centro	31	15	46
Total	104	55	155

Some 50% of farmers interviewed in Tacotalpa, Nacajuca and El Centro spoke of their lack of knowledge and need for proper training and advice (table 5.39). That was not the case in Jonuta where 70% said that they had enough knowledge to manage the pond. As Jonuta's farmers had less technical support it is possible that fish farming had been learnt through trial-

[45] At the time this research was carried out none of the hatcheries were operating because the flood of September-October 1999 greatly damaged the infrastructure.
[46] 7 the best.
[47] Calculated from the municipal administrative centre to the State Hatchery in Teapa. El Centro is a special case because it has two municipal hatcheries. The distance between many villages and the administrative centre can be often long, so that the distance to the hatcheries from the villages is generally longer than it appears in the table.

error tests without the guidance of aquaculture technicians. For these reasons they do not seem to be aware of their management problems.

Table 5.38 Thieving incidence by pond location

Pond location	Person living there	Number of thefts	Person not living there	Number of thefts	Total No Farmers	Total number of thefts
Tacotalpa	19	6	29	17	48	23
Jonuta	18	3	16	5	34	8
Nacajuca	16	4	14	5	30	9
Centro	28	6	18	9	46	15
	81	19	76	36	158*	55

* One missing value

Table 5.39 Farmers declaring not having knowledge for fish farming

	no	yes	Total
Tacotalpa	24	24	48
Jonuta	10	23	33
Nacajuca	15	15	30
Centro	22	23	45
	71	85	156*

* Three missing values

Table 5.40. Municipality and type of organisation

Municipality	Individual, family or groups of relatives	Production Groups	Total
Tacotalpa	45	4	49
Jonuta	30	4	34
Nacajuca	17	13	30
El Centro	24	22	46
Total number of farms	116	43	159

More FGs (Farmers Groups, section 5.2.2) were found in plain and lowlands. This result is not related to topography but to administrative region (tables 5.40 and 5.41). When we observe the number of FGs in each municipality, we find that the majority are in El Centro.

This is linked to the institutions in charge of aquaculture development. There are several government institutions dedicated to aquaculture development, but three are the most important: There is one Municipal Development Department in each municipality, depending on the local government. SEFOE, which is a State Government institution; and SEMARNAT, which is the federal body. The municipal institutions vary in their strategies as each one has a different budget for fish farming extension. Generally they have little influence in fish farming due to the lack of resources but sometimes they work in co-ordination with SEFOE. The Municipal Development Department of El Centro is different. It has more resources, two hatcheries, a fish feed production unit and a small team of extension officers. Traditionally this institution worked mainly with groups of farmers, promoting the communal work in large ponds. SEMARNAT promotes fish farms with groups rather than individual families but its influence in the study area is very small. On the other hand, the Secretariat of Economic Development provides fry to both families and groups and there is no apparent attempt to organise groups of farmers. Its work covers all the state but less in El Centro where the Municipal Development Department plays an active role in aquaculture extension. The higher number of groups of farmers in El Centro is thus the result of the differences in strategy between institutions rather than a culture between municipalities. More details of the approach to aquaculture by the different institutions will be presented in the next section.

Table 5.41. Type of organisation in fish farming in three topographic areas.

	Plain	Lowland	Hills	Total
Individual Family or relatives groups	41	30	45	116
Production groups	23	15	5	43
Total number of farms	64	45	50	159

5.7 Commercially successful rural fish farming in Tabasco

As most fish farming in Tabasco is carried out at subsistence level, success in commercial terms is very scarce. One farmer in Buena Vista Rio Nuevo 1a sección, El Centro, near Villahermosa was the exception. Jesus is a 55-year-old, literate farmer who owns a plot of 4 ha where he has his house, and is married, with 2 married sons and their wives living on the same plot. Like other semi-subsistence farmers he farms for on-farm consumption, both vegetables (tomatoes, chillies, pumpkins, cassava, papaya, bananas, maize and beans) and livestock (chickens, pigs, sheep, cattle, turkeys and ducks), but his high farming intensity and greater area cultivated let him have much surplus for sale, mostly directly to consumers in the markets of Villahermosa. He is also a part-time fisherman who sells his catch among other villagers and started aquaculture in order to stock the small fish caught when netting the river. His pond, which is also used as a cattle drinking reservoir is $400m^2$, and was dug by hand, with spades. He farmed wild fry: tilapia, *tenguayaca*, *mojarra castarrica* (5 fry/m^2, stock density) and turtles. The farming management is simple but implies more labour than the average farmer commits. Feeding is three times a day, applying agriculture wastes, stale bread and commercial chicken feeds; and chicken manure and urea as fertilizer. Initially he applied the manure in bags but as he saw this did not turn out as expected, he started applying it spread. The pond had some design problems but works fairly well for the farming intensity practised. He had had some problems with droughts and floods, but had made the effort to make some adaptations to the pond. The business soon started to go well; at the time of the interview, he had completed 4 farming cycles obtaining 7500 kg ha^{-1} a^{-1}. Fish are sold on the farm where villagers go to buy it; his wife and daughters in law capture a few at the time of the sale, charging 15 mxp per kilo. Jesus does not receive support from any extension institution, because, he says, working in farmers' groups is a condition and he prefers to work alone.

This case differs from other fish farms in which there is a combination of factors favouring farm success in material terms. The farm is near a large urban centre where feed inputs are easier and cheaper to get, there is a river from which to collect fry near the farm and there are villagers with enough purchasing power to buy fish often. In addition Jesus has an entrepreneurial mentality and was motivated to farm fish by the wish to earn more cash. However this case shows that it is technically feasible to improve cash income through fish farming in semi-subsistence farms with hard working farmers whose main motivation is to increase their cash income, provided that conditions for trade exist.

Successful communal fish farming (groups of farmers) in commercial terms were also scarce but rather more numerous than individual farmers. All the successful farms were in El Centro, mainly resulting from the work of the

Municipal Development Office (see section 5.2.3). Of 22 APSs[48] visited, four were successful and currently in operation. Others failed or had been successful in the past but due to internal problems were not working; and others were new so that it was not possible to assess their success as at the time of the survey no fish harvest had been completed.

The APSs in Torno Largo is a good example of a commercially successful farm. The farm started in 1990 when SEMARNAT and the Municipal Development Office of El Centro got villagers together in a villages meeting. 45 people attended the meeting but only 20 wanted to join the APS. In the beginning the plan was to work in a big lagoon (Santa Rosa) but it was all covered with water hyacinth so that cleaning it implied too much work for the group. Then the extension officers talked to the owner of a plot and asked for permission to exploit a small lagoon (8 ha) there. Thus the owner would become a member of the APS, receiving the same benefit than the other members in exchange for the permission to work in the lagoon.

The work to clean the lagoon was hard as 80% was covered with water hyacinth. People put in some cash, to buy tools in order to clean it, as the APS did not have money to start with. Cleaning the lagoon took 8 months and during that time most members were quitting as no income was received for their work, so that they had to look for jobs to support their family. As the work was hard on the farm, most members could not do the two jobs at the same time. As a consequence, only nine partners remained when the lagoon was ready to start the first farming cycle.

One and a half years after starting, fish began to be sold. As the APS did not have any infrastructure, members brought tables, chairs and cooking tools and advertised the farm among friends and relatives so they could sell fresh and later roasted fish to get a better price. Meanwhile the society created a bank account to save money in order to built the first *palapa*, which was achieved 1.5 years later. As a recognition of their effort, the local government

[48] Aquaculture Production Societies, see 5.2.3

provided more support to the UPS, first providing more fry and later subsidising the electricity installation reducing the bill at 'government price' from 22,000,000[49] mxp (£4400)[50] to 5,000,000 mxp (£1000[51]), but they only paid one third of it as the local government absorbed the rest. Then they could buy a fridge and a freezer so that they could sell cold drinks and the restaurant could be open to more customers. Now the business has three *palapas*, furniture, kitchen, and all cooking tools required in a restaurant.

The activities on the farms are carried out in rotation, normally working 19 days and resting 11 when the members can work in other activities to earn extra cash. Every two weeks a meeting is held, where the profits are divided according to the workload provided by each partner. The farming activities includes water plants and grass clearing, fertilising (not often), transporting and stocking fry, daily harvest (they only sell fresh fish), cooking, guarding, serving the customers in the restaurant, and purchasing inputs.

The most important problems on the farms are the occurrence of predators and the difficulty of fertilising the lagoon; as it is 8 has, it requires large amounts of manure, implying considerable workload for the reduced number of members Sometimes floods have had negative affects as fish escaped, reducing the yield, and also because they have to stop working for up to 45 days when the access to the restaurant is interrupted. Advertising the restaurant is also a constraint as fees in radio stations and TV are very expensive. Nevertheless sometimes the local government TV station has supported them by advertising the restaurant free of charge.

The support from local government is continuous, every two years they are trained in technical and business subjects and they also get continuous water quality monitoring. In the beginning APS received fry from the Municipal Development Office, SEMARNAT and SEFOE, but as SEFOE stared charging for the fry and they do not have enough resources to afford it, they

[49] 1mxp is equal to 1000 mxp before the reduction of three zeros in the currency.
[50] The price was high because the restaurant is located far from the crossing of electricity lines.
[51] The conversion rate in 1990 was £1 = 5000 mxp.

depend almost exclusively on the local government and SEMARNAT to restock the lagoon.

The APS plans in the near future to built a small swimming pool for children and to plant more trees to increase the green area because many trees died in the last flood season. Jose Antonio, the present manager of the APS said that the APS had benefited all members because before, none of them had a job and now they have a secure income, which has been good for raising their standards of living. He, for example, was able to build a house for his family.

The APS in Torno Largo shows the potential of farmers groups in fish farming to become a sustainable community business. Nevertheless that could only be achieved (like in the case study presented above) because there were a number of favourable conditions. First, this group was small and also had the advantage that all members were relatives so there was a better attitude to solve organisation problems compared to other APSs. Second, the farm is near Villahermosa, having more chances to get to customers. Third, all members had more education (secondary to high school) than the average farmers, having thus more chances to attend and take advantage of training courses. Fourth, It was observed, that there was considerable initiative to improve the farm, probably passed on by the manager who showed leadership skills. Finally, the most important factor for success was the extensive support received (and still being received) from the local government which in the words of the manager, was so important that it would have been impossible to achieve the present stage without it.

This case study also shows the limitations of working with large groups. Generally most groups that have or had success had a small number of members. Other, large groups which were successful in the past ended up failing precisely because of organisation problems and arguments provoked by the number of members. If a group does not fail in the first years, generally the number of partners declines naturally until a sustainable number is achieved, as in this case.

In summary, when the conditions are favourable (appropriate number of partners/members, adequate training programmes, continuous support, farm located close to potential farmers, members with medium scholarly level and honest leaders among members) and the development work is carried out properly fish farming as a community business can be successful provided that farmers' motivation is cash income despite incrementing the workload in their farms.

5.8 Description of the major public extension aquaculture institutions in Tabasco

5.8.1 Secretaría de Fomento Económico (SEFOE) (Economic Development Secretariat)

The Aquaculture Department of the Economic Development Secretariat of the State Government seems to work very inefficiently. This is because there are no clear objectives, or strategy so that each head of the department in turn defines priorities in accordance to their own will and the available economic resources. There is no common ideal about what aquaculture development in Tabasco should be. There are no definite goals and objectives so no accountability. One extension officer said:

'*It is assumed that objectives are the promotion and propagation of aquaculture, training of extension officers, mechanization of the farms, species improvement, training of farmers but they are not doing it. Just a bit.*'

The lack of an action plan is the main characteristic of the Department. A head of Department said that some proposals for the aquaculture programmes had been presented but there has been no response from those in charge of decisions. Middle level staff, such as heads of Department said that they do not have authority to decide certain things without the authorisation of the Director but they have communication problems because one is a vet and the other a biologist. Their argument is that in fisheries more people are benefited but in the view of the aquaculture staff support for aquaculture are more sustainable as people benefited in aquaculture are less likely to go back for support again.

The department is evaluated according to the number of fry provided to farmers, regardless of whether any fish were harvested. What is important is how much fry provided to farmers appears in the annual statistics. At the same time, the department does not have the staff or resources to visit the number of farmers they want. For example in 1999 it was possible to visit only 24% (334 out of 1379) of the production units. There is a political objective involved, to visit as many farmers as possible regardless of the quality of the service. Saying 'no' to farmers is bad for the political party. The Department has essentially become an agency providing fry, with little transfer of technology or advice.

The programme operates as follows: A group of farmers or fishermen sends a letter of application to public institutions such as the Governor's office, SEFOE, Directorate of Fisheries, Mayor's offices or Municipal Development Offices. Letters of application are forwarded into the Department of aquaculture where they are classified into to the following categories of request: requests for fry, pond digging, training and advice and inputs. Once classified, requests go to the staff who carry out technical evaluations or technical assistance. Requests are classified into viable and non-viable and the requested support in theory is provided. Non-viable requests are sent back to the farmer with the results of the evaluation.

The small budget is the source of most of the Department's problems. The department received a budget in 2000 of 500,000 mxp (£36000), compared to 6,500,000 mxp (£464,286) received by the Fisheries Department. In the opinion of the Head of the Aquaculture Department, the budget is small because the state government undervalues aquaculture. Apart from limited resources, the problem of the whole secretariat is the distribution. One Head of Department said '*vehicles are used here to carry political propaganda but not for aquaculture extension... The money is centralized for the travels and expenses of the Secretary and the General Director.*'

As a result, the staff have to work under severe limitations and face many operational problems. For example, the state hatchery does not have a pump so that they have to work with the rainwater that the ponds retain. This affects the service they provide: the hatchery in Teapa, for instance, should produce 10 million fry and only produces 3 million. Similarly from the 1300 production units that they should visit they only visit 300 per year, the technical advice is not consistent and there is no follow up at the farm after the pond is stocked.

Another problem is the poor qualifications of the extension officers. They cannot select candidates, as they have to contract those who will accept low wages. They cannot train them later because there is not enough money to start a training programme for the staff.

Every extension officer visits 5 or 6 farms a week but all depends on the availability of transport or money for petrol. There is only one vehicle in Villahermosa, so that those extension officers in charge of the other 16 municipalities have no transport or travel expenses, so that when there is no money for petrol or chance of a lift to the farms, the visits are cancelled. The Department works inefficiently because the staff are often not working. Most extension officers live in the municipality where they work, and go to the office once every two weeks to present reports, so that there is no check on their work.

5.8.2 Secretaría de Medio Ambiente, Recursos Naturales y Pesca (SEMARNAT) Delegación Tabasco. (Environment, Natural Resources and Fisheries Secretariat. Regional Office, Tabasco)

This aquaculture unit is part of the sub-division of Fisheries in the Regional Office of SEMARNAT in Tabasco. SEMARNAT is a federal Secretariat in charge of Natural Resources, Environment and Fisheries. The head of the Unit is a Biologist. This unit is divided into two Departments: Aquaculture Development and Aquaculture.

1. The Aquaculture Development Department has its base in Villahermosa. It has a staff of four, one biologist (head of the department), and 3 extension officers (2 biologists and one technician) who have temporary contracts. Most of their time is spent operating the National Programme of Rural Aquaculture, which has 'the rural poor' as the target group. The field staff carry out site surveys, give technical advice and run training courses. The programme should reach all the State but in practice some municipalities are not included, especially the poorest. The process to obtain support is simple. A letter of application is sent to the SEMARNAT Regional Director and from there to the Aquaculture Brigade, but if the village is very poor a visit is carried out to check whether there are interested groups.

The Aquaculture Brigade from SEMARNAT has a different strategy from SEFOE as they focus on a smaller number of farms with a closer follow up of performance. They seem to provide a better service than SEFOE, offering more technical assistance and support to farmers. SEMARNAT is better organised and follows a work programme based on definite and achievable objectives. Its action is less politically oriented. In other words, they only visit as many groups as they can provide with good, sustained advice, even if that means a small number. According to internal documents in 1995 11 groups were served while in 1999 the number rose to 38. The problem is the limited scope and the programme does not seem to be reaching the target group. Even when the programme focuses on the poorest farmers, the benefit does not reach the poorest regions although it is well represented in the richest. For example, in 1999 Tacotalpa and Jonuta, two of the poorest municipalities, were not included in the programme while Centro and Nacajuca, which are in the upper levels of welfare, were. In fact, none of the poorest municipalities of Tabasco were included (SEMARNAT, internal document).

This Department provides project design and technical assistance to interested groups of farmers (between 15 and 80 members each). The department works with groups of both men and women but in practice the majority are men (60%). Groups can be already established or their formation can be promoted. These groups can be registered or not. SEMARNAT promotes group organisation, directing resources to specific target categories. For example in 1998 they formed 6 women's groups. As the number of members in each group is high, they recommend semi-intensive, commercially oriented systems such as enclosures in lagoons and floating cages in deep 'sand extraction holes', to ensure a fair profit for everybody. They rarely work with small ponds. The Department does not train groups in organisation because another Department in the Secretariat has that function. The projects they manage seem to be more structured, and sometimes include cage-making materials but generally they do not provide support in digging ponds.

Unlike SEFOE, extension officers in SEMARNAT have a guide to making technical evaluations of farms. This enables them to have more reliable control of farms and provide better advice. For example, up to 6 advice sessions per group per farming cycle can be achieved. They are careful about delimiting boundaries when the water body could be next to another property, to avoid problems with the neighbours due to property right.

2. The Department of Aquaculture has its entire staff working at the Hatchery in Puerto Ceiba. The Head of the Department is a biologist. The hatchery monitors the oyster population in a coastal lagoon and produced tilapia fry with a capacity of 2 million fry per year. Fry production stopped because the costs were too high compared to the hatcheries managed by the State Government. Now they obtain the fry from other hatcheries. The fry is provided free of charge to farmers. In the past they only provided the fry but now they give advice throughout the farming cycle and also provide training to farmers. The services are offered to the public, private and social sectors. The hatchery has a manager who also visits farms. In addition there are fifteen workers, two technicians, and two secretaries. The main problems in the hatchery are related to labour. There is little renewal of staff and the older workers are less motivated, they are skilled, experienced workers but sometimes they are too old and no longer have the fitness to carry out the work. New contracts depend on retirements. The trade union is strong so that the working day has been reduced to 6 hours because the hatchery is

considered an unhealthy zone in the Secretariat ranking because it is located in a warm and humid region the workers have to spend long time in the water.

Since both Departments are very small and the economic resources are insufficient, the scope of the programme is small and it is not possible to meet all requests. They must select the farmers to be assisted and generally those who insist more are selected. In 1999 38 out of 700 groups were visited. Technical assistance is carried out through direct visits to the farms or telephone and personal meetings. Because their fry availability is limited, they give preference to applications for a small number of fry in order to benefit more people. In their strategy the number of beneficiaries counts for more than the number of fry stocked. The Departments have one vehicle each but money for petrol is not always available. They also have water quality equipment. The number of extension officers is not decided in accordance with the workload but to the posts available.

SEMARNAT has the same transport problems for extension officers but here the problem is more a lack of money for petrol than vehicle availability. Equipment is available for technical evaluations and they seem to provide better advice than the State counterpart. But the attention to farmers is irregular and the farmer-technician relationship is limited because different extension officers visit the same farmer. Sometimes visits are more complicated because extension officers also have administrative tasks and very often get the day's programme that very day so that they cannot notify farmers of the visit. Each extension officer visits 2 farms per month.

There is no training programme for extension officers because they have short-term contracts and so do not qualify to attend refresher courses. This affects their work negatively. It seems that there is not even a transfer of knowledge from experienced people to the newer members in the same institution.

'I did not get any training to work with farmers and I should have. I feel that people who have worked with farmers should tell us how to approach them, how to say things, what to say and what not.'
Extension Officer (SEMARNAT)

5.8.3 Desarrollo Municipal, Municipio del Centro. (Municipal Development, El Centro Municipal Administration)

The Municipal Administration in El Centro works a little differently. The aquaculture programme started 15 years ago, with the goal not of serving a massive numbers of farmers but of recruiting people who are interested in aquaculture. Groups can be women, men or mixed and age ranges from young teens to old people. The programme seeks to organise self-sufficient groups to produce and commercialise fish. They claim that it is why they have had good results. Groups may sell the produce raw or cooked, as sometimes the programme finances groups to open their own restaurants, a strategy which has proved to be successful in some cases but has failed in others.

The Municipality owns two hatcheries[52], which in total produce 2 million, fry per year. One of the hatcheries was built on the abandoned infrastructure of a zoo, which was never finished. They also have a feed processing plant, to provide fish feeds to farmers at low prices, but that was almost destroyed by the recent flood.

The budget is very low, less than a tenth of the money assigned to the agriculture, forestry, horticulture or livestock programmes. The Municipality funds 100 % of the budget. Because of this programme, SEFOE and SEMARNAT pay little attention to El Centro farmers. As the budget is limited, they work with little equipment and no vehicle, and share vehicles from other programmes. There are no training programmes; extension officers may attend courses at their own expense.

[52] During this research the hatcheries were not working because they had been damaged by the largest flood in the last 50 years.

The programme has three biologists and a changing number of other workers. The biologists think that these staff can satisfy the maintenance of the hatcheries and the technical assistance to farmers. They work almost exclusively with groups of farmers. More support is given to the group at the beginning, and little by little it is reduced as they try to make the group independent but this is not always the case as it depends on the interest farmers pay. The programme normally provides technical assistance for intensive and semi-intensive systems such as floating cages, enclosures and pond cultures, generally oriented toward commercialisation.

5.9 Concluding Remarks

It seems that water quality and soil characteristics are not the main limitations for fish yields at the present level of intensity in the regions studied. Management such as density, feeding and fertilisation rates and the mixture of other practices, seem to play a major role in affecting yield. The problem is that it is not possible to identify the extent in which each management practice affects yield because of the great variety of management practices performed by the farmers. This complicates the analysis. Such complexity does not permit the presentation of concrete conclusions pointing out the specific management practice or group of practices influencing more significantly fish production. Such specific findings are beyond the scope of this research, but should be explored in the future. Nevertheless the findings presented here are enough to sustain a proposal for defining actions toward the improvement of the technical conditions of fish farms in the area studied.

Considering that aquaculture was introduced in Tabasco more than 25 years ago, it is remarkable that ponds are still dug with basic mistakes, and located in places likely to overflow. Why has pond design not changed to a more appropriate design? In my view, the problem is that knowledge of fish farming is not widespread. People do not share their fish farming knowledge, mainly because aquaculture is not a major activity. The incursion of farmers into aquaculture is mostly experimental to assess if the activity is feasible. If the experience is positive and no major problems occur, then it is adopted. But, if problems such as floods take place, the practice is abandoned. In addition government generally makes the ponds or construction companies in exchange for sand, but the current machinery operators do not understand the requirements for fishpond construction and in any case the pond is usually dug for other purposes, so that aquaculture is just an alternative use for the pond. Most importantly, the aquaculture institutions have not been able to appropriate the pond digging programmes, so that the institutions in charge do not consider aquaculture standards when they dig the ponds.

The construction of elevated ponds such as those designed for commercial aquaculture is not a solution because they are not affordable for most farmers and need an external and controlled water source, elevating the energy demand. They are therefore less environmentally sustainable. At present there is no proper design of phreatic ponds for each topographic area. Designing proper ponds should be a priority, so that people could accept aquaculture as an activity to be done with less risk.

Aquaculture in rural Tabasco is practised at a low level of intensity both in energy-material and labour inputs. Generally farmers misuse resources available on farms, mainly because of ignorance, which often reflects inappropriate extension work. The most important negative factors affecting the farms are thefts, predation and poor feeding and fertilisation. The major regional differences in fish farming were influenced by topography, mainly in floods, droughts and the farming of native species. There were differences in the support received by farmers among the 4 municipalities, and those who did not receive support lived mainly in the poorest areas.

Individual successful farmers in commercial terms are very scarce in Tabasco. Some APSs have succeeded, mainly in El Centro, some even becoming a job generator in the villages. This seems to be the result of the extensive support provided by the local government. Nevertheless it cannot be regarded as a full success since the number of members in the groups tend to reduce as the profits are not enough for numerous members, there is trouble to get agreements and the farms require much hard work a long time before the benefits are seen.

CHAPTER 6

PEOPLE AND FARMED FISH: CULTURAL VALUES AND FISH FARMING IN RURAL TABASCO

6.1 Introduction

The 20 interviews with aquaculture staff in the public government and the private sectors (see chapter 7) indicate a consensus that fish farming is a failure in Tabasco. But is it in fact a failure? Despite of some views valuing the positive contribution of subsistence production, it seems that the impression of failure comes from a lack of understanding of subsistence. In order to explore the contribution, both present and potential, made to human well-being by subsistence aquaculture in Tabasco, and its wider significance, this chapter introduces a discussion about fish farming-livestock-agriculture systems in the framework of farmers' views based on their cultural and socio-economic characteristics.

6.2 Farmers' profiles and the difficulties of classifying farmers by wealth.

Most of the survey respondents were men (78%). This was because men are seen as head of household (99%), even in those cases when the woman was the owner of the land (5.7%). Women responded mainly when the husband was not at home.

76% of respondents were aged between 31 and 60 years old (most between 41 and 50), with 12% younger than 30 and 14% over 60. If those farmers who have ponds are like those who do not, these figures imply that there are fewer young farmers, probably due to emigration to urban centres, as jobs for landless people are scarce in rural areas. In a number of interviews, respondents expressed their unease about the lack of attachment of young people to the land, so that they tend to remain in bigger villages or cities after they have completed their middle or professional education. Nevertheless, at least one member of the family seems to stay on the farm to help.

Wealth was difficult to measure because the parameters used usually overlap. For example, farm size cannot be used as a single indicator as other factors such as land quality and proximity to urban centres also influence the value of the farm. Thus the smallest farm does not necessarily have lower value than the largest, indeed larger farms were generally situated in the most remote areas. The same is true for housing, as it was possible to find farmers who own large farms and a large number of cattle living in humble homes. In the areas studied the number of wooden houses has decreased in the last 20 years due to the implementation of national house-building programmes such as *Programa Nacional de Solidaridad (PRONASOL)*[1] at the beginning of the 1990s and some programmes promoted seasonally by *INDUVITAB*[2]. A family owning a brick and concrete home is not necessarily wealthier than other farmers living in simpler ones. In fact, those with the poorest houses were often young couples, as the housing programmes seem to have slowed down in the last 6 years.

The number of cattle seemed to be a more reliable parameter, but it is still not infrequent to find wealthier farms with fewer cattle but larger plantations of bananas or cacao. In other cases the head of household had a job in the city and consequently the farm was mismanaged because they could not allocate enough time to the farm operation. For this reason, several parameters were used as indicators of wealth: literacy, housing quality, farm size, number of cattle and off-farm income.

Most farmers were literate, as only 8% said that were unable to read and write. Housing fell into three categories. The first group had houses of wood with palm leaf or corrugated zinc roofs, with or without concrete floor; these comprised 18% of the sample and implied the lowest economic level. The second group had houses of brick and concrete, with corrugated zinc or asbestos roofs, representing the medium economic stratum, 72% of the sample. Finally, the highest level had houses of one or two storeys made of brick and concrete and with concrete roofs, which comprised 11% of all homes visited. Land ownership was another indicator of economic wealth.

[1] *'Programa Nacional de Solidaridad' (National Programme of Solidarity)* was a programme promoted by the Federal Government between 1988-1994. It consisted of micro-credit for income-generating projects, infrastructure, house building, etc. Generally the credits were large enough to buy the materials and the beneficiary provided the labour. The programme disappeared in 1994. It was claimed that there was corruption, and that this scheme was used for electoral purposes by the Institutional Revolutionary Party which remained in power until 2000.

42% had less than 5 ha and 44% between 5 and 19.9 ha, with only 14% owning more than 20 ha (table 6.1). Cattle ownership presented a different pattern, as 76% owned no more than 10 cattle, while 18% had between 11 and 30 and only 6% more than 30 cattle. The figures for off-farm income are more complicated. Agricultural labour and low intensity fishing were the most frequent activities reported (18% and 14%) followed by trade and blue-collar working for the government (5% and 4%). Most women fish-farmers described themselves as housewives, unwaged, and therefore also low-income (15%). Off-farm income is a difficult variable, because only the income of agricultural jobs and fixed wage jobs can be calculated, while the income of fishermen and self-employed people is highly subject to variation. Agricultural labour is the worst paid work in Mexico. In 1999-2000, the current wage in rural Tabasco was around 35mxp per day (£2.50). It is important that as farmers have to work on their own farms as well, the time that they can spend earning extra cash is minimal, generally 2 or 3 days per week, and work is not always available. So farmers often cannot work off their farms even if they want. Fishermen are believed to earn more, but as fishing depends on the season, weather, abundance of fish and even luck, it is not possible to get an average of the income these farmers earn monthly or weekly. Of the respondents, 31% of farmers declared no extra source of income other than that gained by the sale of farm products. Cash availability tends to be scarce amongst a high proportion of farmers, only those with large numbers of cattle, which can be sold, if necessary, have immediate access to cash. The off-farm and unwaged jobs were divided into three groups according to the income these jobs can currently generate:

- agriculture, housewives, construction, seamstress, tailor, artisans and gardeners in the low income group (36%),
- fishermen, trade, blue-collar workers for the government, retired employees, herbalists, NGO workers, machinery operators, mechanics, carpenters and technicians in the middle income group (32%),
- and those with no extra job in the high income group (32%) (assuming that these farmers do not need to work outside the farm, but that is not always the case).

[2] Instituto de Vivienda de Tabasco (Tabasco's Housing Office).

Of the 69% of farmers with off-farm jobs, 45% reported an additional income of less than 500 mxp per month, 23% between 501 mxp and 2000 mxp, and only 12% were earning over 2001 mxp while 10% were unable to produce an estimate of additional income. These figures imply a scarcity of cash in these families and suggest that neither income nor job are appropriate parameters to evaluate the wealth of these farmers (table 6.2 and 6.3).

Table 6. 1 Plot size

Plot size/ha	Frequency	Percent
0.1-0.4	30	18.8
0.5-0.9	4	2.5
1-4.9	33	20.8
5-9.9	24	15.1
10-14.9	28	17.6
15-19.9	18	11.3
20-29.9	14	8.8
30-39.9	1	.6
40-59.9	3	1.9
60-100	4	2.5
Total	159	99.4

Table 6.2 Waged off-farm activities

	Frequency	Percent
No extra job	50	31.4
Temporal agriculture workers	28	17.6
House wives	25	15.7
Fishermen	22	13.8
Trade	8	5.0
Bureaucrats	8	5.0
Machinery operator	3	1.9
Carpenter	3	1.9
Retired (pensioned)	2	1.3
Mechanics	2	1.3
Seamstress/tailors	2	1.3
NGO project designer	1	.6
Construction worker	1	.6
Herbalist	1	.6
Technician	1	.6
Handcrafts	1	.6
Gardener	1	.6
Total	159	100

Taking into account the 5 indicators, I estimate that 48% of farmers belonged to the low-income group, 36% to the middle-income and 16% to the richest group. No data were recorded to establish whether or not fish farmers differed in wealth from those who did not farm fish, but field observations suggest that no differences exist.

According to my personal experience (remembering that I belong to the same cultural group as the subjects of this research), and to direct observation, there are other elements to be considered when grouping farmers by wealth.

Table 6.3 Off-farm income (monthly basis).

	Frequency	Percent	Valid Percent
< 240 mxp	4	2.5	8.2
241 - 500 mxp	18	11.3	36.7
501 - 1000 mxp	6	3.8	12.2
1001- 2000 mxp	10	6.3	20.4
2001 - 4000 mxp	6	3.8	12.2
Variable	5	3.1	10.2
Total	49	30.8	100.0
No extra wage	74	46.6	
Refuse to answer	36	22.6	
Total	110	69.2	
Grand total	159	100.0	

Rate of change GBP 1 = 14.00 MXP

First, in most villages most farmers classify themselves as 'poor'. The parameters used among farmers to measure wealth are related to quantity and quality of food consumed, land property, dressing and housing, rather than the ownership of consumer goods. Some seen as among the poorest have problems in securing daily food. Second in importance is the quality of food, *"sometimes we have had such hardship that we could not eat meat* (beef, pork, chicken or fish) *even once a week!"* *"If I don't eat meat I feel I eat nothing"*, *"they are so poor that they only eat vegetables"*, were common comments. Consumption of animal protein at least once a day is of major importance for heads of household in order to feel that they are providing their family with their minimum requirements.

6.3 Are these farms subsistence systems?

Strictly speaking, it is not possible to talk about fish farms in Tabasco, for the fishponds are part of a larger system in which many agrarian activities contribute to the performance of the whole farm.

Table 6.4 Product diversity on farms

Product	Total number of farmers	farming for on farm consumption	farming for trade	Both on farm consumption and trade
Livestock				
Fish	159	103	18	38
Chicken (free ranching)	141	107	0	31
Chicken (enclosure)	27	18	0	9
Pigs	114	73	9	32
Sheep	20	7	7	6
Cattle	95	0	95	0
Turkeys	101	79	1	21
Ducks	99	80	0	19
Geese	16	13	1	2
Agriculture products				
Fruits	127	103	4	19
Grains	127	94	0	33
Legumes	100	69	0	31
Green vegetables	114	87	2	25
Plantations/field crops monoculture	23	0	23	0

The questionnaire, interviews and direct observation show that all farms studied produced a wide variety of goods (table 6.4), both agricultural and livestock. Most farmers grew maize and black beans and had a vegetable garden, mainly managed by women, with cassava, coriander, tomatoes, pumpkins, chillies and other products. Similarly, most farms had a variety of fruits, oranges, lemons, mangoes, coconut and papaya being the most common. Chickens, pigs, turkeys and ducks were also usual. These products are farmed mainly for on-farm consumption, and only an area expected to fulfil their needs for the year is planted. Nevertheless when the crop is good, any surplus is sold. Livestock, especially cattle, are the main source of cash. No farm was found with only one crop or species of livestock and none was producing only for sale. Production from communal fish farming groups was generally sold mainly because of i) the practical difficulty of dividing the produce (fish size, quantity, harvest frequency etc.) or getting agreement about harvest times and ii) the influence of the aquaculture extension officers. Generally every member of such groups also owned a diversified farm.

The choice to have a diversified farm and to produce goods for on-farm consumption seems to have cultural motivations. Most farmers said that their main priority was to secure their food for the year and that earning cash comes second.

"I think that if we've got many activities on the farm, if we work we can take a bit from here and a bit from there, and then we can keep ourselves. But if we think of specialising, if that activity fails, then we have nothing. If we have several activities, we can survive. Food is very important and so is some cash. Having some cash is important because without money we can't pay for medicines in case of illness".
Fish farmer, Boquer6n 4ta secci6n, El Centro

"The most important thing is to be sure of food. Money is good, I'm not saying it isn't, for emergencies."
Fish Farmer, Vainilla, Nacajuca.

"For me it's better to keep everything I farm for my family instead of selling it. Because, as you can see what I farm is a little maize and all that (bananas, beans, etc.) and there are times when we don't produce enough and you see how the climate has changed. We can plant a lot but we don't harvest a lot. We harvest so little. If I sell that, it doesn't do any good because we sell it cheap and then we have to buy it back dear. That isn't good business at all."
Fish Farmer, Lomas Alegres 1a secci6n, Tacotalpa

It is remarkable that this mentality persists today in spite of the external influences trying to persuade farmers into commercial production. For more than 50 years there has been an aggressive official strategy for promoting a more entrepreneurial attitude among farmers. The persistence of this lifestyle indicates strong cultural values, but at the same time reflects the failure of the government and the market to provide the tools (infrastructure, technology transfer, fair trade networks, etc) needed to make the change (*Proceso,* 15/07/01b).

"Because if the government would help, sending experienced people to help the rural poor, the peasant could get ahead. And it could also use its resources to sell their products. It would be great if they provided machinery to dig big ponds and if they provided the fry and there was also a place to buy the special food. Because the taxes on the land have increased very much, the payments were high and everything gets worse. Before, taxes paid for the land were small, but now it went up almost 200%. What you are paying for the land and the taxes it's very expensive. One works a lot to pay the taxes to the government".

Fish farmer, Macultepec, El Centro

This land-attached mentality has also made some farmers resist the temptation to migrate to urban centres in the way migration has occurred in other regions of the country (INEGI, 2000; *Proceso,* 15/07/01b). This is in spite of the changes which occurred here and elsewhere after the neo-liberal reforms which left agriculture with practically no support (Preibisch, 2000; *Proceso,* 29/10/01).

Crop fields use few external inputs, and the use of chemical fertilizers in the fields is low, mainly due to the high costs, but some farmers have learned to make the best use of crop rotation and polyculture. Similarly, commercial feed is rarely fed to livestock, which are kept free range eating grass with the manure being used for the fishpond. Small livestock such as pigs, chicken, turkey and ducks are free range and get extra maize, which is produced, on the farm.

Most households characteristically had few material goods and low levels of energy-material consumption. Some wooden chairs, one table, one radio and sometimes a TV set were the furniture found in the living room of most houses. Few light bulbs were observed and the families tend to go to bed early in the evening and get up early in the morning, implying a low expenditure of commercial energy. Similarly, although most farmers claimed they owned a gas cooker, housewives said they mostly used firewood for cooking, and the gas cooker only to prepare breakfasts[3] quickly. They economise on gas because it is expensive in relation to the family budget. Some households had a small refrigerator, but the local culture is to consume fresh food cooked on the day, feeding any left over to the small livestock. The low availability of cash might seem the main factor determining the low energy consumption and heavy use of local resources, but the fact that the most prosperous families maintained the same practices suggests that this is influenced by culture. The main source of cash income on the farms is cattle and sometimes plantations such as banana, cacao or oil palm[4]. Turkeys also can be a source of income, mainly for women in the Christmas season. Part-time and temporary jobs are also important sources of income (above). Tables 6.2 and 6.3 show the different kind of wage activities farmers perform off-farm, and the estimated monthly cash income.

As few farms produce enough cash to fulfil all economic needs in the household such as health and education requirements, some members of the family work part-time in other activities (see table 6.3 and section 6.2). In most cases this is after all the labour the farm requires is covered, in other words the farm management is the first priority and other sources of income come second. This is because securing the year's food is considered the most important.

"For example, with sugar cane, you take it and sell it to buy a few little things, what you need at home, and with bananas it's the same. Like the fish, the maize and the beans are eaten by the family. Many men who don't have many children sell one portion and keep the rest".
Fish farmer, Tucta, Nacajuca

As table 6.3 shows, little cash is obtained from these waged jobs. But it seems enough to enable farmers not to quit the farm or to sell their land. In other words,

[3] This is because lighting a fire is time consuming and farmers wake up very early in the morning: the use of the gas cooker is convenient to save time. Little gas is used because generally breakfast is simple (fried eggs, maize tortillas, coffee and black beans already cooked the day before).
[4] The introduction of oil palm trees is recent and the plantations are not yet producing. Its introduction is due to a State Government programme, which includes the construction of a factory to process the oil. The main purpose is export.

they still have the opportunity to maintain the way of life learned from past generations.

These farms are not isolated from changes in market and government policies, as their main source of income is cattle, and they have accepted the introduction of cash-oriented production such as oil palm and ornamental palms. Their farming systems still limit the extent to which changes in the market affect them, because the diversity of their farming systems permits them to compensate for losses in one activity with earnings in another. If it is a bad year for cattle, the effect on the family budget is smaller because they have already secured the family food for the whole year by raising corn, beans, chickens, pigs, fish etc.

Under Wharthon's (1970) criteria for subsistence (chapter 1), these systems could be called semi-subsistence because:

a) Most farms are small, 86% of them have between 1 and 20 ha (table 6.1).
b) Most farms' agricultural produce is for their own consumption (table 6.2). The exception is cattle which are mainly for sale as calves or young bulls, and some crops such as bananas and cacao production (cacao is 100% commercially oriented).
c) Cattle are the main source of income on the farm. They are a kind of savings account which provides the farmers with cash for children's education, health emergencies and purchases of goods not produced on-farm such as farming tools and clothes[5].
d) The rate of consumption of goods produced outside the farm is low, and dependence on urban markets for purchases is almost absent.
e) Farms' agricultural produce is diversified; food is mainly produced on-farm. Most farms have chickens, pigs, ducks and fields of beans, green vegetables and maize (table 6.4). Some also have small fields of green and jalapeno chillies, oil palms, bananas and cocoa trees, which are also used to obtain some extra cash for the farm.

[5] 47% of farmers interviewed did not have an extra waged job. Of the remaining 52% who had extra income, 56.5% saying they earn less than 1000 mxp (71 British pounds) per month. The majority of them were fishermen and seasonal rural workers on large farms.

f) Yields of all agriculture and livestock activities are low if we consider each as a separate unit. For example, maize yields about 0.73 t ha^{-1} a^{-1}, beans 0.388-0.435 t ha^{-1} a^{-1}, and cattle less than 2 head ha^{-1}.

g) Cash availability is low; most farmers only obtain cash from selling farm produce, small subsidies[6], and seasonal jobs.

Nonetheless, conceptually these farms can be included under subsistence in accordance with the rather different and radical definition of subsistence production by Bennholdt-Thomsen and Mies (1999) (Chapter 1).

How far farmers have chosen these systems in resistance to modernity, or how far they have been preserved by poor farmers' exclusion from modernity, is obscure. But Preibisch (2000) argues that this is surely farmers' choice as rural people in Mexico manifest the desire to maintain community life despite the unfavourable conditions. Furthermore migration remittances have subsidised this life-style.

But this way of life has been part of the local culture for many generations. Evidence can be found in Campos (1996) where people in the Chontal[7] region recalled this life-style and their farming practices as the common way of life in the past, as confirmed by this research. The case of farmers in the Camellones agro-piscicultural system in Tabasco (Pierard *et al.,* 1993), who improved their standard of living through the re-adoption of integrated semi-subsistence systems after they had tried urban wage labour, implies strong cultural roots to this lifestyle.

"Before, none of this land could be farmed. We always walked there, but in the floods everything had to be embarked because the water reached right here. The water flowed to the town. Then nobody could plant maize or bananas, nothing. And many went to Villahermosa to work, to other cities, to other jobs, and there were other people who could not go. The old people no longer left to work and just walked about. They had nowhere to work!... Then the director of INI[8] *saw the hardships of the people who just hung around the village. When we knew him* (the director of INI)

[6] Such as PROCAMPO, which provides farmers with 500 mxp (£ 38) per cultivated hectare.
[7] Mayan related ethnic group inhabiting some areas of the Chontalpa region in Tabasco.
[8] Indigenous National Institute.

he was very involved with people. One day he said, "Do you know what? Soon you are going to receive a small gift!" But nobody imagined... Then, soon, the dredger arrived and people said: "So what's that dredger for? Who knows!" Nobody knew. Then the lawyer came and the engineers too and then Mr Governor used to come very often, here to the dikes. And the President of the Republic also visited the dikes about three or four times when they were being constructed. Then people realized. "Then these dikes are going to serve us! In order to sow maize or something we need." Then when the dykes were already built, people realized that this was going to serve us. Of course, many people left jobs in the city and dedicated themselves to farm the dikes".
Fish Farmer Camellones Chontales, Tucta, Nacajuca.

Farmers run the farms to reach the lowest possible ratio labour:food production. Their goal is the production of enough food for the year for the least possible effort rather than the monetary profit. For example, aquaculture extension officials seek to get farmers to move to a more commercial aquaculture and feel frustrated by the poor results. But as we shall see later, farmers do not seek the maximum possible fish yield, because fish is just part of the food they need for the year and intensification means the diversion of time and energy required by other parts of the farm system. When an activity requires intensive labour, such as harvesting fish, sharing both labour and produce is the commonest strategy. Even though it is not possible to measure how fair the sharing of harvest among villagers is, it is clear that there is reciprocal exchange in which market prices of labour and product have a minor role. For instance, one farmer can give away fish for which the market price is high one day and get back some cassava, which is cheaper, another day. If the first impression is that farmer number one is losing on the exchange, we would have to evaluate the total exchanges for a long period, and their exchange value and use value at the specific moment of the transaction. For example, cassava might be cheap, but if it is received in hardship periods, then there is no monetary way the recipient farmers can calculate its value. In the same way, gains in social status through the exchange are difficult to calculate in material terms. For instance, in the case of fish farming the pond owners often agree to take the same quantity of fish as a villager who helps with the netting, when large harvests are carried out. This is, as we shall see later, because of the social role aquaculture has taken on in this region. It is clear that the pond owner is losing in material terms but values the social gains highly.

"Undoubtedly this is not for business but for the consumption. And for the friends because when I will net the pond I invite several people because I like to share. Then at a time when one can net, when it is not very deep, about twenty people help and all share equally. The same quantity to everybody, as if the pond belonged to them and I feel good because I don't have it as business".
Fish farmer, Lazaro Cárdenas, Tacotalpa

There are therefore many arguments to consider, such as the values behind the management practices, the cultural and ecological values motivating fish farming and the social roles local people have given to this activity. These and other aspects are presented in the following section.

6.4 Management of fishponds by local farmers in Tabasco

Fish-farming systems in Tabasco differ greatly from that expounded in textbooks on traditional entrepreneurial aquaculture. This is in part due to local environmental and socio-economic conditions but more importantly to local cultural values, which dictate the purpose for which fish are farmed.

To repeat, like other goods produced on-farm (except cattle and some plantation crops), fish is produced to satisfy the household's food needs. In general these farmers do not try to commercialise fish but may sell any surplus.

"Fish is mainly for our own food. The main purpose of my land is to provide the main support for my home. Can you imagine? Sometimes there's no money, and enormous hunger. If we have small livestock near the house, we can eat them, especially fish. That's the reason. To sustain my home".
Fish farmer, Macultepec, El Centro.

"All this fish is to feed my family. If anytime we need some money, then we sell them. Fish is good both to eat on the farm and to sell, because when I've no money at all, I know that I've some cash there. I catch two or four kilos, I sell it and I solve the problem. As long as I don't catch all of them, because in that case I'd finish them off".
Fish farmer, Lomitas, Nacajuca.

Farmers conceive of fish farming as a good option for the poor because in their view it requires less effort and expenditure than other activities. For that reason aquaculture is done at very low farming intensity. Therefore for the outsider the first impression is that aquaculture is practised with little understanding leading to many management mistakes. There is no doubt that this is partly true, but at the same time some of the non-conventional management depends on the demand for labour of other components of the farm. In a diversified farm system, practices that minimise labour requirements are chosen to guarantee the production of a variety of goods. In other words, the extent of management is determined by the quantity of fish they want to produce (which is related to how much they like fish) and the time and labour they are able to spend on it without neglecting other parts of the farm.

"I like fish farming very much and I also cultivate. My plot is 3 ha; I've bananas, sugar cane, timber trees, 'toatan[9]', oranges, green vegetables.... We like to produce many crops, we are used to doing everything... I've shallots, maize, black beans.... I like farming fish and raising livestock".
Fish Farmer, Playa Larga, Jonuta

"My idea of fish farming is just for food on the farm. I think that the ideal is producing for the family to eat and if there's any surplus then we can sell some".
Fish farmer, Pueblo Nuevo, Jonuta.

The variety of products produced on-farm (table 6.4) illustrates the availability of resources for fish farming. In fact, there is a dynamic use of materials (when they know the benefits), which are integrated into the different production systems in the farm. The fishpond is part of this dynamic. Fish farming is rarely separate from other

[9] Timber tree

activities. For instance, the fishpond is used as a reservoir for watering cattle, raising ducks and sometimes to water the family vegetable garden. The ponds therefore rarely have the best design and soil conditions for fish because farmers have to look to the best outcome for as many components of the farm as can be favoured. In other words, farmers perceive the pond as a multi-purpose facility (fig 6.1).

"Having the ponds has been very helpful because the poultry and cattle drink there, we wash the corn there, and we take fish from there too, when we don't have money to buy food. With this pond we don't go hungry".
Fish farmer, El Sandial 1a sección, Nacajuca.

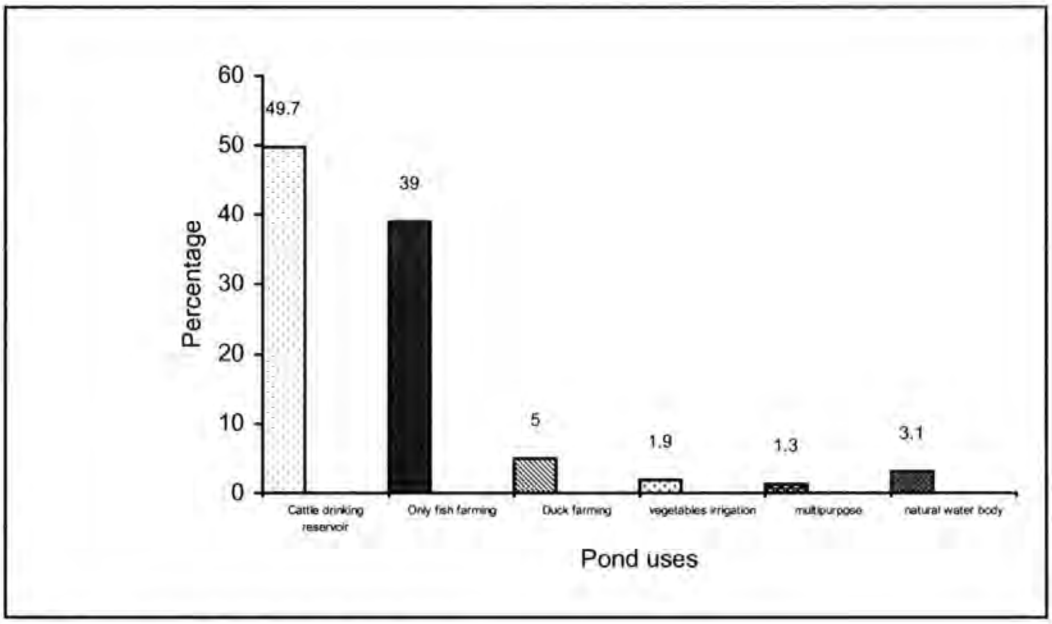


Fig 6.1 Main uses given to the fish ponds

In many cases farmers have obtained the pond in exchange for the earth which is used for the constructions of roads or embankments. Very often the construction provides very inadequate ponds in return: the ponds often lack embankments (chapter 5), have uneven bases and are too deep; as it is in the companies' interest to dig as fast and cheaply as possible besides they do not have expertise in pond design. The problem is that farmers do not know that the ponds they are obtaining are not good, due to lack of experience.

"I got the pond in exchange for sand which the construction company required to build the road...but they dug the pond in a low-lying area and they made it with a dredge. It came out uneven and could not be fished. It came out very bad, I guess a good pond should not be very deep, mine is too deep. About four meters deep would be better because the water stays at one and a half metre in the dry season. That would be a big change because it could be fished better."
Fish farmer, Medellín y Pigua 3a sección, El Centro.

Farmers who have the knowledge often use farm by-products (chapter 5) to feed the fish but rarely use by-products to the full because of lack of knowledge.

'I use whatever's available. If I have bananas, I feed the fish with bananas. When it's the season for avocados, I pick them and give them to the fish, fish really like avocado. I collect termites for them.... I also use chicken feed and leftover bread.'
Fish Farmer, Buena Vista Rio Nuevo 1a sección, El Centro

'We use all kinds of waste to feed the fish. Fruit that's rotting is good. We give all the waste to the fish, even the hyacinth. Fish eat all that.'
Fish Farmer, Zapote, Nacajuca

For example, of the 77% of farmers who feed their fish, all use at least one type of agricultural product or by-product produced on farm, whether greenstuff collected from the fields, kitchen waste or grain produced on the farm. As there is a tendency to believe that commercial feeds are better, 65% of farmers use commercial feeds, but they are usually used only for the first two months after stocking. Agriculture by-products are used mostly in the cases when farmers do not have cash to purchase commercial feeds. This mirrors their use of feed in chicken farming, when commercial feed in the first stages makes the chickens more resistant to disease. In the case of fish, this practice has no technical or practical advantage. Farmers indeed compare fish faming with chicken as they have to feed them everyday, but with the advantage that fish require less care and that apparently fish do not get sick and thus they do not have to spend money on medicines and vaccines. Thus food free of chemicals is guaranteed. In this respect, fish are better than chickens in most fish farmers' view.

"This is like a chicken farm. We have to look after them, it isn't like in the river".
Fish Farmer, La Providencia, El Centro

Nevertheless it can be seen that very often farmers under-utilise the by-products for lack of knowledge and depend on grains to a great extent to feed fish. This creates competition with other components of the farm and increases the demand for labour to produce grain. Farmers use maize because they assume that fish feeding is similar to that of the small livestock such as chickens, turkeys or pigs. Some farmers said that if they are shown practically that the same growth can be obtained with other feeds, they could easily change this practice. This change would enable farmers to save effort and money, but proper technical advice is necessary.

"I've some lemons, avocados, ciruela[10], anona[11], oranges round the pond. I don't use the fruits or coconut to feed the fish because I don't know whether fish can eat that. That's why I told you I need advice. If the experts tell me something is good, then I do it. I use kitchen wastes, pasta, rice, etc... Because a guy from Macultepec told me. He told me to add 'pozol[12]' wastes to the pond. Then I saw all the churning the fish made when they were eating. I hiss and you see how the fish come quickly. The fact is that we don't have experience with ponds, because there were no ponds like these in other places, like those you see on TV, where they catch fish, but the water is clean, with no hyacinth. I don't fertilise or manure it. You can get cow manure here, but I haven't done it because I didn't know whether it's good to add that".
Fish Farmer, La Cruz, Nacajuca

Sometimes this under-utilisation is due to a lack of knowledge but also because feeding the fish depends more on the pond's proximity to daily labour than on the availability of feed. Feeding was carried out more often when ponds where located near the house. For example 71% farmers reported feeding the fish at least once a

[10] Local tropical fruit.
[11] Local tropical fruit.
[12] Traditional local drink made of cocoa and maize.

day when the pond was located next to the house. This figure falls to 56% for those farms with a pond on plots far form the house. The best use of any available by-product as feed is achieved when any member of the household has easy access to the pond at the cost of a few minutes. This does not distract the family from the other daily tasks.

"...there is time to work on another part of the farm, to work in the maize crops. If it's my turn in the afternoon I work in the pond, tomorrow will be another's turn. It is not necessary that you are anchored there. We are close".
Fish Farmer, El Zapote, Nacajuca.

Nevertheless the aquaculture extension staff does not always understand this:

"People usually want their ponds to be built next to their house where they can watch over them. But the fact is that sometimes their houses are on a hill, then they cling to wanting it there and thinking they will manage to fill it, then that is a problem[13]. But we always think to look for the appropriate place. Appropriate not for the farmer but for the fish culture. Near a river, with good phreatic level, soil with good characteristics for water exchange. Sometimes farmers are discouraged but it's better that they are discouraged, then sometimes we have to work discouraging the farmers".
Extension Officer, SEFOE

The majority of ponds are small in size; 51% are less than 900 m^2. All the ponds visited were phreatic; in other words, the pond is dug until ground water is found. The phreatic level and the rainfall then regulate the water level in the pond. This means that no artificial energy is required for water input and that fertilization can be more efficient. As this is a semi-closed system because there is no input or output of water, even if the pond is overused and the level of nutrients becomes a problem, it has little effect on the surrounding environment. The fact that these ponds cannot be drained is a technical problem as it is very difficult to maintain high yields when the ponds have an accumulation of nutrient rich sediment at the bottom. This is because

[13] Because the phreatic mantle in the hills is too deep.

such accumulation of sediment makes it very difficult to apply conservative rates of fertilizers such as manures because even when the water is short in nutrients (and therefore needs fertilisation), the wind could disturb the sediment, causing a sudden enrichment of nutrients in the water leading to eutrophication and the danger of a massive fish death. The enrichment of nutrients is regulated naturally, to some degree, through the floods when the turbid nutrient-rich water can be exchanged in quantity for more clean water. The problem is that during this process the fish escape too, with a consequent loss for the farmer. It is possible to find a solution to this problem but aquaculture research on this kind of pond is necessary. Unfortunately, today no institution is making this kind of effort in Tabasco.

Yields are generally low (chapter 5). Nevertheless there were several farmers who claimed to produce yields as high as 15 $t\text{-}ha^{-1}\text{-}year^{-1}$. These high yields are possible because most farmers prefer to make partial harvests, in other words small numbers of the largest fish are caught continually. This practice lets the smallest fish have less competition for space and food and growth can then be optimised.

"After 4 months the fish start breeding, and so on. Then we catch fish, others remain, and so there's always fish in the pond. It's enough to stock once, with the same fish the pond gets restocked. I've seen it, there's always a lot of fish left".
Fish Farmer, Medellín y Pigua 3a sección, El Centro.

"We only harvest the biggest fish, in that way we let the fish breed and we don't have to stock again. You can see the huge amount of fry which is going around!".
Fish Farmer, Lomitas, Nacajuca.

This management is one of the greatest differences between these systems and commercial aquaculture. For the latter, all the fish is harvested at once to increase efficiency and reduce cost. In Tabasco fish production is more related to reproduction, to the generation of life and to the self-sustenance of the system. In the regions studied, the Spanish word *'producción'* (production) implicitly means regeneration of the fish population with no human intervention rather than merely production (i.e. strictly meaning *'reproducción'* (reproduction). This concept also mirrors the subsistence culture (Bennholdt-Thomsen and Mies, 1999) inherent to these farmers.

"I don't net so often because I don't want to deplete the fish. Once I harvested fish with eggs but I returned them to the water because I felt pity. Thus I kept keeping them to check whether or not there was production (reproduction) *because what I like is that fish are always available".*

Fish Farmer, Lomas Alegres 2a sección, Tacotalpa.

Although some farmers in the survey had been practising aquaculture for more than 10 years, fish farming is still considered a new activity. More than half the farmers in the survey had started within the last three years. In spite of the novelty, farmers are achieving more experience and local knowledge is developing. This is not always necessarily good as some practices are clearly not improving pond conditions and others definitely have negative effects on the fish. Nevertheless the farmers' perception is that they are getting better results as time goes on. For instance, 57% of farmers interviewed said that the yield was rising and only 19% reported a decrease in yield. As with other goods these farms produce, fish is farmed mostly for their own consumption (65%) while fish farming exclusively for sale is less common (11%), this being performed mainly by groups organized by local government. In spite of government encouragement of group work, the most common organization is family, or associations of relatives. Groups managed only 26% of ponds visited. Most farmers think that individual or family work is better because they have less difficulty in getting agreement over management and dates for harvest. They also see group work as not worthwhile as not everybody contributes the same effort. In fact, most farmers interviewed had participated in credit societies, although recognising that to make them work often requires the solution of many conflicts with the other partners, affecting social relationships in the villages.

"I've always worked the fish on my own. I've worked the cattle in groups because they gave us credit. I think it's better alone because there's a lot of disorganization in groups. One gives one opinion and another a different one and then it isn't easy to get agreement. Many problems emerge, of course we always face them and then

they are solved. When we work in groups it's because the government demands it. If we don't go in groups they don't recognise us... We have told them that it's better to work individually but they say that it isn't possible... They say, "that's how it is!" and there's no other option. They listen to people saying that we'd like the programme to be individual, but they say that it isn't possible. They say that that's how the government works, in groups. Bigger the group, the better, they say they have more priority. ...The small groups come last".
Fish Farmer, El Ular, Tacotalpa.

"In my view, it's better to work individually because not all of us work the same... but at harvest time, everybody eats the same. Your partners get angry when you tell the truth...".
Fish Farmer, Santa Catalina, El Centro.
(See Chapter 7 for official views of groups.)

As we have seen in this and the last chapter, the ways in which these semi-subsistence systems function are far from being optimal for these rural households, but the basis is there and problems could be solved with the application of simple, appropriate technologies. It is here that research could be of great utility.

6.5 Social, cultural, environmental and economic factors in fish farming.

What is the meaning of fish farming for an average family in the countryside? Why do people choose to include fish farming among other activities in the farms? At the beginning of this research, the answers looked simple – People farmed fish because they wanted to produce food and money in order improve their standard of living and selected fish farming among other activities because they accept any programme offered free. These statements are part of the answer to these questions. But the reality is far more complex. Attitudes to fish farming are in my view related to the specific views of local people about a number of issues such as quality of life, poverty, environment, food, work, etc.

6.5.1 Experience

Attitudes to fish farming depend on previous experiences both from the individual/family practising it and from experiences observed in other members of the community. Even though fish farming was introduced in Tabasco more than 20 years ago, most farmers interviewed had been engaged in fish farming for only 4 years or less, stocked fry 3 times or fewer and the last time they stocked the pond was less than 2 years ago. For instance, 13% started so recently that they still have not made the first harvest (tables 6.5, 6.6, 6.7, 6.8). Aquaculture is still considered a novel activity and has not been perceived as an important component of the semi-subsistence farm, (37% farmers who have practised fish farming failed, mainly at the first attempt (65%)). Nevertheless only 8% decided not to attempt it anymore (table 6.9, 6.10).

Table 6.5 Time doing fish farming

Years	Frequency	Percent
0.5	4	2.5
1.0	46	28.9
2.0	20	12.6
3.0	23	14.5
4.0	19	11.9
5.0	15	9.4
6.0	14	8.8
7.0	3	1.9
8.0	7	4.4
10.0	3	1.9
11.0	1	.6
12.0	2	1.3
14.0	1	.6
15.0	1	.6
Total	159	100

Table 6.6 Last stocking

	Frequency	Percent
Less than 6 months	38	23.9
6-12 months	37	23.3
13-18 months	5	3.1
19-24 months	19	11.9
25-36 months	10	6.3
37-48 months	12	7.5
49-72	20	12.6
73-96 months	8	5.0
97-120	6	3.8
More than120 months	3	1.9
19	1	0.6
Total	159	100

Table 6.7 Number of times stocked

Times	farmers	Percent
1	71	44.7
2	40	25.2
3	18	11.3
4	10	6.3
5	4	2.5
6	6	3.8
7	4	2.5
8	2	1.3
12	3	1.9
20	1	0.6
Total	159	100

Table 6.8 Number of fish farmers who had completed at least one harvest cycle.

	Frequency	Percent
Pond Not harvested yet	20	12.6
Pond harvested at least once	139	87.4
Total	159	100

Table 6.9 Number of farmers motivated to continue fish farming

	Frequency	Percent	Valid Percent
The farmer will not try fish farming again	13	8.2	8.2
The farmer will try fish farming again	127	79.9	80.4
Yes but with support	17	10.7	10.8
Does not know	1	0.6	0.6
Total	158	98.7	100.0
Information Lost	1	0.6	
Total	159	100.0	

Table 6.10 Present status of the farm

	Frequency	Percent
Not working	64	40.3
Working	95	59.7
Total	159	100.0

This high rate of failure could be due to lack of experience causing many management mistakes. Low motivation together with lack of advice could also be important, as many farmers started aquaculture through the encouragement of somebody else but without proper technical support. Many farmers started aquaculture when extension officials offered a programme. Nevertheless that did not imply access of advice, as one of the most common problems was shortage of knowledge due to lack of advice (table 6.11, 6.12).

Table 6.11 Motivation for fish farming

	Frequency	Percent	Valid Percent
Farmers' own idea	25	15.7	15.8
Copying other farmers	21	13.2	13.3
Offered by extension staff	72	45.3	45.6
To make use of a water body	9	5.7	5.7
Farmer's necessity to produce food	2	1.3	1.3
Motivated by a friend or relative	17	10.7	10.8
Fish was scarce at the river	5	3.1	3.2
To save fish dying in the puddles	6	3.8	3.8
That was the only way to eat fresh fish	1	0.6	0.6
Total	158	99.4	100.0
The respondent does not know	1	0.6	
Total	159	100.0	

Table 6.12 Farmers declaring lack of knowledge on fish farming

	Frequency	Percent	Valid Percent
No	71	44.7	45.5
Yes	85	53.5	54.5
Total	156	98.1	100.0
did not report any problem	3	1.9	
Total number of farmers	159	100.0	

6.5.2 Thefts

Traditionally, Tabasco's farmers used to live near their crop fields because phreatic water is easily obtained on site for household's needs. This allowed them to look after their crops and animals. With the introduction however of new Ejidos[14], now many farmers have to live in villages to have access to services such as water and electricity and it is now less common to find people living on their plots so livestock or crop theft is easier. Thus valuable crops are not grown when plots cannot be guarded. This problem seems also to affect fish farming. Findings from interviews and questionnaires with farmers show that farmers' perception of theft occurrence is affected by pond location. 50% of ponds located far from the farmer's home had reported problems with thefts, compared to 23% with ponds located near the house (table 6.13).

[14] Land ownership form, introduced as a result of the Mexican Revolution, in which farmers get the right to work a plot but, until 1991, with no right to sell it.

Table 6.13 Difference in thefts in accordance to pond location

Pond location	Number	Yield	Farms reporting thefts
Near the home	81	782	19
Far from the home	76	736	36

In the past, fish could be caught almost anywhere. Now that fish are farmed, catching them becomes theft. The reasons are diverse: poverty, social decomposition in the villages and cultural factors. Before aquaculture was introduced in Tabasco, there was more freedom to catch fish in any water body; private or public because fish entered naturally so were considered wild. This generally did not affect owners when no effort was made to culture the fish, and letting other villagers catch fish on their land was part of local social relations. When aquaculture was introduced, social relations changed because farming the fish required inputs and the fish acquired ownership and so owners can refuse to allow others to net their ponds. The change had some negative impact, because according to some villagers people who had asked for permission were refused and therefore sometimes changed to stealing the fish at night, provoking fights and mistrust between villagers. The problem is complicated because there is no efficient, reliable justice system to deal with thefts, the farmers therefore have no official way of dealing with thefts and become disillusioned in obtaining low yields returns for their efforts. In the worst case, thefts result in the farmers abandoning fish farming.

Keeping watch at ponds not at the house is difficult because at present yields the output does not repay the effort. Theft was a common reason given to explain low yields. 40% of interviewees said fish thefts diminished their yield, being a cause of disappointment.

"There are many ponds which are wasted because farmers don't want to make the cultivation because thieves rob them of their fish".
Fish Farmer, Lomitas, Nacajuca.

6.14 Mean yield of fish farms kg-ha-year

	Reporting thefts	Pond is near the house
Yes	734	782
no	764	736
Mean	755	755
Mean	830	830

Nevertheless there was no significant difference in reported yield by pond location or by whether thefts were reported (table 6.14). There could therefore be an exaggeration of the number and the effect of thefts. In other words, the farmer may find it easier to use theft as an excuse when the catches are less than expected than to review their own management practices. It should be remembered that farmers' expectations of yield are generally impractically high for the local conditions (chapter 5). Frequently, when farmers do not overlook the pond, if the yield is not as expected, the farmers' first idea is that somebody else got the fish before them. Sometimes just because the pond is in a lonely place, farmers take it for granted that thefts are taking place.

6.5.3 Motivations for fish farming

The fictional, composite case of Juan Hernandez, Maria and their children (chapter 5) illustrates motivations. Every member of the household has different motivations because fish farming has different meanings for each one. Juan, who is expected to be the householder, provider and guide for his family, farms fish because he wants to secure food for his family. He also wants to be part of a group, therefore he needs to have something to offer other villagers, and fish is an excellent gift. At the same time he feels that if he is able to offer a special banquet (in this case the fish) when he receives visits, then he is not so poor. In other words fish give him a kind of self-esteem. For Juan fish is something else. Farming fish is a kind of hobby, a relaxing activity. Juan feels joy and tranquillity when he sees the fish active when he feeds them. He also says he has a responsibility to preserve the way of life for his grandchildren so he wants to protect native species in his pond because he knows that such species are now scarce in rivers and lagoons. Fish farming is also a question of pride. Juan thinks that practising an activity different from other villages arouses the respect of the others. Finally, fish farming offers a good opportunity to train his children to work.

Maria has other motivations. Mainly she is concerned to provide a varied diet for her children; she tends not only the fish, but also the chickens, ducks, turkeys and pigs. As she knows that sometimes her children need to buy books and clothes and that her husband is not a good manager, the fish can provide some money in times of hardship, of illness and other emergencies. Maria, therefore fishes with a rod spending a couple of hours catching fish either for the family or to sell to other villagers. She likes having the pond at home because fishing distracts her children from idleness.

For the children, fish farming is a party. They enjoy people coming to their house to net the pond. They like eating fish and they feel important at the harvest because not many people in the village have ponds. They like to fish with rods because they feel they are contributing to the family. Sometimes, during the hot season, they enjoy swimming in the pond.

Motivations for fish farming are diverse; it depends on the subject's attitude to work and social relationships, on gender, security, age and education and on how integrated the community is. Motivation in fish farming has economic and socio-cultural components. The importance of each component in decision-making depends on individuals and on the sets of preferences of more than one member of the household. These factors also change in relation to the degree to which a village is affected by the urban way of life. Gradual change was perceptible in attitude between villages near cities and those farther away. In the first, farmers are keener to sell their fish, while in the second fish is farmed almost entirely for on-farm consumption. People living near cities depend more on cash as they generally have jobs in urban areas while their attitudes to cooperation and integration in the community are less positive.

On the other hand, families such as that of Juan Hernandez depend on co-operation with other members of the community for their survival. It is a system of reciprocity in both goods and work which makes a number of activities such as fish farming possible, activities that in other circumstances would not be possible because paid jobs are scarce in the locality so cash is not available to pay for labour. Harvesting fish is a good example because it demands a great deal of human energy and time.

Motivation for fish farming differs by gender. For both, the image they project to the community is very important. Women attach importance to the well-being of their family: diet issues, quality and diversity of food, cash security for her family and the image of a good mother, which she must project in the village. Men on the hand are concerned mostly about species diversity, protection of traditions and preserving their images as providers. A mixture of economic and social motives in the household will thus influence the relative importance given to the pond among the other activities on the farm.

The importance farmers give to aquaculture as against other activities can be inferred by looking at why they dug their ponds. Farmers who dug their ponds especially for fish farming were generally those most motivated to carry out this activity. More farmers (54%) dug their ponds especially for fish farming on the plains, compared to 18% on hilly sites. This confirms other data above indicating that hill zone people could be less motivated for fish farming, given the lack of a fisheries tradition and a lower predisposition to eat fish often. When asked why they did not eat fish often, many farmers in the hills said it depended on how often traders bring fish to their villages. The scarcity of fish for sale in the hills was one of the main motivations expressed for starting fish farming. The fish traders' main reason is that for most of the year the fish price is outside the purchasing capacity of the villagers so that the small sales do not cover the expense of special journeys to distant places. Thus, traders often bring fish of the minimum commercial size which most farmers do not like (see below). Another factor is the bad condition of rural roads, especially during the rainy season, which discourage traders.

6.5.4 Fish farming and the environment

In addition to food production there are other motivations for farming fish that are equally important, such as environmental conservation. As the scope of this research was not broad enough, it was not possible to compare attitudes to environment among farmers culturing fish and those who do not. It is possible that farmers doing aquaculture are the most concerned with the environment, as aquaculture seems to be locally linked to environment-friendly practices and even perceived as a tool to help biodiversity regeneration. Aquaculture thus may provide social status implying farmers' concern for the community's well being.

Although farmers did not use an explicit scientific vocabulary in expressing their environmental awareness, this concern appeared through the language they used for wildlife, nature, and specifically the native fish species. Not all farmers have this view, but these values have been inherited from past generations. On many occasions people said to me: *'my father taught me that...'* *'my mother told me that...'* *'my grandparents used to say...'* etc. suggesting that environmental concern is more a cultural value rather than a result of the formal education system with its scientific approaches. Environmental concern was higher on those farms with a stronger subsistence culture, generally located in remote regions, as against the farmers living near large urban centres, who had a more entrepreneurial view and were more interested in profit.

As reported in chapter 5, 99% of fish farms were raising tilapia, an exotic species, because from the first (middle 1970s) rural aquaculture programmes were based entirely on tilapia farming, so that if anybody wanted to practise aquaculture she/he had to farm tilapia. Nevertheless an unexpected 51% also farm native species such as native cichlids, turtles and *pejelagartos* (*Astractosteus tropicus*). Aquaculture with native species has been developing without institutional support of any kind. This practice is not recorded in official statistics because the fry is not obtained from hatcheries but from natural water bodies. Similarly, at the time of this research no academic publication on this practice was found and even most extension officials interviewed were ignorant of it.

It should be stressed that no technology has been developed in Tabasco to farm native species. This practice is being performed by trial and error, apparently with no organized methodology. Understanding seems to have developed from the experience of farming tilapia, but with specific motivations. For instance, in many cases the main motivation is to preserve local species for the farmers' descendants. In some cases, native fish were farmed to preserve the species but not harvested at all.

"I got the idea of farming fish because you couldn't find fish round here anymore. On some rivers near here, birds were dying because they couldn't find any fish. The raccoons were also found dead because there wasn't fish like before... My friends told me no, don't waste the land, but I paid no attention to them because if there are no fish anymore, where are we going to get it? I stocked the pond with different kinds of turtles too".
Fish Farmer, La Cruz, Nacajuca

"Native fish live in large lagoons where there's lots of space... I say that as native 'mojarras[15]' can't live with the tilapias they have been wiped out. Tilapia has been stronger, it survives".
Fish Farmer, Macultepec, El Centro.

"I used to hunt birds but I only hunted the biggest to eat, I respected the smallest. Instead of taking, we must add!... I have iguanas, I have them here to breed, that's why I look after them. Eat them? No!.... I have 58 guaos[16], and 30 hicoteas[17]. I put them in when they were already full grown. I don't put the turtles in to eat them. I farm them to breed them. I haven't eaten a single turtle".
Fish Farmer, Vainilla, Nacajuca.

There was great consensus amongst farmers, nearly 97% claiming that native species, mainly cichlids, are now diminishing in natural water bodies. In the farmers' view this is because of the tilapia. Many farmers said that local fish species were

[15] Several native fish species belonging to the genus *Cichlidae*.
[16] A turtle species.
[17] A turtle species.

abundant before the introduction of tilapia and that they have noticed that tilapia is very efficient at catching the offspring of the native fish, so that the catch of local species has been diminishing while tilapia today is the most important fish in the region. This farmers' view differs from the official discourse (see Chapter 7) that the decline of local fish species is the result of over-fishing rather than of the ecological impact of tilapia. Nevertheless, even though there are no scientific studies to prove either hypothesis, there is some consensus among the local aquaculture scientific community supporting the farmers' view (Rafael Meseguer, Eduardo Mendoza, personal communications).

Native fish farming experience seems to be developing a local model of fish-turtle polyculture with more errors than right answers, because there is no management of species ratios, stock densities, etc., but at least it is a beginning.

"I've farmed pejelagarto and I fed them with mollies[18]. Those fish grew very well".
Fish Farmer, Acachapan y Colmena 2a sección, El Centro.

"Native fish are the best. I don't know why, but those fish grow naturally because they don't need to be fed... they go eating along the sides of the pond, they eat wastes, anything they find. In addition it's tastier... We want to keep farming native mojarras[19]".
Fish Farmer, El Maluco, El Centro.

"We have thought about starting to try other species, we already have farmed freshwater prawn (a native species). *It works. It grows fast. We got the juveniles from the lagoon...".*
Fish Farmer, El Espino, El Centro.

This empirical practice is leaving local aquaculture research behind, which is limited to the study of basic biology and monocultures under semi-intensive commercial conditions (Mendoza *et al.,* 1989; Mendoza *et al*, 1995; Galmiche and Sanchez, 1995), the results being useless to the typical fish farmer in this region.

[18] Fish species.

Local attitudes to fish farming are related to local notions of sustainability, but not in the formal way a western educated person would consider. The use of low quantities of inputs, the preference to maintain a stable fish population in the pond by avoiding total harvest, the absence of artificial inputs, the low expenditure of energy, the minimal usage of water, the defence of local feeding habits, the concern about the permanence of native species and the emphasis on reproduction are elements of the local culture. Many academic publications have considered these characteristics positive in the search of sustainable systems (see chapter 4). Probably these attitudes result from the farmers' low purchasing power as they have to find ways to survive using minimum off-farm resources, but at the same time they result from local cultural values. In trying to make aquaculture more productive, a quandary arises. If this environmentally friendly management is mainly the result of lack of cash, the possibility exists that improvements (reaching higher yields, for example) would translate into more dependence on energy-costly off-farm resources. This seems to be the more likely choice as local aquaculture institutions tend to recommend the use of external sources of energy such as water pumping and artificial feeds because that is the easiest way to increase yield.

6.5.5 Food culture

Most people interviewed (99%) said they liked fish. The only two farmers declaring they dislike fish in the whole study live in hilly areas. In lowlands and plain areas people eat fish more often and there are more water bodies available for fishing. Zones near population centres (generally on the plains) also have a greater tendency to consume fish, probably because in cities fish is more regularly on sale (tables 6.15 and 6.16).

Table 6.15 Fish eating frequency

	Plain	Lowlands	Hills	Total
Daily	10	15	0	25
Weekly	25	23	6	54
Less than weekly	29	7	44	80
Total number of farmers	63	45	50	159

[19] Spanish word for native cichlid fish (mayan cichlid, *paleta*, etc).

Table 6.16 Last time fish was consumed in the household

	Plain	Lowlands	Hills	Total
Within the last week	33	35	11	79
Within the last month	22	7	16	45
More than one month ago.	9	3	23	35
Total number of farmers	64	45	50	159

Acceptance of fish farming is related to the view of food quality in the countryside. Traditionally these rural people consider fresh food as the best, cleanest and most nutritious, frozen food having a very bad reputation. Similarly meat fed 100% with formulated feeds is liked less, being perceived as having the poorest flavour and additional chemicals. Producing fish under more natural conditions is thus a way to secure a tasty and healthy product impossible to get by other means.

"We like the natural fish, the fish that you don't give with commercial feed. The fish which eat the root of the water hyacinth. It doesn't matter what species but only to eat on the farm, not for business because for business you have to give more time and patience to the pond".

Fish Farmer, Oxiacaque, Nacajuca.

Reasons for farming fish were often related to the need for fresh, clean fish, as they do not trust the quality of fish brought by traders. Commonly, frozen fish is considered bad due its taste and dangerous due to the time frozen, and to its uncertain origin as rivers and lagoons are seen as polluted. But there is an economic component too, because in general fish traders bring the lowest quality fish to rural areas.

In fact, this is the rationale of these semi-subsistence farms because unskilled workers are not really paid enough to buy food as good as that produced on farm, for example, fresh, and almost organic chicken[20], green vegetables and grains. Aquaculture, along with other subsistence activities on the farm, is the only way to

[20] Chicks are fed with commercial chicken feeds in the first weeks after birth.

maintain their traditional standard of living[21] and their dignity in the face of the strength of the neo-liberal national agricultural policy. This seeks to make them more dependent on external markets, in which clearly they do not have the means to compete. In other words, aquaculture is a way to empower oneself, as Mies and Bennholdt-Thomsen (1999) describe, *"the empowerment which only can be found in ourselves and in our cooperation with nature, within us and around us'* (p5), the power which gives us '*control over means of subsistence"* (p3).

There are many cultural attitudes about fish. Fish have seasonally been part of the traditional diet mainly in the lowlands, when the floods bring numerous fish down from upstream. The preferred species are mainly cichlids such as *Petenia esplendida* (*tenguayaca* (Bay snook)), *Cichlasoma urophthalmus* (*mojarra castarrica* (Mayan cichild)) and *Cichlasoma synspilum* (*paleta* (redhead cichlid)). Other species such as *Centropoumus undecimalis* (*robalo* (common snook)) and *Ostractocteous tropicus* (*pejelagarto* (tropical gar)) are also important in the traditional diet, the last one being considered the symbol of Tabasco's cookery.

Tilapia came on scene in the 1970s with little acceptance because to rural people it has a muddy flavour and the flesh is softer than those of the native species. Nevertheless, nowadays it has been accepted as part of the diet and has the largest fishery in the region unlike the native species that are very scarce today. People's perception about tilapia is that it grows faster. A comparison is made between tilapia and fast growing chickens on the one hand and native fish and free range, slow-growing chickens on the other, the former being convenient due to its fast growth and quantity of meat and the latter because of its better flavour and texture.

Preserving traditional food habits is also a motive and one of the reasons for the culture of native fish. Even though tilapia has been already accepted as part of the local food culture, native species, mainly *pejelagarto* which is the most appreciated, and also common snook, *tenguayaca* and *mojarra castarrica*, which are among

[21] By standard of living I do not mean any consumption index but the features locally considered as the minimum acceptable for an individual or family. Locally, food is more important than housing or clothing. Those who cannot have access to healthy, fresh food and cannot consume meat or fish are generally seen as the poorest. In their view, fresh beef is better than frozen, free range organic chicken is superior to commercial chicken, etc.

those most preferred. The scarcity of these species in natural water bodies and in the markets seems to be an important motivation to include them in their ponds and even to start fish farming. As hatcheries do not provide these species farmers have to collect them from the wild. The fact that native fish generally grow slower than tilapia does not seem to discourage its farming as 36 out of 62 farmers said that slow growth is not a problem as the most important satisfaction is to have fish always available.

"I've talked to one guy to ask him to bring pejelagarto and guavina[22] *to me. That's pure flesh. I'll farm those, not this* (tilapia) *anymore). I want the fish to be tasty, it doesn't matter if it's slow to grow. I told a chap to get some 'pejelagarto' and 'guavina' for me. Tenguayaca and 'bobo*[23]*' too, to stock them here... Those are people who go fishing downstream, they bring the fish alive and I buy it from them. The other day a lady brought a turtle'.'*
Fish Farmer, Vainilla, Nacajuca.

"I think that native fish are the best, but as there aren't any, we have to stock the others (tilapias). *Native fish are tastier. I would like to farm native fish because it's tastier, it doesn't matter when it grows slower and yields less because we hardly try to catch any. We fish from time to time. It's my wife who comes to fish, so as to cook some dish whenever she wants".*
Fish Farmer, Lomas Alegres 1a sección, Tacotalpa

Large fish seem to be a valued food. In general, people preferred consuming fish larger than 500g (table 6.17). From the 156 farmers of both genders and different ages who liked eating fish, 49% that they preferred fish bigger than 500g. This preference can be observed from the harvesting size; 50% harvest fish larger than 400g. 44% caught fish at or below the recommended commercial size of 250g, but usually this was not through choice but in an emergency because of flood or drought problems.

[22]Native fish species.
[23] Native fish species.

Table 6.17 Fish Weight preferred to eat (g)

	Frequency	Percent	Valid Percent
Any size	18	11.3	11.5
>250	61	38.4	39.1
>500	62	39.0	39.7
>750	5	3.1	3.2
> 1000	10	6.3	6.4
Total	156	98.1	100.0
Not applicable	1	.6	
Data not available	2	1.3	
Total	3	1.9	
Total number of farmers	159	100.0	

"We like eating fish which is good to eat, 400g or more".

Fish Farmer, Santa Catalina, El Centro.

"I grow fish just for on-farm consumption. The fish are big, one kg or more. Most people enjoy big fish here, but the only big fish is tilapia. It has spread, I think they escaped when all the ponds overflowed".

Fish Farmer, El Ular, Tacotalpa.

There was some regional difference. Some 51% of farmers in hills and lowlands generally farther from large urban centres, said they prefer fish bigger than 500g. This falls to 43% on the plains, and seems to be affected by the distance to urban centres. In supermarkets and city markets the minimum commercial size is generally 250g, and rural areas around cities may also accept this standard. In contrast, people in more rural areas prefer larger fish. This is, perhaps, because large fish were abundant in rivers and lagoons in the past, being available to farmers who used to fish occasionally. As population, pollution and other environmental problems increased in the last 20 years, fish has become scarce. Nevertheless the tradition of consuming large fish remains. As fish of 250g are for many farmers unsatisfactory for eating, they started farming fish farming in order to consume large fish and therefore harvest fish bigger than 250g (table 6.18).

Table 6.18 Size at Harvest (g)

	Frequency	Percent	Valid Percent
70	1	0.6	0.9
100	2	1.3	1
150	1	0.6	0.9
200	2	1.3	1.9
250	28	17.6	25.9
300	12	7.5	11.1
350	2	1.3	1.9
400	7	4.4	6.5
450	2	1.3	1.9
500	28	17.6	25.9
600	1	0.6	0.9
650	1	0.6	0.9
675	1	0.6	0.9
700	1	0.6	0.9
750	2	1.3	1.9
1000	13	8.2	12.0
1500	1	0.6	0.9
2000	2	1.3	1.9
2500	1	0.6	0.9
Total	108	67.9	100.0
Not applicable	40	25.2	
The respondent did not know	5	3.1	
Data not available	6	3.8	
Total	51	32.1	
Total number of farmers	159	100.0	

Most inland fishermen in the study area fish for their family, leaving the surplus for trade, and keeping what they see as good quality fish for their own consumption. Now that fish is not abundant in the natural water bodies and they started farming it, the custom of eating large fish still persists.

"It's cheaper to farm the fish. But let's suppose that it was not cheaper, the advantage is that you have it available. You don't have to go to look for it, I don't know where, and come back bringing it. And that's not the case here, the fish is near here, you only have to throw the net and in a few minutes you catch some for lunch. I think it's better to farm it".
Fish Farmer, San Miguel Juarez, Tacotalpa.

It appears that aquaculture and artisanal fishing are among the few options for poor farmers to have access to large fish in Tabasco to satisfy these food habits, but as natural fisheries seem to be over-exploited, aquaculture remains the most likely source of large fish in the future. Fish traders can go to rural areas to sell but not often and they mostly take small fish that are affordable for poor farmers. A certain pride was noted over rejecting small, cheap fish.

"We farm 'mojarras' and pejelagarto here. We like to catch big fish because it's a shame to catch small fish (less than 400g), *I really believe that. We use a three-cornered net, because with two corners we might catch small fish...".*
Fish Farmer, Xicotencatl, Tacotalpa.

"We are not interested in consuming small fish. Because indeed we have the means to raise one chicken, and then we eat chicken, one turkey, one little pig, some eggs with black beans, and so on, we spend our life in that way, because we are poor and we cannot live as the rich, because if today you have something, only God knows how we are going to manage tomorrow".
Fish Farmer, Pueblo Nuevo, El Centro.

Eating fish is seen as a special event and it is consumed mostly on Fridays in Lent and in Holy Week. This habit is attributable to religion but there is an environmental component too. Lent takes place in February, March and April, which coincides with the dry season when fish are easier to catch because water bodies are shallower. Similarly fish from the sea are more abundant because the *'Nortes'* (north winds), also blow in these months bringing an abundance of fish to the coast of Gulf of Mexico. Nevertheless as demand for fish increases, prices also rise, leaving no choice for many farmers but to farm their own fish. Lent is an important motivation because it is a holiday season and friends and relatives from the cities visit them, and offering fresh fish for supper makes farmers feel good hosts/hostesses. Fish are held all year in the ponds and usually farmers delay the harvest to fit these dates. Many farmers adapt their fish management to their social needs; feeding is intensified some months before Lent to ensure a good size at harvest while they hardly feed at all in the rainy season when they can afford and catch fish from other sources.

When fish farming is promoted with a harvest at 6 months[24], extension officers refer to fish of 250g but usually farmers expect larger fish. For an extension officer it is perfectly possible to farm fish in unsuitable ponds such as those which dry out during the dry season (March to June) or those which overflow during the flood season (September-December) because, unless the pond has both problems, the unproblematic seasons are long enough to hold fish for 8 months and harvest fish of nearly 250g. In ponds which do not dry during the dry season, some extension officers recommend stocking the fry at the end of December, when the current flood is over so the fish have eight months, from January to August in which to grow. This is long enough to harvest 250g fish at the beginning of September when the flood season starts. But as farmers prefer partial harvests of 500g fish to a total harvest of smaller ones, 8 months is not long enough (table 6.18). But holding the fish in ponds for more than 8 months brings some problems (as discussed below) and often farmers are so disappointed that they give up. As farmers want to consume fish during Lent, they do not harvest before the flood season starts (September) but risk keeping the fish through the flood season. Ponds very often overflow and fish escape. In addition, harvesting fish larger than 500g is very inefficient in financial terms because it can take more than 2 years to achieve that size, so the annual yield decreases compared to harvests every 6 months of 250g fish.

6.5.6 Local knowledge in fish farming

In some regions people have identified two kinds of tilapia with different external characteristics, *'tilapia'* and *'carpa'*. Most farmers apply the term *'carpa'* for large tilapias and *'tilapia'* to the smaller ones but no difference between the two can be established, as the use of the term is very inconsistent. In other regions they identify up to four different races of tilapia on the basis of the size, colour, and shape. The reason is that the tilapia population that is found in natural water bodies is a mixture of three species: *Oreocromis aureus, O.niloticus*, and *O. mossambicus*. The phenotypic variation among individuals is therefore large and it is easy for rural people to classify individuals into different categories. In general this attitude is not useful, because on many occasions farmers consider failure of a growth cycle to the

[24] This can be achieved with semi-intensive management (Chapter 2) but farmers are hardly able to

prevalence of a certain phenotype when the fact is that often the fish population has mixed characteristics and the external traits are not related to growth or survival. Nevertheless, research would still be needed in order to prove or reject farmers' perceptions.

The reasons why people confuse tilapia with carps are not well understood. Introduced grass carp (*Ctenopharingodon idella*) exists in the area but under the local name of *'bobo escama'*. They probably confuse tilapia and carp due to similarities in size and colour with the common carp (*Ciprinus carpio*) which was introduced in central Mexico earlier. Nowadays tilapia has been accepted as a local fish and local knowledge is being developed about fish behaviour, yield and management. Observation of tilapia habits in the wild by fishermen and farmers suggests that this species has caused a great deal of damage, especially to the populations of other species. Here there is a contradiction in farmers perceptions and motivations to farm fish, because on the one hand they say that they culture fish to protect native species from disappearance and on the other they mix these species with tilapia in their ponds. Why do they expect that the behaviour of tilapia in the ponds with respect to native species will be different from that in the wild? Perhaps farmers think that if they feed the fish, tilapia will not need to eat the other fish. There is some truth in this but it is affected by stock density, stocking size, ratio Tilapia : other species, and feeding rate and management. As people manage their ponds without advice, sometimes in bizarre ways, successes in farming mixed species are circumstantial. There is no doubt that local knowledge is starting to develop, related to farmers' preference for polyculture, as opposed to official advice for monocultures. Rural people have been used to polyculture in livestock and crops, but without a well established practice of recycling. Old farming practices may have been disrupted by a number of programmes for mechanisation, monoculture and the substitution of organic materials by agrochemicals. Recovery of local knowledge and the improvement of these systems would be necessary to establish a local model of polyculture.

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provide such management.

6.5.7 Other social benefits of fish farming

In spite of the preference to work independently, fish farming plays a role in social relationships inside the villages. The harvesting of fish remains a group activity and usually the owner of the pond receives help from other members of the community, so that 77% of farmers fish with large nets, and only 4% exclusively with lines. 67% receive help for harvesting from immediate family, relatives or friends, while only 1% of farmers hire labour.

"I like fish farming, I feel so relaxed when I look at my wife catching large fish. As the fish you can catch at the streams here are small, the women get very excited catching very large fish with a hook... I'll meet with my friends to bring tilapia from the river, the ones which are potbellied (with eggs) *and stock them in the pond. I'll bring them from the stream of the Ranch of Mr Felipe. Many people ask the manager for permission, they use the net and catch some which already have eggs... When we were living on our previous plot, we let other families fish in our pond. They asked for permission to fish there, and we let them to do it. Even when I harvested the fish, I invited some friends who have a net. They came and we harvested the fish. Of course, we shared everything in equal parts. People enjoy participating in the harvest. It's a kind of sport".*

Fish Farmer, El Ular, Tacotalpa.

Social satisfiers may have more weight in their decision on how to manage the pond than the search for high yields or optimal cash production. Aquaculture can be seen as a way to gain status and respect in the community, it can stimulate self-esteem and at the same time improve social relationships between villagers.

"When people from Macultepec came to visit the village for recreation, they used to ask me to sell them fish, and they asked for permission to fish with the net themselves. They threw the net in the pond and caught plenty of fish, but I didn't let them take them all because I like fish to grow large... Once a chap told me, if a machine comes some day, please tell me because I want to have a pond like yours. Another chap told me he wanted one too. This is great because not everybody has a

pond. Someone told me I was very wise, because I dug this pond and made this high embankment to build my house on".
Fish Farmer, La Cruz, Nacajuca

"I've thought about eating the fish and selling them in the village as well, but cheaper... the idea is to sell them in the community to save people paying high prices to the fish traders. Because now they're paying here 15 to 18 mxp (£1 to £1.20 per kilo*) for small fish; from 25 to 35 mxp in the town markets (*£1.80 to £2.50*). I want to sell them for 10 pesos (*70 p*). Like that, they can buy it and they can help themselves".*
Fish Farmer, Medellin y Pigua 3a sección, El Centro.

Nevertheless such factors are not currently measured or taken into consideration when aquaculture extension programmes are evaluated. None of the staff interviewed in aquaculture departments mentioned even one of those roles. The problem is that generally programmes and projects are evaluated with a quantitative reductionist approach while empowerment, self-esteem and leisure look too abstract and impossible to measure. If we think that development must be for people then these factors have to be considered as they are part of human well being. To make such a change a transformation is necessary of project designers' and project managers' mentality towards a re-evaluation of non-economic satisfiers. That change would imply the acceptance of subsistence culture as it has evolved within other modern ways of life in as in other countries. This will not easily occur, because as will be discussed later in this chapter, subsistence can be seen as a constraint and even a threat to industrial urban societies, which need rural areas to produce large volumes of food to meet demand.

6.5.8 Evaluating yield in subsistence fish farming

Farmers' management of stocking and harvesting (chapter 5) brings a number of problems when technicians evaluate results. Very often, textbooks on aquaculture consider a "farming cycle" from the stocking of fry to the total harvest, which can last from one to two years depending on the species. In that sense, evaluating yield is a simple operation resulting in t ha^{-1} a^{-1}or t ha^{-1} cycle. Not surprisingly, all Aquaculture Extension Institutions in Tabasco evaluate farms under this criterion (See chapter 7). But, how can we evaluate yield if even the duration of the cycle is not defined? What is actually a cycle under these conditions? Extension officers and farmers seem to have a different view. Yield is a very important factor for aquaculturists to evaluate results. But observing the complexity of evaluating yield on the semi-subsistence farms, more basic questions emerge: Is there a concept of fish farming yield for these farmers? Is yield in fish farming something that farmers pursue? These questions are complicated since evidence is contradictory. Probably there are several categories of farmers with different needs and expectations and generalisations would be very inadequate. As we have seen, expectations of yield are too high, perhaps because extension officers have projected wrong ideas; but as seen before, very commonly farmers prefer to catch fewer larger fish than more kilos of smaller ones. At the same time, as farmers are not keen to sell the produce or to net the ponds more often and on a regular basis, there is no way to know the fish quantities in the pond. Farmers use mostly a visual measure, if they see a large quantity of fish in a net, they feel that the pond is high yielding, but that does not mean that the all the produce will be harvested. Or if farmers catch a few fish due to incorrect net management, the perception is of low yield, even if the pond in reality is highly productive. Some farmers do not net ponds often because they do not like eating fish frequently, but the same pattern occurs in areas where farmers like eating fish very often as on certain sites, in some seasons, fish are still available in rivers and lagoons. Thus ponds are a kind of fish storage for scarcity seasons. This requires meticulous analysis and detailed research.

Looking at the existing systems and their management, and considering whether it would be possible to increase yield dramatically, the first impression is that farmers have a lack of interest in higher yields. Nevertheless, farmers' lack of interest may be more apparent than real and can be understood by trying to see the system from the farmers' viewpoint. The culture of subsistence is clearly governed by values different from those implicit in consumerist cultures. Such values are difficult to understand when we have lived in urban centres where economic motivation is felt to be universal. But that is far from being the case in the regions studied.

If fish farmers had a monetary mentality, it could be expected that when the price of fish is high, they would sell it to buy more cheap food and other household needs. Similarly it could be expected that they would harvest the pond when the fish weigh 250g which is both considered the commercial size and the maximum size at which tilapia grow with the lowest food conversion rate (in other words the size at which it is more profitable to harvest because larger fish grow slower and the cost in food and time raises the production costs), nevertheless that is not the case in most farms studied.

That could be because in past generations, before maldevelopment[25], the environment could provide an abundance of high quality food for them (Tudela *et al.*, 1989), or because 'good eating' is the main priority, such as and when they cannot afford to eat animal protein regularly they consider themselves really poor.

6.5.9 Gender and fish farming

The results of the 62 semi-structured interviews and the 159 questionnaires indicate that fish farming is an activity of both men and women. Nevertheless looking at specific activities, differentiation of task by gender was found. The owner of the plot, whether male or female, mainly does the formalities required for obtaining the fry. It was mainly men who did the transport of the fry from the hatchery to the farm, as for fry stocking, pond cleaning, manuring and fish harvest. Fish feeding is generally by both, but if the pond was near the house, by women. Fish feed preparation such as maize blending is carried out almost exclusively by women (table 6. 19).

"This is an activity for both sexes. Women can collect, grind the feed and give it to the fish because it's not something heavy. Women also can cook the fish and help in the harvest with hooks, but men can manage cleaning better and harvesting with nets because it requires more physical strength".

Fish Farmer, Reforma, Tacotalpa.

Table 6.19 Differences in farmers' sex according to work unit

Work unit	Sex			Total
	Males	Females	Mixed	
Individual	19	2	0	21
Family	0	0	82	82
Relatives	10	0	3	13
Farmers' groups	25	4	14	43
Totals	54	6	99	159

Looking at table 6.19, the first impression is that it is mostly men who carry out all activities. Nevertheless the type of organization influences the pattern. Although blending maize is a typical female activity, table 6.20, shows that many males do it. This is because most "fish farming producers groups" have only men (table 6.21) who have to blend maize. In many cases they get help from their wives, which was hidden in the statistical analysis of the questionnaires, because when men were asked about tasks, members of groups always replied that each member did everything in turn. But when some were interviewed a second time (semi-structured interview) they usually said they got help from their wives. Not being part of the groups, their wives' work was invisible.

Table 6.20 Fish farming activities by gender

Activity	Males	Females	Both sexes	Not applicable	total
Fry request	108	10	21	20	159
Fry transport	112	5	28	14	159
Fry stocking	112	7	28	12	159
Cleaning	106	7	40	6	159
Feed preparation	39	39	44	37	159
Feeding	59	14	54	32	159
Fertilisation	61	5	45	48	159
Harvest	84	5	69	1	159
Marketing	22	3	24	110	159

[25] Tudela et al (1989) use the phrase *mal desarrollo* (bad development) for the process of forced modernization which brought environmental and social degradation in rural Tabasco

Table 6.21 Blending Maize and gender

Gender	Alone	Family	Groups of farmers
Male	10	10	19
Female	5	29	8
Both	N/a	26	16

In the same way, looking at Table 6.20, it could be accepted that both men and women participate in harvest to a similar extent, as 69 respondents said so (given the number of mixed groups). Nevertheless, when the semi-structured interviews were analysed, it was found that women rarely participate in tasks that involve staying in the water. But they also collect and choose the fish to be harvested and clean and cook them.

Fishing with a line is carried out by women and children but, apart from a few cases in which both sexes participated, netting is generally carried out by men, (table 6.20). This mostly depends on the women's preference not to go into the water. Most men said that women do not participate in netting because it involves physical strength such as pulling on the net, and swimming skills, nevertheless women's dress may have something to do with it as women in trousers or shorts are very rare in rural Tabasco.

When women harvested the fish (mainly all female farmers' groups), they usually require help from their husbands. Women harvest with nets mostly when they have no choice, as it is expected that all members of the group participate equally in all activities and being a woman is not considered an excuse to avoid a particular farming task. This suggests that fish farming has hardly changed the traditional gender attitudes in the four zones studied. It seems that fish farming has been adapted to the local worldview.

More in-depth analysis of the interviews suggests that gender attitudes to fish farming depend on pond location. Generally those people thinking that fish farming is a male activity had their pond in a plot away from the house. This is because it is not usual for women to participate in agriculture or cattle raising, the activities carried out on the plots. One farmer said that he knew women were strong enough and able to do the same work as men but if he let his wife go with him to the plot, people in the village would think he was not man enough to sustain the household.

"I think that this is for both men and women...but here in this village we are not used to women working in the crop-fields. I see that in our State women don't work in the crop-fields, maybe in other States, in Chiapas women do. In my case my wife can work in the house but not on the crop-fields because many people will think that I cannot support her. People are stupid because most of the time they ignore the situation and say, 'look what a bastard he is, his wife helps him work! He's very poor!' – that's what they'd say."
Fish Farmer, Oxiacaque, Nacajuca.

The typical activities in which women are involved are those in or close to the house and yard, or in some cases the village, such as chicken, pig, duck and turkey raising, vegetable gardening and other domestic work. If the pond is located outside the women's physical space, fish farming becomes purely a male activity, but if the pond is located at the house, it becomes an activity for both sexes, sometimes being managed exclusively by women. These results agree with Townsend *et al* (1999) who describe the rural Mexican view of a good woman being at home, consequently women who work in the fields are the very poor as most who can choose, get out of it. Preibisch (2000) found forced feminisation of agriculture in Emilio Portes Gil in the State of Mexico, Mexico, through impoverishment of rural households. Coincidentally that was found in this study too, as only the poorest women participated in fish farming when the pond was not located near their house.

6.6 What do farmers want? Farmers express their priorities for improvement in fish farming

A number of ideas emerged in the interviews with farmers about ways to improve their subsistence systems. There was great awareness of the limitations of the ponds for good management, but lack of money prevents them making the necessary alterations. Pond depth is one of the commonest worries because pond depth directly influences the occurrence of overflow or drought, the major constraints detected in this research. Access to machinery, in order to make ponds more manageable, therefore came first on the list of help most needed. Nevertheless, in the absence of locally adapted pond designs, errors could result instead of improvement. Farmers often think the deepest ponds are the best, but sometimes those ponds are less productive and difficult to harvest (chapter 5). Although the new measure of charging for fry was considered discouraging, many farmers said that if people received support to improve their ponds, they would be keener to pay that cost.

Technical advice from experienced staff was another major request. There was extensive criticism of extension officials who were considered inexperienced and lacking in application. In reality 20 out of 62 farmers claimed to have obtained their limited knowledge of fish farming from relatives and friends. This shows that informed farmers are playing the role that extension staff have not been able to fulfil. Proper advice is thus of great importance to optimise management and use of time and on-farm resources.

Availability of fish feed at low prices, access to cheap transport to get the fry, and advice and organization for selling the produce were also recurrent requests. Far from being comfortable with the current situation, farmers want to improve but for their requirements and their pace.

Farmers themselves identified some proposals for improvement. For example, many farmers think that it is of primary importance to draw together all fish farmers in order to exchange experiences and build the capacity for obtaining credits. Other farmers thought that in every village there is an abundance of under or misused communal ponds which could provide self-employment to the landless, but that the Government has made no effort to take advantage of these resources. Disregarding the feasibility of these proposals, the important thing is that farmers have much to say and no efforts to listen to them prior to this research were identified. Most farmers commented that this was the first time they could express their insights. This is significant, considering the large sample size in this research.

6.7 Is semi-subsistence a good option for the rural poor in Tabasco?

Farmers' views and management of their production systems mirror a subsistence culture. Can the officials really consider semi-subsistence agriculture-livestock-aquaculture systems primitive? Can we talk about a failure of rural aquaculture in Tabasco? What is the place of fish farming there? Can its success only be measured in cash income and yields?

There is an extensive literature demonstrating that subsistence provides food security (for example Sahlins, 1972), together with physiological evidence, namely the diet of most subsistence cultivators in the world is not on average inadequate physiologically (Clark and Haswell, 1970). In fact, if subsistence-agriculture households produce surplus, much of the increment is spent on other needs, for clothes, housing, fuel and medicine and education. In addition to food security and the social gains discussed above, subsistence provides farmers with a kind of autonomy hardly satisfied by other means. Bennholdt-Thomsen and Mies (1999) call this a kind of empowerment that gives farmers control over their means of subsistence and some independent money income, providing the community with the capacity to reproduce itself with less dependence on outside forces and agents. I argue that subsistence also gives the 'power to do' (Mercado, 1999), the recognition that each has a leading role in their own life, the power to decide. The seasonal waged work practised by many farmers clearly exemplifies this kind of power.

Politicians see low wages in Mexico as the result of an abundance of labour. Conversely it is the common feeling in urban centres and even in rural areas of Tabasco that labour is scarce, as employers grumble that it is very difficult to find workers. In their materialist analysis they conclude that rural people are lazy, but what in fact may be happening is that peasants are aware that they are exploited with such low wages[26].

[26] In fact some farmers in the interviews mentioned the importance of the products they produce for the people living in cities and the low rewards they obtain in exchange.

"...For example, we work for Nestlé. You go to the supermarket and buy a big can of milk, but you don't know where it comes from on under what conditions it was produced. With or without rain, with or without mosquitoes, we have to go to milk the cow...and you end up getting cheap prices. How much is a coke? It's almost 10 pesos. And how much is a litre of milk? It is not even 3 pesos, and the coke is rubbish...and we earn a misery".
Fish Farmer, Barrial, Jonuta.

As farmers can choose to stay on their farms and work elsewhere to get only the minimum cash to cover their indispensable material needs, they can refuse to be paid labour for long. Few sell their labour on a long-term basis. Some must sell their labour on a temporary or casual basis, and may rarely achieve 200 days in a year. The present wages are not enough to purchase the same food they can produce on their land let alone the free time they can enjoy on their farm. Peasants with access to enough land (owned or *ejido* land, rented or sharecropped) can guarantee their food needs by their own labour. Those with inadequate farms and the landless, on the contrary, do not have the power to refuse exploitation, but hire their labour at the legal minimum wage.

It can be argued that subsistence is not a satisfactory option because it guarantees food only for normal and good crop years, whilst the threat of hunger is present in bad crop years. I agree that this threat is present in zones with large climatic fluctuations[27] (long dry or flood seasons for example) and in communities practising total subsistence, but neither is the case in Tabasco. Dry seasons in Tabasco are short and even during them, enough rainfall occurs to water the fields (figure 6.2). So two crops of maize are possible each year. Flood is truly a threat to crops, especially in recent years when extreme floods have taken place more often, but in general farmers avoid risky crops for that season. Similarly the farming of cattle and other goods for profit secures cash used to acquire food in hardship periods. At the same time farmers do not seem to me to be reluctant to make their farms more productive and to sell their surpluses as most of them said that they were not cultivating all their

[27] And even there subsistence can succeed if farms have technology adapted to local conditions, as with Mexican prehistoric irrigation or *'chinampas'*. I think that there is no reason to believe that subsistence is incompatible with technology.

land only because they did not have an adequate infrastructure (trade links, fair crop prices, technology transfer, machinery, loans, etc) to be competitive. Once they felt that the conditions existed for them to make the farms more profitable, the farmers could be the generators of their own change. I argue that this change should be on their own terms. Subsistence seems to be their refuge to resist external attempts to change their cultural values and way of life, whilst defending themselves from extreme poverty. Barkin (1998), when reflecting on more than 50 years of efforts to remove the peasantry from rural Mexico through discriminatory economic and social policies, was surprised that there are still more than 30 million people living as peasants or seeing rural communities as their true home. I think that is a sign of resistance to the forced change of life-styles and a sign of hope in the conservation of the immense knowledge reservoir that still exists in the countryside. Nevertheless at present this resistance could imply social costs. Preibisch (2000) argues that seasonal migration has been a way of preserving rural communities, bringing changes in social and family relations and passing to women the load of subsistence work

Given these characteristics, three questions emerge: Is it desirable to preserve such systems? To what extent? And if so, what is the best way to develop aquaculture without changing the strength of the system?

To be able to answer these questions it is necessary first to determine whether there are moral arguments to support the free choice of human groups to define their own direction of change instead of the dominant view of the universal validity or unavoidability of a materialistic, money-based economy (Chapter 1).

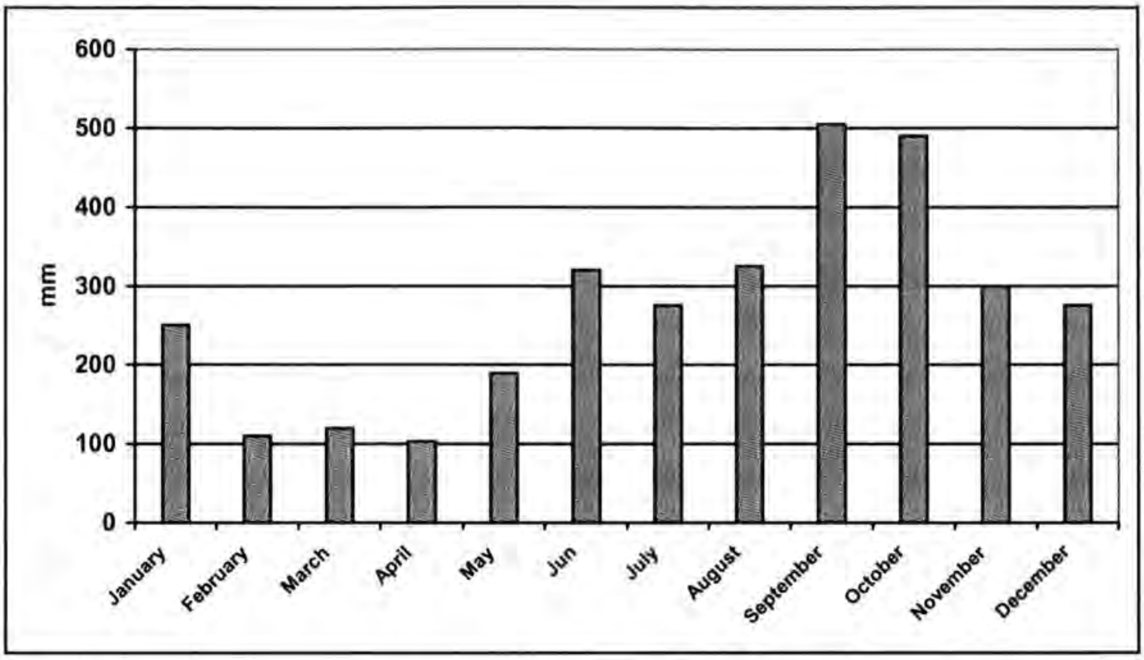

Fig. 6.2 Average monthly rainfall in Tacotalpa[28].

This has to be demonstrated in practice, but there are already examples indicating that success in small-scale aquaculture can be obtained when people are listened to and local conditions are considered. An example is the case of the Cuyutlàn lagoon, where evidence has been presented that that aquaculture can be socially acceptable, economically viable and environmentally friendly when consideration is first taken of the local circumstances and environment (Hugues-Dit-Ciles, 2000)

In spite of the virtues which subsistence systems may have, their permanence cannot be taken for granted, precisely because their main virtue is in its simplicity and the acceptance of natural limits. This humility generally impedes their defenders (e.g. some indigenous and grassroots movements) from setting themselves up as the possessors of the truth. In addition, like any other alternative way of life, subsistence has to prove its viability in the very arena of the dominant economic view itself. This of course is a disadvantage that is very difficult to overcome as the framework of the modern world has been established to favour a monetary economy. Therefore *"people who have lost their subsistence outside the cash economy, and who under these conditions have only occasional and minimal access to cash, lack*

[28] Source: SEDESPA (1997a)

the power to behave according to economic rationality" (Illich, 1993, p94). A subsistence farmer in rural Tabasco is probably close to this threshold.

But, is there any chance of making these systems so much more productive that even in the face of modernity they would be able to resist and preserve their qualities? I argue that there is. As I have shown, this aquaculture is practised with a large number of technical errors that could easily be resolved. A number of textbooks on aquaculture already exist with simple technologies that could be adapted to local conditions (Mulero, 1983; FAO, 1985; Lovshin, 1986; ALCOM, 1989; Bosec, 1991; Mollison and Beyor, 1988; Nyman, 1988; ICAAE, 1992; etc). Other problems would have to be solved by conducting applied research directly with the farmers, but, most importantly, this research would have to be defined taking into consideration the farmer's rationality and priorities. In other words, if farmers prefer polyculture, research should seek to produce efficient systems of this kind even if this involves methodological problems, instead of imposing monocultures, which would probably be abandoned later or modified by farmers to suit their convenience. Change would also be necessary in the attitudes of research, extension and senior staff, and also of the people in charge of designing projects and programmes. Farmers would have to be listened to, and their cultural values understood for officials to be able to make evaluations closer to the farmers' reality. These realities are often local, complex, diverse, dynamic and unpredictable (Chambers, 1997); but ultimately farmers' reality is what must count if the goal is human well-being. Farmers must not be seen as mere objects. The realities of socially dominant professionals (who are in charge of planning) are often neither true nor right (Chambers, 1997). If, as in Tabasco, there are other, non-economic satisfactions, such as cultural and social rewards, then more weight must be given to such values. In other words, it would be better if the rewards of development were less exclusively material.

Having reflected on the importance of the local and of people's moral right to choose their own way of life or system of production (Chapter 1), it would be contradictory to make generalizations here or to assert that subsistence systems are either a superior or a unique way to seek sustainability. Each specific locality has its own peculiarities, and the interpretation of what is sustainable or not could be equally specific. The community sustainability approach seems to be sensitive to such differences (chapters 4 and 8). Should it be shown that such subsistence aquaculture can work efficiently and sustainably, locations will still differ. Institutions could fall into the temptation to spread it as a magic recipe to alleviate poverty in rural areas; in other words there is a danger of falling into generalizations as has happened with 'participation', 'micro credit' and 'group organization'. The creation of a global standard for reaching sustainability is in my view not possible. If we seek to generalize, that could in the end make it more difficult to achieve a more sustainable planet. A more promising way to achieve more sustainability in the world could be by change at the community level, so that the addition of each and every effort would lead to global change (Bridger and Lullof, 1999). Thus more active people's participation might be expected to develop better and more sustainable production systems, if they could count on the freedom to choose their own changes. Subsistence systems can be the answer for specific human groups in specific environments but I am far from considering them an alternative for all or the majority of rural environments. This reasoning, although hypothetically possible, has huge obstacles to being put into practice.

Subsistence is often seen as major constraint for economic development (Bauer, 1981; Bauer, 2000; Seavoy, 2000[29]) because massive production of food is needed to satisfy the industrial urban markets and such (still unsustainable) massive production cannot to be reached under the existing subsistence practices. Under such a dominant ideology, it is evident that a process to change subsistence farmers into full-time paid labourers exists. Many arguments are used to justify this policy: poverty, the backwardness or primitiveness of subsistence culture, the unavoidable evolution from subsistence to commercial practices etc. This has generated a very large literature, which will not be reviewed here. I argue that subsistence systems are not primitive but the product of knowledge accumulated over centuries, and that they can become highly productive and contribute substantially to food production for urban markets. Nevertheless to achieve that, trade structures and rural policies must be modified. No matter how sustainable and productive subsistence farms can

[29] This author argues that if economic development is to be maintained, it may be that peasants must be forced to perform commercial labour norms to end subsistence cultivation.

become, the possibility of becoming a significant development option is limited under the present trend to a more globalized world.

Subsistence aquaculture systems seem to be one opportunity for the improvement of nutrition, social life and the environment in rural areas of Tabasco. They have environmental and social characteristics that meet some conditions listed as necessary for sustainability by some authors. Nevertheless, due to its non-monetary nature, its permanence is threatened by the expansion of modern production systems and culture in the villages. I argue that subsistence systems have the potential to become more efficient and productive if locally based research is conducted and farmers' cultures and motivation are understood.

6.8. Local aquaculture and national rural policy: can subsistence aquaculture be considered by decision-makers?

I have argued in this study that semi-subsistence, theoretically and practically has much to offer a better life for the rural poor. But what possibilities exist for its recognition as a real choice for rural development in 'modern Mexico'? Debates about data will not be entered here, but accounts from *La Jornada* (a newspaper) and *Proceso* (a magazine) which use official figures will give a flavour of the situation.

Most recent data on the nutritional status of the Mexican population seem to justify the 1970s and 1980s National Development plans for the promotion of on-farm production and on-farm consumption of food. In 1999 at least 20 million people suffered severe malnutrition, while 66% of municipalities and 31% of the population are at serious risk of the existing 'chronic hunger' which is worsening (Proceso 24/10/01), mainly in rural areas. The malnutrition problem in Mexico not only remains but the numbers have grown. Nevertheless, the objectives of rural plans, in this case aquaculture, have changed towards entrepreneurial activities mainly associated with high priced goods and non-food products. Farm and national self-sufficiency was taken out of the national Rural Development discourse (Chapter 7).

The future not only for subsistence but also for the whole of agriculture in Mexico does not look promising. The rural policies implemented by the government in the last 20 years have been followed by agricultural crises and the loss of food self-sufficiency. 70% of rural people lost their jobs, seeds are 63% and fertilizers 52% more expensive while there are still peasants earning 10 mxp (about £ 0.70) per day which is one fifth of the industrial worker's wage (*La Jornada* 18/07/01). Similarly from 1981 to 2000 agricultural GDP fell 14%, production of the 8 main grains 29%, red meats 32%, milk 11% and timber 28%. Food consumption fell and millions of rural people fell into extreme poverty. Food imports increased from US$ 1,790 million in 1982 to US$ 9,782 million in 2000 (*Proceso* 29/10/01). In addition agriculture products lost value in real terms. Maize and wheat lost 43%, and sorghum 55% of their price in real terms between 1997 and 1999. According to CEPAL[30], between 70% and 80% of income in rural households now comes from non-agricultural activities (*Proceso* 15/07/01a). Little importance was given to agriculture when the government started inserting Mexico into global markets. Subsidies were reduced and in some cases eliminated, public expenditure in rural areas fell by 95% and public expenditure for rural development 87% between 1982 and 2000, affecting research extension services, crop health, machinery projects etc (*Proceso* 29/10/01). In 1999 the dependency of Mexico on the USA for food was 58% for rice, 23 % for maize, 49% for wheat, 43% for sorghum and for soybean 70%. But the 17,777 million t of imported grains do not reach the poorest people, only the grain-processing industry (*Proceso* 29/10/01). Migration to urban centres increased, and 45% of rural households are believed to lost at least one member to migration (*Proceso* 15/07/01b), or violence (*Proceso* 16507/01b, *Sur Proceso* 07/07/01a). This is a crisis in national agriculture. According to Victor Suarez[31] *"the fact that the national production has not collapsed even more is due to the multiple strategies of subsidy and subsistence to production by the peasant economy at expense of reinvestment by decreasing levels of consumption, and living-standards –food, clothing, housing, education and health-, at the expenses of their forms of production and soil fertility"* (*Proceso* 15/07/01c). In the view of some grassroots movements and analysts, this strategy seeks to transfer agricultural labour to industry to serve as

[30] Comisión Económica para América Latina y el Caribe (Economic Commission for Latin America and the Caribbean).
[31] Chairman of the National Association of Trade Enterprises of Farmers (ANEC).

cheap labour, especially in Southeast Mexico with the Puebla-Panama Plan (PPP) (*Sur Proceso* 07/07/01a, 07/07/01b).

Especially in the last 20 years, subsistence has been a way to defend agriculture as the foundation of the rural way of life, to resist attempts to divert agricultural labour to urban centres. In other words, a defence of rural cultural values and traditions. Apart from encouraging the depopulation of rural areas, change has included the replacement of food crops by non-food and luxury crops for export such as flowers and cotton and, in the case of aquaculture, by shrimps. It is estimated that 14% of land (invariably the best) in poorer countries is used to grow crops or horticultural produce for export, and the amount of land under export crops is expanding (Madeley, 2001). This indeed threats subsistence cultures. Implications are well presented by Shiva (in Madeley, 2001) " *we are told we would be able to buy more food by selling flowers than we grew for ourselves. But selling flowers destroys your food security –you can only buy a quarter of the food that you stopped producing. For every dollar earned by shrimp exports, more than ten dollars in local food security is being destroyed.*" Wealth produced through subsistence has never been part of statistics, so does not exist for the decision makers. The change from more to less and from benefit to the masses to corporate benefit looks legitimate. Tabasco is no different, but some farmers who can now resist the seduction have experienced previous manipulation and the instability of agricultural prices.

"I prefer to farm maize. If nobody wants to buy it, my family still can eat it. If nobody wants to buy oil palms or the price falls I cannot eat that".
Fish Farmer, Lazaro Cardenas, Tacotalpa.

It is difficult for small-scale agriculture to survive in these conditions, and more difficult subsistence. There are few possibilities to compete in the global market against TNCs (Madeley, 2001).

Scientific advances such as genetically engineered crops, the sustainability of which is contested, also threaten the survival of the semi-subsistence way of life. Effects of these technologies over the sustainability of traditional agriculture systems have begun to be reported. For example transgenes have been detected in between 3 and 13 % of plants of local varieties of maize in Oaxaca, Mexico even when the introduction of transgenic maize in Mexico has not been authorised *(La Jornada* 15/10/2001; the findings are strongly contested). If local crops free of transgenes could be an option for semi-subsistence farmers to compete in the organic food market, the Oaxaca case shows the fragility of small farmers when there are strong commercial interests. It may also illustrate the danger of commercial distribution of imported transgenic food goods which easily escape control and may contaminate local varieties with unknown effects on people, wildlife and yield of local crop varieties threatening even the permanence of wild animal and plant populations. Recent advances of research on genetic engineering of tilapia indicate that there will be commercial transgenic tilapias soon (Rahman and Maclean, 1999). If transgenic land species, in theory easier to control, may already be causing problems, the introduction of transgenic fish is worrying. Mexico's acceptance of commercial exploitation of transgenic potatoes, tomatoes, soybeans, canola and cotton[32] (IICA, 2000), indicates that the government's attitude to the interest of agribusiness TNCs seems favourable. The inclusion of other species such as fish thus is not unlikely.

Because of the government-TNC resistance to options other than the global market, semi-subsistence may only have a real chance of success in organised communities that are aware of the environmental and social threats that consumerist culture implies. Subsistence life-styles could then become a conscious resistance to over-consumption. But they could only be a real option for change if the possibilities to become more efficient and productive were explored. The way is long, but there at present there are some good signs that make me believe that it is possible. The Zapatistas and other grassroots movements in the world are presenting interesting proposals, including the right to say no to consumerism. The resistance of the trans-national elite is enormous and for that reason it is necessary to count on even more educated people who have become conscious that consumerism has not satisfied their human needs. The existence of these communities could *per* se act as the promoters of subsistence options. This is not new, great philosophers as well as

[32] While zucchini, melon, banana, pineapple, maize and carnations are in experimental phase.

indigenous cultures have always praised the value of simple ways of life. The love of nature and simple things is an important philosophy of life.

6.9 Is Commercial aquaculture the answer for rural poor?

There is total agreement among aquaculture professionals in Tabasco that aquaculture is good for the poor. This feeling seems to be reinforced through their personal experiences in the field. The benefit is judged to be through income generation and food production.

"One poor man said that he produced carp, tilapia, guavina and common snook, 500 kg in total and he got 6,427 mp (£460). *But he said that he spent 3000 pesos on his children's education and the other 3,427 (£245) on medicines and radiography for his wife and himself because he has heart disease. He ate the fish left in the pond. He has a 2400 m^2 pond which is relatively small, so his yield was very good, aquaculture thus benefited his family".*

Head of Sub-directorate, SEFOE.

It is therefore believed that the rural poor are the correct target group. The problem is the kind of approach to aquaculture development. All professionals say that they try to work with the poorest farmers. Nevertheless it is likely that those who apply for ponds and aquaculture programmes are among the poor in a given area, because they cannot fund pond construction by any other means but as discussed in chapter 5, in practice the supports do not reach to the poorest of the poor do to peripheral problems (some farmers can apply for supports but not necessarily obtain them, others can get support but not necessarily make use of it because of lack of the basic cash to implement its practice).

"Well, we have cases where we are fulfilling the objectives, we have gone to poor communities indeed... well, there is always something to eat here in Tabasco, but ... nevertheless I do think in some groups we do go to the poor communities, but in other cases we don't. But we try to see that the supports are for the groups who really need the fry for free".

Extension Officer (SEMARNAT)

In extension officers' view, the benefits are reaching the target group. They consider that generally poor farmers think about subsistence while rich farmers more often try to do it as business. There was some consensus in recognising that rich farmers are more successful commercially because they have the money. So for them the role of the government should be helping the poor to reach the same standards.

In the last 6 years the government has not been very successful in making farmers go into commercialisation but in future things could change. Important steps have been taken by a private enterprise; Pucte del Usumacinta, with the approval of the State Government, has started persuading farmers to change. This organisation has plans to sell 400 tons of fish per week. As they could not produce that quantity, they are actively looking for farmers through a programme of the formation of commercial units, so that they can establish cage cultures in large water bodies in the villages in order to produce the fish to be traded. The programme sells fry to farmers, and provides technical assistance and advice. Similarly they write farmers' projects to be presented at banks in order to obtain credit.

The government acted as a facilitator, locating the groups with potential to go into commercialisation. As a result, 16 groups have been recruited and at present 8 are already working. One has already formed a cooperative. The government provides them with infrastructure for fish farming and the bank would lend them money to grow. The production is sent to the national market, but their intention is to export to USA as soon as they can collect the minimum volume required by the importers.

For the company, the aim is a business in which both farmers and the company benefit. For the government the goal is to use those groups as demonstration farms so that other farmers will follow the example and could be displayed as Government success. The head of an aquaculture department described this cooperation was an example of their work *'to provide sustainable activities to poor farmers'*. To me in promoting such aquacultural systems the government looks only for economic sustainability. Environmental, social and community sustainability is left aside.

For the government, these are the exemplary groups, the people who want to work. For that reason most support is provided to them. This information confirms in practice the dominant prejudices about subsistence. The idea of promoting fish farming for export markets was presented as proof of their achievement. Everything but commercialisation seems to be work invisible to them. This suggests that there is little hope that the government will offer alternative programmes taking into consideration the physical, social and cultural environment in order to assist the poorest farmers.

But the conditions for commercial aquaculture are not easy in Tabasco. At present there are few commercial fish farms. It seems that government strategies for the promotion of this sector has not worked. Evidence from professionals involved in the business suggests that bringing poor farmers into this arena will be risky.

The case of Roberto Luna[33] in Emiliano Zapata exemplifies how difficult aquaculture is as a business.

Roberto started working in aquaculture because he realised that Tabasco has great potential. He has been trying to set up a business with his tilapia hatchery for 4 years. He built the hatchery there because he already owned the land and well, and also because a pump was already installed. He unsuccessfully tried to obtain a loan, because banks still consider aquaculture a risky business, so that everything at the farm has been done with his own money. He brought broodstock from abroad in order to sell better quality fry. This would make him able to compete with the public hatcheries, as he has to sell at higher prices due to higher operation costs. He manages an intensive system with aerators and high protein feed. Access to markets was difficult at the beginning, so he got some support from SEMARNAT and SEFOE to find potential customers. Four years later, the hatchery is in business as he is selling to the private and the public sectors in several States of the region. The hatchery produces 2,000,000 fry/year, but still works below capacity as there is not

[33] The original name has been changed.

enough demand. After he dug the ponds he realised that the soil was permeable and he had to line the pond with expensive membranes imported from USA.

Roberto tried to produce fish in floating cages but there were too many thefts. He started the business because he knew that export markets were paying good prices *"I was interested in farming shrimps, freshwater prawns or crocodiles. But then tilapia started to be an attractive species, as the market for red tilapia, especially in USA, started to be important. That was when I decided to farm tilapia. The price got better and it is easier to farm"*. Today he has still not been able to export so he has had to work hard to open city markets, and as it was difficult, he ended up selling to intermediaries who pay poor prices. *"I make good business in Lent and Holy Week when fish has a good price. Except for that season the intermediaries exploit you too much. You have to take your produce to Mexico City or Veracruz. It is the best way to look for markets but sometimes you don't have time and money to do it, and you fall into the hands of the intermediaries. They are a 'necessary evil'..."* At present he is thinking of expanding because he thinks big fish have a good local market. He is not interested in native fish because they have no markets abroad, and his goal is to export his produce.

This is not an uncommon case in aquaculture. It shows the difficulties of competing in the market and the obstacles to access to the big markets abroad. If being successful is a difficult task for a rich person, what we could expect for poor farmers is limited if not negative. The most probable outcome is that they end up exploited by intermediaries as happens in agriculture and fishing. It can be argued that this could be avoided through organisation and the formation of unions of fish farmers could help them to trade their produce. Nevertheless political will is necessary and at present intermediaries still have political power to influence the authorities. With very few exceptions, the opinions of bureaucrats in this study on aquaculture development have a certain naivety.

6.10 Concluding Remarks

Given the farming systems within which fish is cultured in Tabasco, fish farming must be analysed in the context of all farm components such as crops, livestock and off-farm income, because the fish is just one additional resource, which is affected by the availability of labour, materials, and other uses given to the pond.

Because most fish farming in Tabasco is for on-farm consumption, has a low intensity management and produce low yields, it can be considered subsistence (although the farm itself is considered semi-subsistence because cattle and some plantations are 100% commercial). Besides the role of fish farming in the food security of households, fish also plays important social roles that would be difficult to fulfil by other means. Since it is still considered a novel activity, fish farming augments self-esteem to those who practice it, as other villagers consider them innovators. Fish farming also provides a feeling of service to the community as it is seen as an environmentally friendly activity which helps in the preservation of native species, helps to maintain local food habits and enables poor farmers to consume valuable food which is difficult to access with the current farmer's purchasing power. Motivation and success in fish farming are affected by the farmer's experience, vulnerability to thefts, and gender. Material aspects, food security and income generation are women's main motivations, while men are also inspired by social gains. Local knowledge about fish was recognised, but is dispersed and related mainly to the culture of native species and turtles. Given farmers' difficulties in being competitive in commercial activities, subsistence aquaculture, even though the yield is hard to estimate, can be a good option for raising the standard of living of the rural poor in Tabasco, particularly under the present unfavourable market conditions. Subsistence aquaculture is an especially good option for farmers who own land, since it is a good way to secure food which demands little labour or cash yet optimises the recycling of nutrients on the farms. The high yields found in some farms imply that, with good management, these subsistence systems have high potential to become more efficient and high yielding, maximising the utilisation of on-farm by-products through the use of appropriate extension. Nevertheless due to its non-cash oriented characteristics, its permanence is not guaranteed as it is little valued by most aquaculture professionals and extension institutions working in

Tabasco. For this reason the improvement of subsistence aquaculture can only be obtained with the support of the local, regional and national governments, which first need to replace negative attitudes to subsistence by the recognition of the social and economic benefits that subsistence aquaculture can provide.

CHAPTER 7

AQUACULTURE FOR WHOM? TWO VIEWS, TWO GOALS PROFESSIONALS AND FARMERS

7. 1 Introduction

Given the conditions in which aquaculture semi-subsistence systems operate in rural Tabasco and the social and environmental qualities which it may be desirable to preserve, very different from the more unsustainable commercial aquaculture, questions arise: 1) Did aquaculture develop as aquaculture professionals and decision makers expected? If not, 2) are they happy with the course it has taken? Are aquaculture professionals and decision makers, on whom change depends, aware of the positive aspects of subsistence production systems? The view of the local professionals in aquaculture is therefore explored in this chapter, and the organization of local aquaculture institutions analysed.

7.2 Aquaculture as seen by aquaculture professionals in Tabasco: a 'development dream'

7.2.1 Professionals' view

Professionals working on aquaculture in Tabasco displayed little diversity in interviews in their views about aquaculture. All technicians and senior staff agreed that fish farming has great potential, especially in Tabasco, as there is much water. Similarly they said that aquaculture was a good strategy for solving problems of poverty but still not widespread because it is still new for most farmers.

Aquaculture is judged backward and even non-existent in Tabasco, as most is subsistence, which is seen as mere restocking of water bodies. Professionals commonly said that farmers do not like tending fish and that they know absolutely nothing about fish farming. Their frustration was clear. *'Aquaculture is a failure', 'aquaculture in Tabasco is in the stone age', 'after more than 20 years aquaculture has not reached take-off in Tabasco'*, and so on, were all common expressions when they were asked about aquaculture development in Tabasco. For them, aquaculture has not been successful because after 20 years there are few groups exploiting fish farming commercially (chapter 5).

"Our goal is to provide the farmers with their urgent basic needs, to bring them high quality protein and excellent food, later we try to help those groups on to a commercial stage, when one portion is kept for consumption and the surplus is sold"
Head of Department (SEMARNAT).

Many reasons were given for this poor development of aquaculture in Tabasco:

- Projects sometimes fail because people still see aquaculture as subsistence.
- Local fisheries are still abundant and rural people find it easier to exploit natural water bodies than to make the effort to culture fish.
- Farmers' apathy.
- People's habituation to getting support without accountability.
- Lack of resources for extension services.
- Customs or cultural barriers.
- Farmers' inadequate schooling.
- Wrong or no infrastructure on fish farms, etc.

Of course, extension officers around the world may be heard making negative, scornful comments about their clients. For them, the 'backwardness' of clients is a common excuse for failure. In this case, however, negative comments are particularly common and the content of those comments seems very illuminating.

It is clear that some points on this list have caused a slow down in the process of extension of aquaculture in Tabasco, but I believe that perception of failure is exaggerated because of the dominant idea that the subsistence production is an archaic stage of development. This was expressed clearly by one aquaculture researcher.

"Aquaculture is backward in Tabasco because there are no successful groups. Okay, there are successful groups but at another level. If success is measured in subsistence, groups with no commercial vocation, then they are successful because they spend little money, harvest food, make parties, share everything with their neighbours, with their relatives. It's socially profitable. There are many groups like that, but there are very few which are commercially successful (Such as the APS 'Tornolargo' and APS La Mojarrita Velóz' in El Centro)*".*
Aquaculture professional in Business

In the opinion of some aquaculture professionals, that is the result of a rich environment which still offers many satisfactions to farmers with less effort than farming fish. It was said that compared to other regions, fishing in natural water bodies in Tabasco still provides more income they could obtain through fish farming. In their view, fish farming would have to be very attractive economically to encourage them to take more interest. But as was seen in chapter 6, that is not necessarily true. My perception is that technicians give too much importance to income in their analysis, as they are not able to recognise the social role of fish farming. Farmers may not necessarily want to produce the maximum possible yield if the promised profits imply a big increase in workload.

There seems to be no room for a more sustainable subsistence aquaculture in this view. The text below is an example of how the farmer's subsistence view is ignored, even despised.

"*People think that aquaculture is fishing, just stocking the fry, to fish them. But not culturing it.*"
Aquaculture Professional, Municipal Development, El Centro

Technicians have a pessimist view about the stage of aquaculture in Tabasco, I believe mainly because of a simplistic view of success, which is reduced merely to higher yields and money profits. This may be partly due to their aquaculture background. Aquaculture is taught in most universities as a commercial activity, which has maximising profit as its main objective. In this view, it is clear that subsistence does not fulfil the standards of a profitable activity. As a result subsistence fish farming appears as a pure constraint.

7.2.2. Analysing professionals' attitudes: An evolutionary perspective of fish farming.

The shift toward commercialisation is seen as a necessary stage to success in aquaculture. Professionals say that at present farmers do not conceive of the fruits of aquaculture as tradable, that most of them have very small water bodies and no entrepreneurial mentality. Subsistence is seen as a synonymous to inefficiency and a lack of interest and of work, a temporary stage which has to be 'overcome' sooner or later; as a valuable but early stage in solving problems of malnutrition and poverty in rural areas.

"The evolution of the group is measured in the change from subsistence to commercialisation. That is not easy because sometimes the objective of the group is to stay... just satisfying the basic need for food and a little money. In that case it is necessary to do something convincing to motivate them to move into the commercial stage".

Head of Department, SEMARNAT

Nevertheless such a transition is seen as very difficult mainly because of the farmers' mentality.

"Farmers see aquaculture as subsistence, they don't put enough care into the ponds."

Extension Officer, SEFOE

"Well, simply farmers do not see aquaculture with that view (commercialisation), *they still do not have that view. They practise aquaculture as a backyard activity – I stock it and I'll see what I get – just for eating... but no, they still don't take that responsibility* (intensification)*".*
Extension Officer, SEFOE

Many technicians judge that the resistance is more accentuated in Tabasco. The problem is not analysed holistically, considering environmental, cultural and socio-economic aspects. There is a tendency to hold the old paternalist government policy responsible because *"it has made them used to getting programmes every year, it doesn't matter if they fail".* (Head of Sub-Directorate, SEFOE) Some examples were given of this.

"I remember when I arrived in Tabasco in 1984. There was a state strategic project to establish 5000 cage fish farms. They already had 50. They spent lots of money. They gave fry and materials to farmers as well as technical assistance. That was in theory, but in practice the government never had the capacity to support them, as there were too many farmers. They gave cages to many people but the truth is they never asked them if they wanted to have cages. So there were people who ended up with the cages as chicken runs, hammocks...90 % of farmers were not interested in commercial activities but in subsistence. Giving cages and feed to them is to waste the money... too much money has been wasted because of political interests".
Ex-researcher (Now in Business)

There is no doubt that there were many mistakes in that strategy, and that there were political interests involved. It is almost certain that people were affected negatively during the process to become more willing to receive assistance in exchange for votes, but reducing everything to that perhaps is to ignore other sides of the problem. This research suggests that monetary profit does not necessarily move rural people to change their way of life.

The acceptance of profit as the only way to development leads to conceiving of farmers as objects whose cultural values have to be changed to move on to the next development stage. Thus local culture has come to be a constraint which needs to be eliminated. Therefore looking for methods to make people change their way of thinking or to seduce them through profit is seen as a convenient solution.

"*It's helpful to adapt them to semi-intensive aquaculture in order to try to produce as much as possible...I think that the mentality of producing for on-farm consumption is wrong. Our idea at the aquaculture programme is to build in them the idea, the mentality of getting extra income.*"
Extension Officer, SEFOE

"If you go and try to impose certain rules on them, they don't accept them, do they? They have to decide but it should be a task of making people aware. To coax them toward the changes you want. But in that case the extension officer has to go and live in the village, to be more in touch with them and to advise them".
Head of Sub-Directorate, SEFOE

Bringing farmers into commercial aquaculture thus becomes a synonym for success. Success translates into the ability to change farmers' vision towards greater materialism. The more westernised a farmer, the better. For instance, when asked with which kind of farmers aquaculture was more successful, one head of a aquaculture sub-directorate (SEMARNAT) said *"Well, it depends...the socio-economic aspect has much to do with the interest they have in aquaculture and what they really want to develop. It is not enough for us that they just want support to harvest the pond without selling the produce".*

"I have seen how people change, I have seen their development".
Head of department, Municipal Development, El Centro

Nevertheless they have found that changing people's mentality is not easy. The problem is not analysed in a cultural context but as a question of farmers' mediocrity or conformity.

"I feel that there is conformity. Aquaculture doesn't become the main activity but a secondary one. For example, I go to work on the crop fields, my maize, my cows, and in the afternoon I work in aquaculture. Then I believe that there is certain fear of the risk of concentrating on only one activity. They don't risk it with aquaculture because they have activities that they have practised for longer with good results. So I believe that it's some kind of fear".

Head of Department, SEMARNAT

Some are aware that the change is difficult, not only due to the farmers' mentality but because the necessary economic conditions are lacking.

"But in the commercial stage they face many problems. They require investment, more labour effort. They need to register in the Treasury Secretariat; they need to give receipts and things like that. That stage is our goal, but it is not easy to reach it."

Head of Department, SEMARNAT

Sometimes persuasion towards more intensive aquaculture works very well. This happens when farmers realise that the transition from subsistence to commercialisation is necessary to keep government support, especially in those programmes which provide many benefits, such as feed, nets and other equipment. Nevertheless that may become a problem for the technician as some people alter their production data in order to appear more successful.

"Sometimes I understand these people. They are desperate because they have children. But I have worked here for two years and I cannot say that I have advised a unit that is working 100%. Sometimes farmers inflate their reports of harvest. They cheat because they know that we try to support those groups with more of an aquacultural vocation, they don't want to lose the support".

Head of department, SEMARNAT

On the other hand, what is a sign of success for most technicians may annoy others. In their view some farmers have become extremely materialistic. This is seen negatively because the expectation of making easy quick money sometimes makes farmers disappointed in aquaculture.

"Some farmers do not see aquaculture as a food source for their family, they want to get rich quickly, they don't see that this is to grow slowly".
Extension Officer, SEMARNAT

This behaviour by farmers probably results in part from technicians' own work in trying to convince farmers that being 'modern' is to have an entrepreneurial mentality.

7.2.3. Who will make the change?

Bearing in mind how difficult it is to changing people's mentality, some professionals still believe that new generations will make the change.

"15 or 20 years could pass and farmers wouldn't go into commercialisation. That's why entrepreneurs will make aquaculture before them. Because the law is becoming more flexible in order to take advantage of all natural resources, and farmers and fishermen haven't made the best use of them. I see it as more difficult for fishermen to develop by themselves. There's one kind of fishermen that's the only kind I've watched advance: the technicians who are the sons of fishermen. At present they're fishermen because they haven't found a job. They've organised in fish aquaculture societies. They're the ones who have worked hard. They now farm pargo[1] *(*in Paraíso*); it's been difficult for them but we've been supporting them, very discreetly to avoid spoiling them because then they just feel that there's money and...what we've been doing is giving the money for specific things like equipment, feed. In other words, we don't directly give them cash."*
Head of Directorate, SEMARNAT

[1]Kind of expensive fish

Aquaculture seems to be a question of opportunity, if farmers do not exploit the ecosystem intensively, others will. This seems like a manifest fate, that there is no alternative to the intensive exploitation of resources. This also indicates the problems of communication with farmers. Farmers' sons who have more schooling have generally lived in bigger urban centres for a long time. That experience, together with years of study, may make their mentality more materialist. It is not surprising that extension officers have major successes with them. They can understand each other because both speak the same language, which reproduces the government's discourse of the last 20 years, in which development mostly means cash and trade. It also expresses the widespread belief among bureaucrats and urban society that poor farmers have become parasites on society by receiving constant assistance (money) from the government without using it for production. This vicious circle comes from both farmers' low aspirations and the paternalist policy of the government in search of political dividends.

Some professionals challenge this view, citing the prevalence of corruption in the distribution of support, inappropriate technical assistance, inconsistent technical advice, too many changes in development strategies (development fashions) etc. My argument is that farmers have not been listened to, and even where dialogue exists, there is no real communication because each party wants different things.

7.2.4. An alternative perspective

A few technicians do differ from the dominant view. They argue that aquaculture should not be considered a failure, because the state government has never thought of promoting commercial aquaculture seriously, only as 'assistance' for the poor. The fact that there is no high technology does not mean the absence of aquaculture, but that it has developed differently: as subsistence aquaculture. They argue that the slow development is understandable because *"it has been hidden behind agriculture, livestock and fisheries"*. That tradition has led both farmers and government to give less importance to aquaculture.

7.2.5 Social Aspects

The social benefits aquaculture brings into communities seem to be invisible to aquaculture extension officers and mid-level staff. In 20 interviews only one mentioned social aspects as important in aquaculture development.

This research found that extension officers and senior staff do not take into account cultural aspects when defining how aquaculture must develop in Tabasco. In some cases they are ignorant of what cultural values have to do with their work. For instance, when asked whether or not they take into account cultural values when working with farmers, one head of department answered:

"Yes, in fact we go and talk to them. First we see what kind of water body they have or where they can practise aquaculture. Then we tell them how fish is farmed in other regions... different forms... we bring slide and acetate projectors, if necessary, even videotapes. Then we tell them what and how much they can farm there and what is the cost".

Head of Directorate, SEMARNAT

Nothing about, what farmers want, which kind of farm it is, what are the farmers' expectations, what the fish is for, to what extent the farmer likes fish etc. It seems more a means of persuasion to commercial production, giving commercial choices, than a dialogue to learn about the farmers' needs.

7.2.6 Extension and aquaculture management.

A mechanisation-development approach was the major common feature found among professionals working in aquaculture in Tabasco. Anything outside that approach is seen as backward although not necessarily negative. In any case, in their view, simple practices must be replaced by more technical or systematised practices in order to achieve a 'real development of aquaculture'.

Every extension officer has his or her own criteria for managing ponds. Some recommend stock density in accordance with the pond age, from 5 fry m^{-2} ha^{-1} $year^{-1}$, when the pond is new to 2m^{-2} when the pond is old. Other technicians do it in accordance with the oxygen content in the water, generally recommending between 2 and 3 fry m^{-2} ha^{-1} $year^{-1}$. A few adopt a more scientific approach and recommend stock density in accordance with the pond's carrying capacity. Although the latter is correct, most extension officers have not adopted it. It seems that senior staff who guide all the extension officers and should have more knowledge do not transfer it to their subordinate staff.

Different criteria for fish survival at the end of the cycle are used to estimate yields. In no case are site conditions taken into account because most technicians lack equipment and time to record growth rates under different management conditions. They assume that tilapia reach 250g in 6 months, as in the literature, but that rarely happens, according to farmers. Survival then is calculated as 40% to 86% depending on the technician's criteria and the farming intensity.

Most extension officers recommend feeding. Generally commercial feed is advised. As most farmers are semi-subsistence, the extension officers recommend using the money obtained from surpluses to get commercial feeds for the next culture cycle. As they do not often see the farmers, they try to teach them to manage feeding rates in accordance with consumption by the fish. Checking how much feed is left on the feeding trays some hours after feeding does that. A few of them recommend catching cheap fish from the natural water bodies or predators from their own ponds to prepare fishmeal. This is advised when expensive species are farmed. (This practice is highly unsustainable as it takes 2 kg of fish from the market to make the fish meal to produce 1 kg of fish. In addition, homemade fishmeal can transmit many diseases to the farmed fish).

Some extension officers said that farmers sometimes ask for advice about pond design but that is pointless because farmers have always already chosen the place to dig. That is because farmers use marginal land to dig the ponds, land that they cannot use for agriculture, or which is in a convenient place for livestock drinking.

Criteria to evaluate success of farms were similar in the three institutions. High yield, cycle length, the shift to commercialisation, increased standard of living[2], growth of the production unit and the capability of groups to keep united were the most common answers. For example, when asked about successful farmers the current response was like this *"successful farmers get yields of 5* t ha^{-1} $year^{-1}$*, or in cages 750 kg* $cage^{-1}$*".* Nevertheless two extension officers were critical of that view. They said that present measures are not suitable to evaluate the projects because they are too numeric; too much emphasis is given to yield and the process does not take into consideration social aspects such as people's satisfaction or the ability to continue in aquaculture. Although extension officers think that alternative approaches would be appropriate only in the case of subsistence systems.

For example, one technician said he found that groups in which people were motivated and happy in aquaculture were considered failures because the yield was low. Similarly another had seen that aquaculture was important for family integration as many families work all together around a pond. He saw how people feel happy to produce a few fish in areas where there were no fish before. The problem is how to express that in reports. Happiness, satisfaction and other non-material values cannot be translated numerically. It may be argued that new forms of evaluation, including people's self-evaluations, should be developed. These are already being developed by some organizations abroad (www. Mande.co.uk/news.htm).

The tendency to recognise only 'technically' based aquaculture as 'real aquaculture' has led advisers to try to persuade farmers to adopt less environmentally sustainable intensive or semi-intensive aquaculture systems such as floating cages and pens. This is to imitate aquacultural systems from the North and ignore the value of the local and other subsistence and semi-subsistence systems.

"Well, we have worked with groups on restocking lagoons with fish. Sometimes we have the chance to get resources. If there are resources, we tell people that instead of restocking, we can make a more sophisticated system, a semi-intensive culture. I have seen some good results. In one, they harvested 6 tons in 1.5 hectares" (in Paraíso).
Extension Officer, SEMARNAT

This more intensive aquaculture has brought some social problems in the communities because most of the time, pens and floating cages are put in public-owned water bodies, because such systems require large rivers or lagoons. One technician reported the recent emergence of problems between fish farmers and fisheries cooperatives, because cages and pens can disturb current boat traffic routes and fishing sites. Similarly fish farmers sometimes collect wild fry of species which only fishermen's cooperatives have the right to exploit (always high priced such as shrimp or common snook). As could be expected, fishermen are not keen to lose control of their resources and conflicts such as vandalism (when somebody breaks the nets to let the fish out) and conflicts of resource usage between fishermen and fish farmers have taken place, similar to what is reported by Ridler (1996) in Bay of Fundy, Canada. Nobody mentioned the environmental impact caused by those systems, which has been well documented in the literature (chapters 2 and 4). This may be because any impact is still not perceptible here to either fishermen or technicians.

Although all technicians recognised that aquaculture must be adapted to local conditions, when they were asked specifically about that, there was a tendency to compare local with overseas aquaculture, as in Israel, for example, seeing it as superior and therefore the model to follow. It is obvious that in such a comparison local aquaculture loses. The problem is that they

[2] When asked how to evaluate standards of living, responses always were focused on money

think that they should aspire to such a model. There are always things to learn but it may be argued that Israel has very different environmental, socio-economic and cultural conditions. It would be good to see professionals start to develop aquaculture based on local farmers' needs and on what is possible under Tabasco's environmental and physical conditions.

7.2.7 Farmers and extension officers

Some extension officers divide farmers into two kinds. One kind practises aquaculture for their family's subsistence and another sells fish to improve their families conditions. The latter is, in their view, the more advanced.

Generally professionals expect farmers to follow advice exactly without questioning or opposition. If the farmer does not follow the instructions then he/she is treated as obstinate. For example, one extension officer advised a group of women to harvest the fish before they were big enough because the water quality analysis indicated that the pond was eutrophicating and there was danger of death to all fish. The women did not do it and all the fish died next day. So to the extension officer the women were stubborn. To the women he was guilty of the failure. For that reason he started making written instructions and asked farmers to sign his copy. That was the way he found to protect himself. But attitudes like that do not solve the problem. First, the extension officers did not consider that rural people generally do not like small fish, so that harvesting the fish too small would also be seen as a failure. Second, managing high fish density in phreatic ponds with supplementary feed is likely to bring eutrophication problems. Arguably, in such conditions neither intensive nor semi-intensive cultures should be recommended. If the group is too big to benefit from an extensive culture, then it is preferable to reduce the size of the group or suggest another activity. Many professionals lean toward intensification. A belief was evident among extension officers that the more intensive the better, because in old aquaculture books innovations were toward intensification. Today, the inefficiency and the environmental

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income.

impact of intensive cultures are well documented (Beveridge, 1986; Beveridge *et al*, 1997a). To a specialist, there is also evidence that high yields can be obtained from extensive and integrated agriculture-aquaculture-livestock cultures (see Prein, 2002). In this context, extension officers proved to be misinformed. I believe that intensification is not the answer in Tabasco.

7.2.8 Gender issues

A preference for working specifically with women or men proved to be individual rather than dependent on the extension officers' gender. Nevertheless it appeared that women extension officers were more often able to understand and communicate with both women and men while male extension officers had more difficulty in communicating with female farmers. Expressions such as: *"it is difficult to work with women because they are stubborn',* or *"women do not follow the indications";* were used sometimes by male extension officers. One example of misunderstanding is that several male technicians stated that women do not like heavy work, or going into the water. Nevertheless in this study I observed many women doing work which requires strength and hard work, such as handling pigs, grinding maize etc. Thus the first statement, in my view, is insufficient, so that something else may be limiting their participation in aquaculture. A possible answer came up in an interview with a woman professional who said that the problem was clothing (chapter 6). In addition, many of them do not know how to swim. This example indicates the need to employ extension officers of both genders. What is obvious to one gender may not be perceptible to the other. It is important to look at the problem with different perspectives and a mixed staff is a great help. Unfortunately female extension officers in aquaculture are in a minority: from 20 aquaculture professionals interviewed only 3 were women.

Extension officers saying that they preferred working with men said that there is no difference in how men and women work, as arguments in women's groups are also common.

"I had the idea that women were more observant, more relaxed, less keen to fight... nevertheless in my experience with these 6 groups, everything I believed broke down because...it was disappointing because logically, at least with the groups we worked with, they never agreed. I can tell you that it was better with men".

Extension Officer, SEMARNAT

Extension officers who think that women work better than men do in aquaculture said that it was because women are more responsible and care more about the environment. For example, they take the crocodiles out of the ponds without killing them and care about the turtles. One extension officer said that he had worked with two groups in the same village one all-women and the other all-men. He felt that women were more successful because they followed advice and made more effort. Women produced a lot of fish and the men nothing because their fish escaped, as they never took any notice of his advice to reinforce the embankments.

Opinions are divided however. For example another group of extension officers said they preferred working with mixed groups because women pay more attention and are more dedicated, while men can do the work that requires strength or swimming. This suggests that the perception of the work capacity of each gender depends on the personality of the technician and their communication skills.

The gender division of labour is not simple and depends on local conditions and many other factors which sometimes technicians do not take into account. The next case is a good example. SEMARNAT was working with a group of fishermen in Santa Anita Lagoon. According to a senior professional who does go to the field, the growing cycle was successful but as there were too many members, the production was only enough for their consumption. But the fishermen dismantled the cages, sold the nets and said that the project was a failure. Nevertheless, later on they said the project was successful but as the money of the project had to be given to them as compensation for pollution by PEMEX[3] they had the right to sell everything. Now their wives are running the cage culture. He said that in that specific locality women like fish farming and men prefer fishing. This example indicates how complex the problem is and that solutions can only be given when there is detached knowledge of the community, the local culture and, most importantly, of what farmers want. It has been stated that in general fishermen dislike aquaculture because they look at it as a less independent activity (Pollnac, 1982). Though there are some exceptions, this also seems to be true for Tabasco (although not in the case of farmers), according to the opinion of some fishermen interviewed who have practised aquaculture and later quit it. On the other hand it seems that groups of women are more stable, they are more open to express their discontent in the group which is therefore a factor helping to solve the problems. Similarly they are keener to work in groups just for consumption, as feeding their children is a major concern. On the other hand men, especially fishermen, are more used to working outside their homes or farms for cash. If, as is usual in large groups, the project does not provide them with enough money, there is no way in which they can be motivated to continue. Illogically, most fish farming groups formed in Tabasco are of men. All extension officers said that most farmers they visit are men. Some estimated that women comprise about 20% of fish farmers, which agrees with the findings of this research in which women comprised 22% of the sample. In the technicians' view the small proportion of women is due to cultural and biological factors.

"It is maybe partly the ideology of these regions. Feeding is not a problem because it does not require much strength. But maybe pulling the net ... or to drive and bury the poles for the pens, men have the hands. Maybe that's why there are more men than women. Generally women stay at home cooking, looking after the children and grinding maize".
Extension Officer, SEMARNAT

[3] Petroleos Mexicanos (Mexican Petroleum)

Women technicians think that although aquaculture is an activity for both sexes, ponds are better for women because it is work they can do at their house or near the village. They said that women consider cage culture inappropriate because it distracts them from their domestic work, as cage culture is usually done outside the farm.

For some extension officers all-men groups seem to be more problematic but this is because generally they are already organised or are in cooperatives, which had problems before they started aquaculture. Similarly, *"men have more job options so they don't feel they depend on the project"*. (Head of Directorate, SEMARNAT)

7.2.9 Group or family?

Differences appeared among the three institutions researched in their experiences of working with groups. For both SEMARNAT and El Centro Development Office, groups work well as they have been successful with some groups which have stayed together more than 8 years. Nevertheless they see working with groups as problematic, mainly when the groups are not well organised. On the other hand SEFOE staff said that people prefer working with their families rather than in community groups. Mistrust, envy, corruption, irresponsibility, disagreement about sharing out the profits etc. were reported as common problems.

In spite of the long list of difficulties the Federal, State and Local governments still promote collective work, as this is a cheap way to reach more families. It does not matter that the project is almost condemned to fail from the beginning, because it looks better in the statistics. Working with groups is a practice based on political convenience and national tradition rather than on technical appropriateness or farmers' preferences (see chapter 6).

The difference in experience of groups between institutions may be due to the different strategies employed. SEMARNAT and El Centro Administration work with fewer groups so that more attention is paid to solving the intra-group problems, and advice sessions are more frequent, so that they have the opportunity for a more personal approach and get more information about the problems.

Extension officers' position over the desirability of promoting group work is related to the institution to which they belong and their individual experiences. In SEFOE, there was a tendency to say that groups were undesirable because the rate of success was very low. They say that people dislike working in groups, there are problems in getting agreement and problems over the dividends and sometimes they have to act as referees. In their experience, family work is in the local culture and it is difficult for the farmers to change.

"Yes of course, it is because when there is only one person he/she is responsible for his/her own pond, so they work hard. It is the same person who contacts you, asks about places to buy feed..."
Extension officer, SEMARNAT

Nevertheless group work is very often a norm the institutions have to follow because FONAES[4], a federal programme, request it. Probably the Federal, State and Local Governments prefer groups because in that way it is supposed more people obtain benefit. But in most technicians' experience that is a strategy that has rarely worked. However this is not something that they can change because the order comes from ministerial levels. A new strategy has therefore developed recently under which several families, with a pond each, form a group to get the state support but each works as a family.

"*Sometimes several families form a group because programmes such as pond digging requires at least 10 households... but in the end each family keeps working their own pond. It is better to work with one household because with fewer members each has more profit.*"
Extension Officer, SEFOE

On the other hand, some extension officers defend group work. They argue that groups can work well if they are well organised and experienced. They say that groups are a way in which more families benefit and the ponds are easier to look after because members can take turns. Members also can cooperate to buy commercial feed so that the culture can be more intensive, and very importantly these groups produce a lot of fish. They say that small groups (up to 4 – 17 members, depending on the extension officer) work better and so do families, which they say, work harder and are easier to advise but generally have small ponds so that the production is small. They accept that most groups are large (more than 80 partners) and therefore very problematic and difficult to train so that having a good leader is important. But they say that individual farmers generally do little management, do not have the knowledge, do not add feeds or fertilisers and cannot control theft.

The problem is that farmers often think that the bigger the group the better because they believe that the economic support they get from the government depends on the number of members. This is not necessarily true as most of the time the minimum number of members is enough to get the same benefit. According to extension officers, ten members is the minimum to get support and for many technicians it is a good number to work with.

Regardless of their interest in working with groups, most extension officers recognise that support of bad groups should be ended, but they do not have enough information to do it.

7.2.10 Management Problems

Aquaculture staff 'dream' of a more intensive commercial aquaculture. When they referred to successful projects and ways to develop aquaculture in Tabasco, mono-sex culture (100% male fish), hormonally reversed fry and

[4] Fondo Nacional de Apoyo a Empresas de Solidaridad (National Program of Support for Solidarity Enterprises)

cage culture were commonly mentioned. Therefore as local conditions force the systems to be far from such a model, many practices implemented by farmers are seen as constraints.

1) Polyculture and predator removal

Extension officers said they recommend tilapia monoculture, but they reported prawns, common snook, *pejelagarto*, *tenguayaca*, *mojarra castarrica* and different kind of turtles as the species most desired by farmers. Nevertheless as these species are not produced by local hatcheries, they have to discourage farmers from culturing them by offering tilapia instead.

Extension officers commonly advise farmers to remove predator fish but they recognise that farmers do not always listen. This is because people prefer to eat carnivorous fish, which are exactly what they would prefer to farm. In extension officers' view the fish quality, food habits and the economic value are the reasons for that preference. If they suspect that some predators remain in the ponds after cleaning, some extension officers recommend placing the tilapia fry in cages for 2 months, feeding them with commercial feed. Farmers can thus release the fish when they are big enough to escape from being predated by bigger fish. To me, this solution is good but instead of being offered as an option only when the removal of predators fails, it should be one form of management in a more efficient local polyculture.

Some extension officers are aware of the role of native species in local food habits. Nevertheless the yield optimisation approach always wins and native species are almost never recommended. For example, one extension officer said that he always suggests farming tilapia because that is what he knows. Farming *pejelagarto* can take more time, 2 to 3 years and that in his view is too much time, so that it is better to give something faster to farmers. The reality is that it is not always what farmers want.

"Sometimes they said that they'd removed the predators but at the end of the cycle we realised that it wasn't true...we tell them to remove all predators but

that's like telling to them to stop eating pejelagarto, which is a traditional dish here...they want to eat all kinds of fish and turtles".
Francisco Barrios, SEMARNAT

Farmers' attitude toward mixing species of different trophic levels in the same pond is seen as pure ignorance. In reality mixing species is similar to the Chinese polyculture approach, but with the difference that here there are no scientific studies to establish good management. Great effort is made to persuade farmers to cultivate only one species and to avoid stocking turtles in ponds. Yield reduction is the main argument used to persuade farmers. But that is not an easy task and there is frustration when farmers ignore the advice. For example, if farmers insist on farming turtles the advisers often suggest a special project in a different pond. Regulations for farming turtle are very complicated and it is very difficult to meet all requirements to get authorisation.

"Many farmers want to make a species cocktail. That is a bad idea. We try to change that attitude".
Extension Officer, SEMARNAT

Extension officers think grouped farmers pay more attention to advice than individual farmers. I think that as the groups are more oriented toward commercialisation, optimising yield is a priority for them. On the other hand, individual farmers are more interested in fish variety than fish yield or profit so they see monoculture or predator removals as more negative than positive. This is something that extension officers do not seem to be aware of. The removal of turtles is a special case. Most technicians said that farmers never listen their advice on this. One extension officer said, *"they say they do, but I know they don't".*

"There are two kinds of farmers, those who want turtles, pejelagartos, native cichlids, mojarras castarrica. They don't want to remove the predator. The other kind are those who want tilapia, they prefer to remove the predators".
Head of Department, Municipal Development, El Centro

That indicates a failure of communication between professionals and farmer. Professionals are aware of, but they do not know how to address it. They say it is difficult to communicate with farmers who often say that they will follow the advice but do not do so. Extension officers recognize the problem from their side as their inability to persuade farmers, so on they could improve by learning extension techniques but in the interviews, they never questioned the compatibility between what they and farmers expect from development.

"If we adapt to farmers' ideas we wouldn't do anything because in their way aquaculture wouldn't work. In practice we shall have to try to get them to take on our ideas. As I told you, it's difficult... But you never are going to get positive results because farmers aren't going to take on the advice we give".
Extension Officer, SEFOE

"I can say that some people in the communities are negative because they're the first ones to reject the projects....they say that they won't be able to pay back the loans".
Extension Officer, SEFOE

"Farmers listen when you explain the techniques but they don't apply them; maybe it's apathy, lack of interest or lack of knowledge".
Extension Officer, SEFOE

Some extension officers recognise that this is not always the case, as some farmers really want to learn from them.

2) Incomplete harvests

Some extension officers see farmers' practice of taking incomplete harvests as a problem because yield cannot be measured (chapter 6). When farmers only catch a few fish at a time, they do not realise whether the total yield is small or large. To the extension officers this is not aquaculture *"practising aquaculture is to stock a certain number of fry, to programme the harvest for a certain period of time and at the end of the cycle to harvest everything"*

(Extension Officer, SEFOE). This comment emphasises the commercial aquaculture perspectives, and illustrates most extension officers' unwillingness to consider any other approach. For example, it does not matter that a farmer can make better use of the pond by making multiple harvests, because multiple harvests make it more difficult to register the yield. In this way, data collection becomes more important than effective farming because yield data information makes it possible to achieve technical control.

"Most farmers take incomplete harvests, they don't care how much fish they produce. That isn't good because we want the farmers to get more interested in aquaculture. If we let the farmers catch the fish when they want, because they don't care how much they catch or the size, that means that they are seeing aquaculture as a loss. They are not following anything related to pisciculture. And we as professionals are concerned for interest in aquaculture to increase".
Extension Officer, SEFOE

"That's why (incomplete harvest) *we still keep doing subsistence aquaculture, what farmers get is good but it isn't what we would like".*
Head of Department, Municipal Development, El Centro

"They haven't achieved good production, precisely because of the continuous harvesting".
Extension Officer, SEFOE

Comments like this imply that generally the local professionals in aquaculture perceive this activity as a set of fixed rules that can only be learnt from prestigious books. Their outlook does not seem to include empirical knowledge or the possibility that farmers make changes in accordance to local conditions and their own convenience.

3) Pond problems

Most extension officers see phreatic ponds as a major problem:

"Also the infrastructure they get. It is only dredging, jagueyes[5], ponds below the phreatic mantle which aren't appropriate. Everybody would like us to dig ponds for them but not ponds designed to be filled and drained".

Extension Officer, SEFOE

"That ponds cannot be drained is a problem, because predators cannot be removed completely therefore we need elevated ponds to manage them well, to be able to fill and drain them. That's why we are trying to promote cage culture. These are cheap cages. Fixed cages not floating".

Head of Sub-Directorate, SEFOE

"The problem in the region is that land is low and it is difficult to manage the ponds. Ponds are phreatic and having and managing elevated ponds is more difficult for farmers because it is expensive".

Head of Department, Municipal Development, El Centro

These were common opinions held by extension officers. There was no intent to try to understand these systems and implement appropriate management technologies in order to make phreatic ponds more productive. Of course, most of the research has been on commercial systems with elevated ponds and most textbooks therefore present that approach.

4) Fry quality

Some professionals see fry production as problematic, because there is no infrastructure in the state to produce mono-sexed fry[6] and because they think that the broodstock is poor quality. In their view these problems limit the success of cage cultures.

[5] Reservoirs for cattle drinking

5) Poaching

Poaching is seen as a major problem, difficult to control because law and policing are felt to be inadequate (chapter 6). For that reason it is currently recommended to have someone on guard especially at nights. Groups generally adopt such recommendations because group farms are commercially oriented so there is more money involved. Nevertheless family farms rarely consider it because the effort does not compensate for costs (chapter 6).

6) Farmers' Vocation

Many technicians think that many of the problems are the result of a lack of vocation for aquaculture amongst the farmers, because people sometimes go into aquaculture just because programmes are offered to them. They say that when farmers are already interested it is they who should be supported. In other words, the quality of farmers must be privileged instead of quantity. Charging for the fry is seen as a way to select motivated farmers but data on fry sales does not support that argument.

"I think that fishermen who have looked to aquaculture as an alternative have been forced to by circumstances because the catch has diminished and because we have made them aware with talks and training that catches are going to be depleted...the other group are farmers who have never done fishing or aquaculture. They have been convinced through media and extension officers".

Head of department, SEMARNAT

Some extension officers consider that a vocation for aquaculture is not necessary because it results from farmers' necessity. *"If a farmer does not have another option he will accept aquaculture"* (Department Manager SEMARNAT).

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[6] Hormonal treatment is currently used in commercial aquaculture to produce all-male populations. Mono-sexed populations grow faster and bigger because the energy used naturally for reproduction is diverted to growth.

7) Other problems in the field

Other common problems extension officers reported are:

- Some farmers are not interested in feeding the fish and those who are do not have money to buy feed. Sometimes there are programmes in which the government provides 50% of the money to buy feed but this is useless because usually farmers do not have the other 50 %.
- Lack of loans.
- Farmers tend to want to stock more fry than the carrying capacity of the pond. They think they will produce more if they stock more.
- Sometimes there is vandalism, especially of floating cages or pens.
- Floods.
- Parasites.
- *'Embarbascamiento'*. This is a phenomenon that comes with the floods, when nutrient rich water with algae blooms gets into the pond, depleting the dissolved oxygen and causing death to the whole fish population.
- Harvesting problems in sand extraction pits which are too deep for netting.
- People get used to being advised by one specific extension officer, but not all of them are always available. One extension officer said that there are farmers who do not want to talk to him, only to his boss, because they have known him for a long time. Then farmers may have problems because if the boss is not available, they do not accept other advice and can have serious problems in the pond.
- Farmers are not interested in being in touch with the extension officers.
- People's apathy about improving techniques, about mechanising.
- People practised aquaculture only because fry were free.
- Farmers got wrong ideas about fish farming which are difficult to change.
- Difficulty in advising because most farmers are illiterate.

8) Another view

Some technicians are in agreement that *"what we need is a special technology, because this is lowland and we need a special infrastructure to work".* *Others* say that intensive aquaculture with drainable ponds is impossible because the physical conditions do not permit it. These remarks imply that some people are looking at the problem and taking into consideration the local environmental and physical conditions. They do not however necessarily understand the socio-economic side and still consider commercialisation to be a necessary stage for farmers.

"Now people know what aquaculture is, and what we are doing. The advance is slow but there are already some commercial fish farms in other municipalities working pretty well. But there is still a lack of a commercial aquaculture view; we are still at subsistence, but people already know aquaculture and for the politician that is also important".
Head of Department, Municipal Development, El Centro

"Aquaculture contributing to household subsistence and not advancing to commercialisation is not necessarily a failure. It is playing an important role and it is valid to remain at that stage, but if there is a follow up we can make farmers change toward commercialisation".
Head of Department, SEMARNAT

Some technicians have learnt to reduce the problems on the basis of experience and a better knowledge of the local environmental conditions.

"In Tabasco good conditions for fish farming start in March and finish in September when a phenomenon known as 'el barbasco'[7] *starts, because everything in the pond dies. This leaves about 6 – 7 months to farm fish and*

[7] This is a phenomenon that comes with the floods, when nutrient rich water with algal blooms gets into the pond, depleting the dissolved oxygen and causing death to the whole fish population.

harvest fish at 250 to 300 g, in my experience there are groups in Cardenas producing up to 7 tons per year with this system".

Extension Officer, SEMARNAT

7.2 11 Farmers and environment as seen by extension officers

Some extension officers have noticed certain environmental concerns of fish farmers. They have observed that farmers care not only about fish or turtles but also mammals and trees. They think that people look after native species because they have learnt the idea from previous generations, although that is changing quickly. In the technicians' view, at present about 90% of the people do not care about the environment in the areas they visit. For some, it seems that farmers conducting aquaculture belong to the group concerned about the environment. Thus a positive attitude to aquaculture, in the local culture, could be linked to environmental preservation.

7.2.12 Aquaculture professionals' criticism of the aquaculture offices.

Some criticism by aquaculture professionals was recorded about the local aquaculture extension institutions. In general it was argued that the rural aquaculture strategy has not been correct. The commonest critiques will now be briefly outlined.

The programmes have, said many, been technically wrong, moreover there was no real programme of aquaculture development because the decision makers were not interested. Suggestions have been made to them but were ignored.

The institutions failed to consider farmers' motivations, but forced them to get involved in aquaculture, or (said others), the government has been too paternalistic, wanting to give everything to farmers without recognising that they do not have the necessary skills to go into aquaculture.

In the bigger institutions, the aquaculture departments are wrongly located.At present, the size of the aquaculture budget is reduced because it is seen as a branch of fisheries. Aquaculture is therefore misunderstood and therefore receives less support. Some mid-level bureaucrats think this is wrong because aquaculture is not an extractive activity like fisheries or forestry. In their view aquaculture should be placed with other farming activities such as livestock or agriculture.

All institutions had inadequate training opportunities. None have a training programme, so there are no opportunities to learn about new technologies even when local universities or research institutions offer sometimes courses. One current discontent was that senior staff sometimes attend courses abroad instead of the extension officers who are in direct contact with the farmers.

Aquaculture budgets are small. There were (most aquaculture extension officers agreed) too few staff for too many fish farms. An extension officer can be responsible for more than 100 farms. Many extension officers agreed that optimally they should visit each farmer every month and for some even every two weeks, but that never happen. Advice visits are therefore very rare and many farmers are never advised at all. For that reason, many extension officers recently decided to select a number of farms to assist and forget about the rest. The criterion is the potential for success they see in the farmer or group. A business mentality seems to have much weight in the decision. For example, one extension officer (SEFOE) said that he wanted to help a group because they were working well and selling fish to other communities.

> *"I have changed my strategy; I don't want to have so many production units. I don't mind having only 10 or 15 but to attending them well".*

Poor organisation led to other problems. For instance, there were no objectives, or at least they were not shown clearly to the extension officers, who may feel that their work is going nowhere. There was a lack of good tracking of the farms, and a failure to build on previous achievements. Administration of the budget was poor. (All these were common comments.)

There was little cooperation, said the officers, from the municipal development offices. How much importance is given to aquaculture depends on who is in charge. Generally municipal administrations are not interested in establishing an office for aquaculture promotion. Many staff also claimed that there was no relationship between the institutions which dig the ponds and the aquaculture extension offices, so the ponds are inappropriate, too small, not deep enough, etc. People get angry with the extension officers because pond digging as a political tool and politicians do not care if the pond works or not. For example politically they prefer to dig four inappropriate ponds rather than one good one in the same period of time because it is more important to reach more farmers.

The inadequate budgets and poor organisation therefore affect the professional performance of the staff. Most extension officers claimed to have no help in providing good advice to farmers, as there are no refresher courses for extension officers and no training on how to work with people. (Both are important. to keep up to date and for better communication with farmers.) This is, according to most extension officers, because the budget allocation is very inappropriate. *"There is money for overseas travels for senior bureaucrats in the ministry, who do not know about aquaculture".* (Head of Sub-Directorate SEFOE).

Finally, strong criticism of colleagues was heard in most interviews. For example, extension officers tended to criticise the higher posts, but there was more criticism among the highest posts themselves, suggesting certain rivalry among equals. Senior staff sometimes expressed scorn towards extension officers. Such a working environment may adversely affect the performance of the institutions and the service they offer to the fish farmers. Again, criticism of seniors and juniors is common in many offices, particularly where these are hierarchical, but the strength and the generality of criticism in these interviews were striking. For example, there was clearly a feeling among extension officers that "bosses" neglect the work. They also argued that the bosses change too often and each arrives with different ideas, so that every time that a new manager appears, they change everything, normally without reference to earlier or ongoing work.

7.3. Planning in local aquaculture development

After seeing how aquaculture institutions operate, their successes and mistakes, a question emerges. Has aquaculture been deliberately developed like this? Does effective planning on aquaculture exist?

The Federal and State governments have different approaches to aquaculture. Both changed their approach in the same way in the last 20 years. Food production was the most important priority in the 1980s with a shift toward economic growth and money income in the 1990s.

In 1980 aquaculture was considered a priority activity in the National Plan for fisheries development published by the Aquaculture Department (equivalent to the present Directorate of Aquaculture, which is part of SEMARNAT). The objectives were to satisfy the nutritional requirements of the poor, raise living standards through production of high protein fish species and generate employment in rural areas. Aquaculture was managed with a preference for native species in natural ecosystems, while small-scale aquaculture with tilapias and native cichlids was recommended on farms engaged in agriculture and/or livestock. Programmes were set up to encourage on-farm consumption of fish. The integration of aquaculture with other forms of production, income and food in rural areas was pursued (Zarur, 1980). By the 1990s the objective of the programme on aquaculture was *"to promote the sustainable and ordered development of aquaculture of such species for which a scientific basis and reliable technologies are in place...."* This was undertaken through 7 sub-programmes in which commercial mariculture[8] and shrimp farming were favoured. In 1990 the sub-programme on rural aquaculture had as its main objective "*to meet the food demand generated by the poor communities of the country*". In 2000 it was modified: "*to contribute to the improvement of the well-being of the rural poor by providing a*

[8] The cultivation of fish or other marine life or food.

subsistence diet with high protein content, and additionally contributing to increase the household income by trade of surpluses" (SEMARNAT, 2000, 25). This is through seven lines of action that seek (SEMARNAP, 1996, p79).

"1. *to increase the consumption of high protein fish products and to diversify the diet in rural communities;*

"2. to offer a productive alternative complementary to the traditional activities in the countryside,

"3. to enhance the attachment of villagers to their communities;

"4. to provide an alternative source of income by trading small surpluses;

"5. to promote community integration,

"6. to make the best integrated use of the natural resources in the countryside", and,

"7. to establish a basis for the development of commercial projects from subsistence projects."

Source INEGI http://www.inegi.gob.mx

Fig 7.1 Welfare Levels in Mexico

To me, the objective of the sub-programme seems to be sensitive to the rural conditions and the first 6 lines of action seem to be solutions which can clearly improve the well-being of the rural poor. Nevertheless there seems implicit in number 7 the belief that the only way to make real improvement is through changing the farmers' mentality toward entrepreneurship, which could work in some cases but not with all kinds of farmer. Although the sub-programme seeks to privilege the poorest municipalities in the country, Tabasco was not considered a priority despite having level 6 of welfare (in a scale in which 7 is the worst, fig 7.1) and having the best surface water resources in the country. Similarly inside Tabasco, the programme was not operating in two of the poorest municipalities (Tacotalpa and Jonuta) (SEMARNAT, internal document).

In the Tabasco state development plan 1989-1994" (Gobierno de Tabasco, 1989) aquaculture was very minor. "With regard to *aquaculture and inland fisheries, it is necessary to carry out actions in order to promote a harmonious development of fisheries activ*ity" (Gobierno de Tabasco, 1989, p81). "*As basic activities for food production, agriculture, livestock and fisheries* (including aquaculture) *will receive the required support in order to diversify the production structure...*" (Gobierno de Tabasco, 1989, p82). In this plan, subsistence production is considered as backward, and for that reason is the subject of change. Great importance is given to the satisfaction of state food demands, to be achieved through a subsidy programme. In the 1995-2000 version, the central objective was no longer food production but an increase in economic growth through a more diversified, integrated and competitive economy. Reduction of imbalances between the 'dynamic' and 'backward' sectors was pursued, but the importance of semi-subsistence farms was ignored despite their majority status in Tabasco's countryside. The object of development was thus entrepreneurial aquaculture. *"It is necessary, therefore, to reach optimal exploitation in coastal and deep sea fisheries and to develop aquaculture mainly with the entrepreneurial approach*"... *"Similarly, all efforts will be devoted to the determination of the real potential of inland water bodies and coastal lagoons for the industrial development of aquaculture"* (Gobierno de Tabasco, 1995, p61). Operationally, entrepreneurial aquaculture is seen here as the only option, but ironically in the same document an inclusive view of other options is found: "An *essential part of the re-valuation of our culture, our past and our roots, is to give value to the dignity of minority ethnic groups: of all indigenous groups which represent our identity and which require our support and respect. Our objective is to include them in the new advances and achievements which Tabasco has reached, giving the necessary inputs and satisfiers to them without detriment to their customs, habits or specific ways of life".* (Gobierno de Tabasco, 1995, p33). What can be read in this statement is rhetoric. This contains an enormous contradiction which at the same time calls for respect for all ways of life (subsistence as part of the local culture might be included), and values only entrepreneurial activities. Other forms of production simply do not have the state government's support. We have seen that in this study subsistence aquaculture accounted for 89% and commercial only for 11% of rural farmers. Government support is thus for a minority and for those who are keen to change their mentality[9].

No document or evidence was found on the translation of general statements into programmes and lines of action. When asked about programmes and objectives the answer was always "*there are none*", both from extension officers and heads of Departments and Sub-Directorate. Strategies and actions are carried out as each manager in turn chooses. It seems that results depend on how much budget is received and how the department adapts to the shortages (which seem to be the common problem in the last five years). In other words there are no written objectives, and decisions are taken in response to the budget. In practice the budget defines the form of aquaculture development. Although it was claimed to be to reduce paternalism, it may have been in response to budget cuts that farmers were charged for fry. If a decision had been taken in accordance with a development strategy, a document might exist on the implications of such a measure. But no such documentation exists. Thus two years after the decision the result was a sharp reduction in fry demand (nearly 70% down, according to a professional working in the hatchery), and a reduction of farmers going into aquaculture. If

[9]At this time, subsidies for farmers to get fry were eliminated in the State Government

this measure was intended to promote commercial aquaculture, the result was again negative.

"When fry were free about four trucks per day used to come here to pick up fry for farmers, but now nobody has came to take fry in the last 40 days".
Hatchery sub-manager, (SEFOE)

Attempts have been made inside the SEFOE to establish clear goals and objectives defining different strategies for small scale and industrial aquaculture (Diego-Peralta[10], not published). In the case of small-scale aquaculture the new idea is to look at the community, not the fish product, as the focus of development. The poorest groups become the targets, with a better understanding of the needs, wishes, conducts and abilities of both the people and their traditional associations. Regional development, people's attachment to their villages and the reduction of social exclusion are proposed by Diego-Peralta (not published) as the core of the local aquaculture development. The proposal recognises the sustainability of the subsistence phreatic ponds, the importance of the use of by-products produced on-farm and the limitations of group work in this region. As in the case of the national rural aquaculture programme, this proposal presents aquaculture as an option for improving the diet of rural communities, creating complementary employment and commercialising surplus in order to improve income. Finally it identifies the need to integrate all local institutions working of aquaculture (research and extension) and to have a training programme for extension officers. Sadly these proposals have not been included in any State programme for the development of aquaculture. There is some awareness of constraints by at least some of the people involved, but the change depends more on political will than on knowledge or academic work.

Although such proposals appear to be well structured and inclusive of socio-economic, cultural and environmental aspects, when people involved in their formulation were interviewed, the same pejorative attitude to subsistence

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Aquaculture Department

aquaculture was found. That is to say that subsistence aquaculture helps households but a jump to commercialisation is always desirable. Evaluating rural aquaculture with parameters other than yield and money is not even considered.

This contradiction suggests that even when socio-economic and cultural factors could be included in programmes and projects, putting this into practice is a different matter. Holistic and sustainability approaches look attractive on paper but they may be empty words. Sustainability, participative and holistic approaches are fashionable terms used everywhere in aquaculture projects with little awareness of the meanings commonly attached in social science. This is just to sell the projects so they become mere rhetorical terms that further confuse the issue (chapter 4). Farmers' participation can be used to make projects attractive, but in practice they can speak without being heard (Cooke and Kothari eds., 2001).

Despite all operational difficulties, it seems that rural aquaculture in Tabasco originally developed in accordance with development plans. Aquaculture was conceived of as a means for food production for on-farm consumption, so people adopted it. Even when, as in the case of the State Aquaculture Department, there were no clear objectives, rural people adopted aquaculture as expected, perhaps because there was no change of attitude demanded. Aquaculture was a new activity, but on-farm production for on-farm consumption was already practised with the livestock and crops. Even though fish farming is still not a generalised activity, it had some success but not necessarily because of good performance by the aquaculture extension institutions. The 1990s change of approach in plans for aquaculture is another matter. Commercial aquaculture is rare in the region, in part because the change in policy did not come with other necessary measures such as trade mechanisms, loans and appropriate technology; and in part due to the refusal of semi-subsistence farmers to take on aquaculture as a full time or main activity. Charging a price for the fry, therefore, instead of awakening the

[10]Head of the Aquaculture Sub-directorate in SEFOE.

farmers' entrepreneurial side, contracted both the demand for fry and aquaculture itself.

7.4 Aquaculture research and extension in Tabasco

This research found little cooperation between the three major institutions working on aquaculture extension in Tabasco (Chapter 5). There is no single list of fish farmers; therefore each institution works with their own list. This is very inefficient because there is duplication of functions. There is no exchange of experiences or feedback among the three institutions so staff cannot learn from each other. Material resources are also wasted. Each institution has one vehicle. When there is no money for petrol, or the car breaks down, extension officers cannot do their work. The following experience describes the lack of coordination well:

"We were managing two projects in Parrilla, and the El Centro municipality were also supporting them. Sometimes they (the farmers) *cheated. They used to say that they had not received stock and they wanted us to stock their pond. They had the idea that by double stocking they were going to produce more than could be possible in the pond. That meant they stopped us helping other farmers because we were only helping them".*

Head of Directorate, SEMARNAT

There is no link between extension and research institutions. So researchers study what they think is important but this may not meet farmers' needs or even those of extension officers. During the 8 years I worked at an aquaculture education-research institution, there was no any attempt by any extension institution to ask for research based on farmers' needs.

One ex-researcher from a local institution was critical of his own work:

"Research is not linked to farmers' needs. Research is done with good intentions but it's done in accordance with our own personal interests...that

does not mean that it's what people are waiting for. There is no connection between the researcher and the farmer".
Researcher (Now in Business)

The result is not applied research but research for publication and for researchers' CVs. There have been some recent attempts to start some collaboration with the Local State University in Villahermosa (UJAT), as the head of one aquaculture department stated:

"The Fisheries Directorate did not have any linkage with anyone before, but I am starting to link with the UJAT now. The UJAT is studying native species. They already have the technology for farming pejelagarto, mojarra castarrica and paleta. There are no studies of the other species. They are researching into feeding tenguayaca with tilapias (in the same pond)*I have contracted a biologist to research pejelagarto and native cichlids. We have lots of potential for exporting aquarium species and for re-population of natural water bodies but we need to investigate them".*
Head of Sub-Directorate, SEFOE

Nevertheless, all this is the result of personal initiative, not from a well-structured programme. Such co-operation could stop when staff change, because there is no officer agreement.

The researchers think that government rather than the research institutions should promote the link.

"That should be the role of the government. It happened to me that once we finished some research with a practical approach. When we presented the results to the State and Federal government, all we got was "thanks" but they never applied the results".
Researcher (Now in Business)

Intermediary development institutions such as ISPROTAB[11] seem not to carry out such tasks any better.

"In fact ISPROTAB's role is clear 'on paper' but not in reality. Courses for farmers are too short, they prefer to have many weak courses rather than a few well designed. They know their strategy is wrong but they have goals to accomplish per year: number of courses, number of farmers".
Researcher, UJAT

In 1997 I taught some aquaculture courses to farmers financed by ISPROTAB, and observed not only corruption (by both academics and bureaucrats), but a lack of interest in serving the farmers who were supposedly the reason why such institutions were created. As it was a commitment I could not avoid, I found myself teaching theoretical aquaculture to bored farmers. I thought then that there were not many farmers interested in attending aquaculture courses, and was surprised when aquaculture training was one of the main spontaneous requests from farmers in this study (this of course does not mean that they would necessarily attend).

Local researchers are seen as having limitations. Their knowledge of local environmental and technical conditions for aquaculture qualifies them well to design projects and courses for local farmers. Nonetheless, the government tends to look for answers to local problems from non-local researchers, probably because of mistrust of the local research institutions and excessive admiration of 'the foreign'.

"People from abroad show photos of intensive fish farms with high volumes of production and the bureaucrats are dazzled. They do not see that this is achieved under different conditions".
Aquaculture Professional (ASPRO[12])

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[11] An institution of the State Government which gets important money resources for research and technology transfer in agriculture, livestock and aquaculture.
[12] Private consultancy firm

"It happens that somebody from abroad or from other regions of the country comes and the state government wants their advice. But those people do not know the local problems. The government does not recognise the local academics".
Researcher, UJAT

This, in the opinion of some local professionals, causes projects to fail which otherwise could have been successful, like the case of "El Cuyo de Guadalupe' where a large project failed because of bad design and ignorance of local conditions for aquaculture.

7.5 Has aquaculture been used for political ends?[13]

Local aquaculture professionals attribute 'the failure' of aquaculture partly to its use in maintaining political control. Fish farming is not developed in the physically most suitable areas but rather anywhere the politicians, the decision-makers, needed to buy voters, regardless of whether or not the group is appropriate, or even whether they practised aquaculture or even had ponds. It did not matter if failure could be predicted, the soil was not suitable or stocking times were not appropriate.

Support of aquaculture might always have hidden purposes. This is not always apparent. In general, fry was available to anyone with or without political connections, but in some areas farmers still believe that obtaining support is easier with a political leader's mediation. This is not true: fry was available to all farmers with an appropriate water body and transportation for the fry. But in practice networks made it easier for leaders to get transport from the municipal administrations for their clients, and transport was often the problem, not the right to the fry.

Political interest is more obvious in farmers' access to training in aquaculture. There is strong criticism among middle ranking bureaucrats who say that such orders originate from Secretariat or even Governor level. The aquaculture staff has little capacity to assign aquaculture courses to farmers who are really interested. Timing depends on budget availability and to whom and where the course is taught depends on the leader the state government wants to favour.

"They give the budget and the Fisheries Directorate in theory can distribute it at will. But as they have the 'pressure of demands' from people, and as it is election year, then everything is given to the Fisheries Department. Most of the budget goes toward net repair, boats, engines, etc., so long as it is very expensive. And you cannot favour all cooperatives. A 5 horsepower engine costs about 60000 mp[14]. With that amount of money you can carry out an aquaculture project in a big pond, and more people will benefit".
Head of Sub-Directorate, SEFOE

Sometimes courses include scholarships and leaders look to use these to benefit the farmers who support them. The farmer sees the course as a temporary paid job. Most of the time he/she has no interest in aquaculture at all.

"Scholarships for farmers' training are politicised here. Then, they manage it with political aims. One leader comes and says, "Hey, I want training scholarships for my people!" It looks as if they say, "we are going to make this leader strong and we are going to give him scholarships" so, the money is paid to the farmers, if they want to go, it's okay, if they don't, it's still okay. Then the money is wasted. The training is wasted. If technical things were managed apart from politics, maybe we'd have better results. But if everything is done with political aims the farmer feels that it's a present that he deserves if she/he goes to vote...then they don't come to ask but to demand. If you say that nothing is given to them anymore, then they say 'we are not going to vote

[13] The Institutional Revolutionary Party (PRI) has been in power for more than 71 years in Tabasco. After two contested elections, PRI has assured staying in Power until 2007.
[14] About £4300

for you any more, we are going to support the PRD[15]'. The people from the government provide it in order to maintain the unity of the party. They keep giving and giving to the people".
Head of Sub-Directorate, SEFOE

Aquaculture bureaucrats complain that very often farmers have unreal expectations about their pond yields, which seem to be created by politicians. Municipal governments sometimes offer pond-digging programmes to farmers with the promise of very high yields, because for voters the important thing is that they can get support, so the government ensures votes for the next election. Sometimes the size of the pond and the capacity of the farmers make the promised yields impossible because they simply do not have means to practise intensive aquaculture. This comes about because machinery operators know nothing about aquaculture, nor how to dig ponds for it, and there is no cooperation between pond-digging and aquaculture institutions. Farmers confirmed this.

"I feel that farmers who are really convinced about aquaculture are seriously misled by the machinery operators who don't explain well to them so that farmers think that they are going to harvest tons of fish in a little pond, I don't know, 200 square metres... with no water exchange... and that fish farming is just stocking the fry. That is the idea most people have. And as those who own the machinery are the Municipal Councils...it has become a political matter, instead of saying "you know? The conditions for aquaculture are not good here" No, in places where aquaculture is not possible, it is better to say it!' you know? It's not possible here, it's all wrong, I'd better build a chicken farm for you or something else".
Head of Directorate, SEMARNAT

[15] Democratic Revolutionary Party

"Aquaculture is managed depending on political questions, they don't see it with a social approach, let's say, to serve people. This is managed as politics".
Extension Officer, SEFOE

Others went further, arguing that any programme for subsistence farmers seeks political gain. Government concerns about the poor are conceived of as political manipulation or populism, reflecting extreme capitalist positions. This attitude can affect sound projects focused on subsistence farming in which farmer's economic gains would not be obvious.

"The strategy is not working because the objective has been diverted to political matters. There is no promotion, extension. There is no economic benefit for people. That's why investors don't have the confidence to invest in aquaculture, there is no guarantee for the investment".
Extension Officer, SEFOE

Similarly the exhibition of successful projects on the media in order to advertise the work of the administration is seen in its turn as harmful to the groups on display because it affects their performance and make them more dependent.

7.6 Is tilapia the best choice for aquaculture development? Contradictions in the institutional view.

One of farmers' commonest comments was about the impact of tilapia on native fish species (chapter 6). They say, wild tilapia originated from those that escaped from cages stocked with tilapias in the first aquaculture projects.

Tilapia is an exotic species that has high tolerance to extreme environmental conditions and high competitiveness in both feeding and territoriality (some of the main reasons why tilapia was domesticated). Farmers say it is common to find fry of native species in the gut of tilapia. Some local biologists suspect that 'competitive exclusion'[16] is occurring (Meseguer personal communication), tilapia being the winner against the native species.

Stocking tilapia in natural water bodies has been a common practice not only in Tabasco but also in other states of Mexico. SEFOE and its precursor SEDES (Development Secretariat) have long concurred in this practice to increase inland fisheries. This has in fact elevated fish yields spectacularly in Tabasco, for example (inland fish catches, in natural water bodies, rose from between 1000 and 2000 tons per year to 13000 to 15000 tons per year in 20 years (SEFOE, internal document). But according to many fish farmers, fishermen and academics, it was at the expenses of native species such as *C. urophtalmus and P. splendida*, populations of which decreased dramatically, so that now they are considered scarce. Why are natural water bodies still being stocked with tilapia by the aquaculture department of SEFOE? Because there are no studies proving such environmental impacts. As tilapia stocking in natural water bodies has provided economic benefit to fishing communities, environmental voices are unheard. One high rank bureaucrat in the aquaculture department of SEFOE said categorically that the reduction of native fish populations is the result of over-fishing and not because of the introduction of tilapia and that now tilapia could be considered a native species because it has adapted well.

"Tilapia has adapted very well to the local environment and has invaded our water bodies, but not to displace the native species, because it is the opposite, native species are carnivorous and predate large number of tilapia fry. But even so tilapia has good ability to breed and has led to the rise in fish production in the State".
Head of Sub-Directorate, SEFOE

Those who defend this position said that the introduction of tilapia has been good for fishermen and consumers. For fishermen because the increased catches have brought more income and job opportunities. For the consumer,

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[16] A stronger species takes the place of a weaker one through competition.

because they have more access to fresh fish. At present, demand for tilapia has risen and people have got used to the flavour.

There is no doubt that over-fishing is relevant, as farmers and fishermen recognise, but denying the potential involvement of tilapia in the problem does not help. Surely a strategy based more in scientific knowledge and rural people's experiences is needed to achieve a more sustainable management of both natural and artificial water bodies?

Sometimes the acceptance of the ecological impact of tilapia over native species depends on the institution or the director. SEMARNAT, the Federal counterpart in aquaculture development, also stock natural water bodies but accepts that some impact may occur. In order to reduce impact they intend to stock mono-sexed tilapia (all-male populations, reversed through hormonal treatment). They intend to reduce the ecological impact by avoiding reproduction but that may not necessarily happen. It is understandable that an institution created for economic development such as SEFOE disregards ecological arguments in the search for more productivity, but it seems contradictory that an institution dedicated to environmental protection and rational use of natural resources such as SEMARNAT does the same. For the native fish species it makes no difference whether tilapia breed in the wild or in captivity if in the end tilapia is in the wild so the same competition for habitat exists. In the fishermen's and aquaculture farmer's view, the problem is that adult and juvenile tilapia predate the native species' fry, so diminishing native species' populations. In a paper presented by the Department of Fisheries (precursor of SEMARNAT), at the Latin American Symposium on Aquaculture in 1980, the threat from exotic species introduction was recognised *"no introduction of exotic species is procured until the foundation is there ....to avoid imbalances in the biotic environment which remove the more profitable species."* (Zarur, 1980, p181) *"The introduction of exotic species with high reproductive potential and adaptability to changing environments as in the case of tilapia is being avoided, until it is shown that it is not detrimental"* (Zarur 1980, p182). In 1999 it is clear that such statements are not correct. Tilapia is continually introduced to natural water bodies, and presented as a success of fisheries management. No research into its environmental impact was ever conducted, and therefore tilapia's effect on the environment was never scientifically proved in Tabasco. What we have is only the talk of farmers and fishermen versus that of aquaculture bureaucrats. Farmers' observations deserve to be taken into account at least until proper studies are carried out. It would arguably be better to re-stock with native species to avoid extinction. Such a programme would imply more expenditure but in the long run it could bring more benefits by preserving diversity, which in this case also creates economic resources.

7.7 A change of strategy: from paternalism to self-development.

Fry used to be provided for free, but in the last two years charging was introduced, at 10 cents per fry. All extension officers interviewed agreed that the demand for fry fell dramatically after that but there are different interpretations of that decrease. One group said that it is because most farmers are poor and do not have the money to buy fry.

"If people do not have money for the transport, would you think that they have money to pay for the fry?"
Extension officer, SEFOE

"They said, the goal for this year is to stock 2 million fry throughout the State. But where? If people don't want to buy it, how are you going to force them? They say that in previous years more fry was stocked, but that was because fry was given for free before, now it's sold".
Extension Officer, SEFOE

Others said that this is the obvious result when a paternalist policy is removed. There is however some agreement that now people practising aquaculture are those who really want to do so.

"I think that it (charging for the fry) *should have been done from the beginning, not now. While the Government keeps giving things to people, not only in*

fisheries but in everything, houses, roads, boats, scholarships; people will never change. They always are going to have this mentality – that the government provides for me. It is that the government has got them used to that...We haven't stocked anything this year in Centla because nobody wants to pay! We've received many applications and we have made many technical evaluations but we still haven't got as far as stocking anything".
Extension Officer, SEFOE

"I have noticed a change in demand for fry since they've been charging because the farmer had everything for free and of course, now that it has a price, they do not want it anymore. I think they are used to getting everything free".
Extension Officer, SEFOE

Both views may well be right. In this study many farmers, especially those from remote regions, had been left with no opportunity to farm fish once the fry was being sold. The problem is to distinguish those who are used to support and getting it without any interest in working hard from those who really need it. Eliminating the scarce support for the farmers may well have been used both to conceal government incapacity to make projects work and to display the benefits that the previous strategy provided to poor farmers. Similarly, farmers' attitudes may have been used to legitimate the reduction of the aquaculture budget. The present budget is not enough to maintain the hatchery, and selling the fry does pay for that maintenance. But with a reduction in demand for fry of such magnitude, neither aquaculture promotion nor resource generation for the programme is achieved. The result is that the social orientation of aquaculture has been lost.

7.8 *"Thanks! This interview was a catharsis for me!"* Extension Officers talk about Motivation.

Copious critiques were recorded not only of Federal and State Government policy towards aquaculture but also of the work and the motivation of colleagues. Some extension staff felt that the senior staff did not care about their institution or were not motivated to provide a good service but only by money. Senior staff considered the extension officers to be lazy and mediocre. The Department does not work as a team. As a result, there is poor cooperation, affecting the quality of service provided to farmers.

"As a secretariat they are only interested in how many people they support, how many fry were given, and how many families were involved. In the end, as a government programme, the goal is a number appears in the report. It's just to say: "we invested something in the fisheries development office and we supported this number of people".
Extension Officer, SEFOE

Most staff said that they were working in aquaculture because they liked the subject and because they wanted to work in something which used their qualifications. Nevertheless, others said that they were at the institution because it was the only place they could find a job. Only a few said that they liked working with farmers and the feeling of doing something to help and guide people. Others said they liked the outdoor work. A few considered their job to be temporary until they find something better paid.

There are few incentives to help extension officers feel happy with their jobs. Almost all thought their salaries were very low, and by Mexican standards the 2000-4000 mxp/month they earn is very low for a graduate.

"Oh my friend! Our work is not fairly paid here. We are the extension officers, without us the Department couldn't work. We are those who get exhausted walking around the countryside, and the pay is so low".
Extension Officer, SEFOE

In addition, as we have seen, there are no training programmes for them. Most support for attending courses is assigned to senior staff who frequently are not involved in the practical work. This prevents extension officers having the opportunity to get more knowledge.

"We don't get training, when there is a course, or conference, they send the bosses'".

Extension Officer, SEMARNAT

Besides the lack of resources there is the need to beg transport from other departments or lifts from strangers, and the lack of equipment for proper evaluations of the farms. All this means that extension officers work under very difficult conditions. A common complaint was that they do not have the equipment they had in the past.

"We have to spend our own wages to pay for transport to the farms, that's a limitation because I work to keep my family and I'm not willing to spend on that".

Extension Officer, SEFOE

"I have worked here for 12 years and sometimes we don't have the means, there are not enough resources to make good aquaculture. I'm disappointed, so now I'm trying to find entrepreneurs, to see the fruits of my career and my vocation, that I can do what I really should do".

Extension Officer, SEFOE

Some officers believe that the coverage the department wants is impossible given the number of extension officers. They cannot provide good service, as visits cannot be frequent. This is discouraging for both the officer and farmers.

"I manage about 100 farmers and it's rare that they say that they've harvested some fish. The result we get is that the fish died because the pond dried, the fish were stolen, or the fish didn't grow. And sometimes it is our fault because we cannot provide sufficient advice, as we cannot visit them, there is no money. So, if we, who know about aquaculture are not interested enough, then the farmer says 'I stock fish, if it works, great! If it doesn't, no problem', so they don't care about managing the pond properly. That has been the

result we have found with 80 % of the farmers. It's had few positive results although it's feasible".
Extension Officer, SEFOE

The same feeling is met when they refer to the lack of equipment. As minimum requirements for a reasonable service, extension officers said they required good quality fry, a car, water quality analysis equipment, and nets, none of which are readily available.

"When farmers don't get production, I feel bad as a professional. I would like to do good work, but we can't, we don't have the means... we can say that a pond is good because it looks good but in fact we don't know what the water quality is because we don't have the equipment. I feel ashamed! What do farmers think of us?- 'This guy only comes to walk around! Better I telephone him and I describe my pond!'- That affects our profession, later farmers are going to say –'No! the biologist is bad because the culture didn't work, he said that my pond was appropriate but it wasn't".
Extension Officer, SEFOE

In the State Aquaculture Department, the new changes to make farmers pay for the fry sometimes lead to frustration.

"I don't feel happy here, there are no resources, things go wrong. Farmers don't want the fry anymore because now it costs, the bosses demand results but I can't provide any advice because farmers don't want that anymore. I can't force them to buy fry if they don't want to. On top of that the office does not pay my expenses in the field, I have to buy the bus tickets with my wage".
Extension Officer, SEFOE

The human side in the institutions also looked unappealing. Most officers said they felt their bosses or colleagues did not appreciate their work.

"If they had valued our work, I think support would have already been assigned. We've had no equipment for about 3 years, we don't get training.

Then that means that they don't value our work. We are here because they need to keep this going, not because they value what we".
Extension Officer, SEFOE

There is no recognition of their work.

"I don't feel motivated here. Sometimes we do the work and submit it, but in the end someone else signs it, maybe because we don't have permanent contracts. I don't think I belong here. The contract is for one year and when it finishes you have to hope they give you another one. The institution has no commitment to us, so I'm disappointed because I'd like to be more involved. And farmers perceive that".
Extension Officer, SEMARNAT

One complaint from those with temporary contracts in SEMARNAT was that they were discriminated against because, unlike the people with permanent posts, they had no fixed schedule so they could work at any time, on any day including Saturdays and Sundays while other people in the institution earned more and worked less. One said, *"I feel I'm nothing here".* (Extension Officer, SEMARNAT)

If there is any satisfaction from the work, it always comes from the farmers' side. Most extension officers feel that farmers value their effort. Sometimes farmers pay their bus fares and give them tips. On the other hand, less experienced officers can feel rejected when farmers mistrust their knowledge, preferring the advice of more experienced staff.

"I feel that farmers do appreciate my work, they are very grateful. But here in the Department they don't. My work doesn't count here, they describe us as lazy, so there are some colleagues who don't do their best".
Extension Officer, SEFOE

"I feel motivated, not as I would like, but I like my job. Sometimes things are so unpleasant at the office, but the simple fact of serving farmers make you forget about that, and feel satisfaction".
Extension Officer, SEFOE

Most staff, especially at lower levels, think that their prospects are poor in their institutions and are working there just for a while. Others would like to continue, but only if they get better salaries. For some it is just a way to get some experience, in the hope of a better job later, so generally the best and the less conformist stay a very short time. Still, the lack of opportunities for some officers has led them to stay there permanently, especially the locals who do not want to move to other areas of the country. That is one of the worries for some of the heads of Departments, but the solution is out of their control as pay and budget distribution is decided at much higher levels in the Secretariat and the State government.

"Staff who remain in the Department are the ones who have no aspirations, those who don't want to advance. The most active professionals move to other jobs as soon as they can. People who remain in the Department are the most conformist. That is because of the lack of incentives. Pay is between 2000 and 3000 pesos a month. It is difficult to live on that, especially if they have to keep a family. They have so many problems in surviving that instead of reading a book they look for ways to get some extra money".
Head of Sub-Directorate, SEFOE

Motivation in middle positions depends on the institution. It seems to depend on how much freedom the staff have to express ideas and put them into practice as well as on their seniority in the staff. If they feel attached to the institution they perceive its achievements as their own.

"Working in the programme has been satisfactory. It has been slow but we have made the foundation".
Head of Department, Municipal Development, El Centro

For others it is a question of professional responsibility, so that recognition is secondary.

"People value our work if the result is good. But my goal isn't to get my efforts recognised but to fulfil the objectives and goals of the institution".
Head of Department, SEMARNAT

Mid-level position bureaucrats feel that there is some opportunity to make a career in their institution, but that is not as easy as before.

As we have seen, all these problems, economic and organizational leave staff with little motivation to do their work. This has a direct influence on the services they provide to farmers and it is one cause of the slow development of aquaculture in Tabasco.

7.9 Concluding remarks

Aquaculture developed as subsistence in Tabasco because the local and federal government and rural people shared similar objectives when fish farming was introduced in the region. Nevertheless at present aquaculture seems to be constrained, as new national and regional policies promote entrepreneurial attitudes, but farmers are not provided with the necessary infrastructure and support to adapt to change. This contradiction seems to be reinforced by the professionals' mentality, which sees subsistence as primitive and focuses their efforts into farmers changing to commercial oriented systems with no apparent results. Aquaculture extension officers in Tabasco follow a reductionist, technocratic approach, always seeking high yields through the transfer of standardised disciplinary knowledge. Social aspects of fish farming are rarely considered and there is a lack of analysis of the different components of the farms or the farmers' time and effort budgets. This creates a conflict of interests and a cultural clash between aquaculture professionals (disciplinary thinking) and farmers (tacit knowledge and multidisciplinary, non-systematised thinking), which together lead on to failure.

In the view of aquaculture professionals, aquaculture programmes in Tabasco have failed because, after more than 20 years of their efforts, farmers still practice subsistence. (This is seen as a primary stage that should necessarily have been overcome by the farmer's transformation into entrepreneurs.) Leaving aside deliberations as to whether this change is positive or not, the entrance of small farmers into commercial aquaculture is difficult because there is a lack of appropriate trade mechanisms, farmers organizations, suitable extension services, and on-farm infrastructure. Moreover, the input availability for more intensive farming is poor and farmers' access to loans and technological information is almost non-existent. This, together with the internal problems in the extension institutions such as lack of motivation and small budgets make it difficult at present for aquaculture to develop as aquaculture professionals in Tabasco expect. I argue that until good conditions are established for farmers to enter commercial aquaculture (which would need very substantial investment: see section 6.9), the work of the institutions could be much more cost-effective if channelled into the improvement of subsistence fish farming through appropriate technology and research. Nevertheless, this can only be achieved if aquaculture professionals' view of subsistence aquaculture is transformed, recognising the importance of social satisfactions and of farmers' aspirations.

CHAPTER 8
CONCLUSIONS

8.1 Introduction

This thesis has explored socio-economic, cultural technical and environmental factors of aquaculture in Tabasco. In response to the unexpected findings from the fieldwork, it has examined the debates around subsistence and sustainability. It has described the technical conditions and management on fish farms in Tabasco, and expressed local farmers' and professionals' view of fish farming and their ideas for positive change. This concluding chapter recalls and examines the most important matters resulting from this research, presents some ideas for improving aquaculture extension and suggests some proposals for future research.

8.2 Fish farming systems

Two modes of aquaculture were found in the four regions of Tabasco studied, subsistence aquaculture and small-scale aquaculture enterprises run by groups of farmers, the first being the most widespread.

Subsistence aquaculture is carried out with basic and often incorrect management and few inputs. Generally farmers do not make the best use of on-farm and locally produced goods and have inadequate ponds, but produce sufficient fish to satisfy the household needs which they perceive

Most collective aquaculture enterprises have failed in commercial terms and have stopped operations. The current management was semi-intensive with a high use of feed inputs. The current causes of failure were organisation and personal problems among members, high input costs and technical deficiencies. Successful groups were very scarce but showed that this kind of organisation can be appropriate when groups are small, have an entrepreneurial mentality, receive continuous technical support, and have access to credits, subsidies and markets.

The most important constraints on the two forms of production were technical, socio-economic and environmental (this last in the form of recurrent floods and droughts) while physical factors (water quality and soil) do not seem to have a major influence on yields.

8. 2.1 Subsistence aquaculture

This thesis has argued (chapter 6) the merits of subsistence and the potential possibilities for it to become more productive. The improvement of subsistence systems appears to be more socially, economically and environmentally sustainable than the wider implementation of commercial aquacultural systems. The former is technically possible and less risky for the farmers, and a positive attitude to the change is more likely.

Subsistence systems could also be an option to enable farmers to choose to retain more of their traditional ways of life in the countryside. Individuals seem to be moved mostly by non-consumerist preferences, which implies a non-entrepreneurial mentality that is difficult for people accustomed to the profit motive to understand, as in the case of many decision makers and educated people who interfere in farmers' lives with intention of helping them. As a consequence, positive response to change is rarely obtained. When it does, the farmers can end up in worse conditions than before, if they replace farming practices which ensure food security by more intensive mono-cultures which could provide them with more cash income but are subject to price variation. Thus subsistence could be a way for farmers to protect themselves against extreme poverty and exploitation. For that reason I believe that while the conditions simply do not exist to integrate small farmers in the market, the best way to support farmers in improving their lives is not in the arena which has proved to be detrimental to them but in that which they know: subsistence.

Making such a change is not easy. The first requirement is to eliminate prejudices against subsistence. Subsistence production is not valued by the extension institutions, which look for solutions in technologies not related to farmers' realities, so creating a communication gap. The 'problem to solve' seems to be perceived differently between farmers and professionals. For one, success is profit, for the other it is a mixture of economic, social and environmental gains. Thus successful subsistence systems may pass unnoticed by official institutions. Arguably it should be the task of official institutions to re-establish that communication, but if real improvement of farmers' conditions is intended, then development dogmas must be put aside along with established prejudices against rural cultures. Instead, to support farmers' transformation of their own mentality, extension institutions should look at the reality with a different perspective, be open to learn and improvise under the local conditions until scientific literature based on local conditions is available.

This is very important now, when it is believed that Mexico has reached a democratic government. A true democracy would consider local cultures; it would take into account the voices of the communities who elected the decision makers. Bringing back sophisticated attempts to change people's mentality through macro policies and massive media output against people's wishes would be a move towards a 'disguised oppression' in the so-called 'democratic society'.

In the case of a slow or difficult or change of attitudes to subsistence in official institutions, a different initiative to revalue subsistence could come from the farmers' side or from NGOs. For example, if successful farming systems were developed by some farmers then the possibility would exist for official institutions to notice and for the experience to be spread to other rural areas so that development could be re-directed to promote these more sustainable systems.

8.2.2 Commercial aquaculture.

The extent in which farmers have chosen or have been forced to accept subsistence production is unknown. Doubtless the best outcome in economic (but not environmental) terms would be that all farmers would have a production unit like that described in aquaculture textbooks: an elevated pond that can be drained and filled, a well with a pump to fill the pond, drainage to discharge dirty water, electricity to pump water for daily water exchange, good pelleted feed, etc., all supported by co-operative purchase of inputs and perhaps marketing. I argue that that should not be the choice because, in such cases, farmers could raise their standard of living but at expenses of higher environmental cost (see environmental impact of commercial aquaculture, chapter 6). I argue that yield could be significantly increased by the improvement of the existing systems while preserving their sustainability, but local and participative research is required. The average farmer, however, simply does not have the economic resources or the entrepreneurial mentality to undertake the economically ideal project, and the market conditions for inserting farmers into commercial aquaculture in Tabasco do not seem favourable. I argue that if conditions for commercial production were suitable for small farmers (good trade channels, fair input prices, cheap energy, good access to credit and the processing industry etc), more farmers could change to a more intensive and more commercial aquaculture, but that that should be promoted among farmers who want to change, and favouring more sustainable practices.

Market opportunities could be changed by alterations in rural policy at national or local level. Farmers have to be able to reach urban markets and to insure so that their incomes were not at risk. Similarly high technology and mechanisation are needed to transform their farms to be competitive with the existing commercial farms. I believe that only under these circumstances would farmers abandon semi-subsistence systems or at least intensify their farms to sell substantially more of their produce. Nevertheless, such a change seems unlikely today, when the national strategy is toward greater integration in the globalized world. Food products are every day defined more in the international market where TNCs dominate and in which small farmers have lost influence. A small farmer from Tabasco does not seem to have good prospects to compete, and furthermore the government is unwilling to commit the resources to bring farmers to such a transformation. While rural conditions remain the same, the only option to bring fish farmers into commercial activities is providing extensive support, as the case of successful APSs in El Centro shows (Chapter 5).

8.3 Sustainability and subsistence aquaculture

Subsistence fish farming in Tabasco is a semi-closed system with little opportunity to affect the surrounding environment. It uses low levels of inputs, does not depend on external sources of energy, contributes to the recycling of nutrients on the farm, does not interfere with the traditional farming practices in the countryside, does not seem to disrupt social relations in the community or household, has been adapted to the local culture, contributes to environmental protection and so forth. Folke *et al.,* (1998) support this view from evidence worldwide. They found that in contrast to intensive, one-species aquaculture, integrated cultures tend to be based on recycling or ecocyclic production, and have the potential to be more in tune with the processes and functions of the supporting ecosystems. In such integrated systems, the cultivation contributes to improving environmental quality, in contrast to intensive one-species aquaculture, which causes environmental deterioration. Consequently, cultures that combine species from different trophic levels, apply cyclic production and generate multiple service outputs should reduce the ecological footprint substantially. Similarly Pullin and Prein (1995) concluded from their work in Ghana that farm ponds can be important social and environmental assets in addition to their role in fish production and their contributions to other farm enterprises and household needs. They found that both economic and ecological indicators were improved through the integration of a fishpond with vegetables. Indeed, through the addition of the fish pond to the farms, seven new flows recycled available nutrients (six to the pond, one from the pond). While these nutrient transfers required only minor amounts of on-farm labour, the pond acted as a digester for the raw nutrient materials added, enabling the farmer to reclaim these by re-use. More research such as ecological footprint analysis (Fricker, 1998; Folke *et al.*, 1998; Kautsky *et al.*, 1997; Wackernagel *et al.*, 1997a, 1997b, 1999; Wackernagel and Rees, 1997) and life cycle analysis (Mathews *et al.*, 1997; Cole 1998; Wyatt *et al.*, 2000) is needed to establish these virtues. I still argue that there are enough elements here to establish that subsistence fish farming should be considered for inclusion in that group of more sustainable practices, the preservation of which becomes desirable.

The five dimensions of the ideal typical sustainable community defined by Bridger (1997, cited in Bridger and Luloff, 1999) (chapter 4) support the argument that subsistence aquaculture in Tabasco can be defined as a more sustainable production system. Leaving aside the fifth dimension, which is broader and difficult to measure, the semi-subsistence systems studied in this research fit very well in the first four dimensions of community sustainability. First, as this is an alternative activity, easy to perform and yielding a product often difficult to access by other means, fish farming is part of the economic diversity of the community providing nutrition and sometimes extra cash and/or exchange value to households. Second, as a food and cash source that uses mainly by-products produced on nearby farms, it is a practice that reduces dependence on purchased food and on sales. Third, it not only uses mainly by-products which are low energy-cost materials but at the same time recycles wastes such as manures and unwanted biomass (grass, etc) which would otherwise be burned, causing air pollution and an increase in CO_2[1] Subsistence fish farming also helps

[1] It could be argued that a eutrophied or mismanaged pond releases high amounts of CO_2 to the air, but as a part of the organic material is stored in the bottom and decomposed by micro organisms which are part of the trophic chain in the pond, much of the organic matter is recycled. The continuous harvest of fish is a way in which this organic matter is released. The effect of this

in the conservation of native fish species as farmers raise local species in spite of their inferior growth rate compared to the exotic species. Finally it helps in the preservation of food habits as people are able to consume fish in the traditional diet which otherwise would have to change because of ecological changes provoked by the inclusion of tilapia in the natural water bodies.

8.4 Official strategy for aquaculture: some proposals for positive change

Aquaculture developed as subsistence partly because the government in 1970s and 1980s promoted this and because subsistence systems were part of the local culture so there was no resistance to this new technology. Nevertheless government plans to make farmers move to commercial aquaculture failed for two main reasons.

- First, farmers have both economic and social motives and it seems that aquaculture has been given more of a social than an economic role, which extension institutions have ignored.

- Second, efforts to change farmers' attitudes have failed because under present conditions few can succeed in commercial aquaculture. Government agricultural policy in the last 10 years, which has depressed rural development, determines that.

Instead of taking advantage of past experience, monoculture aquaculture was imposed, ignoring local farmer opinions. If people were used to cultivating and raising a variety of plants and livestock, why would not they prefer polyculture in aquaculture? As a response farmers resist by maintaining their old production systems. Given farmers' lack of cooperation, the easiest response is to blame farmers for project failure, and that is not always correct. Understanding farmer's

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CO_2 is thus lower compared to the effect of CO_2 produced by the direct burning of such by-products.

motivations will permit the detection of the real causes of failure and the design of more appropriate projects. It is understandable that aquaculture in the form of tilapia monoculture is considered a failure by most aquaculture professionals working in the local, state and federal Government (chapter 7) because, contrary to current advice, rural people often include other species of fish and turtles in their systems, sometimes at the expense of yield, but as seen in chapter 6, that may be very appropriate, if social gains are also considered. I argue that research on the improvement of a local model of polycultural aquaculture is necessary.

Despite the environmental impact and mistakes of promoting tilapia as the only choice for subsistence fish farming in Tabasco, at present it would be equally wrong to disregard tilapia in any aquaculture development programme. Tilapia is already part of the natural aquatic ecosystems in Tabasco (and its elimination almost impossible) and its advantage to fish culture should be fully used, but its exploitation should be promoted only in closed systems such as ponds. Nevertheless efforts should be made to research and promote the culture and restocking of natural water bodies with native fish species as a way to protect biodiversity, inland fisheries and the traditional food habits of rural people.

In Chapter 6 we saw how culture affects these farmers' attitudes to fish farming. In order to understand farmers' requirements, it is necessary to speak a common language so as to learn farmers' definitions of concepts implicit in programmes and projects designed to improve their standard of living.

If the main purpose is to raise standards of living, first of all it is necessary to compare the aims of present programmes with farmers' aims in order to identify whether or not the programmes are fulfilling their objectives. It would be necessary to examine carefully what aquaculture means for the villagers in order to find common objectives. If the aim is to raise food production for the market, or income generation, then it is necessary to establish first the conditions for a successful entrance of farmers in the markets. One single aquaculture programme is not enough to make farmers shift to a single intensive activity, because to get started farmers need adequate opportunities to commercialise, means of communication, machinery, access to loans, etc., which are outside of the scope of any Mexican aquaculture or small farmer programme to date. For that reason aquaculture should be considered inside a comprehensive regional integrated development programme.

If both objectives are mixed, that is to say that farmers will increase their standard of living through the generation of cash income, then the assumption is debatable as cash does not translate necessarily in improvement for all members of the household, especially in areas where poor people are inclined to consume commercial products which are non nutritious or harmful to health, such as 'junk food' alcohol, tobacco and soft drinks. In this case, a meticulous analysis of aims and objectives of aquaculture programmes would be desirable.

A change of the mentality of professionals and decision makers is needed. Solutions depend on the context; money is the key for survival in urban centres, not necessary in rural areas. Other technologies need to be explored. This idea is surely lacking in higher education institutions related to rural development. Then a dialogue with farmers could begin, probably resulting in very different but more successful rural change.

Aquaculture technicians could learn to understand subsistence through experience and training programmes. But first, cultural baggage is difficult to change especially when, as in this case, professionals have had at least 16 years of formal education. It is easier to think that farmers are obstinate or lazy than to question their own beliefs. Second, in practice training is not a priority in any institution related to technical assistance in aquaculture in Tabasco. Lack of opportunities to update their knowledge was a leading complaint of extension officers. Field-staff in Tabasco have normally no access to courses. Any courses are technical or commercial but not adapted to the local socio-economic and physical conditions.

8.4.1 Technical recommendations and proposals for research

1. According to the yields obtained by some farmers, high yield aquaculture is possible in phreatic ponds but it is necessary to design a model based on the local conditions. The problem is, according to most extension officers, that generally farmers do not ask for advice before their ponds are dug and when they do it they never implement it. Effort also must be focused on the municipal administrations that have been responsible for digging very inadequate ponds.

2. As the most frequent justifications for not feeding fish were lack of time, knowledge and money, farmers could be keener to start a feeding programme with proper advice and motivation from the extension staff, if they are shown, in practice, that there is no need to spend more money or much time in raising fish yields through a better use of on-farm by-products.

3. This research found much dispersed local knowledge of aquaculture, especially about fish feeding. As many farmers continue to mismanage and misuse available resources, a programme to collect this information and transmit it to the farmers would be desirable.

4. There is no doubt that many faults in these polyculture practices could be resolved using existing knowledge from local aquaculture experience, rural aquaculture handbooks (Hilbrands and Yzerman, 1998, for example) and, from Chinese polyculture (Bardach *et al.,* 1976) and integrated agriculture-aquaculture (Prein, 2002) literature. Others still have to be overcome by farmers' experience and ideally scientific research of a farming systems type as suggested by Edwards (1998). For example, applied research on the production of species, the basic biology of which is still unknown; field research with many species at the

same time, research on mixtures of species including predators, even when it is known that the results will not provide the highest yield, etc. In other words the researcher must not lose the understanding that the research must be for the people who will put it into practice. If the motivation of the farmers is not only for food production but also for social, cultural and ecological satisfaction, then rural aquaculture research must not only be looking for high yields but to cover all the farmers' requirements at the highest possible level. For example, it is technically possible to produce 10 t of fish under certain conditions, but where farmers prefer to consume many fish species, some of which are carnivorous and can reduce the yield of others it is better to invest the effort in polyculture although the yield will be much lower. Doing the opposite wastes time and money, because farmers with a diversified subsistence culture and another source of cash income may not adopt monocultural systems conceived with a simple urban entrepreneurial mentality. It could be argued that the research proposed here would be short of scientific rigour because of the lack of control of the variables and at the same time would have many methodological problems, so that it will be difficult to get published. But if the purpose is to improve the conditions of the rural poor then the main objective must be the applicability of the results rather than the fame of the researcher. Substantial changes cannot be achieved if rigid schemes are not broken. In order to achieve such change, Chambers (1997) thinks that the solution is in a paradigm change to a new professionalism whose challenge is learning how to learn, learning how to change, and learning how to organize and act.

5. In order to solve problems of sediment accumulation, making some simple modifications to the existing ponds, such as dike restoration and the addition of inlets and outlets at ground level with nets to prevent the fish escaping could partially solve the problem. But as floods do not occur every year the achievement of sustained yield could not be guaranteed without the removal of sediment. The design of a simple mechanical tool to remove the sediment from the water could be practical and effective.

6. To achieve more sustainable and productive systems, extension workers and research staff should learn to see the problem from the farmers' perspective. Useful advice could be provided and changes in management could be more feasible. A study of all components of the systems is recommended, identifying good and wrong practices and producing a flexible technology package of a integrated system of farming for each of the four areas studied.

8.4.2 Policy recommendations

Some changes in the Government strategy are needed to implement such a transformation. The following are some practical proposals.

- The purpose of aquaculture development must to be re-defined. If the social purpose is to be maintained, it would be necessary to re-value subsistence and to redirect the efforts to engage farmers in commercial aquaculture to the farmers whose main motivation is cash income. Subsistence aquaculture can help in raising living standards without disrupting the farmers' way of life.
- Extension officers need more knowledge of farmers' motivations. This could be obtained by using participative methods with farmers. Focus group sessions could be of great utility. Similarly, refresher courses for extension officers should become a priority in order to provide appropriate advice to farmers.
- The form of project evaluation should be changed, giving more weight to farmers' own evaluation. Farmers' satisfaction at the end of the cycle must be taken into account. Using yield and money as indicators is unreliable because farmers rarely record catches.
- Professionalisation of the government aquaculture institutions is needed with experienced staff (both in the field and in the office), those who have

worked in the locality and have an idea of farmers' needs being considered for senior posts.

- Extension institutions need to work on farmers' organisation to enable them to be more active in their own development, by promoting the formation of fish farmers' associations in villages, for example.
- A reorganisation is needed to make Aquaculture Departments more efficient. Planned field visits coordinated with other Departments, for example would save money on transport.
- A link between Aquaculture Departments and institutions in charge of pond digging is necessary to ensure that ponds will be suitable for fish farming.
- Programmes need to be redesigned. A ponds reconstruction programme would bring better results than the existing programmes of pond digging.
- Aquaculture Departments need to collaborate with research institutions. Research based on farmers needs is necessary in order to improve the present aquaculture farming practices. There are many fields which research can explore: pond design for local conditions, polyculture, native species farming, etc.

I believe that all these are possible but political will is necessary to implement the change.

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APPENDIX I

LIST OF FARMERS INTERVIEWED

QUESTIONNAIRES.

El CENTRO

No	Name	Sex	Age	Plot size (ha)	Village
01	Hector Brito Correa	M	36	0.1	Acachapan y Colmena 2a Seccion
02	Francisco Jimenez Diaz	M	38	7.5	Acachapan y Colmena 2a Seccion.
03	Joel E. Valencia MacDonald	M	50	15	Acachapan y Colmena 3a
04	Gabriel Caraveo Gomez	M	52	0.1	Anacleto Canaval 2a Seccion
05	Jose Jimenez Rivera	M	48	0.1	Anacleto Canaval 4a Seccion
06	Maria Dolores Jimenez Ventura	F	59	2	Barrancas y Guanal 1a Seccion
07	Santiago Torrez Castro	M	52	7	Boqueron 2a Seccion
08	Antonio Reyes Alvarez	M	60	2	Boqueron 4a Seccion
09	Encarnacion Jimenez	F	48	2	Boqueron 4a Seccion
10	Maria Suarez Gomez	F	43	0.1	Buena Vista-Rio Nuevo 1a Seccion
11	Jesus Sanchez Silva	M	55	4	Buena Vista-Rio Nuevo 1a Seccion
12	Candelaria Gomez Rivera	F	38	2.5	Buena Vista-Rio Nuevo 1a Seccion
13	Concepcion Gonzalez Geronimo	M	54	0.1	Buena Vista-Rio Nuevo 1a Seccion
14	Cipriano Concepcion Marin	M	36	1	Buena Vista-Rio Nuevo 3a Seccion
15	Homero Mazariego Montejo	M	47	8	Chiquiguao 1a Seccion
16	Carmelita Lopez Sarracino	F	60	4	Chiquiguao 2a Seccion
17	Andres Asencio Lopez	M	27	0.1	Cocoyol
18	Jose de la Cruz Perez	M	46	1	Cocoyol Mantillas

19	Juana Hernandez Escalante	F	45	0	Col. San Jose
20	Flavio Jimenez Zapata	M	33	0.1	Corregidora 3a Seccion
22	Jose L. Oporto Perez	M	38	10	Ejido el Agricultor
23	Juventino Avalos Mezquita	M	37	0	El Espino
24	Joel De Dios Torres	M	30	1	El Espino
25	Candido Rodriguez Avalos	M	42	0.1	El Espino
26	Julian De los Santos	M	73	0.1	Emiliano Zapata
27	Carmen Cadena Magaña	M	62	5	Huapinol
28	Guadalupe Lopez Ruiz	F	25	4	Huasteca 1a Seccion
29	Norma A. Lopez Hernandez	F	33	0.1	Huesode Puerco
30	Juan Montero Martinez	M	60	4	Ismate Chilapilla 2a Seccion
31	Jose A. Garcia Chanona	M	29	0	Ismate Chilapilla 2a Seccion
32	Alfonso Garcia Hernandez	M	70	0	Jolochero
33	Daniel Ruiz Moscoso	M	58	2	La Cruz del Bajio
34	Maria De los Santos Lopez	F	48	0.1	La Providencia
35	Paulino Geronimo Torres	M	59	5	La Tarantana, Buena Vista-Rio Nuevo 1a Seccion
36	Ruffo Peralta Jainto	M	59	15	Lagartera 1a seccion
37	Maurilia Garcia Lopez	F	46	1	Lazaro Cardenas, Buena Vista 1a Seccion
38	Julia Pairo	F	46	1	Macultepec
39	Juan Geronimo Vidal	M	64	14	Medellin y pigua 3a seccion
40	Rodolfo Flores Gomez	M	58	14	Medellin y Pigua 3a seccion
41	Pedro Garcia Valles	M	42	2	Pablo L. Sidar
42	David Camara Ortiz	M	30	0.1	Sanmarkanda
43	Eleutereo Contreras Cruz	M	68	8	Santa Catalina
44	Jesus Izquierdo Cerino	M	57	7	Santa Catalina
45	Juan Jesus Leon	M	87	0.1	Tierra Amarilla 1a Seccion
46	Jose A. Martinez Morales	M	34	0.1	Torno Largo
47	Hipolito Palacios Ruiz	M	66	5	Tumbulushal 1 Seccion

JONUTA

No	Name	Age	Sex	Plot size (ha)	Village
01	Pablo Cardeno Hernandez	63	M	0.1	Barrial
02	Osvaldo Rosario Dominguez	40	M	7	Barrial
03	Bernabe del C. Ramirez Dominguez	24	M	3.5	Barrial
04	Francisco de la Cruz. Duran	31	M	6	Barrial
05	Rubicel Perez Lopez mismo grupo	46	M	10	Bejucal
06	Enrique Benitez Lopez	65	M	12	Boca de San Geronimo
07	Silvino Rodriguez Lopez	49	M	15	Boca de San Geronimo
08	Artemio Mendoza Lopez	51	M	14	Boca de San Geronimo
09	Manuel Suniga Lopez	33	M	5	Cuyo de Guadalupe
10	Armando Centeno Zuniga	28	M	4	Cuyo de Guadalupe
11	Francisco Centeno Damian.	76	M	55	El Cocoyolar
12	Manuel Reyes Hernandez	45	M	15	Guarda Tierra
13	Joaquin Ramiez perez	40	M	6	Guarda Tierra
14	Alberto Perez Reyes	32	M	15	Lazaro Cardenas
15	Salud Morales Ojeda	39	F	22	Lazaro Cardenas
16	Arturo Morales Ojeda	38	M	9	Lazaro Cardenas
17	Maria C. Ojeda C.	30	F	3	Lazaro Cardenas
18	Edith Luna Chable	24	M	7	Monte Grande
19	David Pascual Mendoza	30	M	12	Monte Grande
20	Basilio Jimenez Soliz	46	M	25	Playa Larga
21	Manuel A. Perez Mendoza	40	M	25	Playa Larga
22	Marco A. Perez Moreno	66	M	66	Playa Larga
23	Angelta Ewan Perez	36	F	4	Playa Larga
24	Juana Jiminez Soliz	31	F	10	Playa Larga
25	Atilana Zumarraga Sanchez	34	F	15	Playa larga
26	Gldardo Ruiz Mendoza	47	M	40	Playa Larga
27	Enrique Perez Lopez	62	M	2o	Pueblo

28	Angel Ramos Palma	25	M	20	Nuevo Pueblo
29	Jorge Dominguez Ramos@	37	M	17.5	Nuevo Pueblo
30	Medardo Dominguez Ramos	35	M	36	Nuevo Pueblo
31	Jeremias Dominguez Ramo	49	M	22	Nuevo Pueblo
32	Braulio Dominguez Ramos	52	M	20	Nuevo Pueblo
33	Andres Cruz Mendoza	76	M	20	Nuevo Torno Largo
34	Manuel Sanchez Hoy	16	M	50	Zapotal 1a

NACAJUCA

Sex	Name	Age	Sex	Plot size (ha)	Village
01	Marcos Lopez	43	M	0.1	Arrollo
02	Onocifero Zapata Tosca	44	M	2	Arrollo
03	Candelario de la Cruz May	23	M	15	Banderas
04	Flora Cerino Sanchez	55	F	30	Corriente 1a Seccion
05	Maria I.de la Cruz Arellano	46	F	2	Corriente 1a Seccion
06	Higinio Hernandez Lazaro	29	M	0.5	Guatacalca
07	Cirilo Lazaro Garcia	59	M	1	Guatacalca
08	Cesar de la Cruz Osorio	42	M	0.1	Jimenez
09	Porfirio de la Cruz Ovando	60	M	0.1	Jimenez
10	Cesar Gomez Rivera	25	M	0.1	Lomitas
11	Israel Zapata Hdz.	45	M	0.1	Lomitas
12	Lazaro Cerino Perez	76	M	8	Lomitas
13	Martha A. Jimenez Gomez	50	F	2	Lomitas
14	Sofia del C. Gomez Cerino	22	F	22	Lomitas
15	Elvira Cerino Garcia	48	F	6	Lomitas Pob. San Miguel
16	Gustavo de la Cruz Garcia	35	M	20	Oxiacaque
17	Jose de Luz Sanchez May	22	M	2	Oxiacaque Camellones
18	Ouclides de la Cruz Lopez	47	M	2	Sandial
19	Maria J. Contreras Ballona	58	F	4	Sandial
20	Guadalupe Hernandez Ovando	52	M	2	Sandial, Pob La Cruz
21	Remedios Chable Hernandez	33	F	3	Simon Bolivar
22	Santiago Hernandez Roman	60	M	0.5	Tucta
23	Viviano Hernandez Perez	55	M	0.5	Tucta
24	Agustin Rivera Cruz	72	M	100	Vainilla
25	Andres Jimenez	60	M	8	Zapotal 1a
26	Jose de la Paz Landero Lopez	66	M	8	Zapote 1a
27	Adolfo Silvan Lopez	49	M	4	Zapote 1a
28	Bartola Alvarez Ramon	54	F	8	Zapote 1a
29	Sebastian Silvan Lopez	37	M	0.5	Zapote 1a
30	Jesus del C. Ovando Alvarez	19	M	0	Zapote 2a

TACOTALPA

No	Name	Sex	Age	Plot size (ha)	Village
01	Lluvia Reyes Garcia	F	44	0	Ceibita
02	Dario Jimenez Reyes	M	45	28	El Limon
03	Felicito Rodriguez Hernandez	M`	48	7.5	El Limon
04	Enoc Pereda Vazquez	M	46	9	El Limon
05	Oscar Martinez Calderon	M	38	14	El Limon
06	Samuel Alejo Reyes	M	49	12.5	El Ular
07	Ortelio Sandoval Hernandez	M	39	23	Jose Ma. Morelos y Pavon
08	Carmen Sandoval Montejo	M	34	3	Jose Ma. Morelos y Pavon
09	Sebastian Lopez Jimenez	M	56	16	Lazaro Cardenas
10	Ramon Hernandez Baeza	M	73	16	Lazaro Cardenas
11	Ovidio Dominguez@	M	38	14	Lazaro Cardenas
12	Omar Narvaes Cruz	M	32	13	Lomas Alegres 1a
13	Federico Hernanez Ortiz	M	40	13	Lomas Alegres 1a
14	Gabriel Nunes Arevalo	M	45	7	Lomas Alegres 2a
15	Jose Narvaes Nieto.	M	34	5	Lomas Alegres 2a
16	Pines Cruz Lara	M	43	1.5	Lomas Alegres 2a
17	Juan Calderon Hernandez	M	36	10	Lomas Alegres3a
18	Petrona Flores Sanchez	F	45	12	Pochitocal 1a
19	Iturbide Dominguez Ocana	M	55	0.1	Pochitocal 1a seccion
20	Mateo Martinez Encino	M	48	14	Raya de Zaragoza
21	Lilia Pintado Govea	F	63	10	Reforma
22	Daniel Perez Hernandez	M	56	10	Reforma
23	Onorio Custodio Mendez	M	43	63	Reforma
24	Cruz Ma. Hernandez Ramos	F	46	3	Reforma
25	Alfonso Reyes Lopez	M	63	19	Reforma
26	Antonio Perez Cornelio	M	72	17	Reforma

27	Daniel Garcia Perez	M	35	3	Reforma
28	Maria A. Morales	F	37	15	Reforma
29	Manuel Lara Sanchez	M	47	24	Reforma
30	Hector Alcocer Dominguez	M	43	16	Reforma
31	Jose de C. Jimenez Garcia	M	34	1	Reforma
32	Guadalupe Cruz Alvarado	F	37	10	Reforma
33	Tila Del C Arpaiz	F	60	10	Reforma
34	Nely Vazquez Cruz	F	51	12	San Antonio
35	Ramiro Rodriguez Alvarado	M	47	12	San Antonio
36	Cosme Alvarado Castellanos	M	55	12	San Miguel Juarez
37	Sara Hernandez Maldonado	F	43	16	San Miguel Juarez
38	Javier Sanchez Gomez	M	55	14	San Miguel Juarez
39	Juan E. Garcia Tosca	M	27	14	San Miguel Juarez
403	Miguel Angel Santos	M	57	0.1	San Miguel Juarez
41	Juan Galicia Diaz	M	55	10	Santa Rosa
42	Ausencio Perez GUILAR	20	M	18	Santa rosa
43	David Galan Rojas	M	20	18	Santa Rosa 1a
44	Arturo Mayo Perez	M	40	0.1	Xicotencatl
45	Adan Dominguez Lara	M	42	20	Xicotencatl
46	Voltimer CorreaHenadez	M	48	19	Xicotencatl
47	Trinidad Sanchez Garcia	M	60	0	Xicotencatl
48	Jose M. Calcaneo Perez	M	50	60	Xicotencatl
49	Elda Martinez Perez	F	45	4	Xocotencatl

SEMI STRUCTURED INTERVIEWS

No	Name	Municipality	Village
01	JOSE OVANDO CONTRERAS	Nacajuca	Lomitas
02	Antonio Reyes Alvarez	El Centro	Boqueron 4a Seccion
03	Bertha Alicia Dzul Ovando	El Centro	Anacleto Canaval 4a Seccion
04	Candelaria Gomez Ruvera	El Centro	Buena Vista Rio Nuevo
05	Carmencita Lopez Sarracino	El Centro	Chiquiguao 2a Seccion
06	Daniel Ruiz Moscoso	El Centro	La Cruz del Bajio
07	Erasmo Barabata Ramírez	El Centro	La Providencia
08	Federico Ramon Castro.	El Centro	Macultepec
09	Flavio Jimenez Zapata	El Centro	Corregidora 3a Seccion
10	Guadalupe Lopez Ruiz	El Centro	Huasteca 2a Seccion
11	Hector Brito Correa	El Centro	El Maluco
12	Inocente Mario Vidal	El Centro	
13	Jesus Izquierdo Cerino	El Centro	Santa Catalina
14	Jesus Sanchez Silva	El Centro	Buena Vista Rio Nuevo 1a Seccion
15	Joel Enrique Valencia McDonald	El Centro	Acachapan y Colmena 3a Seccion
16	Jose A. Martinez Morales	El Centro	Torno Largo
17	Jose de la Cruz Perez	El Centro	Cocoyol Matilla
18	Jose Luis Oporto Perez	El Centro	Acahapan y Colmena 2a Seccion
19	Juana Hernandez Escalante	El Centro	Col San Jose
20	Juventino Avalos	El Centro	El Espino
21	Maria Dolores Jimenez Ventura	El Centro	Barrancas y Guanal 1a Seccion
22	Rodolfo Florez Gomez	El Centro	Medellin y Pigua 3a Seccion
23	Artemio Mendoza Lopez	Jonuta	Boca de San Geronimo
24	Braulio Dominguez	Jonuta	Pueblo Nuevo
25	Edith Luna Chable	Jonuta	Nuevo Mundo
26	Enrique Benitez Lopez	Jonuta	Boca de San Jeronimo
27	Francisco Centeno Damian	Jonuta	Cocoyolar
28	Francisco de la Cruz Duran	Jonuta	Barrial
29	Gildardo Medoza	Jonuta	Playa Larga
30	Manuel Reyes Hernandez Perez	Jonuta	Guarda Tierra
31	Manuel Zuniga Lopez	Jonuta	Cuyo de Guadalupe

32	Marco Antonio Perez Moreno	Jonuta	Playa Larga
33	Rubicel Perez Lopez	Jonuta	Bejucal
34	Salud Morales Ojeda	Jonuta	Lazaro Cardenas
35	Agustin Rivera Cruz	Nacajuca	Vainilla
36	Anacleto Hernandez Roman	Nacajuca	TUCTA
37	Lazaro Garcia	Nacajuca	Guatacalca
38	Eulalio Sanchez May	Nacajuca	Oxiacaque
39	Gloria Gordillo Garcia	Nacajuca	Simon Bolivar
40	Guadalupe Hernandez Ovando	Nacajuca	La Cruz
41	Iginio Hernandez Lazaro	Nacajuca	Guatacalca
42	Jose de la Paz Landero Lopez	Nacajuca	Zapote
43	Juan Antonio Leon Magaña	Nacajuca	Lomitas
44	Lazaro Cerino Perez	Nacajuca	Lomitas
45	Maria de Jesus Contreras Ballona	Nacajuca	Sandial
46	Ouclides de la Cruz	Nacajuca	Sandial
47	Porfirio de La Criz Ovando	Nacajuca	Jimenez
48	Antonio Perez Cornelio	Tacotalpa	Reforma
49	Cosme Alvarado Castellanos	Tacotalpa	San Miguel Juarez
50	Cruz Maria Hernandez Ramos	Tacotalpa	Reforma
51	Danel Perez Hernandez	Tacotalpa	Reforma
52	Gabriel Nunes Arevalo	Tacotalpa	Lomas Alegres 2a Seccion
53	Iturbide Dominguez	Tacotalpa	Pochitocal 1a Seccion
54	Jose Maria Calcaneo Perez	Tacotalpa	Xicotencatl
55	Juan Galicia Diaz	Tacotalpa	Santa Rosa
56	Miguel Angel Santos	Tacotalpa	San Miguel Juarez
57	Noe Gonzalez Dominguez	Tacotalpa	Xicotencatl
58	Omar Narvaes Cruz	Tacotalpa	LomasAlegres 1a Seccion
59	Onorio Custodio	Tacotalpa	Lazaro Cardenas
60	Ortelio Sandoval Hernandez	Tacotalpa	Jose Ma Morelos, lomas alegres 2ª Seccion
61	Ovidio Dominguez	Tacotalpa	Lazaro Cardenas
62	Samuel Alejo Reyes	Tacotalpa	El Ular

AQUACULTURE PROFESSIONALS INTERVIEWED

Institution	SEFOE	SEMARNAT	Municipal Development	Private Sector and Academics
Senior Office Staff	2	2	1	2
Junior Office/Field Staff	8	2	1	0
Technicians	2	0	0	0

APPENDIX II

Questionnaire

Code Number ☐

Name____

Address____

____

Sex:
Male..................1
Female...............2

Age__________

Literacy
Yes....................1
No.....................2

Records of calls

	Date	Day of the week	Time	Outcome and notes
1				
2				
3				
4				
5				

Accommodation type

Modern house..........................1

Brick and asbestos house.............2

Standard house*.......................3

Thatched roof house or
Wood wall with corrugated zinc or
asbestos roofs ... 4
Thatched house........................5

Property size

no property................1

lot (< 1000 m^2).............2

< 4 has......................3

5 - 10 ha 4

11 – 20 ha 5
< 21 ha 6

Pond Location

On the house yard..........................1
On the plot.............. 2
The house is on the plot 3

* Brick made with corrugated zinc roof. Two bedrooms and living room – dining room area. Toilette at the yard and kitchen made of palm leaves.

Questionnaire

1. When was the last time you stocked fish in the pond?

2. How did you get the idea to start practicing fish farming?

3. How many cycles have you run?

4. If you've run more than one cycle, have the fish yield risen?

5. With whom did you work?
   Alone
   With my immediate family
   With my relatives
   As a co-operative
   Other (specify)

6. How large is your pond(s)?

7. How much fish did you harvest last cycle?

8. Are you happy with the results?

9. How much do you think your pond should yield?

10. Do you feed your fish?

    No (go to question 13)
    Yes

11. What on?
    Grains (indicate which ones)

    ____

    Commercial feed (indicate which one, where it is purchased and how much it costs)

    ____

    By-products (indicate which ones)

    ____

12. How?
    Scatter
    With feeding trays
    Other (specify)

    ____

    Frequency amount
    Daily
    Weekly
    Bimonthly
    Monthly
    Whenever necessary (say frequency)

13. Do you use fertilizers in your pond?

    No (go to question 15)

Yes commercial (indicate which ones)

____

____

Manures (indicate which ones)

____

____

14. How?

In bags (slow release)
Scattered
Dissolved

Frequency
Daily (indicate how much)
Weekly (state amount)
Bimonthly (state amount)
Monthly (state amount)
Whenever necessary (state frequency and quantity)

15. Did you remove predator fish before introducing the fry?

No (why?)
Yes

16. How many fish did you put in your pond?

17. How did you stock them?

18. Where did you bring them from?

19. Did you receive any type of support to carry out fish farming?

No (go to question 21)
Yes From whom?
The government
Other (specify)

____

____

20. What type of support?

Transport
Bags
Oxygen
Fish feeds
Training
Advice
Accessories
Loan of fishing equipment
Commercialisation
The fry
Pond construction
Other (specify)

____

____

21. How do you harvest?

Fishing method with nets with rod

In one go
Regularly

22. If using nets, to whom do they belong?

Me
Hired (indicate from whom)
Borrowed (indicate from whom)

23. What do you do with the fish that you harvest?

I eat them (go to question 28)
I sell them (go to question 24)
Both

24. What proportion of the harvest do you sell?

25. To whom is it sold?

26. What's the price per kilo?

27. Have you had problems with fish farming?
No
Yes

The birds eat the fish
The fish don't grow
The pond dried up
The pond flooded and the fish escaped
Inadequate nets
No-one to help
Stolen
Could not catch required fish, but caught other types and turtles.
Inadequate knowledge of how to farm the fish
Other

28. Do you think solutions can be found to these problems?

Yes How?
No Why?

29. Who takes charge of the fish farm?

30. Apart from fish farming, for what else do you use the pond?

31. Do you know of any other person or group who has practiced fish farming?

32. Do you think that this succeeds or fails?

33.Do you like eating fish?
No
Yes_____How big?

34 When was the last time that you ate fish?

35 How did you cook the fish?

36How often and how much fish do you eat?

37 Which other types of livestock do you raise and who looks after them?
None (go to question 39)
Unimproved chickens
Fast growing chickens
Pigs
Lambs
Livestock

Rabbits
Turkeys
Ducks
Geese
Other (specify)

38. What do you feed them?

Scraps
Maize
Balanced nourishment
Other (specify)

39. Do you have family allotments and who looks after them?

No (stop)
Yes
Vegetables (specify)

Fruits (specify)

Grains (specify)

Pulses (specify)

40 To whom does the pond belong?
To me
To an immediate family member
To a relative
To a co-operative
To an acquaintance
I rent it

41. Do you have any off-farm job?

42 How much do you earn per month?

43 Who is the householder?

44. What is your relationship with him / her?

45. How many people live here and what is their relationship?

46 will you farm fish again?

Cuestionario

1. ¿Cuándo fue la ultima vez que crió peces?

____

2. ¿Quién le dijo o como tuvo la idea de criar peces?

____

3. ¿ Cuantas veces lo ha hecho?

Una vez
Dos veces
Tres veces
Cuatro veces
Mas de 5 veces

4. ¿Si ha sido mas de una vez, ha mejorado su rendimiento desde entonces?
Si
No

5. ¿Con quien ha criado pescado?
    Solo (a)
    Con la familia
    Con Parientes
    Se formo un grupo de produccion
    otro (especifique)

____

____

6. ¿De que tamaño son o eran sus estanquea?

	Estanque 1	Estanque 2	Estanque 3	Estanque 4
Dimensiones				
Superficie en M2				

7. ¿Cuanto cosecho la ultima vez? (indicar tamaño)

____

8. ¿Cómo cree que le fue?
    Muy bien
    Bien
    Regular
    Mal
    Muy mal

9. ¿Cuánto cree que su estanque pueda rendir?

____

10. ¿Alimenta a sus pescados?

No (pase a la pregunta 13)

Si

11. ¿ Con que?
    granos (indique cual)

Alimento comercial (indique cual, donde lo consigue y cuanto cuesta)

Desperdicios (indique cuales)

12. ¿Como?
    al boleo
    en comederos
    otra (especificar)

Frecuencia	Veces	cantidad
Diario		
Semanal		
Quincenal		
Mensual		

de vez en cuando (indique frecuencia y cantidad)

13. ¿ Abona su estanque?

No Porque?

Porque no sabia que fuera útil
Porque no tengo tiempo
Porque es mucho trabajo
Otras razones ______
(pase a la pregunta 15)

Si comercial (indique cual)

abonos (indique cual)

14. ¿Como?
    En bolsas
    al boleo
    Disuelto
    Otra ______

Frecuencia	Veces	cantidad
Diario		
Semanal		
Quincenal		
Mensual		

de vez en cuando (indique frecuencia y cantidad)

____

15. ¿Saco todo el pescado criollo antes de meter su pescaditos?
No Porque?
Porque no sabia que fuera útil
Porque no tuve tiempo
Porque no tuve quien me ayudara
Porque era mucho trabajo
Porque el estanque era nuevo
Otras razones ____

si

16. ¿Cuanto pescado puso en su estanque?

Especie	
Numero	
Tamaño	
Densidad en m2	

17. ¿Cómo los puso?
Directamente
Aclimatados

18. ¿De donde los trajo?

____

19. ¿Recibió algún apoyo para llevar a cabo el cultivo?
No (pase a la pregunta 17)
Si De quien?
El gobierno
Otro (especificar)

____

____

20. ¿Que tipo de apoyo?

Transporte de las crias	
Bolsas	
Oxigeno	
Alimento	
construcción del estanque	
obtención de la cría	
Capacitación	
Accesoria	
préstamo de equipo de pesca	
Comercialización	
otro (especificar)	

21. ¿Cómo realiza la cosecha?

Arte de pesca	Chinchorro	Tarraya	Anzuelo
De una sola vez			
Periódicamente (mencione en cuantas tandas)			

22. si utiliza red, ¿a quien pertenece?

Propia	
Prestada	

Rentada	

Oberservaciones____

23. ¿Que hace con el pescado que produce o para que pensaba utilizarlo?
    lo consume (pase a la pregunta 27)
    lo vende (pase a la pregunta 24)
    lo consume y lo vende

24. ¿De toda la cosecha cuanto consume y cuanto vende?
____

25. ¿A quien se lo vende?

A mis vecinos
Lo llevo al mercado
A un intermediario

26. ¿a como vende el kilo?
____

27. ¿Ha tenido problemas en la crianza?
No
Si
    Se los comieron los pájaros
    Los peces no crecieron
    El estanque se seco
    El estanque se inundo y los peces se escaparon
    No pude cosecharlos todos
    No tenia redes adecuadas
    No tuve quien me ayudara
    Me los robaron
    No salió casi el pez que crié, pero capture otros diferentes y tortugas.
    Creo que me falto conocimiento sobre como hacerle
    Se metieron cocodrilos
    Otro____

28. ¿Cree que estos problemas se puedan solucionar?
Si Como?
____

No ¿Porque?
____

Otro ____

29. ¿Que es lo que hace cada quien en el cultivo?
El Esposo
La esposa
Los hijos
Las hijas
Otros

30. ¿Aparte de la crianza de peces, para que otra cosa utiliza su estanque?
Para almacenar agua
Para criar patos
Para recreación
Para que beba el ganado
Para regar mi huerto durante la seca
Otro ____

31. ¿Conoce alguna otra persona o grupo que también crié pescado?
____

32. ¿Cree usted que esa persona esta teniendo éxito o fracasando?
éxito
Fracaso
No se

33. ¿Le gusta comer pescado?
no
Si____ De que tamaño?______________

34. ¿Cuándo fue la ultima vez que comió pescado? (no necesariamente del cultivado)
Hace unos días
LA semana pasada
El mes pasado
Hace dos meses
Hace tres meses
Hace 6 meses
No se acuerda

35. ¿Cómo guisa el pescado?
Frito
En caldo
Asado
Otro ____

36. ¿Que tan seguido lo come y en que cantidad?
Diario
Semanalmente
Quincenalmente
Mensualmente
Cada dos meses
Cada tres meses
Cada seis meses
Cuando hay
Cuando esta barato
Otro ____

37. ¿Que otros animalitos cría en su casa? NumeroEncargado Propósito

	Numero	Encargado	Propósito
ninguno (pase a la pregunta 51)			
Gallina y pollo de rancho	_______	__________	__________
Gallina y pollo de granja	_______	__________	__________
Puercos	_______	__________	__________
Borregos	_______	__________	__________
Ganado	_______	__________	__________
Conejos	_______	__________	__________
Pavos	_______	__________	__________
Patos	_______	__________	__________
Gansos	_______	__________	__________
Otros (especificar)			

____
____

38. ¿Que les da de comer?
desperdicios
maíz
alimento balanceado
otra cosa (especificar)
____
____

39. ¿Tiene huerto familiar y/o otros cultivos?
No (no continuar)

Si	Hortalizas (especificar)	Encargado/a	Propósito
	____________	____________	____________
	____________	____________	____________
	Frutas (especificar)		
	____________	____________	____________
	____________	____________	____________
	Granos (especificar)		
	____________	____________	____________
	____________	____________	____________
	Leguminosas (especificar)		
	____________	____________	____________
	____________	____________	____________

40. ¿A quien pertenece el estanque?
- Al entrevistado/a
- A un familiar
- lo rento
- A un pariente
- A un miembro del grupo de produccion
- A un conocido

41. ¿Tiene otro trabajo aparte de su parcela?
Agricultura
Ganadería
Soy jornalero
Pesca
Otro

42. ¿Quién es el o la jefe de la familia?

____

43. ¿Que es el / ella de Usted?
Esposo
Esposa
Padre
Madre
Hijo/ja
Tio/a
otro____

44. ¿Cuantas personas viven aquí y cual es su parentesco?
____
____
____

45. ¿Volvería a intentar el cultivo otra vez?

Si
No

Observaciones