TECHNOLOGY TRANSFER FOR COMMERCIAL AQUACULTURE DEVELOPMENT IN VERACRUZ, MEXICO

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by

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Declaration

I hereby declare that this thesis has been composed entirely by myself and has not been submitted in any previous application for a degree. The nature and extent of any work carried out by, or in conjunction with, others has been specifically acknowledged by reference.

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"If the word *progress* signifies anything, it means the more general diffusion of wellbeing, or, in other words, the placing within reach of the people at large what was formerly accorded to the favored few".

T. Esquivel Obregón
from *Factors in the historical evolution of Mexico*, 1919

Dedication

To María Antonieta, my mother (1942-2008). An always loving, inspiring and motivating person; lifelong example and support.

To the memory of Alberto, my father (1929-1997), who since the early 1950s intuitively visualized in aquaculture and tourism a real and sustainable possibility to improve the livelihoods of the Mexican tropics' population, and through the Papaloapan Commission enthusiastically promoted the introduction of tilapia into the country.

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Abstract

This work presents results of the research project *Technology Transfer for Commercial Aquaculture Development in Veracruz, Mexico*, conducted during 2001-2006 and whose overall aim was to achieve a better understanding of the different processes involved in technology transfer and extension in Veracruz, and their role in tilapia culture development in terms of characteristics, intensity and direction. Data and information were collected by personal interviews and through participant-observation techniques. The most relevant regional initiatives that have promoted tilapia farming were analyzed, as well as the current key actors of aquaculture development and their roles. 142 tilapia farmers were also typified and closely monitored. Dissemination and adoption of technical information regarding tilapia culture were evaluated through the development and use of a Technology Level Index (*TLI*). Findings revealed that the tilapia sector in Veracruz is diverse and immersed in a rather complex arena, where policy and finance issues, and the role of demand, linked in with market chains and their functioning are major determinants of further expansion. Farm producers were sharply differentiated by production size, degree of commercialisation, experience in production, and access to assets. Most entrants were the result of social development interventions with significant level of subsidy, which often resulted in low levels of productivity and high abandonment rates. However, for the most vulnerable groups, tilapia culture apparently provided a way to diversify their livelihood portfolio. Availability of local knowledge and expertise appeared to enhance and stimulate the dissemination and adoption of tilapia farming technology, and hence human capital. Private sector and collective action are likely to play an increasing and decisive role in the direction of the industry, while people-oriented and participative approaches are likely to be the best way to deliver technical information to small-scale farmers, and maintain good equity of access and opportunity. Methodologically, *TLI*s proved to be useful in the quantification and evaluation of technological change. Moreover, the Sustainable Livelihoods framework provided an adequate platform for understanding the needs of specific groups, particularly in terms of vulnerability and policies, institutions and processes.

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Acronyms

ADB	Asian Development Bank
ADCP	Aquaculture Development and Coordination Programme (FAO)
AIT	Asian Institute of Technology (Bangkok, Thailand)
ASERCA	Supports and Services for Agricultural Marketing (Mexico)
AVAC	Veracruz Aquaculture Association (Mexico)
BRAC	Building Resources Across Communities (NGO, Bangladesh)
CARE	Cooperative for Assistance and Relief Everywhere (International NGO)
CARITAS	International NGO
CEPAL (ECLAC)	Economic Commission for Latin America and the Caribbean.
CETAC	Technologic Centre for Continental Waters Studies (Mexico)
CETMAR	Technologic Centre for Marine Studies (Mexico)
CETRA	Centre for Aquaculture Technology Transfer (Tabasco, Mexico)
CIBIOGEM	Inter-Secretarial Commission on Biosafety and Genetic Modified Organisms (Mexico)
CICOPLAFEST	Inter-Secretarial Commission for the Control of the Processing and Use of Pesticides, Fertilizers and Toxic Substances (Mexico)
CNA	National Water Commission (Mexico)
CNIE	National Commission of Foreign Investment (Mexico)
CODEPAP	Papaloapan Development Council (Mexico)
COLPOS	Colegio de Postgraduados - Campus Veracruz (Mexico)
COMEPESCA	Mexican Council for the Promotion of Fish and Aquaculture Products
CONABIO	National Commission for the Knowledge and Use of Biodiversity (Mexico)
CONACYT	National Council of Science and Technology (Mexico)
CONAPESCA	National Commission on Aquaculture and Fisheries (Mexico)
CONAPO	National Population Council (Mexico)
COSAP	Veracruz Aquaculture and Fisheries Health Committee (Mexico)
CP Group	Charoen Pokphand (Thailand/Taiwan)
DANIDA	Danish International Development Agency
DFID	Department for International Development (UK)
DGECTM	General Office of Education in Science and Marine Technology (Mexico)
DGIE	General Office of Foreign Investment (Mexico)
DOA	Department of Aquaculture
DOF	Department of Fisheries
ECLAC	Economic Commission for Latin America and the Caribbean
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
ETL	Expected Technological Level
EU	European Union
FAO	Food and Agriculture Organization of the United Nations

FCH	Chile Foundation
FINAN	Rural Trust (Mexico)
FIRA	Funds Instituted in Relation to Agriculture (Mexico)
FIRCO	Shared-Risk Trust (Mexico)
FOCIR	Capitalization Fund for Rural Development (Mexico)
FONAES	National Fund to Support Solidarity Enterprises (Mexico)
FONAFE	National Fund for Financing State Enterprise Activity (Mexico)
GCPS	Simultaneous Growth Production Groups
GDP	Gross Domestic Product
GGAVATT	Livestock Groups for Technology Validation and Transfer
GMO	Genetic Modified Organism
HACCP	Hazard Analysis and Critical Control Points
HDI	Human Development Index
ICID	International Commission on Irrigation and Drainage
IDS	Institute of Development Studies (UK)
INCMNSZ	National Institute of Medical Sciences and Nutrition Salvador Zubirán (Mexico)
INE	National Electoral Institute (Mexico)
INEGI	National Institute of Statistics, Geography and Informatics (Mexico)
INIFAP	National Institute of Forestry, Agricultural and Livestock Research (Mexico)
INP	National Fisheries Institute (Mexico)
INVEDER	Veracruz Development Institute (Mexico)
IPCC	Intergovernmental Panel on Climate Change - UN
ISTA 7	Seventh International Symposium on Tilapia in Aquaculture
ITBOCA	Boca del Río Technologic Institute (Veracruz, Mexico)
ITMAR	Former Technologic Institute of the Sea (Veracruz, Mexico 1981-2005)
MAEP	Mymensingh Aquaculture Extension Project
MAP	Mexico Aquaculture Project
MIRNZB	Lowlands Integrated Natural Resource Management
NACA	Network of Aquaculture Centers in Asia-Pacific
NAFTA	North America Free Trade Agreement
NGO	Non-Governmental Organization
NOMs	Official Mexican Standards
ODA	Overseas Development Administration (UK)
ODI	Overseas Development Institute
OECD	Organization for Economic Cooperation and Development
OEIDRUS	State Information Office for Sustainable Rural Development (Veracruz, Mexico)
OMP	Optimal Management Practice
PAN	National Action Party (Mexico)
PD	Percent of Dissimilarity
PIP	Policy, institutions and processes dimension of the SLA
PNUD	United Nations Development Programme
PRA	Participatory Rural Appraisal

PRI	Institutional Revolutionary Party (Mexico)
PRODUCE	State Agricultural Development Foundation (Veracruz, Mexico)
PROFEPA	Federal Attorney General for Environmental Protection (Mexico)
PSSM	Sierra de Santa Marta Project (NGO, Mexico)
R&D	Research and Development
RRA	Rapid Rural Appraisal
SAGARPA	Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (Mexico)
SARH	Former Secretariat of Agriculture and Hydraulic Resources (Mexico)
SECODAM	Secretariat of Administrative Development and Control (Mexico)
SEMARNAP	Former Secretariat of the Environment, Natural Resources and Fisheries (Mexico)
SEMARNAT	Secretariat of Environment and Natural Resources (Mexico)
SENASICA	National Service of Food Quality and Health (Mexico)
SEP	Secretariat of Public Education (Mexico)
SHCP	Secretariat of the Treasury and Public Credit (Mexico)
SIGOLFO	Regional Office of CONACYT (Veracruz, Mexico)
SLA	Sustainable Livelihoods Approach
SNI	National System of Researchers (Mexico)
SPARK	Sharing and Promotion of Awareness and Regional Knowledge
SSA	Secretariat of Health (Mexico)
STREAM	Support to Regional Aquatic Resources Management
SWOT	Strengths, Weaknesses, Opportunities, and Threats Analysis
T&V	Training and Visit
TLI	Technological Level Index
ToT	Transfer of Technology
TVA	Tennessee Valley Authority
UK	United Kingdom
UNDP	United Nations Development Programme
USA / US	United States of America

SECTION ONE: CONTEXT AND SCOPE

CHAPTER ONE: BACKGROUND

1.1 Introduction

This work[1] is an attempt to obtain a better understanding of the different processes involved in technology transfer and extension in Veracruz, Mexico, and their role in tilapia culture development in terms of characteristics, intensity and direction. The next section provides the rationale and justification of the thesis. It is followed by an overview of the national aquaculture scenario and the status of tilapia culture in the State of Veracruz. In sections three and four, the main technology transfer paradigms and their impact on rural and aquaculture development are examined. Finally, the research questions that synthesize the scope of the work and the study hypotheses and objectives are presented in section five.

Within the national context, Veracruz is one of the most privileged states in terms of natural resource assets. Its potential to achieve social and economic progress is enormous and has been recognized by the society and government since colonial times[2]. Actually, the base of natural resources in the region is so prodigious that it enabled the development of one of the great civilizations of the ancient times: the Olmecs.

However, despite this potential and after a number of development initiatives implemented over the past sixty years, Veracruz is now amongst the last placed

[1] The author has been close witness of all initiatives intended to disseminate tilapia aquaculture in Veracruz since the introduction of the species into the country. From the early 1980s onwards, the author was also directly involved in all initiatives presented and discussed all along the thesis.

[2] After the fall of Tenochtitlan (capital of the Aztec empire) in 1521, and for the next three hundred years, Mexico became a Spanish colony. However, it was not until the end of the Mexican Revolution, and with the promulgation of the Constitution of 1917, that many of the existing Institutions of the contemporary Mexico were created and a “new colonization” of the tropics began.

nationally in terms of main indicators of development and well-being (PNUD, 2003). The conditions in which a high percentage of the population lives are shocking: acute malnutrition in many municipalities, illiteracy, lack of basic public services, houses without minimum hygiene conditions, isolation, high unemployment rates –especially in rural areas–, and a great sector of the population with very low remuneration, which originate that hundreds of thousands of families have an income below the minimum required to satisfy their fundamental necessities. In short, there are factors in Veracruz that make possible a vicious circle of poverty, including extreme poverty[3]. Furthermore, diverse indicators suggest that this situation, instead of declining, could be increasing (Sanchez-Gil et al. 2004; Gobierno del Estado de Veracruz, 2005).

In 1964, as an element of one of the biggest and most ambitious regional development programmes ever implemented in the country, the farming of tilapia was introduced as a potential development option[4]. The aim was to improve the livelihoods of the rural inhabitants of the tropics, particularly of those affected by the construction of a large dam over the Papaloapan River.

Although tilapia farming is a relatively new practice in Mexico, it has been playing an increasing role in securing food supply, employment and income generation for a large

[3] Within the national context, a distinction between moderate and extreme-poverty is often required. The moderately-poor lack some goods and services that given the country's wealth everybody should enjoy. The extremely-poor have such low resources as to be at risk of under-nourishment, with higher morbidity and potential anthropometric deficiencies. In Mexico, the extreme-poverty line is 1.25 times the monetary value of a standard food basket, which would provide 2 082 calories and 35.1 grams of protein per day per adult (Levy, 1991).

[4] The Papaloapan Commission (Comisión del Papaloapan) was a federal entity created in order to plan, design and build the required infrastructure for the integral development of the Papaloapan River hydrographic basin, which comprises part of the states of Veracruz, Oaxaca and Puebla and covers an area of 46 500 km^2. Inspired in the Tennessee Valley Authority (TVA) model, the Papaloapan Commission was the first regional development programme of its kind in the country and remained in functions from 1947 to 1986. The author's father was promoter of the aquaculture initiative and responsible for its operation during the first 10 years. Further details are presented in Chapter four.

sector of the population. The current status of tilapia culture in Veracruz –and in the rest of the country– is the result of a number of extension and technology transfer programmes that have been traditionally financed and provided by the State. In the beginning, they aimed to disseminate the species in reservoirs and water bodies all along the country to improve the livelihoods of the rural population. Later on, the aim was to deliver information and different culture technologies to new entrants in order to diversify primary sector opportunities and intensify production. Despite the remarkable overall results of extensive tilapia production systems over the past forty years, most development programs intended to intensify the activity failed to meet expectations, and in some cases it was unclear whether they had any impact at all. Apparently, technical issues and lack of new knowledge have not been the major constraints, but instead were probably social, cultural, political and economical factors.

On the other hand, in the agricultural sector there are a number of innovative and productive experiences taking place in rural communities across Mexico which blend traditional values with modern technology and marketing (Blanco, 1998; Ramos, 1998; Santos et al. 1998; Robles and Almeida, 1998; Alemán, 1998; Jiménez et al. 1998; Pérezgrovas et al. 1998; García et al. 1998; Quiñones et al. 1999; Olguín et al. 1999; Klooster and Masera, 2000; Martínez, 2001; Morales et al. 2004; Aguilar, 2005; Escobar et al. 2005; Romero, 2005; Mendoza et al. 2005). Many of these models are the result of partnerships between rural communities and non governmental organizations. In general terms, communities provide internal reflection, labour and organising efforts; while the partner has provided participatory planning techniques, seed capital, or technical advice and marketing assistance. These are probably not complete top-down or bottom-up schemes, but something in the middle, and their successes can be characterised by the following features:

- They improve livelihoods while retaining cultural values;
- They help preserve important natural resources;
- They frequently include the provision of seed capital which may be more effective than the provision of credit and/or that of a full subsidy;
- They provide new models for resource management that have lessons for other areas.

There are common elements in these success stories that might be applied by the government and other development agencies to promote further aquaculture growth. This, however, would require a fundamental change in perspective by development agencies and agents as well as modified time frames and indicators for measuring performance and impact.

Despite the fact that technology transfer and extension have been recognized as key factors for achieving additional aquaculture growth (Edwards, 1999; Engle and Stone, 1990; FAO, 1997), little efforts have been made to understand the nature and role of these topics on tilapia aquaculture development, particularly in tropical Mexico.

1.2 National aquaculture scenario and status of tilapia culture in Veracruz

Official statistics suggest that Mexican fisheries production has reached its maximum sustainable limit. Table 1.1 shows national fisheries and aquaculture production during the period of 1983-2003. It could be expected that, if a strict national fisheries strategy is implemented, captures in Mexican waters will be able to maintain their present levels.

Nevertheless, evidence also suggests that many fisheries resources have surpassed their sustainable limits by overexploitation, and therefore, in the short term, captures may fall (INP, 2006). However, it can also be observed in Table 1.1 that by 2003, aquaculture contributed more than 13% to national fisheries production, reaching an annual output of over 200 000 tonnes. In fact, the annualized growth rate of aquaculture over this period was 4.5%, compared with 2.0% achieved by capture fisheries. Furthermore, in Mexico, aquaculture is the area of the primary sector with the highest rate of annual growth, even superior to the population growth and that of the entire national economy (SAGARPA, 2001).

Table 1.1. National fisheries and aquaculture production (period 1983-2003).

Year	Total production (metric tonnes)	Fisheries (metric tonnes)	Aquaculture (metric tonnes)
1983	1,075,547	966,486	109,061
1984	1,134,592	990,553	144,039
1985	1,255,888	1,122,579	133,309
1986	1,357,000	1,205,876	151,124
1987	1,464,841	1,290,456	174,385
1988	1,394,843	1,210,504	184,339
1989	1,519,882	1,338,185	181,697
1990	1,447,143	1,256,206	190,937
1991	1,453,276	1,281,868	171,408
1992	1,246,425	1,077,029	169,396
1993	1,191,600	1,021,404	170,196
1994	1,260,019	1,088,630	171,389
1995	1,404,384	1,246,810	157,574
1996	1,530,023	1,360,812	169,211
1997	1,570,586	1,396,708	173,878
1998	1,233,292	1,073,511	159,781
1999	1,286,107	1,119,771	166,336
2000	1,402,938	1,214,780	188,158
2001	1,520,938	1,324,215	196,723
2002	1,554,452	1,366,967	187,525
2003	1,564,966	1,357,190	207,776

Sources: FAO (2002); CONAPESCA (2003).

Altogether, the fisheries and aquaculture sectors in Mexico were estimated to generate 350 thousand direct and 2.3 million indirect jobs, or 1.3% of the working population and contribute 0.7% of the total Gross Domestic Product (INEGI, 2000; SAGARPA, 2001). Moreover, the official sector has estimated that during the next 10 to 15 years the contribution of aquaculture to the national fisheries production will exceed 40% (SAGARPA, 2001; CONAPESCA, 2003). However, unless adequate human and institutional capacities are effectively developed –and thus productive and profitable outputs achieved– it remains uncertain that the expected target could be reached.

Aquaculture production in Mexico predominantly consists of tilapia, shrimp, oyster, and carp, as well as a few other minor species (Table 1.2). Out of the total national aquaculture production, tilapia farming represents a little over 30%. However, if only freshwater aquaculture is considered, tilapia is by far the most important species, accounting around 70% of all farmed aquatic resources.

Table 1.2. National aquaculture production by species (2003).

Species	Production (metric tonnes)	Percentage (%)
Tilapia	67,180	32.3
Shrimp	62,361	30.0
Oyster	48,291	23.2
Carp	22,189	10.7
Trout	3,734	1.8
Catfish	2,516	1.2
Bass	848	0.4
Chirostoma spp	614	0.4
Prawn	43	0.0
TOTAL	207,776	100.0

Sources: FAO (2002); CONAPESCA (2003).

Since 1964, several tilapia species have been introduced in Mexico as part of different development programs (Morales-Díaz, 1991; Barriga-Sosa et al. 2004). Figure 1.1 shows the evolution of tilapia's national production.

After forty years since its introduction, Mexico produces more tilapia than any other country in the Americas (Fitzsimmons, 2000a) and practically all the production is absorbed by internal markets. By 2004, tilapia *per capita* consumption reached around 0.8 kg person^{-1} year^{-1}, nearly 9% of national *per capita* fish consumption, estimated at 8.7 kg person^{-1} year^{-1} (FAO, 2002; CONAPESCA, 2003; INCMNSZ, 2003).

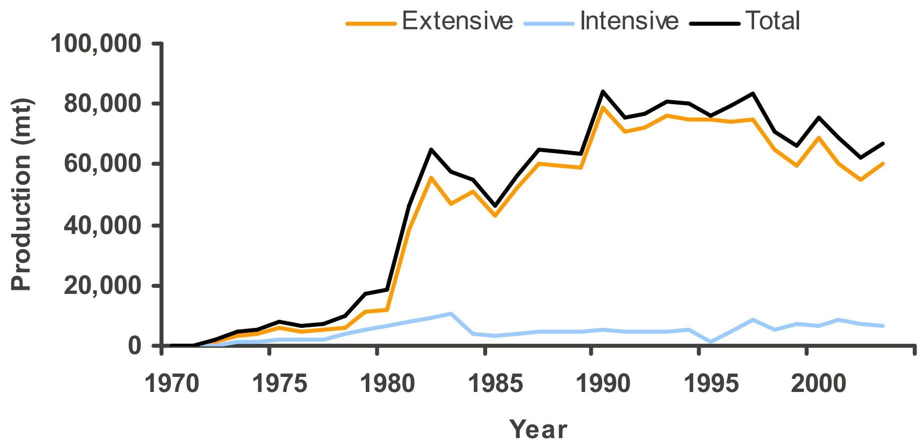


Figure 1.1. National tilapia production (period 1971-2003). Sources: Morales-Díaz (1991); FAO (2002); CONAPESCA (2003).

In Mexico, almost all tilapia is cultured under extensive methods, through capture from reservoirs stocked with fingerlings. Approximately 68 million fingerlings are produced every year in 25 governmental hatcheries located in different parts of the country in order to achieve this target (INE, 2000; CONAPESCA, 2003). However, more intensive systems (including ponds and cages) are becoming more popular. With its large domestic demand, proximity to US markets, and enormous water resources, a significant growth of tilapia aquaculture in Mexico is expected (Fitzsimmons, 2000b).

Tilapia is cultured practically all around the country. However, Veracruz is the leading producer state; its 20 000 tonnes per year contributing around 30% of the national total (Table 1.3). Most of this is also produced in extensive systems. To support this, four governmental hatcheries located within the State produce and deliver approximately 8.2 million fingerling every year (CONAPESCA, 2003).

Table 1.3. National and Veracruz State tilapia production (period 1991-2003).

Year	National production (metric tonnes)	Veracruz production	
		(metric tonnes)	(percentage)
1991	75,174	15,230	20.3
1992	76,964	16,398	21.3
1993	80,635	22,759	28.2
1994	80,463	22,032	27.4
1995	76,128	22,267	29.2
1996	79,154	21,866	27.6
1997	83,132	26,876	32.3
1998	70,576	27,055	38.3
1999	66,366	23,082	34.8
2000	75,498	21,393	28.3
2001	69,181	21,999	31.8
2002	62,172	19,836	31.9
2003	67,180	17,580	26.2

Source: CONAPESCA (2003).

Tilapia culture in these extensive systems is generally conducted in medium to large ponds or reservoirs and fish production relies merely on the natural productivity of the water body. Externally supplied inputs are limited, costs are kept low, capital investment is restricted and the quantity of fish produced per unit area is also low. However, returns on labour are normally high.

Intensive culture systems, on the other hand, imply that the quantity of fish produced per unit of rearing area is higher. As production intensity increases, factors such as water quality, feed and quality of stocked fingerlings are controlled with the purpose of improving production conditions. There is continued management oversight during the production cycle and the returns should justify the increased production costs.

Two major intensive production systems dominate the tilapia scenario in Veracruz:

- Land-based systems, which comprise earth ponds, concrete tanks and other facilities built on dry land, are the most common of all aquaculture systems. Their diversity in terms of size, shape and water management regimes are enormous, to the extent that it is difficult to immediately identify a model that reflects the production systems in the area.
- Water-based systems, which include enclosures and cages, are usually located in inland waters. Enclosures are formed by closing off a natural water body, where the shoreline forms all but one side and access to open water is closed off by a net or mesh barrier. Cages are enclosed structures floating on the water surface and are made from poles, mesh and netting.

Up to date official data indicate that 454 production units grow tilapia in Veracruz (OEIDRUS, 2007). However, the Veracruz Aquaculture Association (AVAC) estimates that the number of active production units is at least 2 000 (Reta-Mendiola et al., 2005b). In any case, the majority correspond to small-scale farms disseminated all along the State, most of them in rural and remote areas. The typology of farmers and their production units will be explored in Chapter five. The interaction amongst farmers and the ways in which the technological knowledge is disseminated and taken up is the core subject of Chapters six and seven. In Appendix 1, a graphic overview of the main production systems in the region is presented.

Despite the overall positive contributions to society and the economy during the past forty years, tilapia farming results in Mexico are still far below its actual potential to increase production in a more sustainable way and thus to contribute to food security and rural development not only in Veracruz, but also throughout the country.

Empirical evidence shows a variety of forms in which the farmers, members of rural communities, extension and other development personnel, researchers, and staff of commercial or public service and support organizations interact (Swanson et al. 1997). Technology transfer services are important elements within this array of market and non-market entities and agents that provide human capital-enhancing inputs, as well as flows of information that can improve farmers' and other rural people's welfare (Anderson and Feder, 2003). Within this context, the key issues with respect to development of tilapia culture in Veracruz would appear to be closely related to the processes by which knowledge is developed and taken up, translated into effective choice and productive, profitable output. As will be developed in this thesis, deficiencies in this process may be at the root of the tilapia sector's disappointing results, and if these could be identified and addressed, its potential might be better realised.

1.3 Technology transfer paradigms and their impact on rural development

1.3.1 Preliminary remarks

According to Rogers et al. (2001), technology is information that is put into use in order to accomplish some task. Transfer is the movement of technology via some communication channel from one individual or organization to another. A technological innovation is an idea, practice or object that is perceived as new by an individual or some other unit. Therefore, technology transfer is the application of information (a technological innovation) into use. So technology transfer is a special type of communication process (Leeuwis and Van den Ban, 2004).

Dissemination involves strategic efforts to get information about innovations out to individuals, organizations and communities, and to help them wrestle with the complex challenges of getting that information used to create change in the real world (Backer, 2000).

Because of the parallels between them, some technology transfer approaches have been linked to communication theories. Murray (2000) points out that communications theory in the Shannon and Weaver model (Shannon, 1948) involves the transfer of information from a sender to a receiver, while technology transfer involves the transfer of such technology or practices from senders to receivers. The receivers in both cases are constructed as essentially passive and relatively powerless. This way of conceiving communication is one of the "traditions" that is suggested as disempowering and destructive to the development of new approaches to extension.

Productivity improvements are possible only if a differential exists between the actual productivity on the farms and what could potentially be produced with better know-how, subject as always, to farmers' preferences and resource constraints. In the agricultural context, for which tilapia farming can be seen as an example, extension can be defined as helping to reduce the differential between potential and actual yields in farmers' fields by accelerating technology transfer (i.e. to reduce the technology gap) and helping farmers become better farm managers (i.e. to reduce the management gap) (Anderson and Feder, 2003).

Rivera and Qamar (2003) noted that the public sector has a continuing and unique role in promoting rural development through extension/communication services.

Governments are well placed to promote increased institutional pluralism in extension service provision and oversee the quality enhancement and assurance necessary for rural development.

A number of technology transfer schemes have been developed and implemented worldwide with different degrees of success during the last century. Each have behind them a theoretical background and can be analysed from various angles. In general, however, two main approaches can be easily recognized: conventional *top-down* schemes; and the alternative, participative *bottom-up* approaches. The line that divides them is sometimes not very easy to draw and there are numbers of variants between these two extremes. Nevertheless, these two major paradigms will be adopted as the cornerstone of the subsequent arguments along the dissertation. A brief description of each is presented next, as well as some of their pros and cons and various examples of their performance.

1.3.2 Conceptual elements

Adoption can been explained in economic terms (the profitability of the investment), in sociological terms (the social rewards associated with adoption and the nature of communication channels), in geographical terms (spatial differences in resource endowment), and in anthropological terms (the compatibility of the innovation with the norms of the society) (Boahene et al. 1999).

Innovation adoption is a multi-dimensional process incorporating elements such as perceived relative profitability (or attractiveness), costs of establishment (including the ability to bear the investment costs and risks associated with innovating), compatibility with value systems, and the ease of communication, i.e. the ability to convey the innovation to other potential adopters (Boahene et al. 1999).

Farmers and development agents may use very different criteria for determining whether or not particular activities make sound economic sense. The effectiveness of any intervention will depend on the farmer's perception of it within the constraints of the rural economy, rather than on whether the intervention makes economic sense in the abstract. Equally, incentives which may effectively support farmers to adopt new technologies, and make sound sense from the farmer's perspective, may neither be sound for the national economy or financially sustainable within the constraints of the public sector (Dewees, 1995). Therefore, different extension models are needed to address different issues (Christiansen and Hunt, 2000).

The delivery of research findings to stakeholders is no longer the exclusive domain of the extension officer. Responsibility for extension and communications is increasingly being shared more widely amongst research teams. By considering the extension role of a project early in planning phases and consulting with or involving key clients, it is possible to make changes that contribute substantially to the applicability of the research programme (Christiansen and Hunt, 2000). Agriculture cannot be developed without banking on the intelligence, creativity and competence of farmers. Instead of adoption, the emphasis now is on learning. Farmers become experts, not by adopting science-based technologies, but by becoming better learners (Deugd et al. 1998).

The integration of extension and research implies that both have the same mission, and under unified direction this ensures that the transfer of technology is the extension agent's main function, is not inhibited by other non-technological functions and is direct from research to the farmer. It also facilitates essential feed-back from farmer to researcher of the real technological needs (Donovan, 1995). Information on the demand for a new technology can also be gained by examining the stated preferences of nonadopters in response to hypothetical changes in the cost of the technology (Hubbell et al. 2000).

Wadsworth (1995) demonstrated that the efficacy of agricultural extension operations might be improved by utilising a targeting strategy based on some measure of clients' ability to adopt innovations. This was evaluated with Costa Rican livestock producers, where farmers' managerial capacity was used to stratify the population into reasonably homogeneous groups for allocation to different extension regimes. However, there is a lack of understanding of why farmers adopt technology that has led to poor uptake (Sinclair, 2001).

Reardon (1995) found that the investments in innovations by rural households in the semi-arid tropics of Africa have to be relatively cheap and emphasize short-run payoffs. What's more, the impact of agricultural technologies depends on the type of decision-making prevailing in the household (Lawrence et al. 1999). The use of gradual methods in elaborating and managing change, plus farmer participation in the solution-finding dynamic, were crucial factors in the success of the change of farming practices with a view to protecting the environment in France (Gafsi, 1999).

Information is processed and disseminated by a range of heterogeneous intermediaries. The contributions of the public sector in the information networks are demonstrated to be widely recognized, especially by the intermediaries who rely on them (Wolf et al. 2001). Agencies propagating technological innovations and supporting information need to promote communication processes (rather than content) for the whole population within the agricultural system (Frank, 1997).

One of the most difficult obstacles for the transfer of technology is the lack of public understanding of the nature and risk-benefits of the innovation. Therefore, education is a fundamental form of technology transfer (Murrell, 1996). Scrutiny of European farmers' perceptions about integrated farming systems (both economically realistic and environmentally beneficial) reflected an awareness amongst the respondents that the new technology will involve learning new skills and highlighted the need for practical demonstration and on-going extension (Morris and Winter, 1999). Analysing how innovations diffuse through populations, Byrd et al. (1999) found that late adopters or laggards require more intensely persuasive communication for change.

Rockström (2000) discussed some of the challenges facing research and extension of introducing water management practices in smallholder farms in Eastern and Southern Africa. The development challenge involves both bottom-up approaches to ensure ownership by farmers, and the critical issues of land tenure. Additionally, the hidden costs of developing the social relationships that support the diffusion of technical innovations to farmers of indigenous communities is often high (Rice et al. 1998b).

At an international level, the purpose of the transfer of technology is to help developing countries with their economic development and advancement of their domestic technology. Conflict in international diffusion of technology is more likely when an advanced country is exporting technology to a developing country. Pricing of imported technology and its appropriateness are two of the most important issues in transfer of technology to the developing countries mainly because determination of “fair” prices is a difficult and unsettled issue. Moreover, transfer of capital intensive technology of the industrialized countries can create or worsen the dual nature of the developing countries economy and their income distribution (Marvasti, 1998).

Farmers have often been considered as the main constraint to development rather than the potential initiators of a solution. The role of the extension agent in a typical top-down model is to assist farmers in putting the ready-made technology into practice, despite the fact that they may not be appropriate (Hagmann et al. 1999). Besides, evaluations of project success by project staff and beneficiaries vary because they may use different criteria (Pomeroy et al. 1997).

Investment in appropriate agricultural technology can make a difference to farmers in difficult environments, but promotion of unrealistic strategies –either high- or low-tech– simply wastes people’s time and diverts attention from strengthening skills and resources for non-agricultural opportunities (Tripp, 2000). The complex route of interpreting information, recommending agricultural strategies and communicating them through extension agents may thus be largely a waste of time. The direct broadcasting of fairly raw data together with the development of rapid feedback systems between users and producers may be more effective (Blench, 1999).

The diffusion of an innovation across firms often follows a sigmoid (S-shaped) time path with the pace of adoption being slow initially, stepping up later on, and finally tapering off (Sarkar, 1998). Extension usually has maximal impact in the early stages of dissemination of, say, a new technology, when the informational lack of equilibrium (and the "productivity differential") is the greatest. Over time, as increasing numbers of farmers become aware of a specific technological thrust, the impact of such extension diminishes, until the opportunity and need for more information-intensive technologies arise (Anderson and Feder, 2003). A further perspective on this process can be given by epidemic models, which liken technological diffusion to the spread of disease by infection. The number of adopters of an innovation is assumed to increase over time as nonadopters come in contact with the adopters and gather information on the innovation. This model assumes that the rate of increased adoption is a function of the product of the number of uninfected members of a fixed population and the share of that population that is already infected (Sarkar, 1998).

1.3.3 Conventional or top-down approaches

The basis of conventional technology transfer schemes has been the unidirectional flow of information between research services and farmers. A typical example of such schemes is the Training and Visit (T&V) approach, promoted worldwide by the World Bank during the 1970s to smallholder projects. In general terms, these approaches proved to achieve uneven impacts. Since then, the premise that low-income farmers are too unlikely to obtain technical information unless it is provided by government has been strongly questioned (Farrington, 1995).

The debate surrounding the training and visit extension model has underlined the futility of searching for a single, universally applicable model for extension. Equally, it has demonstrated the dangers of giving priority to extension structures over functions and of neglecting to identify how extension interacts with other services and information sources, and contributes to a broad process of rural development (ODI, 1999a). However, results of the training and visit system of agricultural extension in countries like Kenya revealed that human capital acquired through schooling or via extension advice enhanced productivity of farmers (Evenson and Mwabu, 2001).

Systemic methodologies necessarily question the efficacy of linear models such as the Transfer of Technology (ToT) approach, which assumes that the problem to be addressed can be accurately identified by researchers and policy-makers. However, theirs is only one possible version (interpretation or construction) of the problem (Ison et al. 1997).

The impacts of the Green Revolution have been also strongly contested. Analysing more than 300 studies on the Green Revolution published during 1970-89, Freebairn (1995) found that interfarm and interregional inequality of benefits increased as an effect of new technology introductions (higher yield varieties, fertilizers, water control and pesticides). A strategy based primarily on technology may have negative effects when the other institutional structures of the overall system are ignored.

1.3.4 Alternative or participatory approaches

There are numerous concepts, approaches, methods and tools which are labelled "participatory". Often this leads to considerable confusion (Hagmann et al. 1999). A comprehensive review on alternative extension approaches is presented by Axinn (1988) and Rivera et al. (2001). Typically, participatory approaches are characterised by a concern with the need for empowerment of disadvantaged groups and a focus on local knowledge and management capacity in the face of formal bureaucratic planning processes (Martin and Sherington, 1997; Tripp, 2005). A distinction between conventional and participatory approaches is synthesized in Table 1.4.

Table 1.4. Research approaches compared.

Characteristic	Conventional or top-down	Alternative or participatory
Main objective	Transfer technology	Empower farmers
Analysis of needs and priorities by	Outsider	Farmers assisted by outsiders
Primary R&D location	Experiment station, laboratory, greenhouse	Farmers' fields and conditions
Main R&D practices	Precepts, messages, packages of practices	Principles, methods, basket of choices
The "menu"	Fixed	*A la carte*

Source: adapted from Loader and Amartya (1999)

Pretty and Shah (1997) point out that the term "participation" has been used to justify the extension of control of the state as well as to build local capacity and self-reliance; it has been used to justify external decisions as well as to devolve power and decision-making away from external agencies; it has been used for data collection as well as for interactive analysis.

A number of innovative approaches to extension in developing countries have been tested with different degrees of success. Examples of these approaches include those based on farmer participation in diagnosis, testing and dissemination; farmer-to-farmer dissemination; "para-professional" extensionists; extension through non-governmental intermediaries using technology transfer units; and innovative use of media, among others (Farrington, 1995).

In a review of participatory research methods, Martin and Sherington (1997) identified that a critical area for their implementation is the capacity (organisational and technical) of farmers' organisations to carry out research. Moreover, they state that if participatory research is to be institutionalised, then organisational innovations are needed to implement these decisions, including a structure of incentives and rewards for scientists working with farmers.

Sulser et al. (2001) examined the application of participatory research methods for assessing potential extension project contributions to the sustainability of a local agricultural system in Ecuador. One of the contributions that these methods make to extension activities is that local knowledge is harmonized with external expertise via the use of group interviews for rating projects on locally relevant biophysical sustainability criteria and indicators.

One problem with a participatory approach can be that some farmers expect their extension agent to provide services for them (i.e. how to solve a problem), whereas the extension agents see themselves as adult educators, whose role is to encourage farmers to develop solutions for themselves. For a consultant who needs fees from customers to earn a living, it can be more difficult to realise this educational role than for a government extension officer, who will not be financially penalised for refusing to perform a service role (van den Ban, 2000).

The major difference between conventional and participatory extension approaches –the change in attitudes and behaviour of extension agents– is not costly, but requires a certain level of motivation, which not every agent has. It involves a transformation in the way extension agents interact with farmers (Hagmann et al. 1999).

Analysing policy implications of participatory development to improve livelihoods in rural Kenya, Sutherland et al. (1999) concluded that to ensure that research results are utilised and farmers have access to new technology and markets, there is a need for external or public sector support to integrate longer-term development initiatives. This may require rethinking the scope of research and development approaches, particularly removing unhelpful boundaries between research, extension and development functions, and increasing farmer participation in the whole process.

A participatory approach of developing appropriate agroforestry systems in Zona da Mata, Brazil demonstrated it to be a dynamic learning process, which required modifications as work progressed, farmers learnt, and family and economic circumstances changed, a process without a time horizon (Cardoso et al. 2001).

On discussing the same tools of participatory extension approaches, Webber and Ison (1995) observed that the main distinction between Rapid Rural Appraisal (RRA) and Participatory Rural Appraisal (PRA) concerns to the role(s) of the researcher(s): whether they see themselves outside the system under study, engaged in the collection of so-called objective data (typically most RRAs) or whether they see themselves as part of the system under study (typically most PRAs), in which case responsibility replaces objectivity as the major ethic of concern.

The nature of change by all participants (including the team) in PRAs is multi-dimensional. With learning as a process of gaining understanding or insight, it may be difficult to attribute change to a singular experience in a cause-effect relationship (Webber and Ison, 1995). The work of Loader and Amartya (1999) revealed that methods (such as conjoint analysis) can add value to current PRA-based studies, without compromising the ownership of the research or the validity of the outputs. They also mention that apart from researchers and farmers, policy makers should also be considered in the selection of methods for understanding the problems among rural people.

1.4 Technology transfer in the fisheries and aquaculture sector

The primary function of extension work has always been that of bringing techniques and information to individuals and organizations in agriculture to solve their problems more effectively (Claar, 1957). In fact, many economists now argue that the free flow of knowledge can facilitate growth for all, rather than generating high returns at the expense of access (UNDP, 2003).

For aquaculture in particular, the findings of this work support the Bangkok Declaration of 2000, which acknowledges that further investments in education and training are essential to build the knowledge, skills and attitude of all people involved in the sector (NACA and FAO, 2000). Moreover, advice is not only needed on the adoption of new technologies, but also on many other decisions farmers have to make (van den Ban, 1999). Accordingly, education and training should focus less on delivering knowledge and more on helping people to learn how to find out for themselves (Bourner, 1998). Thus, extension needs to address vulnerability as well as productivity; and, rather than over-promote diversification, offer a range of new options from which poor households can choose according to their circumstances (Farrington et al. 2002).

Very few quantitative studies exist that document successful transition from public to private or commercialized extension (Dinar, 1996). In an environment that calls for decentralized roles of governments, the immediate impact of the devolution of responsibilities for extension services from central authorities to local government units is often the deterioration of extension quality and frequency of contacts during the transition period (ADB, 2004).

Public sector extension worldwide has been criticized for not doing enough, not doing it well, and for not being relevant. Extension is criticized for insufficient impact, ineffectiveness, inefficiency, and, sometimes, for not pursuing programs that foster equity (Rivera, 1990). However, where innovations are actively propagated by government agencies, the operational activities of the extension body are more important in determining adoption rates than previously thought (Wadsworth, 1995).

European experiences examined by Rivera (1992) revealed at least three scenarios suggested by government and farm organizations with regard to privatization of extension: *i*) public financing by the taxpayer only for the kinds of services of direct concern to the general public; *ii*) direct charging for some individual services that produce direct return in the form of improved income, with the possibility of differential rates for specific situations or target groups; and *iii*) mixed funding shared between public and private professional association contributions for services, with delayed return or collective services, such as applied research, training of farmers and agents, and improvement in extension methods and tools.

Lessons from the international arena also reveal that extension usually has maximal impact in the early stages of dissemination, when the informational disequilibrium (and the "productivity differential") is the greatest. Over time, as increasing numbers of farmers become aware of a specific technological thrust, the impact of such extension diminishes, until the opportunity and need for more information-intensive technologies arise (Picciotto and Anderson, 1997; Anderson and Feder, 2003; Anderson and Feder, 2004; Alex et al., 2004).

Most aquaculture experts advise prospective aquaculturists to set modest initial goals (with lower resource requirements) and expand them as they gain experience. This advice can be followed by starting with a small-scale subsistence enterprise and gradually expanding it into a small commercial operation for farm diversification. Eventually, if the success of the aquacultural enterprise warrants, commercial aquaculture could become the main farm activity (Gegner, 2006).

Although the promotion and dissemination of improved technologies has proved to act as a catalyst to attract new entrants (Sevilleja, 2002), extension cannot continue to deliver the same educational programs to both beginner and advanced farmers. The current mixed-audience educational environment, where every program is forced to start from the least common denominator, is inefficient and drives the advanced farmer away (Knuston, 1986).

Nowadays, aquaculture extension demands a call of terminological attention given to the new communication necessities and the new horizons of concepts and denominations that it generates (Chong Carrillo and Vega Villasante, 2002). For particular higher income farmer groups, extension systems will likely evolve into fee-for-service organizations (Anderson and Feder, 2003). Farmers may expect a concrete recommendation, because they have learned that this is the role of their extension agent and because they cannot accept the uncertainty about taking a decision themselves, whereas the extension agent is convinced that it should be his role to help the farm family to take their own decision (van den Ban, 1999).

Dissemination has been successful with strong initial support followed by long term local support to adopters, often provided by non-government organisations in the absence of adequate government extension services (Prein, 2002). Working with other organizations that have similar goals can also be an effective way to help extension accomplish its goals with reduced resources (Pinkerton and Glazier, 1993). In addition, aquaculture demonstration can mean a challenging new program of applied research and teaching that brings new faces into the ranks of extension clientele (Snyder, 1992).

It has been repeatedly addressed that in Mexico, social policies have been increasingly incorporated into programmes for dealing with poverty (Ziccardi, 1999). In fact, participation has been invoked as a remedy for past failures due to top-down approaches, and as such, has been enthusiastically endorsed by many governments, financial institutions, and bilateral donors worldwide (Koenig, 2002). That was the case in Veracruz, when the idea that participatory approaches were the best solution to all development interventions, started to permeate during the early 1990s.

Experience also suggests that effective participation means influencing decisions, not simply involvement in implementation; it is an essential component of political life (Koenig, 2002). Although in the last decade there have been calls for including social, cultural and political elements, development, as it has been generally and broadly conceived and applied, is the process through which the productive forces of economies and supporting infrastructures are improved through public and private investment (Oliver-Smith, 2002). Pro-poor policies will not produce optimal outcomes where poor people are disempowered (UNDP, 2006). In fact, more than two centuries ago Adam Smith (1776) recognized that “no society can surely be flourishing and happy, of which the far greater part of the members are poor and miserable”.

The increasing recognition of the complexity of rural development processes should be accompanied by the adoption of more multidisciplinary, holistic approaches to analysis and conceptualization (Knickel and Renting, 2000). In many emerging economies, institutions are informal and embedded in the social fabric of the society. Thus, methods to uncover institutions as they are now, and how they may evolve, require a diverse range of data gathering and analysis approaches to deal with ‘‘soft data’’ including an anthropological orientation (Narayanan and Fahey, 2006). Moreover, the collection and dissemination of accurate and verifiable information on aquaculture may help to improve its public image and should be given attention (NACA and FAO, 2000).

It is generally accepted that capital-intensive technologies, import substitution and urban bias growth processes induced by price, trade and public expenditure policies are not good for reducing poverty (FAO, 2005). Although the responsibility for adopting a new technology rests entirely with the farmer (Costa-Pierce, 1997), the level of management skills and technology to culture tilapia using intensive systems are beyond the capacity of most small-scale farmers. However, if they are profitable for the individual fish farmer, unsustainable practices may be observed in the absence of enforced regulations preventing them. Since profitability is the main driver in much of aquaculture development, this is also an area where trade measures can most likely be used to improve production practices (Asche and Khatun, 2006).

Making the right decisions at the farm level in terms of input-use efficiency, human health and resource protection is becoming an increasingly knowledge-intensive task (Tilman et al. 2002). Present investment decisions are influenced by technological progress (Huisman and Kort, 2004). In terms of economic feasibility, and relative cost and returns to investment, the big farmers are placed in a superior position than their smaller counterparts for exploiting the benefits of tilapia farming. The big farms stand to gain more from the introduction of the technology (Sevilleja, 2001).

There are two main recognized forces from which technological innovation may originate, market pull versus technology push. Technology is typically a choice (endogenous) variable rather than an exogenous "driver" (Hazell and Wood, 2000). However, the type of technology also appears to influence the rate of adoption. So, incremental innovations and additions to existing technologies would be adopted earlier (Dupuy, 1997).

Many technology choice decisions are affected by local institutions, particularly the effectiveness of indigenous property rights systems and the local capacity for organizing and sustaining collective action for managing natural resources (Hazell and Wood, 2000). In general, rural and indigenous communities preserve most of their traditional organisational structures. Usually they maintain the communal system of decision-making. As previously indicated, rural settlements are also associated to natural resources of high environmental and biodiversity value. However, many of the colonisers of the rural tropical areas (particularly in South-eastern Mexico) do not possess the traditional knowledge for the management of the local natural resources, and commonly modify and degrade them (Olguín et al., 1999).

So, the benefits from the technology depend upon access to and ownership of factors of production resulting in variations in the level of productivity and an unequal distribution of income (Sevilleja, 2001). However, the "efficient" management of fish resources has eventually meant privatization of the commons, concentrating access to fish resources in fewer and fewer hands, and hence increasing social disparities (Bush and Sabri, 2000). The unequal distribution of ownership of land means that the total benefits which can be derived from tilapia farming are biased in favour of large farms (Sevilleja, 2001). In fact, farmers involved in aquaculture have in general an above average economic status when compared with fishermen (Sevilleja, 2002).

Technology transfer and extension has been recognized as a crucial force in the aquacultural development process. The work of Engle and Stone (1990) offers a comprehensive review of conventional and alternative extension methodologies, strategies, techniques and organizational structures commonly used worldwide. As expected, the vast number of initiatives promoted and implemented internationally during the last decades has produced an equally diverse number of lessons and impacts. In order to illustrate this diversity, some examples are presented next.

According to Edwards (2000), adoption of fish farming technology among farmers in countries where it is neither a traditional nor widespread practice suggests that, with adequate support, aquaculture could contribute significantly to rural development.

Demonstration projects have contributed significantly to the adoption of fish farming technologies in Bangladesh. Such projects include the Mymensingh Aquaculture Extension Project (MAEP) funded by the Government of Bangladesh and the Danish agency DANIDA, the North-western Fisheries Project funded by the UK agency DFID, and the efforts of NGOs such as the Grameen Bank, BRAC, CARE, Proshika and CARITAS. A large number of other NGOs have fish and shrimp culture projects with landless, small and marginal farmers, and the productivity of these ponds is usually higher than many privately managed ponds. These continued initiatives have certainly led to increases in overall production as well as productivity of the culture fisheries. However, many of these efforts are localised, and their widespread adoption is hampered by the poverty of the fishermen, and the lack of credit access (Alam and Thomson, 2001).

The adoption and spread of fishing technologies in Bangladesh depend mainly on extension services. The responsibility for fisheries extension lies with the Department of Fisheries (DOF) but like many other government agencies the DOF is hampered by a severe lack of resources and a rigid hierarchical institutional culture, which inhibits proactive work. These problems make the extension services ineffective, hamper the transfer of technologies, and are partly responsible for the low adoption of semi-intensive fish culture (Alam and Thomson, 2001).

In a very different context, Fundación Chile (FCH) initiated systematic efforts to introduce flatfish into Chile and to adapt flatfish rearing technologies, starting with turbot (*Scophthalmus maximus*), given its interesting market and technical features. The technology transfer and adaptation process included three phases: Experimental, pilot and full commercial scale using FCH's *modus operandi*, which included progressive transfer and the involvement of private investors in the new development (Alvial and Manríquez, 1999).

In Norway, despite Arctic char farming being promoted for more than 20 years, commercial activity has not prospered as expected. Apparently, the lack of adequate conditions for interaction between research and industrial activity seems to be one of the major causes. On the other hand, the fact that salmon farming is an industrial success can be partially explained by goal-directed research (Asche et al. 1999; Aarset, 1999).

Brummett and Williams (2000) noted that aquaculture presently plays two roles in African economies: commercial development and rural development. Commercial enterprises are based on an agribusiness approach and usually culture high value species fed prepared diets. More than 300 assistance projects were initiated from the early 1970s to the early 1990s. They concentrated on extension, training and building state farms and hatcheries. They stressed proven technology imported from established industries. However, these were often introduced with insufficient regard for the prevailing social systems, economic conditions, the indigenous knowledge base and natural resource constraints. That these projects have not resulted in large, sustained increases in fish production, however, does not necessarily mean that aquaculture, *per se*, is a nonviable proposition in Africa. It is more likely that the point of entry and *modus operandi* for earlier development projects was incorrect. One proof of this is that aquaculture among smallholders has recently been expanding across the continent. These new projects have been based on participatory and evolutionary approaches and a rural development focus as recommended in the thematic evaluation of aquaculture.

A detailed analysis of ineffective top-down technology transfer schemes and their impact on small-scale aquaculture adoption among sub-Saharan African farmers revealed that many projects have been fundamentally misconceived because they have depended on the delivery of technical inputs and often use indicators which did not reflect objectives (Harrison, 1993; Harrison, 1996; Harrison et al. 1994). Other case studies in Africa indicate that fish farming might be sustainable transferred into a broad range of farming systems, and that appropriate aquaculture methods can be shown to spread rapidly from farmer to farmer (Brummett and Williams, 2000).

1.5 Approach to the research

1.5.1 Research issues

The key issues with respect to development of tilapia culture in Veracruz would appear relate closely to the processes by which knowledge is developed and taken up, translated into effective choice and productive, profitable output. Clearly broader policy and finance issues, and the role of demand, linked in with market chains and their functioning, are also important, but development would also require adequate human and institutional capacity. The following research questions define the scope of the research:

- How do the processes of aquaculture technology transfer work in tropical Mexico?
- Who are involved in aquaculture development?
- Which are the key factors and the major constraints to deal with?
- Which are the best mechanisms to transfer technology among different kinds of fish farmers?
- Using current approaches, are we pushing people in the right direction?
- How can we improve technology transfer strategies?

1.5.2 Study hypotheses and objectives

Hypotheses

- In the State of Veracruz there are enough sources of information that simply requires effective widespread dissemination to enhance human capital and deliver positive development outcomes (addressed in Chapter 4).
- There is an homogeneity of tilapia farmers and production systems (explored in Chapter 5).
- The dissemination and adoption of tilapia farming technology is dependent on knowledge flow limitations associated to particular characteristics of the different geographic areas (addressed in Chapter 6).

Objectives

- To analyse the different strategies, methods and approaches commonly used in Mexico, and specifically in Veracruz, for the transfer of aquaculture technology, as well as their respective performances.

- To identify the key factors which influence farmers to adopt or reject fish farming technology.
- To find out the present and potential role of tilapia culture, both small and commercial, in the livelihoods of rural communities of Southeast Mexico.
- To address the technical, social and economic features of the different groups involved in tilapia culture, and the manner in which farmers respond to aquaculture technology.
- To understand the role of farmers organisation in the processes of technology transfer and the effects of a producer-producer training program.
- To evaluate the impact and consequences of the promotion and introduction of commercial aquaculture on small-scale farmers.
- To identify technology transfer boosters reflective of the social and economic characteristics of the State of Veracruz.

CHAPTER TWO: CONTEXT OF FIELDWORK

2.1 Introduction

As set out in the previous chapter, tilapia aquaculture in Mexico is a relatively new economic activity. It has been traditionally encouraged by the State and since the beginning has been linked to the fisheries sector. Nowadays, however, aquaculture is immersed in a complex arena that goes far beyond technical and financial aspects, and where different physiographic, economic, social and political issues dynamically interact.

Following the development of the research aims and strategy, this chapter attempts to provide broader context to support the subsequent analysis and discussion. The macroeconomic, political and geographical backgrounds are described in the next two sections. Following this, the agricultural sector scene is briefly explained. Finally, an overview of the legal framework of aquaculture in Mexico is presented.

2.2 Macroeconomic context and national political arena

Although international standards classify Mexico as a middle-income country, the existing poverty and inequality are aspects which are deeply and historically rooted in the country's social life[1]. As in many other countries, wealth in Mexico is unequally

[1] Approximately half of the Mexican population (nearly 50 million) lives in poverty, and one fifth (approximately 20 million) in extreme poverty (World Bank, 2004). The southern states of Chiapas, Guerrero, Oaxaca and Veracruz are Mexico's poorest. Mean incomes in the southern states are roughly half of the Mexican average, such that about two thirds of the population in the south are poor, compared with half of the national population. Moreover, four of five people in the rural south are poor (86%), compared with less than half of the urban population (48%). Rural poverty is also "deeper". The bulk of the rural population –almost three of every four people– lives in extreme poverty (72%) compared with just 21% of the urban population. Incomes also are stratified by ethnicity in the southern states, which have the highest concentration of indigenous peoples (World Bank, 2003).

distributed and its poverty levels have remained high in recent years, causing concern at all governmental levels (Fuentes and Montes, 2003).

These disparities are present across ethnic, social or regional groups. The most remarkable difference appears between the northern and southern regions, the latter being indigenous, rural and mostly agricultural, while the former is primarily urban and highly industrialized. This North-South regional trend has become more evident since the last decade, when Mexico underwent significant trade liberalization with the signature of the North America Free Trade Agreement (NAFTA). Therefore, despite the country's growth, the Mexican economy is increasingly dual in nature, with an even more acute North-South division (Fuentes and Montes, 2003).

The human development indices (HDIs)[2] calculated for Mexico by the United Nations Development Programme (PNUD, 2003) confirmed an acute pattern of regional inequalities (Figure 2.1).

In an increasingly globalized economic context, the Mexican government has bet on the promises of free trade over the past two decades. This facilitated the country's entry into the Organization for Economic Cooperation and Development (OECD) and various trade agreements, such as NAFTA, and agreements with the European Union (EU) and with other Latin American countries (Schott and Hufbauer, 1999; Salazar-Xirinachs and Tavares de Araujo Jr, 1999; Robertson, 2000; Barbier, 2000). To expedite the country's

[2] The Human Development Index (HDI) measures the average achievements in a country in three basic dimensions of human development: 1) a long and healthy life, as measured by life expectancy at birth; 2) knowledge, as measured by the adult literacy rate (with two-thirds weight) and the combined primary, secondary and tertiary gross enrolment ratio (with one-third weight); 3) a decent standard of living, as measured by GDP *per capita* (UNDP, 2004).

move into the economic mainstream, the federal executive established one-digit inflation similar to that of its most important trading partners as a major goal. It continued downsizing the State through privatisation of government-controlled companies, deregulation of economic activities through administrative simplification, a restrictive monetary policy, efforts to put public finances on a sound footing, the cancellation of government posts, the freezing of salaries and the gradual elimination of subsidies on essential goods. Despite macroeconomic advances, deficiencies that make the financial sector vulnerable still persist, with huge external and internal debts and public finances depending on international oil prices (UNDP, 2001).

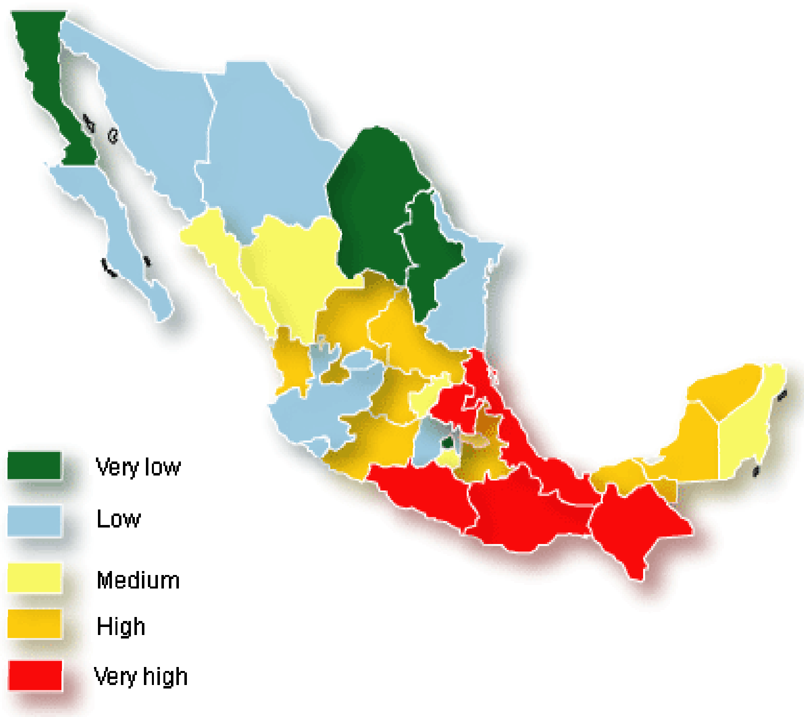


Figure 2.1. Regional inequalities in Mexico: marginalization according to the HDI. Sources: CONAPO (2003); PNUD (2003).

One of the sectors most impacted by these policies has been the countryside. The policy for greater openness in receiving foreign agricultural goods and the reduction or cancellation of government subsidy and technical assistance programmes brought about a major drop in agricultural production and employment. Vast areas of land were left unplanted, while the prices of various agricultural products dropped below costs and resulted in unprecedented increases in the overdue loan portfolios of commercial banks (UNDP, 2001).

Mexico is a federal republic, the President being the head of the Executive, and elected by popular vote for a six-year term. The Cabinet is appointed by the President, and usually remains in function during the same period. In general terms, most of the state secretariats and their respective departments have remained relatively stable during the post-revolutionary history of the country, and their results and achievements can be relatively easy to track. However, the department responsible for normalizing and regulating aquaculture activities within the country (hereinafter: Department of Aquaculture or DOA), has been one of the most notable exceptions.

Table 2.1 reveals that during the last eighty years, the DOA has jumped from one secretariat to another at almost every new governmental period, and has been linked nearly always to the fisheries sector. The most relevant implication of this situation is the fact that the DOA in Mexico does not have “institutional memory”. This unstable condition has major implications for the development and implementation of long-term policies and programmes, and some of its impacts and repercussions will be analysed in more detail later.

Table 2.1. Institutional framework of the national aquaculture head office.

DATE	INSTITUTION	SECRETARIAT
1915	Dirección de Estudios Biológicos	Secretaría de Fomento
1923	Dirección de Pesquerías	Secretaría de Fomento
1926	Comisión de Biología Marina	Secretaría de Fomento
1934	Departamento Autónomo Forestal de Caza y Pesca	Secretaría de Agricultura y Fomento
1934	Instituto Biotécnico	Secretaría de Agricultura y Fomento
1934	Instituto de Enseñanza e Investigación Forestales, Caza y Pesca	Secretaría de Agricultura y Fomento
1939	Dirección General de Pesca e Industrias Conexas	Departamento de Marina Nacional
1947	Sección de Fomento Piscícola	Secretaría de Recursos Hidráulicos
1950	Comisión para Fomento de la Piscicultura Rural	Secretaría de Marina
1954	Segundo Centro Latinoamericano de Capacitación Pesquera	Banco Nacional de Crédito Ejidal
1958	Comisión Nacional de Piscicultura Agrícola	Banco Nacional de Crédito Ejidal
1958	Comisión Nacional Consultiva de Pesca	Secretaría de Industria y Comercio
1958	Instituto Nacional de Investigaciones Biológico Pesqueras	Secretaría de Industria y Comercio
1959	Departamento de Piscicultura	Banco Nacional de Crédito Ejidal
1962	Dirección General de Piscicultura Agrícola	Secretaría de Agricultura y Ganadería
1964	Dirección General de Pesca	Secretaría de Industria y Comercio
1970	Subsecretaría de Pesca	Secretaría de Industria y Comercio
1971	Instituto Nacional de Pesca	Secretaría de Industria y Comercio
1971	Dirección de Acuacultura	Secretaría de Recursos Hidráulicos
1972	Fideicomiso para el Desarrollo de la Fauna Acuática	Secretaría de Industria y Comercio
1972	Dirección General de Educación en Ciencias y Tecnologías del Mar	Secretaría de Educación Pública
1973	Empresas Piscícolas Ejidales FONAFE	Departamento de Asuntos Agrarios y Colonización
1976	Dirección General de Acuacultura	Departamento de Pesca
1982	Dirección General de Acuacultura	Secretaría de Pesca
1988	Dirección General de Acuacultura	Secretaría de Pesca
1994	Dirección General de Acuacultura	Secretaría del Medio Ambiente, Recursos Naturales y Pesca
2000	Comisión Nacional de Acuacultura y Pesca	Secretaría de Agricultura, Ganadería, Pesca y Alimentación

The national macroeconomic policies executed during the past four decades have had a decisive impact on the course of many economic activities, including the primary sector. A synthesis of some decisive events related to tilapia aquaculture evolution and the national panorama since 1964 is presented in Table 2.2.

Table 2.2. Tilapia aquaculture development and key political and economic events.

PERIOD	PRESIDENT	PARTY[1]	KEY EVENTS
1964 to 1970	Gustavo Díaz Ordaz	PRI	Introduction of tilapia to the country by the Papaloapan Commission. Olympic Games. Hundreds of protestors are killed or wounded during a student demonstration in Mexico City.
1970 to 1976	Luís Echeverría Álvarez	PRI	Beginning of commercial exploitation of tilapia in large reservoirs. Promotion of fisheries and aquaculture technical schools. Populist government.
1976 to 1982	José López Portillo	PRI	Dissemination of tilapia fingerlings to many more reservoirs all along the country. Huge oil reserves discovered. Corruption in government reaches alarming levels.
1982 to 1988	Miguel de la Madrid Hurtado	PRI	Introduction of a number of tilapia strains. Promotion of semi-intensive systems. Earthquake in Mexico City kills thousands.
1988 to 1994	Carlos Salinas de Gortari	PRI	Tilapia production through extensive systems became stable. Continuous growth of commercial firms. Privatisation of government-controlled companies.
1994 to 2000	Ernesto Zedillo Ponce de León	PRI	Tilapia *per capita* consumption reaches 0.78 kg. Worst recession in over half a century. Implementation of NAFTA. A guerrilla rebellion starts in southern state of Chiapas.
2000 to 2006	Vicente Fox Quesada	PAN	Domestic tilapia market is not satisfied with national offer. Asian imports grow. Increase of commercial-scale intensive farms. Opposition defeated the party in government for the first time in 70 years. Free trade and openness policies.

[1]PRI - Institutional Revolutionary Party (authoritarian-centrist); PAN - National Action Party (conservative).

Finally, corruption has also been recognised as a complex problem extremely difficult to eradicate and deeply rooted in the society and the public sector. According to SECODAM (2002), characteristics of the State as a factor in corruption include:

- a weak State
- deficient institutions
- overregulation in administrative controls
- an abundant and poorly qualified bureaucracy
- a system of values involving social distrust

Today, the Mexican way of life is a mixture of many traditions, the product of a long and diverse history. People from across the world have migrated and lived there for centuries. Mexico is a land combining ancient customs with the challenges of a changing environment, and in these circumstances, while flexibility and expediency are the means of addressing changing conditions, social institutions may constrain many of the processes regarded in a modernising agenda as “progress”.

2.3 The state of Veracruz: geographic and socio-economic dimensions

Veracruz is one of the 31 states within Mexico. It is located in the eastern part of the country, between 17º 10’ and 22º 38’ North and between 93º 55’ and 98º 38’ West (Figure 2.2). It has a mainland area of 72 815 km^2 and includes several islands in the Gulf of Mexico totalling another 58 km^2. The national survey of 2000 reported a population of 6 908 975, distributed as 60% in urban areas and the rest in rural communities of less than 2 500 inhabitants (INEGI, 2000).

Veracruz is the third state in Mexico regarding population; it represents 7.4% of the total population of the country. The population density of the state is 96 inhabitants km^{-2} (CONAPO, 2003). The State is divided into 212 municipalities or districts with local governments. About 10% of its almost seven million people speak indigenous languages (somewhat higher than the national average of 5 to 7%). More than 1 200 archaeological sites constitute the prehispanic heritage of the State (INEGI, 2005b).

The territory of the State is bounded by seven other states and with the Gulf of Mexico. The coastline of Veracruz is the longest among the many states bordering the Gulf, extending to 684 km. The climate varies drastically, offering humid warm zones and all-year round snow on the highest peaks. However, most of the territory is located in the tropics and it results in a humid warm weather with rain during the summer and an annual average temperature of 25 ºC. The topography is also uneven. The warm and humid weather of the flat coastal region changes into a cooler area of high plains and rugged mountains towards the western limits. In fact, 35% of Mexican rivers flow across Veracruz. The State produces maize, beans, sugarcane, coffee, rice, honey, fruit, tobacco, cattle, and fish. The State's economy is also based on oil extraction and its derivative processes (INEGI, 2005b).

Figure 2.2. The state of Veracruz.

The habitats and biodiversity of the State are threatened by human activities and the resulting associated problems, such as continued clearing of forest for timber, collection of fuel wood, industrial development and agricultural expansion. These threats bring along consequences such as pollution from wastes, clearing of land and alteration of vegetative structure due to gathering of more valuable plants, which are all associated with the expansion of human settlements and mainstream tourism. Ecotourism is increasing but while economic growth is beneficial to the ecoregion, dealing with more people will call for the improvement of the health of related systems (Valero et al. 2001).

According to INEGI (2005b), in Veracruz there are 388 822 rural production units involved in agriculture or livestock activities, comprising a total surface of almost five million hectares. The average size of each unit is 12.8 hectares (the national average is 23.9 hectares), and some 1.3 million people are directly involved in the sector, of whom around 40% are salaried.

2.4 An overview of the national agricultural scenario

According to ICID (2000), more than a quarter of Mexico's economically active population work in the agriculture, livestock and forestry sectors, and a similar percentage of the total population lives in rural areas in small communities of less than 2 500 inhabitants. As such, agriculture is one of Mexico’s most important economic sectors, though it accounts for only 6% of GDP. Out of the nearly 196 million hectares of the country's total area, some 21 million are used in agriculture, around 27 million are covered mainly by pastures, 88 million sustain low bushes, 53 million are covered by forests or tropical woods, and 7 million correspond to deserts, urban areas and water bodies. About 108 million hectares (55% of country’s area) are exploited either in agricultural, livestock or forestry activities. Of this area, approximately 31 million hectares are considered as specifically devoted to agriculture, either on a permanent or occasional basis (on average, some 10 million hectares of this area remain uncultivated and are temporarily –and changeably– mainly used for livestock); 68 million hectares are used mainly for cattle raising; and almost 9 million hectares consist of woods and tropical woods used for forestry purposes.

At present, nearly 21 million hectares –about 11% of the country's total– are currently under cultivation, including over 6 million hectares within irrigation systems. However, taking into account both water availability and productive capacity of soils, only about 32 million hectares is considered to be suitable for agriculture.

Agricultural production in Mexico is extremely diverse, including products from many different climatic regions, and depends heavily on the intensity and regularity of rainfall. The main cropping season for rain fed agriculture is May-November (the spring-summer season), while in irrigated areas cropping seasons vary among regions and are less concentrated during the year. However, the so-called autumn-winter season, extending from October to April, is predominant in irrigated areas. Dry land agriculture and rain fed farming have long been practised mainly in north and northwest portions of the country and in the central high plateaus, although not on a very large scale.

Six crops dominate production in Mexico: corn, beans, wheat, sugarcane, coffee and sorghum (SAGARPA, 2001). The first two are staples of the traditional popular diet, with the result of approximately half of the cultivation land dedicated to corn and beans. Wheat and sugarcane are also widely consumed domestically, though not to the same degree. Coffee is the main export product and sorghum is mainly used in the poultry and pork industries.

The main organisations concerned with agricultural development in Mexico are the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), the Secretariat of Agrarian Reform, the National Rural Bank, the National Water Commission (CNA) and some other institutions of the federal government, and the state governments. The principal legal bodies that regulate their activities are the Federal Public Administration's Law, the Agricultural Development Law, the Agrarian Reform Law, and the National Water Law.

Development policies in the agricultural sector in Mexico have substantially changed over the last few years. They have shifted from a wide governmental intervention in financing production, pricing and trading of main inputs and produces, among other subjects, to a more private sector managed and world market oriented activity. Since 1995, through a new strategy, the Agricultural Alliance Programme, federal government efforts, and especially investments in agricultural development are increasingly being tied to state governments and farmers' investments. Development works are also being managed by farmers themselves to a large and increasing extent.

The main public organisation to promote and support activities in science and technology is the National Council of Science and Technology (CONACYT). Among the various functions of CONACYT the National System of Researchers (SNI) has the objective of fortifying and encouraging the efficiency and quality of research in all fields, including aquaculture. CONACYT also establishes links with international organisations responsible for scientific research and technological development.

Agricultural research is mainly carried out by a federal government agency, the National Institute of Forestry, Agricultural and Livestock Research (INIFAP), and by a number of universities and other organizations. After decades of being provided mainly by government agencies, agricultural extension services are at present in the hands of the private sector; however, federal and state governments still finance these services to a large degree. Wealthy commercial farmers usually hire such services directly.

2.5 Legal framework of aquaculture in Mexico

Aquaculture legislation in Mexico is very complex, mainly because of the large number of administrative entities involved. A summary of the laws and regulations directly related to aquaculture is presented in Appendix 2. Comprehensive reviews of the Mexican fisheries and aquaculture legislation have been made by González-Oropeza and Garita-Alonso (1994) and recently by Spreij (2005). For its relevance within the national aquaculture development and as platform for upcoming arguments, a summary of the findings of the latter is presented next. Further details regarding the different requirements for setting up an aquaculture facility as well as their legal support are also presented in Appendix 2.

The Fisheries Law and its Regulations are the main legislative documents governing the conservation, preservation, exploitation and management of all aquatic flora and fauna. The Fisheries Law was amended in 2001 and the Regulations amended in 2004. In addition, various Official Mexican Standards (NOMs) facilitate the implementation of the Fisheries Law by detailing requirements as to the conduct of activities within and development of fisheries and aquaculture. Generally, NOMs are specific measures and standards required by law, which are proposed by the various administrative

Secretariats in their corresponding area of jurisdiction and issued by the Federal Executive.

Since 2001, SAGARPA is in charge of administering the fisheries and aquaculture legislation. According to the Law, tasks and responsibilities of SAGARPA include –*inter alia*– the designation of areas suitable for aquaculture, regulation of the introduction of species and the promotion of aquaculture development. SAGARPA consists of numerous offices and administrative entities. An overview of its structure can be found in its by-laws.

The National Commission on Aquaculture and Fisheries (CONAPESCA), an administrative entity of SAGARPA, was created in 2001 and is responsible for management, coordination and policy development regarding the sustainable use and exploitation of fisheries and aquatic resources. The Commission has the support of the National Fisheries Institute (INP), also an administrative entity of SAGARPA, which conducts scientific and technological investigations and gives advice on the preservation, restocking, promotion, cultivation and developing of aquatic species. Through the INP, a new instrument for fisheries management has been developed, the National Fisheries Chart, which is an annually updated inventory and summary of all fisheries resources in federal water bodies.

SAGARPA has developed the Sectoral Program for Agriculture, Livestock, Rural Development, Fisheries and Food 2001-2006, which addresses –*inter alia*– the sustainable exploitation of fishery and aquaculture resources and the promotion of profitability, both in economic and social terms, of the fishery and aquaculture sector.

The program also seeks to update and promote the legal measures applicable to fisheries and aquaculture activities (SAGARPA, 2001).

CHAPTER THREE: METHODOLOGIES

3.1 Contexts and strategies

3.1.1 Study perspectives

A prime purpose of the research was to find out the underlying issues and performance of the most relevant regional initiatives that have promoted tilapia farming, as well as the current key actors of aquaculture development and their roles. Furthermore, the work was intended to elucidate the dynamic of dissemination and adoption of technological knowledge amongst tilapia farmers and to identify key factors that influence them to adopt or reject technological innovations. Data were collected from a number of sources, and information (mainly about the typology of tilapia producers and the manner in which technical information flowed amongst them) was also acquired as a collateral output of the "Simultaneous Growth Production Groups" (GCPS) research project, carried out during the 2000-2004 period and examined in depth in Chapter four.

3.1.2 The research process

This work was carried out at the Colegio de Postgraduados - Campus Veracruz (COLPOS) and at the Institute of Aquaculture, University of Stirling. The majority of the fieldwork was carried out during the 2000-2004 period, in which 142 tilapia farmers were closely monitored, as well as the most representative sectors involved in aquaculture development at different levels (community, local, regional and national).

To extend the scope of data collection as organised by the study, assistance and personal communications were obtained from Martín Hernández and Pedro Zetina (former postgraduate students from COLPOS) and four extension agents, employees from different national institutions: Carlos Suárez (municipal government of Angel R. Cabada); Noé Villegas (Sierra de Santa Marta Project, an NGO); Horacio Gallegos (Department of Aquaculture); Katya Andrade (Los Tuxtlas Biosphere Reserve). Their contribution was mainly in terms of collection of requested information at household level, while they performed their usual jobs as extension agents, supplying technical and logistical support to farmers. The performance of their work (in part a reflection of their own institutions) was also monitored and analysed. They were chosen because of their active enrolment with tilapia farmers, and through earlier established friendship and professional work relationships.

The research group based in Veracruz also volunteered to answer a factor-analytically derived questionnaire designed as a research device in the study of personalities (Gellatly et al. 1991; Furnham et al. 1999; Aluja and Blanch, 2004). The Raymond Cattell's Sixteen Personality Factor Questionnaire (Cattell et al., 1993) was selected to identify personality traits and correlate them to the extension agents' performance. Tests were applied and interpreted by a professional psychologist subcontracted for this purpose. The role of extension agent's personality was addressed and discussed at the light of experiences of the national and international arena (Appendix 3).

3.1.3 Sample definition

For the purposes of this research, farmers producing tilapia under extensive conditions (i.e. capture fisheries) were excluded and only farmers (households) using land- or water-based intensive or semi-intensive operations were considered. Both small and commercial scale tilapia producers were considered within the broad context of rural development and each farmer was considered as a decision-making unit. Two main criteria were taken into account for the inclusion of a farmer into the sample:

- That the farmer should be cultivating tilapia for at least one cycle (or harvest), no matter the conditions of its facilities.
- That every production unit were within the range of 250 km from the headquarters of the project, i.e. COLPOS, near the city of Veracruz, in the central part of the State (Figure 3.1). Travel times and costs of transportation were also taken into account at the moment of defining the area.

Previous knowledge of the region facilitated the making of the census within this area. The result was 142 farmers, which according to official figures represented approximately 30% of the total tilapia producers in the State. Strong professional collaboration and friendship links had already been established with most of them, so, after an individual exposition of the purpose and reasons, all of them agreed to participate in the project. The 142 selected farmers and their production units were all distributed in the central portion of the State and within 15 municipalities (Table 3.1 and Figure 3.1).

Figure 3.1. Municipalities with production units contemplated in the research and relevant reference points. The numbers correspond to municipality heads' IDs indicated in Table 3.1.

Table 3.1 also reveals the average altitude of the municipality, which positively relates to the local geographic characteristics of area, particularly to micro-climate and water temperature. Additionally, the Human Development Indices reveal the remarkable disparities between municipalities which reflect the conditions of inequality and poverty of some areas.

Table 3.1. Distribution of sampled farmers and municipal characteristics.

Municipality	Farmers	Altitude[1]	HDI[2]	ID[3]
Angel R. Cabada	63	10	0.6929	11
Mecayapan	14	360	0.6027	14
Catemaco	13	340	0.7005	12
Veracruz	12	10	0.8369	6
Tierra Blanca	10	60	0.7417	10
Ursulo Galván	8	20	0.7957	4
Paso de Ovejas	6	40	0.7425	3
Tatahuicapan de Juárez	5	140	0.6234	13
Pajapan	4	180	0.5934	15
Tlalixcoyan	2	10	0.7080	9
Boca del Río	1	10	0.8456	7
Emiliano Zapata	1	1460	0.7529	1
La Antigua	1	10	0.7910	5
Medellín de Bravo	1	10	0.7474	8
Puente Nacional	1	100	0.7581	2

[1]**Average altitude of the municipality in meters over sea level ((INEGI, 2005).**
[2]**Human Development Index of the municipality (PNUD, 2004).**
[3]**It refers to the location of the municipality head indicated in Figure 3.1.**

3.2 Data collection

3.2.1 Background

Data were collected from different sources and using a number of techniques. A preliminary literature review on topics such as technology transfer and extension and their impact on dissemination and adoption of aquaculture technology provided a background. Secondary data covered also included project documentation and research reports; governmental sources mainly from the Department of Aquaculture; physical data on land and climate; and economic data on marketing and regional development.

The methodological approach was organized into four major sections, each corresponding to an individual chapter of the thesis.

3.2.2 The actors and their roles (Chapter 4)

Data from previous studies were used, particularly from the Papaloapan Commission as one of the most representative and relevant projects at regional level since the introduction of tilapia into the country. As described earlier, the institutions involved in the promotion and development of aquaculture in Mexico can be characterized by their instability over time, and Veracruz no exception. The archives of almost every federal or state entity involved in aquaculture programs –when available– are dispersed. Moreover, most of the former officers are not longer working and/or have disappeared from the aquaculture scenario; some have already passed away. So, information was in some cases collected from interviews with retired employees or former officers, many of them spread along the country.

Three major regional development initiatives were also examined: 1) the Cages and Enclosures Project, implemented by the Department of Aquaculture; 2) the Lowlands Integrated Natural Resource Management (MIRNZB) initiative, implemented by COLPOS; 3) the Simultaneous Growth Production Groups (GCPS) project, also implemented by COLPOS. Collected data included –*inter alia*– information about policies and intentions of the different programmes; human and material resources involved; budgets and work strategies; results and performance; and main difficulties to deal with.

The role of farmers' organizations in the process of technology transfer was analyzed as a study case: the behaviour of the Veracruz Aquaculture Association (AVAC) was closely monitored from its very beginnings. This group is mainly composed of commercial producers interested in protecting market prices in order to get better policies that encourage the activity. Their philosophy and internal dynamic was also documented.

Finally, and in order to identify another key actors and their roles, a series of workshops was organized during the 2001-2002 period. Using techniques of SWOT analysis (Hill and Westbrook, 1997; Houben et al. 1999; Shrestha et al. 2004; Seneviratne, 2004), the main strengths and weaknesses of tilapia culture and technology transfer strategies used in the State were also addressed and ranked, as well as the key opportunities and threats to face. An additional purpose of these events was to discuss and collate ideas and concepts about extension, including methodologies and approaches.

The first event was a two-day workshop that involved approximately 120 farmers and was carried out in the city of Catemaco during October 2001. The second one was a two-day workshop carried out in the city of Veracruz during January 2002 and mainly attended by governmental authorities, NGOs and people involved in extension and research programs. Additionally, six more small workshops were conducted, one with each group of tilapia producers (see Section 3.2.4 for their definition), using the same methodology. This information was complemented with personal interviews and by data produced in two extra workshops: using also the SWOT methodology, the first workshop was conducted during March 2000 in the city of Veracruz; the second one was carried out at the Colegio de Postgraduados – Campus Veracruz during June 2006.

At this point of the research, the particular hypothesis to test was that in the regional arena there are enough sources of information that only require effective widespread dissemination to enhance human capital.

3.2.3 Typology of tilapia farmers in Veracruz (Chapter 5)

Household level data were collected in interviews with 142 individual tilapia farmers (see also Section 3.1.3, in which the target groups and sampling size considerations are addressed). A practical protocol based on the action framework outlined by Lefroy et al. (2000) was established. Preliminary findings of Hernández-Mojica (2002), Reta-Mendiola (2004) and Reta-Mendiola et al. (2005a) were taken into account and expanded. Techniques used included open-ended questionnaires for the collection of household level socioeconomic data and farm level biophysical data, as well as a range of participatory rural appraisal techniques (Townsley, 1993; Webber and Ison, 1995; Townsley, 1996; Loader and Amartya, 1999; Cramb et al. 2004). The identity of all farmers was kept anonymous.

The null hypothesis to explore at this stage was the homogeneity of tilapia farmers and their production systems. Therefore, collected information covered five major areas:

- General aspects (demography, formal education).
- Socioeconomic features (gender, land and water tenure status, family participation, road systems).
- Management characteristics of the production units (water supply, experience, sources of technical information, problems and constraints, purpose of production, labour organization, culture systems, sources of seed, feeding strategies).
- Farm production and productivity.
- Marketing strategies (prices, destination of production, profitability, production diversification).

3.2.4 Dissemination and adoption of tilapia farming technology (Chapter 6)

Twenty key management practices of tilapia culture technology were identified from all farms surveyed. These included those specific technical activities implemented at farm level and considered essential to obtain productive outputs. They were selected using international *state-of-the-art* tilapia culture knowledge as contextual reference and ranged from broodstock management to post harvest operations (Table 3.2).

All selected practices were equally weighted. An arbitrary z optimum (maximum) value was assigned to every i practice, which was then used as a reference to qualify all n practices observed in each farm. The criteria used to qualify the practices are shown in Table 3.3. Objectively verifiable indicators of achievement for each management practice were also produced in order to reduce bias during the qualifying assessments (Appendix 4).

Table 3.2. Management practices.

Hatchery operation
Broodstock management
Rearing and conditioning of broodstock
Fish handling
Method of breeding
Nursery ponds
Rearing of fry and fingerlings
Record keeping
Packing and transportation of fingerlings
Grow-out
Pond (or cage) preparation
Fertilizing and filling the pond
Stocking of fingerlings
Daily management
Feed and feeding
Water quality management
Oxygen monitoring and aeration
Sampling
Harvesting and marketing
Purging
Post harvest handling
Marketing strategies
Record keeping

Table 3.3. Qualifying criteria.

Value	Use of technology
5	Optimum
4	Very good
3	Good
2	Bad
1	Very bad
0	Nil

Both optimal and observed (qualified) practices were used to build up a Technological Level Index (TLI), an adaptation of the technological index proposed by Scott (1964). TLIs were calculated as follows:

(Eq. 3.1) $$\mathrm{TLI} = \frac{\sum_{i=1}^{n} (OMP_i)(QMP_i)}{\sum_{i=1}^{n} OMP_i}$$ where i and n were defined above and

OMP_i corresponded to each i optimal management practice, with $i = 1, 2, \cdots, n$

$QMPi$ corresponded to each i qualified management practice, with $i = 1, 2, \cdots, n$

Thus the numerical measurement of technology may range from zero to z depending upon whether farmer is using no optimum techniques, all z of the possible optimum techniques, or some number less than z but greater than zero of the optimum techniques. This measurement of technology was then scaled to a linear decimal index using the formula:

(Eq. 3.2) $$TLI = \frac{100}{z}\mathrm{TLI}$$ where the lowest possible value of the index was designated by zero and the highest value by 100, the higher the index value, the more developed the management of the system in terms of application of elements of tilapia culture technology. *TLI*s were calculated twice for each farm at two year intervals (during 2001-2002 and during 2003-2004). *TLI*s were also used as a measure of technological change following the methodology described by Jensen (1957), Stout and

Ruttan (1958) and Herr (1966), being the quantitative measure of technological change in each farm the ratio of the increase in *TLI* to the initial *TLI* (Lave, 1962).

The individual 142 farmers were sorted into six groups, each in a different geographic area (Table 3.4). It was expected that remote locations and less populated areas would have different characteristics because of knowledge flow limitations. Actually, some kind of communication among members of each group had already taken place, mainly due to their proximity and common interests, and further interaction was anticipated.

Table 3.4. Group definitions.

Group	Municipality	Farmers	HDI[1]	ID[2]
1	Emiliano Zapata	1	0.7529	1
	Puente Nacional	1	0.7581	2
	Paso de Ovejas	6	0.7425	3
	Ursulo Galván	8	0.7957	4
2	La Antigua	1	0.7910	5
	Veracruz	12	0.8369	6
	Boca del Río	1	0.8456	7
	Medellín de Bravo	1	0.7474	8
3	Tlalixcoyan	2	0.7080	9
	Tierra Blanca	10	0.7417	10
4	Angel R. Cabada	63	0.6929	11
5	Catemaco	13	0.7005	12
6	Tatahuicapan de Juárez	5	0.6234	13
	Mecayapan	14	0.6027	14
	Pajapan	4	0.5934	15

[1]Human Development Index of the municipality (PNUD, 2004).
[2]It refers to the location of the municipality head indicated in Figure 3.1.

With the initial *TLI*s, final *TLI*s and technological change results, median tests (i.e. chi-squared tests of independence between group membership and the proportion of cases above and below the median) were computed to test the null hypotheses that all six groups have the same median. Nonparametric bivariate correlations were also computed to detect pairwise associations between key selected socioeconomic variables and *TLI*s and technological change. In some instances, median tests were also carried out to statistically detect differences between associated variables.

An adaptation of the Bray-Curtis' polar ordination technique (Bray and Curtis, 1957) was used to detect flux patterns of aquaculture technology among farmers. Farms in each group were placed within a *TLI*s hyperspace, that is, farms were arranged within a reduced coordinate system based on their similarities in *TLI* composition. Bray-Curtis' Q-mode resemblances (percent dissimilarities) were computed between all pair of farms in each group. Endpoints "AX" and "BX" for a single-axis "X" were then determined, having AX the largest sum of distances with all other farms and being BX the farm with the largest distance to AX. The remaining farms along the X axis (between AX and BX) were calculated using Beals' (1965) geometric formula:

(Eq. 3.3) $$\mathrm{x}(i) = \frac{\mathrm{L}^2 + d\mathrm{A}(i)^2 - d\mathrm{B}(i)^2}{2\mathrm{L}}$$ where x(i) is the location of the ith farm along the X axis, L is the percent dissimilarity (PD) between AX and BX, dA(i) is the PD of the ith farm to AX, and dB(i) is the PD of the ith farm to BX.

Computations for the periods 2001-2002 (initial) and 2003-2004 (final) were made using the BASIC program PO.BAS (Ludwig and Reynolds, 1988). Graphical displays of all polar ordinations were produced and comparisons amongst groups were made. The presence of at least one experienced farmer in each group was evaluated via the adoption patterns of technology within every group.

In addition, the spontaneous dissemination of an innovative practice among farmers was evaluated by the use of a sentinel technology. The validated protocol for using the synthetic hormone fluoximesterone in order to produce monosex tilapia fingerlings

(Phelps et al. 1992) was suggested to one of the participant farmers at a time when no other farm in the region was doing it. Fluoximesterone is a cheaper and locally available alternative to 17-alpha-methyltestosterone and was immediately adopted by the participant farmer. The adoption of this practice among the other farmers during the 2001-2004 research period was documented and evaluated in terms of its adequate use.

3.2.5 Case studies at farm level (Chapter 7)

The role of the tilapia subsystem within the livelihoods of representative households was briefly examined. Using an agroecosystemic approach (Chambers and Conway, 1991; Yiridoe and Weersink, 1997; Walker and Sinclair, 1998; Viglizzo and Roberto, 1998; Sinclair and Walker, 1998; Altieri and Nicholls, 2000; Carter, 2001; Mayoux and Chambers, 2005), six farms were selected to conduct study cases according to dominant socioeconomic characteristics and production strategies. Data were collected through personal interviews and using the preliminary outputs of the GCPS research project, following the methodological approach and findings described by Zetina-Córdoba (2003) and Reta-Mendiola (2004).

3.3 Data analysis

Qualitative and quantitative techniques were used in the analysis of data. A synopsis of the methodology employed during each part of the research is presented in Table 3.5.

MS Word and Excel were initially used for transcript and codification of responses for determination of certain descriptive statistics and for the construction of graphics. Exploratory data analysis, descriptive statistics, and nonparametric tests were made using SPSS 11.5 for Windows. For the Polar Ordination analysis, the BASIC package Statistical Ecology (Ludwig and Reynolds, 1988) was used.

Table 3.5. Summary of methods of collection and analysis of data.

Chapter No.	Data collection methods	Data collection tools	Methods of data analysis
(4):The actors and their roles	-Literature review -Semi structured interviews -Focus groups -SWOT analysis	-Published documentation -Written descriptions -Video recordings -Photographs	-Transcription and codification of responses -Content analysis -Statistical analysis of text frequencies and code co-occurrences -Descriptive statistics
(5):Typology of tilapia farmers in Veracruz	-Semi structured interviews -Resource flows analysis	-Written descriptions -Video recordings -Photographs	-Transcription and codification of responses -Descriptive statistics
(6):Dissemination and adoption of tilapia farming technology	-Semi structured interviews -Focus groups	-Written descriptions -Video recordings -Photographs	-Transcription and codification of responses -Exploratory data analysis -Descriptive statistics -Technological Index -Median tests -Nonparametric bivariate correlations -Polar Ordination
(7): Case studies at farm level	-Semi structured interviews -Focus groups	-Written descriptions -Video recordings -Photographs	-Transcription and codification of responses -Exploratory data analysis -Descriptive statistics -Technological Index -SLA

3.3.1 The Sustainable Livelihoods Approach (SLA)

A broader context for expressing change was provided by the Sustainable Livelihoods Approach (SLA), developed within research institutes (e.g. the Institute of Development Studies and the Overseas Development Institute), NGOs (e.g. CARE and Oxfam) and donors (DFID and UNDP). As an approach, objective and framework of analysis it has gained increasing currency in development policy and practice in recent years (Chambers and Conway, 1991; Hussein and Nelson, 1998; Scoones, 1998; Ellis, 1999; Carney et al. 1999; Carney, 1999; Baumann, 2000b). The core idea of the approach is to work with people, supporting them to build upon their own strengths and realise their potential, while at the same time acknowledging the effects of policies and institutions, external shocks and trends (Carney, 1999).

Stakeholder analysis was a critical starting point to enable an understanding of the diverse actors affected by any individual project or initiative. PRA methods were essential in order to find out people's own priorities and perceptions of livelihoods, livelihood constraints and possible solutions and to give participants a greater voice and role in the studies (Ashley and Hussein, 2000).

SECTION TWO: RESULTS AND DISCUSSION

CHAPTER FOUR: THE ACTORS AND THEIR ROLES

4.1 Introduction

This chapter assesses the actors of tilapia culture development in the region and their roles. In the first two sections, the most relevant initiatives in the area since the introduction of tilapia into the country are chronologically described and analyzed. Their philosophical, political and economical bases are discussed, as well as their main impacts, costs and benefits. In section three, the current key actors of the regional aquaculture scenario are examined. Finally, some closing remarks are presented.

4.2 Early interventions: the Papaloapan Project

4.2.1 The Papaloapan Commission

The Papaloapan River (which in indigenous Nahuatl language means the River of the Butterflies) is the second largest Mexican river in volume of flow, with a total longitude of 354 km and an average annual discharge of 44 662 million m^3, representing 12% of the national surface runoff (CNA, 2004). Its hydrologic basin is considered the northern limit of the Neotropical Region and covers an area of 46 517 km^2 including part of the states of Veracruz, Oaxaca and Puebla (SARH, 1990).

Around 1940, the population of the basin was nearly 1 million (representing 4.7% of the national total) and overwhelmingly rural. Almost 30% were indigenous people belonging to eleven different ethnic backgrounds. The region was in a great degree of isolation and far behind the national figures in almost all development indicators (Winnie, 1958; Poleman, 1964; SARH, 1990). This situation, along with a devastating flood in 1944, urged the Federal Government to initiate a series of studies aimed at preventing further flooding as well as achieving an integral development in the whole basin (Noriega, 1947). The basin was then seen as the natural unit to promote and implement the required development strategies (CEPAL, 1994).

The Tennessee Valley Authority (TVA) model was looked at as a way to achieve this regional planned decentralization (Poleman, 1964; SARH, 1990; García, 2001). The TVA was originally created in the United States in 1933 to “achieve agricultural and industrial development, and to improve navigation in the Tennessee River, as well as to control the destructive flood water in the Tennessee River and Mississippi River basins” (United States Congress, 1933). Direct governmental intervention and strong centralized planning were its main characteristics (García, 2001).

The Papaloapan Project, the most ambitious of a noteworthy series of Mexican development schemes, was the first in the humid tropics of Mexico (Winnie, 1958), lasting from 1947 to 1986. The administering agency, the Papaloapan Commission, was given an unprecedented degree of autonomy; it cut across many ministerial lines to undertake an integral development comprising sanitation, flood control, irrigation, power generation, water transport, port development, highway and railway construction, urbanization, agriculture improvement, and colonization (Garrison, 1950; Dozier, 1965; SARH, 1972; SARH, 1990).

This was evidently a technocratic and top-down approach, not very different from other attempts at regional planning, the primary difference being that the regions were river basins and more interest was placed on hydraulic structures (García, 2001). Indeed, although the construction of seven big dams were visualized and planned since the earliest studies (Noriega, 1947), only two have been built to date.

The first dam was built between 1949 and 1954 over the Tonto River, one of the Papaloapan tributaries. The dam, with a capacity of 8 000 million m^3, flooded an area of 48 000 hectares. During its construction, approximately 20 000 people were displaced, mainly indigenous Mazatecs. The dam was named “Presa Miguel Alemán” after the Mexican president during the time when the Commission was created; at that moment, this was the largest artificial reservoir in Latin America. In 1962, a hydroelectric plant with a capacity of 154 000 kW was put in operation, which represented nearly 10% of the total installed capacity of the country (SARH, 1972; SARH, 1990).

4.2.2 The aquaculture initiative

Besides the role of the Miguel Alemán dam in flood control, power generation and irrigation, the Papaloapan Commission recognized the tremendous potential of a reservoir of such magnitude to improve the livelihoods of the resettled people who remained on the islands and marginal lands surrounding the dam. Two main pathways were perceived: tourism and fisheries (SARH, 1972). Soon after the dam was finished, the Promotion Department of the Commission endorsed the creation of a research team which integrated personnel of the extinct National Institute of Biological and Fisheries Research, based in Mexico City. The team carried out a series of hydro-biological studies pursuing a comprehensive fisheries development plan for the dam, in which tilapia, until that moment an inexistent species in the country, comprised the key element (SARH, 1990).

Little (if anything) was known about tilapia in Mexico at that point, but its potential caught the attention of the Papaloapan Commission and its Promotion Department.

Following the advice of the expert team, the Commission decided to build the Temazcal hatchery, named after a town close to the dam site. This was the first tropical aquaculture station in Mexico (SARH, 1972; SARH, 1990). In 1964, an initial broodstock of *Tilapia rendalli*, *Oreochromis mossambicus* and *O. aureus* was imported from Auburn University, Alabama, USA (Morales-Díaz, 1991). This was the first and only introduction of tilapia into the country until 1978, when a batch of *O. niloticus* imported from Panama was also introduced into this hatchery (Barriga-Sosa et al. 2004). Since its beginning, the Temazcal hatchery has been used as a research and training facility, as well as to reproduce, restock and disseminate the species. With the technology available at that time, its yearly installed capacity was of around 500 000 juveniles. The hatchery is still in operation.

Originally, the aquaculture initiative was envisioned as a "ranching" operation in which hatchery reared juveniles would be stocked in the dam and allowed to grow. So, resettled families would harvest the fish and consume them directly, sell them locally or market them to the nearest municipalities. Of course, the tilapia quickly became established in the reservoir and began reproducing on their own (Fitzsimmons, 2000a).

According to initial studies made by the research team, the estimated carrying capacity of the reservoir was around 200 kg ha^{-1} $year^{-1}$ (or 9,000 tonnes $year^{-1}$). The first signals of an established population were evident during the 1970-1971 assessments. So, fishermen from Valsequillo, another artificial reservoir in the neighbour state of Puebla, were invited by the Papaloapan Commission to test their fishing gears with this new species and to instruct the local population on how to use them. In 1972, the first commercial catches were obtained and to the astonishment of all the people involved, they reached 200 tonnes. A completely new industry was born. Local people gradually became fishermen and their families were eating more fish; suppliers of boats, nets and outboard engines were making business; brokers distributed the species to both rural and urban communities. Also, and because their physical and flavour resemblance with the already well appreciated native cichlids (mainly *Cichlasoma* spp and *Petenia* spp), tilapia was very easily accepted by the local and regional population.

Fishing effort in the reservoir progressively increased and by the year 1975, a total of 6 200 tonnes were reported (SARH, 1990). Although fisheries data were carefully systematized and management strategies suggested, local fishermen rarely followed the recommendations. Social conflicts among the few organized groups and independent fishermen did not help and, consequently, catches gradually declined (Morales-Díaz, 1991). Nowadays, annual catches reach less than 1 000 tonnes and compared with other reservoirs nationally, it is a clear example of a badly managed fishery.

Throughout the last four decades, the Temazcal hatchery has usually operated with a limited staff: one manager (a biologist generally), between 7 and 10 technicians, two secretaries, and a driver. The *modus operandi* has not changed much: mass production of fingerlings and restocking of water bodies. During the early years and before the catches in the dam declined, the hatchery was under direct administrative control of the Papaloapan Commission. Later, however, it was transferred to the Fisheries

Department. Although working links with the Commission were kept, the operative budget was greatly reduced, thus affecting the overall performance of the hatchery.

In the 1960s and 1970s a number of major dams were built in Mexico creating multi-purpose reservoirs. In addition to providing electrical power, irrigation, potable water and flood control, the reservoirs proved to be valuable as inland fisheries resources (Fitzsimmons, 2000a). In 1967, the Papaloapan Commission along with the recently created Department of Fisheries (Dirección General de Pesca), based in Mexico City, initiated an extensive national program to disseminate tilapia in these large and medium reservoirs. Gradually more hatcheries were constructed around the country following the scheme of the Papaloapan Commission. That was the beginning of the extensive aquaculture operations from where the bulk of tilapia in Mexico is produced today.

Recently, evidence is emerging about unforeseen costs of the introduction and dissemination of tilapia in the natural and artificial water bodies of the country. A growing concern is that all stocks supporting important tilapia fisheries in many reservoirs around the country derive only from those individuals originally introduced in the early years. Because no gene flow from new genetic pools was ever promoted, local inbreeding could be expected to be considerably high (Barriga-Sosa et al. 2004).

Another concern is that, although fish consumption has generally increased in the vicinity of the reservoirs, so has the incidence of gnathostomiasis, a disease that occurs in humans when the second intermediate/paratenic host contaminated with the third-stage larva of the spirurid nematode, genus *Gnathostoma*, is ingested (Díaz Camacho et al. 1998). According to nutritional indicators of 2002, inhabitants of the Papaloapan river basin in the vicinity of the Miguel Alemán dams were considered well nourished mainly because of the ingest of fish protein in their diet (Torres Torres, 2002). However, between 1980 and 1996, more than 400 cases of gnathostomiasis have been documented within this river basin alone, and more than 1 000 have been recorded in the rest of the country during the same period. Data suggest that the number of patients seems to be increasing. Almost all patients had eaten tilapia and/or other freshwater fishes as “cebiche”, a famous traditional Mexican raw fish dish marinated in lemon juice, several weeks to several months before the onset of the disease (Del Giudice et al. 2001). Because tilapia has been cultivated in the endemic areas since 1964, mass production and commercial distribution of this fish may be responsible for the gnathostomiasis problem (Ogata et al. 1998). Data also suggest highly effective transmission between environments within the same basin and that the regional parasite fauna is strongly influenced by fish community composition (Salgado-Maldonado et al. 2005). Clearly, more research efforts need to be made in this field. Nevertheless, present results clearly indicate that gnathostomiasis is a serious health issue in Mexico (Díaz Camacho et al. 1998).

Ultimately, the aquaculture project promoted and executed by the Papaloapan Commission must be understood as a pioneer experience and a collateral outcome of an initiative of a much bigger magnitude. It seems, however, that its overall impacts compared with its costs were massive.

4.2.3 Concluding points

Although an analysis of the Papaloapan Project and its impacts as a whole goes beyond the scope of the present research, remarks can be made to fully understand the approach used at the time for the dissemination of tilapia farming technology, and its results.

When the Papaloapan and three other river basin commissions were first established between 1947 and 1952, they had full support from the Mexican President, and hence they were practically autonomous with almost no budgetary limitations. However, this situation changed with time, since the following administrations had their own views as to what should be the role, if any, of the river basin commissions within the overall economic development strategy of the country (Tortajada, 2005). Nevertheless, these River Commissions proved to be reasonably effective instruments for implementation of the regional policies, mainly because their tasks included not only financial matters at regional level, but also planning and coordination activities, which were earlier the responsibility of ministries and governments at state level (Tortajada, 2001).

Detractors of the Papaloapan Project have mainly centred their arguments on some of the collateral effects of dam construction such as involuntary resettlements of indigenous population and the ecological transformation of the landscape (Molina-Ramos, 1992; Bartolomé, 1992; Quijada, 1992; Barabas and Bartolomé, 1992; Lopez Cortés, 1992; Tyrtania, 1992; Colchester, 2000; Robinson, 2000; Stanley, 2003; Peña, 2004). However, most arguments have been poorly supported and tended to minimize the overall impacts of the initiatives, following a broad anti-development approach, disrespecting or suspicious of the role of the state as mediating and representing the interests of people. Shocking distortions of the facts were often used to emphasize the lack of meaningful participation of affected population in the planning and implementation. By example, a report of the World Commission on Dams (2000) in page 106 quoted: "*In implementing the Miguel Aleman dam in Mexico, employees from the Papaloapan River Commission set fire to homes of 21 000 Mazatec Indians who were refusing to move*". Actually, the displaced inhabitants were all given assistance to resettle in new locations and were fully compensated (Poleman, 1964; SARH, 1972; SARH, 1990). In a similar vein, Lerer and Scudder (1999) note that "*although roads built to the construction site decrease isolation and promote economic activity, an increase in accidents can be expected*". Actually, there is a wealth of articles by dam enthusiasts and dam sceptics, which are often selective in their choice of evidence (Hawker, 2000).

Through time, technological changes have been paralleled with the construction of ever-larger dams to gain control of larger water supplies (Sternberg, 2006). Specific examples of development projects that can cause relocation are the construction of dams for irrigation or hydropower creating man-made reservoirs on previously inhabited land (Vanden Berg, 1999). On the basis of the current evidence, however, it is clear that the dams have fostered the growth of the Mexican economy and social welfare through a myriad of pathways, many of which are still not fully known or understood (Castelán, 2002).

The debate about dams is about the very meaning, purpose and pathways for achieving development. This suggests that decision-making on water and energy management will have to align itself with the emerging global commitment to sustainable human development and on the equitable distribution of costs and benefits (World Commission on Dams, 2000).

In Mexico, as exposed in Chapter 2, the lack of continuity in policies has caused and unnecessary exhaustion of economic and human resources (Contreras Moreno, 2004). This was made evident with the initiatives originally programmed by the Papaloapan Commission and the many others that followed it, mainly because each new program was developed with a different institutional framework, new personnel and new philosophical approaches. The lack of continuity has been mostly due to the political discontinuity from one presidential period to another: it has been a characteristic of each new government to begin new programs without considering the technical-administrative assertiveness of the previous ones (Contreras Moreno, 2004).

More recently and in order to overcome some of the water shortage and quality problems affecting the major river basins, Mexico has been progressively moving toward a system of River Basin Councils that have an increasing degree of stakeholder involvement (Millington, 2000). A dynamic and purposeful interface (consultative process) between projects and people at all stages of planning and implementation is likely to emerge as a key challenge for maximising the benefits from these kind of interventions (World Commission on Dams, 1999). Among the population of the Papaloapan basin, however, there is a growing feeling of distrust about the role of the institutions in charge of enforcing the law, mainly in terms of environmental issues (Murillo Licea, 2003), but also in terms of any long-term development initiatives.

4.3 Other regional experiences and local initiatives

Three specific regional aquaculture development initiatives are examined: 1) the Cages and Enclosures Project, implemented by the Department of Aquaculture; 2) the Lowlands Integrated Natural Resource Management (MIRNZB) initiative, implemented by COLPOS; and 3) the Simultaneous Growth Production Groups (GCPS) project, also implemented by COLPOS. Their strategies, methods and approaches for transferring tilapia culture technology are considered, as well as their main impacts.

4.3.1 The Cages and Enclosures Project

Context

By the early 1980s, tilapia had been already introduced and distributed in many natural and artificial water bodies of the country. National capture fisheries of the species reached sustained yields of around 60 000 metric tonnes, Veracruz being the leading producer State, contributing approximately 20% of national totals. Even though tilapia production through the use of more intensive or controlled methods was until then marginal, both the internal demand and the number of interested entrants were rising.

Since the early 1980s, two independent Departments of Aquaculture (DOAs) have operated in Veracruz simultaneously: the first is a subdivision of the National Department of Fisheries, operating in the State following national policies and making use of federal resources (hereinafter: Federal DOA); the second one is a sub-unit of the State Department of Agriculture Development, which operates exclusively making use of the State's budget (hereinafter: State DOA). Traditionally, both have been working with minimum interaction, following their own approaches and frameworks. As earlier indicated, their institutional instability through time also generated a lack of continuity of the majority of the aquaculture development initiatives they have implemented.

As the culture practices of the species internationally were evolving towards the intensification, both DOAs gradually adopted "technological packages" aimed at promoting semi-intensive and intensive tilapia farming (mainly using ponds and cages) to diversify production in the rural sector and improve livelihoods of the poor. In general terms, these packages included the free delivery of materials to build farming facilities, mixed-sex fingerlings produced in governmental hatcheries, commercial feeds, and some basic training. Sporadic technical advice was sometimes provided. The design and planning of the initiatives were almost always vertically conceived, following a top-down model of extension. This subsidy-dependant approach of promotion of tilapia culture had been in fact the cornerstone of most governmental extension programs during the last decades.

Using this approach and a limited number of qualified personnel and extension agents, the DOAs actively promoted tilapia culture in Veracruz during the 1980s and the 1990s. More than 1 000 new entrants were assisted, mainly from the *ejido*[1] sector and without any previous experience in fish farming. However, barely half the production units now remain in operation. Nevertheless, they constitute the majority of active farmers in the State. Certainly, ineffective targeting strategies have played an important role in most of the numerous badly conceived projects, and their respective low outputs. Irregular

[1] *Ejido* is a communal land tenure system with its own government structure established by the Mexican State to receive and manage the land that was expropriated from large landowners and redistributed to rural peasants and farmers after the Mexican Revolution. The creation and operation of *ejidos* is regulated in the Agrarian Law. The *ejido* sector covers 75% of all agricultural producers in Mexico (roughly 3 million households), and over half of the country's irrigated and rainfed land (Winters et al., 2002).

training schemes provided by improvised and insufficient extension agents have, undoubtedly, also contributed to the high abandonment rates.

The programme experience

Since 1990 the Mexican government has tried to incorporate many of the concepts of sustainable development and conservation into national development programmes (Durand and Lazos, 2004). During the mid-1990s, the World Bank and SEMARNAP (the extinct Secretariat of the Environment, Natural Resources and Fisheries) developed the Mexico Aquaculture Project (MAP) to help both stimulate and regulate the development of aquaculture (World Bank, 1997). The Cages and Enclosures Project was the regional freshwater chapter of the MAP aimed at exploiting natural and artificial reservoirs in Veracruz by the use of two different production pathways: cages and enclosures. The two other chapters of the MAP in Veracruz included the promotion of trout farming in the mountain areas and oyster farming in the coasts. The Cages and Enclosures Project was carried out by the Federal DOA and lasted from 1997 to 2000.

The cage initiative promoted the use of natural water bodies the commercial production of tilapia. During the period of the project, approximately 25 organized groups (on average each with 10 members) were assisted. Seed capital (in form of nets, juveniles and commercial feeds) was provided, as well as regular training during the entire production cycle (Oficina de Pesca en Veracruz, 1997). Due to the eutrophic conditions of many water bodies where the cages were located, most production units suffered high mortalities due to oxygen depletion or derived diseases. As a result, production was in general lower than expected. Nevertheless, in many cases harvests were sold locally at potentially profitable prices. Most farmers, however, never used the returns as an investment for the subsequent production cycles (e.g. in buying fingerlings or feeds), and most of them abandoned the activity when the subsidies were cut off.

On the other hand, enclosures were essentially confined areas in estuaries or coastal lagoons, in which the natural productivity was the basic support system. Twenty enclosures were built during 1997, each with an average size of 25 hectares and managed by approximately 15 members, many of whom were fishermen. Nets were provided by project funds, and the use of local materials such as mangrove or bamboo was promoted (Oficina de Pesca en Veracruz, 1997). The basic idea was to temporarily close (using nets) suitable natural areas and let the native species grow up. A synthesis of results achieved during 1997 is presented in Table 4.1.

Table 4.1 Average production results of twenty enclosures during 1997.

Species	Average yield (kg ha^{-1} $year^{-1}$)
Tilapia (*Oreochromis* spp)	400
Shrimp (*Penaeus* spp)	136
Oyster (*Crassostrea* spp)	500
Snook (*Centropomus* spp)	100
Prawn (*Macrobrachium acanthurus*)	380

Source: Oficina de Pesca en Veracruz (1997).

Although tilapia was already present in all selected water bodies, hatchery produced tilapia fingerlings were stocked in all enclosures and represented the only external input. Production costs were kept low (basically surveillance, net maintenance and harvest operations), and periodic selective harvests gave the groups a regular income to afford them. Although productive outputs were generally achieved, most groups split because of internal problems generated amongst members. The production strategy, however, offered strong potential to be further explored and promoted.

Overview

The Cages and Enclosures Project was envisioned to generate self-sufficient groups. However, soon after official support stopped, most production units were abandoned. It seemed to be the repetition of the old story of many previous interventions: a mixture of bad targeting, internal social conflicts, deficient training schemes, lack of managerial skills amongst producers, paternalistic attitude at all levels, and corruption. This last point will be examined later in depth, but two preliminary ideas could help to understand the results of this and many other initiatives executed by the DOAs:

Firstly, it is widely noted that many official programs which involve some kind of subsidy can be deliberately misused to ensure votes during any governmental election. It is a typical political approach in Mexico and is particularly notable in rural areas at the end of every administration. Therefore, it does not matter if the subsides produce satisfactory and/or productive outputs as long as they provide means to ensure the continuity of the political party in power. Secondly, many senior officers in charge of aquaculture departments (not only in Veracruz) are trying to make a career in public administration, not necessarily in aquaculture or fisheries sectors. They have little (if any) knowledge of the activity or commitment to it, and most do not have a technical background in fisheries or aquaculture. Moreover, their familiarity with the region, its problems, the previous initiatives, current stakeholders, or trends of the activity is barely minimal. Most have been appointed by the heads of the government (at both national and state level) and are removed from their offices in the subsequent administration. Their presence in the regional aquaculture scenario is ephemeral and so is their impact.

As earlier indicated, the Cages and Enclosures Project was a regional component of the World Bank's MAP. A comprehensive analysis of MAP was prepared by DeWalt et al. (2002). They noted that the original key components of the project were to assist SEMARNAP in developing a regulatory structure, to establish a system of environmental monitoring, to engage in resource management planning, and to provide technical and financial assistance to help develop aquaculture parks as a resource for poor individuals. However, after several years of delays due to several redesigns of the project, it was finally approved in 1996 for a much smaller amount of money than originally contemplated. The final loan of US$ 40 million included roughly a quarter of the money for regulatory work and the rest for project investment (mainly for the cooperative/*ejido* sector). By early 2000, less than US$ 1 million had been spent. The major stumbling block seemed to be that personnel in Mexico's Secretariat of the Treasury and Public Credit (SHCP) were not in accord with the part of the project oriented towards the cooperative/*ejido* sector. SEMARNAP attempted to restructure the project but World Bank officials never accepted the plans. The World Bank finally terminated the MAP in March 2000.

In summary, although the Cages and Enclosures Project produced limited long-term impacts, its effects were not nearly so positive as first proposed, and some valuable lessons could be derived:

- The importance of improving the targeting strategies in any future intervention.
- Social issues (e.g. interaction amongst producers, organizational factors) are a major factor to consider.
- Corruption must be recognized as a key and complex problem to tackle and overcome.

- The promotion of any type of long-term subsidy-dependent strategy should be minimized.
- The relevant role of technology transfer as a mean of improving social capital.
- The use of enclosures seemed to be a sustainable, cost-effective and environmentally friendly alternative to improve livelihoods of the rural poor in many estuarine and deltaic areas of the Veracruz coast.
- The promotion of cage farming (i.e. an intensive production system dependant on expensive inputs) proved to be an unsustainable cost-effective strategy for most poor individuals.

4.3.2 The Lowlands Integrated Natural Resource Management initiative

Context

In 1992, the Rockefeller Foundation launched a programme in Mexico aimed at evaluating different schemes of building organizational capacity for the community-based management of natural resources. Attention was given to innovative, participatory and collaborative proposals between research institutions, local NGOs and community organizations (The Rockefeller Foundation, 1999). Fourteen projects were supported for an average period of five years in different areas of the country, which in turn produced a number of valuable lessons (Alemán S., 1998; Blanco R., 1998; Jiménez et al. 1998; Pérezgrovas et al. 1998; Ramos S., 1998; Robles G. and Almeida M., 1998; Santos J. et al. 1998; Olguín P. et al. 1999). One of these was the Lowlands Integrated Natural Resources Management (MIRNZB) initiative, executed by an interdisciplinary research team of the Colegio de Postgraduados (COLPOS), based in Campus Veracruz.

COLPOS is one of the main agricultural research and academic institutions in Mexico, and has presence in many areas of the country, including Veracruz. Due to the importance of the tropical wetlands in this part of the country and their remarkable productivity, since the early 1980s an emerging interdisciplinary research group started to develop a series of cost-efficient and highly productive methods, based on the natural richness of the humid tropics (Olguín and Alvarez, 1980). Making use of a systemic and holistic approach, the research team gradually grew and started to incorporate new productive elements into an innovative strategy (in the Mexican context) of integrated natural resource management in the lowlands. In general terms, the MIRNZB system shares core conceptual issues with the Asiatic integrated production methods: elements and processes form subsystems which dynamically interact, the recycling of matter and energy has a prominent role in the whole system, and productive outputs are obtained (Olguín et al. 1993). By 1992, a consolidated interdisciplinary group of eight young researchers had built up. Up to that stage, however, most efforts had concentrated on developing and evaluating different subsystems within the Campus Veracruz facilities. The financial support of the Rockefeller Foundation allowed the strategy to be transferred and evaluated amongst organized farmer groups in three communities of the Lower Papaloapan Basin. This programme lasted from 1993 to 1998, with a budget of some US$ 200 000, mainly for travel costs and logistic support.

The MIRNZB initiative

Due to the nature of the tropical lowlands environment, the management of numerous aquatic resources always played a fundamental role within the MIRNZB model (Olguín and Asiain, 1994; Asiain and Olguín, 1995). Consequently, tilapia was one of its key elements. The transfer initiative of the MIRNZB model at farm level, however, always aimed to promote the whole system and not only one of its elements. A comprehensive study case of the entire MIRNZB transfer strategy was prepared by Olguín P. et al. (1999), from which the key issues relevant for tilapia culture development are presented and analysed further.

Three organized groups of the *ejido* sector were selected for dissemination of the MIRNZB model, all located within the Lower Papaloapan Basin and with approximately 25 members each. All groups already had earlier contacts with the research team, and interest and potential for evaluating the new model existed on both sides. Participatory Rural Appraisals were carried out in all communities. Training courses were later run in the Campus Veracruz, where a research and demonstrative module had been operating for more than a decade, to familiarize selected members of each group with the different subsystems of MIRNZB. With the support of project funds and constant supervision and advice from the research team, the trained farmers were responsible of coordinating the construction of productive-demonstrative modules in each community.

Taro (*Colocasia esculenta*), water spinach (*Ipomoea aquatica*), native freshwater snail (*Pomacea* spp), native prawn (*Macrobrachium acanthurus*) and ornamental fish (*Poecilia* spp) were among the productive elements promoted, either for human or animal consumption. The use of biodigestors or earthworms for recycling local sub-products, as well as the use of produced fertilizers as inputs for intensive production of edible or ornamental plants, was also encouraged. All modules also included some sort of tilapia farming technology (using cages, ponds or enclosures) and minor livestock. The idea was to disseminate the different production subsystems amongst the other members of the group, and depending upon the results achieved, let them decide which element(s) were best to be transformed into initial commercial-scale activities, after which it was expected that the other elements would also gradually become adopted at a commercial-scale.

There was a great degree of enthusiasm at the beginning of the project. However, soon after the demonstration modules were constructed and before enough productive (and economic) outputs were generated, problems began to emerge. The insufficiency of initial income generation forced many members to be involved in various off-farm activities and hence the time they dedicated to project activities was gradually reduced. Dissimilar religious and political affiliation amongst members also complicated the groups' cohesion. After analyzing preliminary results of the demonstration modules, every group decided what to do next. Although they were apparently convinced of the benefits of the whole MIRNZB system, all groups decided to focus only in one or two productive activities. So, for the commercial-scale phase, one group decided to produce flowers with organic hydroponics; another to invest in monoculture of taro for the US market; a third for the production of tilapia in ponds and cages. After sizing every project, it was evident that to invest (and risk) in one activity was not enough to benefit all involved members, and groups started to segregate. By the end of the project, their deficiencies in managerial skills and entrepreneurial know-how were accentuated by the more sporadic presence of the research team in the communities. Interest was progressively disappearing and finally the modules were abandoned. A few years after the project concluded, only a reduced number of stakeholders in every community continued using one or two of the MIRNZB elements, basically for family consumption.

Lessons learned

The MIRNZB initiative intended to be a truly participative experience, and perhaps it was. Although some collateral outputs of academic value were produced (Olguín Palacios, 1999; Olguín P. et al. 1999; Reta Mendiola, 1999; Olguín and Asiain, 2001; Alvarez Avila et al. 2001), long-term results at community level were marginal. It was clear, however, that integrated systems such as MIRNZB are very labour-demanding without being highly profitable, and would be more likely to be adopted by organized groups, rather than by individual farmers.

The economic and political background also played an important role in the entire process. However, social issues (such as the internal organization) were a major obstacle, as confirmed by findings of an anthropologist sub-contracted at one stage of the project (Alonso, 1995). Apparently, technical aspects of the different technologies of the system were acquired relatively quickly in all cases by most farmers. Their complex nature and their philosophical bases, however, represented a completely new paradigm for many stakeholders, which was not always very easy to accept.

Finally, the phantom of paternalism was latent during the whole initiative. Even after many years of intense collaboration, most group members continued to identify the academic research team as another governmental development institution. Deep inside, they were convinced that they owned the project funds and the research team was entirely at their service. As previously noted, this behaviour is still deeply rooted amongst many rural farmers in Veracruz, as in the rest of the country.

4.3.3 The Simultaneous Growth Production Groups project

Context

During the late 1990s, more than 500 farmers were officially involved in tilapia farming in Veracruz. As earlier noted, most were the result of a number of the governmental initiatives promoted by Federal and State DOAs. Many units were defectively conceived and managed, and productive efficiency was low in general. However, both the regional and the national demand for the species was an attractive incentive for a growing number of new entrants, mostly from the private sector.

At the beginning of 2000, the former regional office of CONACYT (known as SIGOLFO) promoted a two-day meeting in the City of Veracruz with the purpose of analysing the problems of the tilapia industry in Veracruz and Tabasco (the southern neighbour State), and their role in regional agricultural development. Fish farmers (from the *ejido* and private sectors) were present, as well as members of the academic, official and service sectors. SWOT analyses were conducted; much was said though little was done. However, an interesting result of the meeting was the recognition that to overcome many of the detected problems at farm level, different and more efficient schemes of technology transfer and extension should be explored. As a result, SIGOLFO started to consider this research and development issue in its agenda.

The GCPS Project

Within the national agricultural scenario, one of the most successful initiatives of the last decade has been the “Livestock Groups for Technology Validation and Transfer” (hereinafter: GGAVATT), developed by a research group of INIFAP, the National Institute of Forestry, Agriculture and Livestock Research (Román-Ponce et al., 2001), the main sectoral institution involved in technology development and transfer (Aveldaño et al., 1999). The idea of the GGAVATT model was to promote the transfer of technology amongst livestock producers (usually in clusters of 10 to 20 members) by means of a multiplying effect by imitation. Originally implemented with cattle farmers in a small region of the country, the model is now used nationwide with a number of different farm animals, generally producing positive results (INIFAP, 2005).

The Simultaneous Growth Production Groups (GCPS) was a research project conducted by a COLPOS research team. It was inspired by the GGAVATT model and financed through a mix of sources from CONACYT-SIGOLFO and the State Agricultural Development Foundation (Fundación PRODUCE-Veracruz). It aimed to promote the exchange of experience amongst clusters of tilapia farmers located in different areas of the State, in order to improve the dissemination and flow of technical knowledge. It lasted from the beginning of 2001 to the middle of 2004. Project funds mainly covered travel expenses and logistic support (Reta-Mendiola, 2004).

The key elements of the strategy were:

1. Training of five extension agents, employees from different regional aquaculture development institutions and actively involved with tilapia farmers in Veracruz, in the subject of participatory research methodologies.
2. Preliminary characterization of production units (a total of 139) visited regularly by those extension agents, followed by the formation of six groups of farmers according to their production approach (i.e. beginner, small-scale artisanal, semi-intensive and intensive).

3. In every group, SWOT analyses were conducted. The main technical problems at farm level were identified and prioritized.
4. Promotion, on a monthly basis, of one-day on-farm meetings amongst members of each group to discuss, analyze and try to find out solutions to overcome the different detected problems (e.g. water quality management, feeding strategies, genetic management, etc.). Every farmer in each group was the host of one meeting, and one extension agent was present in all meetings. For specific topics, the presence of an external guest advisor (a member of the researcher team or a farmer from another group) was also encouraged. Project funds covered transport costs of guest advisors and those farmers who required them.
5. Periodic evaluations of the production units (in terms of adoption and use of different elements of tilapia culture technology) within each group.

Lessons learned

The idea behind the GCPS project was to encourage farmer-to-farmer interaction in order to disseminate technical tilapia farming knowledge amongst the members of each group. However, the scheme worked only while the research team promoted the meetings. One of the main lessons learned was that most farmers were not genuinely convinced of the value of the meetings, to the point of stopping the gatherings amongst all groups once the research project ended. Evidently, the “unnatural” constitution of the groups played an important role in this. The individualistic nature of many farmers, accentuated by their reluctance (or sometimes genuine incapacity) to collectively afford a private advisor, was another important reason why the meetings did not carry on.

The GCPS project did not promote tilapia farming to new entrants. However, to those farmers considered as “beginners”, the opportunity to learn from more experienced farmers had a positive impact in their production units. In contrast with most of the new entrants persuaded by governmental or NGOs initiatives, where the only source of information was the sporadic visit of an extension agent, their performance turned out to be quite remarkable.

As earlier noted, GCPS project funds also partially covered the travel expenses for the fieldwork of the present research, specifically for collection of information at household level. Despite the close link, a fundamental conceptual difference was always kept: The groups of the GCPS project were formed externally according to productive criteria, regardless of the innate interaction of their members. The groups’ cohesion was kept, in most cases, by the constant “pressure” of the research team, including the extension agents that regularly interacted with the farmers. In contrast, for the present research, the studied groups (examined in-depth in Chapter six) corresponded to geographic clustering, where some kind of communication among farmers had already taken place and further (natural and spontaneous) interaction was anticipated.

Ultimately, the GCPS project produced some outputs of at least academic value. An initial characterization of tilapia farmers in Veracruz and their production units was conducted, and a rudimentary technological index was produced (Hernández-Mogica et al., 2002). The profitability of integrating tilapia farming within different agroecosystems was also evaluated (Zetina-Córdoba et al., 2003b; Zetina-Córdoba et al., 2006). Finally, a preliminary model of technology transfer to improve tilapia farming was produced and has been gradually improved (Reta-Mendiola et al., 2004;

Reta-Mendiola et al., 2005a). So far, this model has been tested with trout farmers in the State of Puebla (Zetina-Córdoba et al., 2003a), and as a diagnostic tool with tilapia farmers in the State of Campeche (Amador del Ángel et al., 2006).

4.4 Key actors in the current regional aquaculture scenario

4.4.1 Overview

This section has provided a chronological account and analysis of some of the most relevant initiatives implemented in the area in order to promote and disseminate tilapia culture technology. More than forty years after having been introduced into the country, tilapia is a strong and growing industry where a number of old and new stakeholders dynamically interact, both in the national and regional contexts. To build information further and to contribute to this research, during the period 2000-2006, ten workshops were conducted in order to obtain a more accurate picture of the tilapia sector, its current actors and respective roles. SWOT analyses and personal interviews were carried out involving a number of stakeholders (Table 4.2). Although many individuals participated in more than one workshop, the overall sample was considered representative of the tilapia sector in the region.

Table 4.2 Workshops' summary.

Venue and date	Methodology	Stakeholders involved
Veracruz (2000)	SWOT	36
Catemaco (2001)	SWOT	120
Veracruz (2001)	SWOT	21
Veracruz (2006)	SWOT	95
Six different communities (2001-2002)	SWOT	58
Various (2001-2004)	Personal interviews	13
Total		**343**

Out of the 343 stakeholders involved, more than 60% were farmers. The remainder were sorted-out into five major categories presented in Table 4.3.

Table 4.3 Characterization of stakeholders.

Category	Stakeholders surveyed	Percentage
Farmers	212	62
Government sector	37	11
Academic and research bodies	33	10
Service providers	31	9
NGOs and foreign entities	11	3
General public	19	6
Total	**343**	**100**

As expected, the perceptions about the main strengths, weaknesses, opportunities and threats in relation to the tilapia sector considerably varied amongst and within stakeholders' categories. However, some points of convergence were evident:

- There is a generalized acknowledgement that significant disparities exist amongst farmers in relation to their availability of various capital assets.
- Effective mechanisms to enhance the human capital need to be developed and implemented.
- The normative framework and the institutional networks must be reoriented.
- The trend of the industry allows further growth expectations.

An in-depth analysis of all the aspects of the workshops goes beyond the scope of this research. Instead, emphasis has been placed on the description and analysis of the different stakeholder categories and their respective role in the current development of the tilapia sector. However, it is pertinent to point out three concise findings, which will be subsequently used to support the final discussion:

- Less than 3% of the total 343 stakeholders (i.e. 9 individuals) were able to understand written English. Only two were farmers.
- Only one stakeholder (a researcher and former Ph.D. student from Stirling University) was aware of the existence of the Sustainable Livelihoods Approach.
- Producers were generally wary with regard to the increasing volumes of imported tilapia in the market.

A brief examination of the different categories of stakeholders is presented next, followed by a review of their perceptions regarding the tilapia sector.

4.4.2 Farmers

It is notable that in recent years, the number of private sector tilapia farmers has been rising. The biggest, most productive and efficient farms correspond to this sector. They have in general better access to resources (financial and human), are more tolerant of risk, and appear to be moving the industry towards more productive and technologically advanced scenarios. About 22% of the farmers surveyed were introduced to the activity by another farmer (e.g. neighbours, relatives or friends).

Commercial-scale farmers in the private sector have been responsible for introducing into the region a number of technological innovations previously unknown to most producers or extension agents. These include genetically improved lines, better management practices, marketing strategies, technologic innovations, etc. It is now possible to find good examples of international *state-of-the-art* culture knowledge within the region (Reta-Mendiola et al., 2005b; Anonymous, 2006; Alvarez-Arrojo, 2006). Some recognition for this has been the holding of the Seventh International

Symposium on Tilapia in Aquaculture (ISTA7), one of the world's most important tilapia events, in Boca del Río, Veracruz, during September 2006.

In spite of the initiatives recounted earlier (or perhaps more accurately because of their failure), regional networks (formal or informal) that might be in a position to offer support to individual households are still in their infancy. The organized work seems to bee poorly rooted within the majority of surveyed stakeholders, and is significantly accentuated by geographic and infrastructure issues. An attempt to overcome this had has been the creation of the Veracruz Aquaculture Association (AVAC) during the mid 1990s. Its internal mechanics and emergent role in the processes of technology transfer will be explored in-depth in Chapter eight.

4.4.3 The Government sector

Traditionally, the State has played a fundamental role in national and regional tilapia industry development. As previously analysed, the government sector usually leads the process to satisfy both political and social goals (i.e. to foster economic and social development). Three main categories of governmental action or engagement can be recognized, i.e.: *i*) policy makers; *ii*) regulatory bodies; and *iii*) development bodies.

The legislative framework of aquaculture in Mexico was examined in Chapter 2. Its complexity derives from the large number of administrative entities involved. However, the analysis of the national juridical framework also reveals that most legal initiatives are supported by political interests rather than technical or scientific knowledge. In this context, the whole policy making process (and their responsible legislative bodies) can be described as dysfunctional or non-coherent, a topic that will be further examined in a subsequent chapter. Instead of promoting and regulating the activity, the juridical framework is restraining its development. As indirect support for this statement, out of the total 142 farms surveyed, none fulfilled the legal requirements or complied with established norms and regulations. A former senior officer of the Federal DOA interviewed in the study about his main approach to promote aquaculture development in the State during his time in the office, replied that this was “by not enforcing the law”. In fact, if the law (as nowadays existing) was enforced, most (if not all) tilapia farms would be shut down, and most farmers would be liable, and even fined or imprisoned. Evidently, a number of contradictions must be addressed and further legislative work needs be done (OECD, 2006).

Due to the number of administrative entities involved in the activity, their respective regulatory bodies are vast and are dispersed amongst different secretariats and departments, both at federal and state level. Their lack of interaction is notable. The resultant bureaucracy is accentuated by a reduced staff supported by insufficient resources to accomplish their work. So, although the regulatory bodies exist (and are supported by their respective legal frameworks), enforcement hardly ever takes place. The popular adage: “it’s better to beg for forgiveness than to ask for permission” perfectly exemplifies the attitude of most existing farmers and new entrants. Paradoxically too, an official entity such as the Federal DOA, simultaneously acts as promoter and enforcer.

The development bodies are also diverse and widespread, most of them acting independently and with a minimal level of interaction. The approaches of the two DOAs (Federal and State) operating in Veracruz have been previously described. Nowadays, both entities actively promote tilapia farming using a top-down and subsidy-dependent model of extension, oriented mainly to poor individuals. The Federal DOA, which operates all governmental hatcheries in the State, also leads the “National Programme of Rural Aquaculture”, aimed at promoting small-scale aquaculture in rural communities. Most of the nearly 500 officially recognized farmers in the State were introduced into the sector (or have at some point been assisted) by the DOAs.

The following data illustrate the approach and the inherent limitations. According to the best available figures (CONAPESCA, 2003; CONAPESCA, 2004), during 2003 alone the DOAs delivered tilapia fingerlings to stock 187 natural water bodies in the State. Using this approach of extensive aquaculture, 13 613 poor households were directly benefited. Additionally, over 450 small-scale producers (using mainly semi-intensive systems) were directly benefited with fingerlings, basic training and advice, and sometimes with inputs such as feed or construction materials. The supported farmers were estimated to produce a total of 422.6 tonnes (annual production ranged from 10 to 12 000 kg y^{-1}; average production 931 kg y^{-1}). Productivity (amount produced / area or volume / time) is not considered relevant during or after interventions; instead, emphasis is made on the amount produced by any individual supported.

Apart from the DOAs, other governmental agencies actively promote tilapia culture in the State (Gobierno del Estado de Veracruz, 2000, 2005). The most important is the Papaloapan Development Council (CODEPAP), created at the end of 1999 and linked to the Veracruz Development Institute (INVEDER). This uses State budget to promote community-based projects aimed at fostering social and rural development within the Lower Papaloapan Basin. It encourages, *inter alia*, small-scale tilapia farming using a similar top-down approach to that of the DOAs. So far, CODEPAP has invested more than US$ 1.4 million in establishing a number of small-scale production units using different production systems (CODEPAP, 2006). A summary is presented in Table 4.4.

Table 4.4 Small-scale tilapia projects financed by CODEPAP.

Activity	Beneficiaries	Projected outputs	Investment ($US)
5 tilapia hatcheries	72 households in 5 municipalities	280 000 fingerlings hatchery^{-1} year^{-1}	117 000
11 modules of circular tanks	120 households in 8 municipalities	5 tonnes module^{-1} year^{-1} (@ 15 kg m^{-3} year^{-1})	230 000
20 modules of floating cages	316 households in 12 municipalities	8.8 tonnes module^{-1} year^{-1}	370 000
3 modules of earth ponds	28 households in 3 municipalities	2 tonnes module^{-1} year^{-1} (@ 0.2 kg m^{-2} year^{-1})	74 000
23 pens	744 households in 10 municipalities	10.5 tonnes pen^{-1} year^{-1} (@ 0.15 kg m^{-2} year^{-1})	480 000
2 enclosures	27 households in 1 municipality	6 tonnes enclosure^{-1} year^{-1} (@ 400 kg ha^{-1} year^{-1})	25 000
Fingerlings and feeds delivered	492 households in 19 municipalities	610 000 fingerlings delivered & 81.3 tonnes of commercial feed Goal: 214 tonnes of tilapia	83 000

Source:(CODEPAP, 2006).

CODEPAP provides seed capital (e.g. infrastructure, fingerlings and commercial feeds) and sporadic assistance. Again, most production units have worked relatively well only while the subsidies last, and many have been abandoned later on.

Finally, a number of minor actors of the government sector also participate in the promotion and dissemination of tilapia culture in the State:

- The agriculture development departments at municipal level. Although theoretically each one of the 212 municipalities in the State needs to have one office, only a small fraction have the qualified personnel, the budget or the interest to include aquaculture amongst their development programmes.

- Federal and State development institutions offer a number of funds aimed at developing the aquaculture sector. Table 4.5 provides a synthesis of the most relevant aid programmes.

Table 4.5 Aquaculture development funds.

Name	Acronym	Modality of aid
Funds Instituted in Relation to Agriculture	FIRA	Offers financial and technical support to promote the agricultural and fishing sectors. Oriented mainly to commercial-scale projects.
Capitalization Fund for Rural Development	FOCIR	Provides risk capital to rural firms.
National Fund to Support Solidarity Enterprises	FONAES	Finances development projects. Oriented mainly to small and medium firms.
Shared-Risk Trust	FIRCO	Offers guarantees for commercial-scale projects.
Supports and Services for Agricultural Marketing	ASERCA	Offers marketing support and direct payment to producers.
Rural Trust	FINAN	Offers financial support to rural enterprises.
State Agricultural Development Foundation	PRODUCE	Finances research and development projects in the agricultural sector.
Veracruz Development Institute	INVEDER	Finances development projects. Oriented mainly to small and medium firms.

4.4.4 NGOs and foreign entities

Since the early 1990s, the number of NGOs involved in rural development activities has been rising notably, both at national and State level. Their areas or influence, their financial sources and their operative approaches are diverse, and so are their impacts. In fact, many national or international resources aimed at promoting community-based development in Mexico have increasingly been allocated to NGOs instead of the traditional official institutions involved in rural development. It can be speculated that this phenomenon prevails because many NGOs operate in remote areas where the presence of the official entities is rare, or due to an increasing feeling of distrust amongst donors concerning the behaviour of many governmental departments. Whatever the reason, NGOs are playing an escalating role in the empowerment of the poor and/or disadvantaged people all around the country.

Although not many NGOs operate in Veracruz, some of them are using aquaculture (namely tilapia culture) as an entry point for building up other assets. Perhaps the most well-known is the Sierra de Santa Marta Project (PSSM), which operates mainly within indigenous communities (Nahuas and Popolucas) in the southern part of the State. So far, the initiatives promoted by PSSM have produced valuable lessons about the natural resources management in these deprived and remote areas of the country (Buckles and Erenstein, 1996; Rice et al., 1997; Blanco R., 1998; Rice et al., 1998a; Rice et al., 1998b; Durand and Lazos, 2004). The aquaculture attempts of PSSM, although modest, have apparently improved the livelihoods of many poor households in the area. All tilapia producers induced by PSSM (23 farmers dispersed in three municipalities) were included in the present research and were closely monitored. Further details will be presented in the subsequent chapters.

On the other hand, the number of foreign entities impacting the area is limited. Sporadic aquaculture-related funds from international donors are generally used in academic activities and basic research rather than in development initiatives. Usually, these granted funds respond to particular initiatives of the own research bodies and are seldom linked to the productive sector. In contrast, an important source of external financial resources and motivation for new entrants derives from the millions of legal and illegal Mexican migrants working in the US. According to recent figures, workers' remittances accumulated in 2005 more than US$ 20 billion, which represented 3% of GDP (Banco de México, 2006). Nowadays, the impact of remittances on the national economy is only surpassed by oil exports (Banco de México, 2005b). Table 4.6 shows the relative importance of workers' remittances to the national GDP during the period of the present research, compared with the primary sector (particularly the combined fisheries and aquaculture sub-sectors).

Table 4.6 Summary of selected macroeconomic indicators (period 2000-2005).

	2000	2001	2002	2003	2004	2005
Gross Domestic Product[1]	580 764	621 823	648 623	638 798	683 067	768 430
Primary sector, excluding mining	20 798 (3.6)	21 896 (3.5)	22 640 (3.5)	24 290 (3.8)	27 24 (4.0)	28 851 (3.8)
Fisheries and aquaculture	666 (0.11)	679 (0.11)	702 (0.11)	826 (0.13)	817 (0.12)	894 (0.12)
Total remittances	6 573 (1.1)	8 895 (1.4)	9 814 (1.5)	13,396 (2.1)	16,613 (2.4)	20 035 (2.6)

[1]Amounts are expressed in million US dollars. Numbers in parenthesis indicate percentage of total GDP.

Sources: (INEGI, 2005a; Banco de México, 2005a; Gobierno de la República, 2006; INEGI, 2006; Banco de México, 2006; INEGI, 2007a).

During the years 2004 and 2005, remittances allocated to families in the State of Veracruzreached approximately US$ 951 million per year, strongly contributing to the regional economy (Banco de México, 2005a; Banco de México, 2006; INEGI, 2006). It has been extensively documented that most migrants keep strong links with their families and communities, and apart from the economic support, they often bring back entrepreneurial ideas that eventually translate into productive activities. Several tilapia farmers in the present study have had access to this sort of financial support. Obviously, the migration phenomenon has also many dark sides (e.g. human exploitation, cultural erosion, abandonment of rural communities, etc.). The entire phenomenon is extremely complex and has been increasingly studied, from diverse angles, by a number of scholars (Arizpe, 1981; Sandos and Cross, 1983; Rhoda, 1983; Durand et al., 1996; Bustamante, 1997; Massey and Espinosa, 1997; Jones, 2001; Orozco, 2002; Solimano, 2004; Aroca and Maloney, 2005). Here, however, the primary focus is on the role in investment, entrepreneurial approach and technology introduction.

4.4.5 Academic and research bodies

The academic infrastructure in aquaculture-related areas goes far beyond the State frontiers, and is the combined result of a number of long-term and continuous efforts of the Mexican government in order to strengthen the human capital within this field (Idyll, 1974; Cifuentes-Lemus et al., 1990; Guzmán and Zarza, 1996; SEP, 2003). Nationwide, 78 institutions offer formal academic programmes involving topics of aquaculture or aquatic resource management within their curricula (INEGI, 2007b). Out of this, 33 institutions (known as CETMAR and CETAC) are technically oriented, offering programmes equivalent to high school level (DGECTM, 2007). More than 30 other institutions are involved in research activities, most of them offering graduate or postgraduate programmes. In general terms, all academic programmes (at every level) are practically free of charge for any Mexican student, and scholarships are usually available in order to encourage enrolment rates.

The regional arena has its own academic tradition in aquaculture-related issues that goes back to the late 1950s, with the creation of the former Marine Biology Station (1957-1965) based in the city of Veracruz. Through time, it has undergone a number of transformations, becoming in turn the National Institute of Marine Sciences and Technologies (1966-1974), the Fishery Technologic Institute (1975-1981), the Technologic Institute of the Sea or ITMAR (1981-2005), and from 2005 onwards the Boca del Río Technologic Institute or ITBOCA (ITBOCA, 2007). During the first years of the 1980s, strong links with the British Government, particularly ODA, contributed to its institutional strengthening, mainly in terms of logistic support and infrastructure. The presence of young M.Sc. graduates from the Institute of Aquaculture of Stirling University (both British and Mexicans) in the undergraduate taught courses brought *state-of-the-art* knowledge to the regional arena, and was a valuable source of inspiration to many generations of students. Although difficult to assess, this particular intervention definitely contributed to the present-day regional human capital, motivated through the many involved in both sides of the Atlantic. In 2000, ITBOCA started its own M.Sc. programme in aquaculture, contributing to the development of better qualified human resources in the region. Although ITBOCA has been gradually expanding its services to the productive sector (e.g. training courses, aquatic diseases diagnostic laboratory, soil and water surveys, etc.), perhaps its major contribution to the regional arena has been the formation of human resources.

Apart from ITBOCA, seven major State-based academic institutions are involved in aquaculture-related programs or research activities (Universidad Veracruzana, Colegio de Postgraduados, Instituto de Ecología, Centro Regional de Investigación Pesquera, Universidad Nacional Autónoma de México, Acuario de Veracruz, and Secretaría de

Marina). Moreover, out of the earlier described 33 technical schools dispersed nationally, four are located within the State of Veracruz (in Túxpam, Veracruz, Alvarado and Coatzacoalcos), Veracruz having the highest number of schools of this sort in the whole country. A secondary school in the northern city of Nautla complements the State academic aquaculture offer at this technical level.

Because of the number of academic institutions regionally, and due to intrinsic differences in their functions, goals and agendas, it is difficult to assess their role in the entire regional tilapia sector. However, some generalizations can be made:

- There is an almost complete lack of interaction amongst institutions.
- Apart from a few exceptions, the links of the academic and research bodies with the productive sector are insignificant.
- Most academic curricula are commercial-scale oriented. The people trained are struggling to find a labour niche within an emergent industry that is not ready to absorb them; their presence in poor and remote areas, where they are most needed, is very small. Few people trained have the entrepreneurial skills and/or assets to initiate new business themselves.
- The participation of the private sector in research and development activities is marginal.
- Most research projects (and derived outputs) follow individual interest rather than long-term planned interventions oriented towards an integral regional development. Within the national schemes of incentives to researchers (like the National Research System or SNI), the publication of papers in international scientific journals has more value than local or regional development initiatives.

In this context, the current national system is rewarding the individualistic work instead of promoting inter-institutional efforts.

- Publications of this form were largely inaccessible to potential users. All stakeholders were asked about their access to those publications, confirming that no one, not even research bodies, had a regular access, mainly due to the high cost of journal subscriptions and the barrier of language. Evidently, the regional impact of this type of outputs is minimum as a technology transfer mechanism. In fact, it is increasingly recognized that articles in scientific journals are a relatively ineffective mechanism for technology transfer, although articles are one of the main technology transfer activities of scientists (Rogers et al., 2001).

Finally, research bodies from institutions based in another States, particularly Mexico City, although frequently found within the region, have in general produced limited impacts regarding the dissemination of tilapia culture technology and/or the community-based management of natural resources. Their presence in the regional arena is, in most cases, associated to the collection of data from *in situ* projects.

4.4.6 Service providers

It was not until the proliferation of semi-intensive and intensive operations, during the early 1990s, that service providers started to emerge. The growing demand of production inputs (e.g. commercial feeds, equipment, etc.) was the result of the expansion of commercial aquaculture. However, the local availability of inputs was simultaneously an incentive to new entrants. So, service providers have been acting, at the same time, both as cause and consequence of the regional tilapia development.

Nowadays, within the regional market it is possible to find several commercial feed brands and a number of other production inputs (e.g. genetically improved fingerlings, tanks, nets, aerators, water quality monitoring equipment, etc.). Because of their high price, some of these inputs are not affordable to most farmers engaged in small-scale operations. However, due to the growing offer of inputs freely competing in the regional scenario, a gradual decrease in prices is expected (Reta-Mendiola et al., 2005b).

So far, the role of this group of stakeholders in the development of the regional tilapia industry has shown itself to be quite important. To increase their sales, most service providers travel from one farm to another, and whether intentionally or not, disseminate information and technical knowledge amongst farmers. Although informal, the approach seems to be an interesting and cost-effective method for technology transfer, with further potential, and will be further explored in the next chapters.

4.4.7 Farmers' organizations: the AVAC case

By mid 1990s, several aquaculture farms (principally commercial tilapia farms of the private sector) were operating near the city of Veracruz, one of the development poles in the State. Due mainly to this geographic circumstance, informal and frequent interaction amongst farm owners had already been taking place. Common problems (mainly associated to markets and input prices/availability) repeatedly emerged, as well as a generalized *sense* of an "institutional vacuum" in terms of technical assistance and normative issues. Encouraged by the former director of the Federal DOA, and with the participation of a few academics and researchers, a series of meetings were scheduled and carried out during 1995 with the aim of exploring the convenience of creating a formal organization with a shared vision of pushing forwards the industry. Eventually, this entity would be the unified voice of the State aquaculturists in order to influence governmental initiatives, protect market prices, stimulate investment, and help disseminate technical knowledge.

The Veracruz Aquaculture Association or AVAC (formerly *Acuacultores del Estado de Veracruz, A.C.*) was formally created in March 1996 as a civil association with approximately 10 members. Although the association was conceived as an inclusive organization, and thus open to all fractions of the society interested in the activity (i.e. farmers, service providers, extension agents, academics, students, etc.), the directing board (democratically elected amongst all members for two-year periods) was intended to be always represented by active farmers. However, because the membership fees were not very easily affordable by most small-scale farmers, their participation during the first years was marginal. Moreover, because of the fact that most small-scale producers in the State are geographically dispersed, attending the meetings in the city of Veracruz represented a big deal for most of them. Accordingly, the association started to become somehow elitist, dominated by commercial-scale farmers and with a strong pro-commercial aquaculture orientation. Nevertheless, during the first five years, approximately 100 members (farmers and non-farmers) were actively participating. Weekly meetings in the city of Veracruz (open to all members but regularly attended mainly by the directing board and local residents), had been regularly carried out since then. During that initial period, AVAC also organized two plenary meetings a year (also in the city of Veracruz) and published the bi-annual informative bulletin *Rostrum*.

In 2002, AVAC was restructured and renamed[2]. Although new statutes were produced, the internal dynamics did not change substantially: weekly meetings in the city of Veracruz and at least two plenary sessions a year, this time organized in farms located in different parts of the State. These open-day meetings have been intended to reach dispersed small-scale farmers and to promote farmer-to-farmer interaction. A guided tour within the host farm is usually complemented with two or more talks on topics of common interest (e.g. water quality management, feeding practices, pond construction, etc.). Service providers are also regularly invited to these meetings; actually, the exhibition of commercial products has proved to be an important incentive to attract local people.

Trying to be more inclusive, the membership fees have been reduced into symbolic figures. Therefore, most of the work has relied on the voluntary work of some members, which at some extent has reduced the impact of many of the originally planned initiatives. The weekly meetings are conducted in a local restaurant and the new bulletin is supported by paid commercial advertising. Nowadays, AVAC includes approximately 250 members and has gathered one of the most reliable databases of aquaculturists in the State. At regional level, it is perhaps one of the most important aquaculture-related institutions in terms of human capital. Moreover, within the regional political arena and for the first time in history, AVAC has become the main voice of many commercial and small-scale aquaculturists.

So far, AVAC has started to influence State policies regarding health management issues for responsible movement of aquatic animals in agreement with international

[2] Acuacultores Veracruzanos, A.C. (http://www.avac-enlinea.com).

standards such as the recent guidelines published by FAO (2007). As previously indicated, amongst many farmers there is a generalized concern about the increasing presence of cheap imported tilapia in the national market, introduced frozen into the country directly from Asian countries or through the United States. Although locally-cultured tilapia has kept their value and its demand is rising (maybe in part to the presence of imported fish in urban supermarkets), AVAC has started pressing federal authorities for the prompt regulation of import quotas, via anti-dumping policies and enforcement of international food quality standards, in order to protect the regional industry.

AVAC had also been using local and regional mass media (namely free spaces in press, radio and TV) to increase the public awareness of aquaculture, particularly in terms of ethical consumerism (e.g. supporting local enterprises and choosing locally cultured fish). Published notes and broadcasted programs had motivated existing and new entrants to join the association and, through the interaction with experienced farmers and technicians, improve the overall performance of their farms. In addition, the AVAC web site had been re-designed to post the new informative bulletin as well as technical communications written by its members.

As an advocate of responsible tilapia farming, AVAC had organized a series of training courses using the existing infrastructure and knowledge of its members. Some courses had been required and paid by government organizations and NGOs interested in promoting aquaculture. Some others had been offered to existing or new entrants at minimum cost (i.e. just enough to cover expenses). Usually, the host farmer provided accommodation and the trainees paid for their catering. The attendants were involved in all farm activities, which were complemented with talks offered by other experienced farmers or academics.

Being a non-lucrative organization, the resources obtained through membership fees or training courses were usually used for the internal operation of the association and/or activities of common interest of its members (e.g. increasing the regional genetic pool, acquisition of bibliographic materials, invitation of guest experts, etc.). For instance, at some point a pure line batch of *O. niloticus* was bought from Stirling University; the broodstock was split amongst a reduced number of farms which had the adequate breeding infrastructure available, and the other members received a fixed quota of the subsequent produced fingerlings. In the same way, another pure line lot was recently imported from Colombia.

During its existence, AVAC has participated in many local and regional agriculture and fisheries events (even co-organizing some of international significance, such as ISTA7 and WAS 2009), promoting elements of responsible aquaculture to the general public, and providing free advice to existing and new entrants. It has been recognized by regional governmental and non-governmental entities as an organized group that include experienced farmers and experts in different fields. For more than a decade, the weekly meetings in the city of Veracruz have proved to be an important contact point for many current and new entrants, both at small- and commercial-scale. In fact, the DOAs and some NGOs have been gradually encouraging existing farmers and new entrants to attend these meetings in order to obtain advice from more experienced people.

As a technology transfer promoter, AVAC has proved to have its strongest impact in the central part of the State, in the immediacies of the city of Veracruz. As indicated in Chapter six, many small-scale farmers located in the surrounding municipalities have improved their technical knowledge after regularly attending the weekly or plenary meetings. However, hundreds of dispersed farmers are still out of reach. For practical and logistic reasons, this situation is unlikely to change, at least in the short term. Nevertheless, AVAC has also served as a source of inspiration for the creation of new associations in other parts of the State. Recently, several new groups have been created[3]. All these organizations have started to interact and in the short term it is expected that an inclusive State federation could be in operation. Optimistically, the organized tilapia farmers might shortly obtain the social and juridical recognition similar to other regional primary sector groups (e.g. the sugar cane organizations), and then gain access to better planned public funds (e.g. credit, social security, extension services, etc.).

Similar findings to those observed in the AVAC case have been noticed elsewhere, where farmers' organizations have attempted to fill the gaps in government services (Bingen et al., 2003). For instance, it has been documented that interpersonal communication roles are critical to facilitate technology transfer (Booz and Lewis, 1997). Moreover, for common resource management (such as the exposed initiatives regarding the promotion of large enclosures), the various stakeholders should cooperate in an holistic fashion to achieve sustainable results and maintain environmental integrity (Holland, 1998).

[3] E.g.: Consejo Veracruzano del Acuicultor; Federación de Acuicultores Unidos por la Cuenca; and Asociación de Acuicultores Olmeca de los Tuxtlas.

Albeit farmers' associations are formal structures with an explicit purpose (Raina, 2003), they are also important by offering leadership and organizational expertise to new producer groups (Lichtkoppler and Passewitz, 1992). Accordingly, extension programmes should encourage and support farmers' organisations and farmer-to-farmer extension (Garforth and Lawrence, 1997). In this context, community-based organizations offer a good opportunity to bridge the gap between federal and State environmental agencies and citizens because they have strong ties with neighbourhood residents and understand the neighbourhood's assets and needs (Kellogg, 1999), while research institutions may provide insights on subjects such as SLA concepts and methodologies, as well as on the analysis and development of innovative strategies (Cotula, 2002).

4.4.8 General public

The strong internal demand of tilapia has been noted. Although this seems to vary according to the region and the season, evidence suggests that farmed fish reaches higher prices than the wild caught, extensively produced or imported (Hartley-Alcocer et al., 2006). However, it is generally accepted that both at national and regional level, prices have dominance on purchasing decisions (Beltrán, 2006). In fact, the growing presence of fillet and other value-added presentations in the supermarket sector is particularly notable, especially in urban areas, where an important sector of the population has the economic capacity to afford it.

Ironically, increasing imports (mainly from Taiwan and other Asian countries) introduced directly or through the US by the big supermarket chains or brokers seems to be responsible of the growing demand for tilapia within national urban markets. Imports are now estimated to have a 20% share on the total domestic consumption of fish and seafood (COMEPESCA, 2007). Moreover, the entry of imported product into the national market appears to be encouraging new entrants, as well as improving the quality standards amongst existing producers in order to remain competitive (Hartley-Alcocer et al., 2006).

It is estimated that from the total Mexican households with a medium to high income, around 35% consume fish and seafood, while from the total Mexican households with low income, only 17% consume this kind of products. Thus, it is quite clear that consumption of fish and seafood is concentrated among the medium to high classes (ECON, 2005). Ultimately, apart from the increasing role in improving the livelihoods of thousands of poor households, the generated demand of tilapia amongst most privileged strata of the society appears to be responsible for turning the industry into a profitable and competitive activity.

To promote consumption of fish and seafood in Mexico, in 2003 the Mexican Council for the Promotion of Fish and Aquaculture Products (COMEPESCA) was created. This association was integrated by Mexican producers, traders and processors of fish and seafood (COMEPESCA, 2007), and in 2004 they launched an intense nationwide promotional campaign denominated “Sr. Pescado” or “Mr. Fish” (COMEPESCA, 2006; Seafood Today, 2006). Using mass media and with the full support of the Mexican Government (namely SAGARPA and CONAPESCA), the campaign has started to produce interesting results. For instance, the national *per capita* consumption[4] increased 5% in 2005, and by the end of that year, the big supermarket chains had an increase in

[4] The annual *per capita* consumption of fish and seafood in Mexico is estimated to be around 8 kg, substantially lower than the per capita consumption in other countries such as Japan (90 kg) and the U.S. (28 kg) (CONAPESCA, 2003; INCMNSZ, 2003; FAO, 2004; ECON, 2005; COMEPESCA, 2007).

sales that ranged from 5 up to 29% with respect to 2004 (COMEPESCA, 2007). Mr. Fish is still in business.

In synthesis, the entire society (namely the market) seems to be playing an increasing and decisive role within the present and future development of the tilapia industry, not only in Veracruz but all along the country.

4.4.9 Collective action

Collective action (e.g. social networks, public-private partnerships, etc.) has shown an increasing and promising role in social capital formation and rural development (Seboka and Deressa, 2000; Perez-Sanchez and Muir, 2003; Scheuermeier, 2004; Place et al., 2004; McCarthy et al., 2004; Poteete and Ostrom, 2004; Gomez Tovar et al., 2005; Moxley and Lang, 2006). From the agriculture sector, valuable lessons are constantly emerging. The spectrum is vast and includes experiences in topics such as agricultural research (Gerpacio, 2003; Spielman and von Grebmer, 2006; Spielman and von Grebmer, 2006-), dissemination and adoption of new technologies (Umali and Schwartz, 1994; Umali-Deininger, 1997; Gisselquist et al., 2002; Solís and Bravo-Ureta, 2005; Rivera and Alex, 2006; Ortiz-Ferrara et al., 2007), soil and water conservation (Pretty and Shah, 1997), rural development (Osti, 2000; Sulaiman et al., 2005; Keefer and Khemani, 2005; Haenn, 2006; Amudavi et al., 2006), agricultural development (Dewees, 1995; David et al., 2000; Alonge, 2002; Marsh et al., 2004; Gomez Tovar et al., 2005), marketing of agricultural products (Londner and Mulholland, 2002), as well as other sectors of the economy (Teitel, 1981; Douglas and Basiuk, 1986; Athreye and Kapur, 2001).

Mimicking the experiences in agriculture, the aquaculture sub-sector has also started to produce lessons on collective action in research and dissemination of research outputs to end-users (Lewis, 1997; Karmokolias, 1997; Tilapia Science Center and WorldFish Center, 2003; Nash, 2004; Gerpacio, 2006; Sevilleja, 2006; Tayamen et al., 2006; Abella, 2006; Hishamunda and Ridler, 2006; Rodriguez, 2006a; Acosta et al., 2006a; Rodriguez, 2006b; Acosta et al., 2006b; World Bank, 2006a).

It has also been noted that the expansion of collective action will inevitably require public policies that capitalize on complementary relationships between the NGOs, the public, and the private institutions that are filling in gaps between the public and the private sectors and helping each other become more effective (Mondal, 2000). In this context, the World Bank (2006a) acknowledged that the most effective mechanisms for the transfer and diffusion of aquaculture technology in Asia, have been:

- national will and commitment, development strategies with a long-term view, combined with appropriate institutional arrangements;
- regional inter-governmental indigenous organizations, particularly NACA;
- FAO's Technical Cooperation between Developing Countries Programme;
- recent innovative extension methods, establishment of producers' associations, and emerging contract farming; and
- long-term regional and interregional programs like FAO's ADCP and AIT's Outreach Program.

Collective action is likely to play a key role in the regional expansion of the sector. For instance, public-private partnerships and regional networks have started to emerge and are gradually gaining recognition, like the Veracruz Aquaculture and Fisheries Health

Committee[5] (COSAP), created in 2005 as a civil association, depending though on federal funds for its operation (SENASICA, 2006). So far, COSAP has provided regular advice to more than 350 trout and tilapia farms regarding health issues (e.g. farm monitoring, lab diseases diagnostics, training, etc.) (COSAP, 2007). Also, and inspired by international successful initiatives such as NACA and STREAM (FAO/RAP, 2007), the Center for Aquaculture Technology Transfer[6] (CETRA) has recently emerged as a pioneer experience in the neighbouring State of Tabasco (CETRA, 2006).

Regional data also suggest that the sector is apparently moving towards a more participative scenario. In this context, farm cluster management has shown to be a successful mechanism to empower small-scale rural farmers and to improve aquaculture practices (UNIDO, 2001; FAO, 2007). Through agglomeration benefits and joint action, clustering can speed up the uptake of research outputs (Garforth, 1998), as well as enhance the performance of small producers (Martínez et al., 2004), thus reducing their vulnerability to external shocks (Nadvi and Barrientos, 2004).

A number of lessons from Asian initiatives show that representative associative structures may act not only to promote and develop aquaculture, but also to provide a pivotal communication centre for the profession (Bueno, 1986; Booz and Lewis, 1997; Hough and Bueno, 2003; Ayyappan et al., 2003). Similarly, findings regarding associative aquaculture networks have recently been reported in Chile (Pérez-Alemán, 2005), Honduras (Martínez et al., 2004) and Norway (Normann, 2005). The role of farmers and aquaculture entrepreneurs in maintaining high levels of product quality and ensuring good practices within the clusters has proved to be essential (Hough, 2002).

[5] Comité de Sanidad Acuícola y Pesquero Veracruzano, A.C. (www.cosap.org.mx).

[6] Centro de Transferencia de Tecnología en Acuicultura (www.cetra.org.mx).

Formal networks (regional, national or international) that might link farmers and institutions are also likely to play a key role in the future of the sector. These, however, are long-term processes challenging to negotiate in a context where short-term needs are often pressing and immediate (Nong and Marschke, 2006). In order to maximise their impact, they should be established with action-based partnerships between the poor and the development professionals (Edwards, 1999).

Despite the momentum gained through more than four decades of development initiatives, the outlook for the regional tilapia industry still seems to be dominated by a high degree of uncertainty. Throughout the previous chapters, elements such as markets and institutional arrangements have repeatedly emerged as serious constraints to overcome. However, the role of human and social capital has proved to be a key contributor to the situation of the industry. In the short term, innovative boosters that might encourage further strengthening of the sector–both at small and commercial-scale– are likely to be explored.

Specific action lines linked to the manner in which technology transfer processes might be enhanced include further use of mass media. A number of experiences have shown that radio is an efficient mechanism to reach rural groups in remote areas and to deliver technical information at relatively low cost (Fraser and Restrepo Estrada, 1996; Garforth and Lawrence, 1997; Ramos and Díez, 2003). Putting extension programs on television may also increase farmers' awareness of technical topics (Norrish et al., 2001; Boz, 2002; World Bank, 2006a).

4.5 Overall perspectives

"If *we are to look into the future, we must begin by looking back into the past*."

Sir Patrick Moore (2002)

Examination of the regional actors and their roles during the past four decades provides a number of topics worthy of further analysis. However, the two major detected approaches that have dominated the development of the sector will be used as the basis of the subsequent discussion. The first corresponds to the social function of tilapia culture as a catalyser of rural development through the empowerment of the poor and disadvantaged. The second relates to the commercial expansion of the industry as function of an increasing market-driven phenomenon.

4.5.1 In pursuit of rural development: the social role of aquaculture

"Mainstream development" is often simplified as a single, homogeneous thrust toward modernization and its diversity, complexity and adaptability are underestimated (Nederveen Pieterse, 1998). However, it seems that the whole concept of modernization and development –as conceived and practised– as a universally desirable end to be achieved by all countries, needs to be revised (Nabudere, 1997). As Paz (1991) points out, "all countries create their own modernity[7]". At any rate, alleviation of poverty is generally accepted as a central concept for rural development (Freebairn, 1969; Levy, 1991; Mckinley and Alarcon, 1995; Shrestha, 1997; Carney, 1999; Muir, 1999; Cord

[7] "What is modernity? First of all it is an ambiguous term: there are as many types of modernity as there are societies. Each has its own. The word's meaning is uncertain and arbitrary, like the name of the period that precedes it, the Middle Ages. If we are modern when compared to medieval times, are we perhaps the Middle Ages of a future modernity? Is a name that changes with time a real name? Modernity is a word in search of its meaning. Is it an idea, a mirage or a moment of history? Are we the children of modernity or its creators? Nobody knows for sure. It doesn't matter much: we follow it, we pursue it". Octavio Paz, Nobel Prize in Literature 1990.

and Wodon, 2001; Dorward et al., 2001; Tacon, 2001; Allison and Ellis, 2001; Farrington et al., 2002; Kydd, 2002; Edwards, 2002a; Edwards, 2002b; Barrett and Swallow, 2003; UNDP, 2003; Wade, 2004; Halwart, 2005; Finan et al., 2005; Rigg, 2005; Dollar, 2005; ADB, 2005; Soloaga, 2006; UNDP, 2006; Pritchett, 2006).

It is generally accepted that rural wage workers and agricultural farmers in Mexico are the most numerous among the country's poor and experience severity of poverty to the greatest extent (Mckinley and Alarcon, 1995). There is also a strong inequality as to productive and technological development levels between regions and even in activities performed within the same geographical zone (ICID, 2000). The problem is particularly notable in Veracruz because it has the highest rural population (i.e. those living in places with less than 2 500 inhabitants) in the whole country: 2.8 million in 2003 (CONAPO, 2003). Although theoretically all *ejidatarios* —perhaps the poorest sector of the rural inhabitants— have access to land, many of them are no longer dependent on agricultural production for most of their income and are using the assets at their disposal for a number of income-generating activities (Winters et al., 2002).

Natural resources extraction is still an important source of income for many rural households, particularly the poorest groups. Without it, many households' ability to meet their basic needs would be jeopardized (Lopez-Feldman et al., 2006). Nowadays, more than half of the total rural Mexican farmers produce maize and depend on it, mainly for self consumption (Olivo et al., 2001). Moreover, evidence from studies across Latin America show that rural households in the region are increasingly employing a diverse set of activities to maintain and improve livelihoods, suggesting that households use multiple paths to get out of poverty (Winters et al., 2001).

It has been documented that anti-poverty programs often target poor states in the hope of reaching poor people. However, the governments of poor states (provinces or countries) do not seem to be very good at targeting public spending to their poor (Ravaillon, 1999). Whenever an enterprise or programme involves substantial funds and massive planning and implementation, funders typically question whether existing local agencies will be efficient administrators (Colson, 2003). In fact, additional resources to the rural areas in the absence of institutional reforms will not help the rural poor; moreover, the focus of reforms should be to promote rural development, which should not be equated to an increase in food supply (Levy, 1991).

Worldwide, aquaculture has expanded, diversified, intensified and advanced technologically; as a result, its contribution to aquatic food production has also increased significantly (Stagnitti, 1997; Jia et al., 2001). The extent to which this increase has contributed to improving food security remains to be assessed (Cunningham, 2005). In any case, the vast majority of aquaculture practices around the world has been pursued with significant nutritional and social benefits, and generally with little environmental costs (NACA and FAO, 2000). However, the poor face many constraints to entry into it, particularly impediments to the uptake of technologies and management practices because of such factors as lack of access to capital and resources, vulnerability, and aversion to risks (ADB, 2004).

Interventions using aquaculture as an entry point for rural development have provided a number of lessons about potential constraints associated with the wealth creation dynamics, such as the rise of resource access conflicts or the disadvantage of poorest groups and vulnerable sectors (Muir, 1999). Furthermore, aquaculture often focuses more on increasing production rather than promoting a system security, stability or sustainability, being thus liable to become another high risk technology (Cunningham, 2005).

Policies for the extremely-poor need to exploit the complementarities among nutrition, health and education. More food by itself will only give transitory benefits to the extremely-poor; it will not allow them to eventually get on their feet and work their way out of poverty (Levy, 1991). In fact, the poorest people may be generally excluded from engaging directly as operators in aquaculture production not only because of limited access to land and reliable supply of water and lack of access to financial capital to meet investment and operating costs, but also because of inability to meet specific requirements for technology adoption and inadequate capacity to overcome these constraints (Muir, 1999; ADB, 2004).

It is widely recognized that aquaculture in many parts of Latin America continues to grow steadily but will need greater organization and coordination between the private sector and government particularly to achieve larger social effects (Morales Q. and Morales R., 2006). Actually, the greater the magnitude of rural poverty and the greater the number of fishers, then the greater the potential opportunities for inserting the fisheries sector into national development and poverty reduction strategies on equity grounds (Thorpe et al., 2006).

There is no standard method of measuring and quantifying the contribution of aquaculture to food security (Cunningham, 2005), in particular the contribution of small-scale aquaculture, since production data do not appear in official statistics and the produce is typically consumed or traded locally (Halwart, 2005). The large amounts consumed by tilapia farmers' families and the amounts that are locally marketed informally, might turn production statistics incorrect and unreliable (El-Sayed, 2006).

Although aquaculture is a relatively new and underdeveloped farming practice compared to agriculture and animal husbandry, its positive social and environmental attributes make it an attractive entry point to improve the livelihoods of the poor in rural development programmes (Edwards, 2000). While traditional projects may be suitable initially, there must be room for expansion into other activities that reflect the diversity of livelihood strategies that households employ. In this manner, rural development is more likely to succeed (Winters et al., 2001). The expansion of land-based culture systems in inland areas has a great potential because aquaculture can be integrated with agriculture on current agricultural land in smallholder and commercial farms (Halwart, 2005).

Moreover, apart of successfully coexist, it is generally accepted that aquaculture and agriculture can be mutually complemented through integrated approaches (Chan, 1985; Little and Muir, 1987; Liu and Cai, 1998; Khan et al., 2000; Little and Muir, 2003; Little and Edwards, 2003). However, its integration in a given region is possible only if the different farming systems and their respective dynamics are sufficiently understood (Lazard, 1996). Further direct benefits from rural integrated aquaculture, aside from increased household nutrition and income, are local availability of fresh fish and the provision of employment for household members (Prein, 2002). Within the regional context and from the described MIRNZB experience, it is also evident that a number of constraints must be overcome (namely cultural and labour-related) if integrated systems are to be seriously considered during future interventions.

Land tenure and water rights have always been key elements in the history of Mexican agriculture (Tortolero, 1998). Traditional fishing exists under weak property rights, and intensive aquaculture exists under strong property rights. As property rights strengthen, firms become more forward looking, invest in new technology, and attempt to gain control of their production and marketing systems (Anderson, 2002). Aquaculture involves an acceptance of ownership of products and, often, production facilities, while capture fisheries exploit common property (De Silva et al., 2003).

Although small hatchery operations may increase the local supply of fingerlings and can enable farmers to enter aquaculture as an activity (Halwart et al., 2003), it is also accepted that in comparison to ongrowing, hatchery production costs are generally several times higher (Young and Muir, 2002). Hatchery operations also depend on more skilled and better trained personnel. In general, indigenous knowledge on aquaculture is limited compared to other farming activities. Moreover, aquaculture is very knowledge-intensive and a relatively complex technology for novice farmers to absorb quickly (Prein, 2002). The high rate of failed experiences at regional level, where hatchery operations were encouraged amongst poor individuals (i.e. people with no skills, no time or no resources), should be a constant remainder of the importance of appropriate targeting strategies. Maybe the best approach to empower the very poor should focus in economically and environmentally sustainable technologies compatible with resources they can obtain (Beltrán, 2006).

Sustainable aquaculture must consider the ecological, social, and economic aspects of development (White et al., 2004). The increasing recognition of the complexity of rural development processes should be accompanied by the adoption of more multidisciplinary, holistic approaches to analysis and conceptualization (Knickel and Renting, 2000). Livelihoods approaches may help to better understand (poor) people, many of whom rely on fishing (STREAM Initiative, 2005). Thus, through integration and alteration, people-centred approaches have the opportunity to contribute significantly to poverty reduction and rural development (Cleary, 2003).

Elements of diverse people-centred approaches are often found in existing case studies, providing a number of valuable lessons (Sarkar, 1998; Hussein and Nelson, 1998; Scoones, 1998; Carney, 1999; Carney et al., 1999; ODI, 1999b; Nicol, 2000; Ashley, 2000a; Turton, 2000a; Baumann, 2000b; Allison and Ellis, 2001; Dorward et al., 2001; Muir, 2002; Adato and Meinzen-Dick, 2002; Baumann, 2002; Toner, 2002; DFID, 2002a; DFID, 2002b; Solesbury, 2003; Toner and Franks, 2005; Amilhat et al., 2005). However, it is also acknowledged that their use does not make other approaches unnecessary, and is not necessarily the “best” approach in all situations. The costs and benefits compared to alternatives need to be carefully assessed (Martínez-Espinosa, 2000).

Any approach emphasizing the dynamics of rural development should rely on a socioeconomic analysis of the history of agriculture in order to characterize the region's specific agrarian system. Agricultural or even fish farming practices are not reduced to their sole productive dimension, but are also considered as social practices (Koffi et al., 1996). Farmer’s community and sub-community context contain variables that sometimes are more important than the farm and farmers' characteristics, influencing long-term sustainability probabilities of new technologies to be adopted (Moxley and Lang, 2006). For instance, social relationships of labour cooperation between community members are still a very common practice, mainly in rural and indigenous areas (Cabrera et al., 2001).

Extension needs to address vulnerability as well as productivity; and, rather than over-promote diversification, offer a range of new options from which poor households can choose according to their circumstances (Farrington et al., 2002). Farmers may expect a concrete recommendation, because they have learned that this is the role of their extension agent and because they cannot accept the uncertainty about taking a decision themselves, whereas the extension agent is convinced that it should be his role to help the farm family to take their own decision (van den Ban, 1999).

4.5.2 The role of commercial aquaculture in the context of rural development

Evidence worldwide suggests that during the last two decades, approaches to achieve economic development have evolved away from reliance on government towards greater emphasis on the private sector. This new development paradigm uses the neo-classical free market prescriptions to induce a more efficient allocation of resources (Ridler and Hishamunda, 2001). In this context, commercial aquaculture has the potential to increase food availability, and through employment income and externalities, food accessibility. It need not be at the expense of rural subsistence aquaculture; in fact there may be mutually reinforcing links in marketing and technical dissemination between rural and commercial aquaculture (Hishamunda and Ridler, 2006). In fact, most successful aquaculture projects have not invariably supplied production inputs but have focused on providing technical assistance, information, and training (Engle and Stone, 1990). Therefore, if Mexico is to become one of the major tilapia producers in the Americas, as some scholars predict (Fitzsimmons, 2000b; El-Sayed, 2006), technology transfer is expected to have an increasing and decisive role in this future development of the industry.

Technological progress is supposed to be evident when the world is increasingly subject to modification, but it is also believed that when there is adaptation, further improvements to progress will be made (Rivers, 2002). In the presence of asymmetric information, when income requirements constrain the public objective, public investment would be designed to smooth informational, and hence income, differences between farmers (Bourgeon and Chambers, 2000).

As previously exposed, the broad and inclusive term “transfer” encompasses diffusion of technologies and comprises the process of learning to understand, utilize and replicate the technology, including the capacity to choose it and adapt it to local conditions and integrate it with indigenous technologies (IPCC, 2000). Moreover, it is generally accepted that the rate of technology transfer is affected by the balance between incentives or promotion measures that encourage the flow of technology (e.g. incentives to encourage investments) and barriers that impede the transfer process (e.g. lack of information and local knowledge) (Campos-Arriaga, 2003).

Technology transfer results from actions taken by various stakeholders. Although stakeholders play different roles, as indicated in depth in the previous sections, there is a need for partnerships to create successful transfers. Governments can facilitate such partnerships (IPCC, 2000).

However, commercial projects are complex and risky because they convey a great deal of uncertainty made up of technical, organisational, market, social, political and cultural factors. Success is therefore not always guaranteed (Ahmed and Lorica, 2002). Moreover, when innovations are actively propagated by government agencies, the operational activities of the extension bodies are more important in determining adoption rates than previously thought (Wadsworth, 1995). Therefore, information exchange and transfer through collaboration and coordination between national and regional aquaculture institutions and official agencies should be further promoted (Halwart, 2005).

In general, technology implementation programmes for rural development continue to be weak in the aspect of networking of external resources such as expertise and funding. During the phase of technology development the interaction with users is very poor (Pulamte and Abrol, 2003). In this sense, aquaculture farmers organisations are expected to play an increasing role in the development of the industry by facilitating the provision of extension services, credit and market information (Hough and Bueno, 2003). Aquaculturists, associated by agreement on common standards and objectives, are in a better position to defend their interests, and to negotiate for rights and privileges against competing interests (NACA and FAO, 2000). Additionally, for particular higher income farmer groups, extension systems will likely evolve into fee-for-service organizations (Anderson and Feder, 2003).

Prices for the individual segments of the tilapia market are not expected to increase due to strong competition among producers. In the fresh and frozen fillet segments, higher production is expected to put downward pressure on prices as countries try to capture a larger share of the market (Harvey, 2005). If production efficiency is improved, cost reduced and key high markets are further targeted, it is likely that larger quantities of tilapia will be produced in Mexico efficiently and competitively (Hartley-Alcocer et al., 2006). Agreeing to apposite quality standards and ensuring their effective and efficient enforcement is clearly going to be more difficult as the number and location of producers increase, especially with each attempting to lower production costs (Young and Muir, 2002). Furthermore, the collection and dissemination of accurate and verifiable information on aquaculture may help to improve its public image and should be given attention (NACA and FAO, 2000).

Access to credit is consistently rated by commercial firms as one of the greatest barriers to operating and growth. Small businesses are constrained the most (World Bank, 2006b). In 2004, for the first time in more than a decade, commercial banks in Mexico granted more credit to both households and firms. Such environment fostered the continued growth of consumption and the recovery of investment (Banco de México, 2005a). However, and despite the changes made by the Government in order to simplify some aspects of the business regulations, starting a business in Mexico is a leap of faith even in the best of circumstances (World Bank, 2006b).

4.5.3 Conclusion

Although recent studies using remote sensing confirm that both commercial and small-scale fish farming are possible over vast areas of the region without serious constraints

(Kapetsky and Nath, 1997), emergent evidence suggests that most of the identified and previously explored production-related issues in Veracruz amongst the different stakeholders involved in the tilapia sector are also restraining its development in many other parts of the country (INP, 2003).

With the economic and institutional reforms that began in the late 1980s, the Government has reduced the widespread providing of technical assistance, input and output subsidies, and government marketing channels. It has been an institutional vacuum without much governmental support to facilitate the adjustment to a market economy with rapidly changing incentives (Cord and Wodon, 2001). As result, the productive capacity of most Mexican farmers and peasants had been eroded and the majority of them could no longer compete against world prices (Mckinley and Alarcon, 1995). The real minimum wage has also fallen considerably (ECLAC, 2004).

Experiences from the international arena show a number of cases where dissemination has been successful with strong initial support followed by long term local support to adopters, often provided by non-government organisations in the absence of adequate government extension services (Prein, 2002). Although in the last years there have been calls for including social, cultural and political elements, development, as it has been generally and broadly conceived and applied, is still a process through which the productive forces of economies and supporting infrastructures need to be improved through public and private investment (Oliver-Smith, 2002). Moreover, there is an increasing recognition that public policies in Mexico should encourage more investment in human capital (Díaz-Bautista and Díaz-Domínguez, 2003).

Participation has been invoked as a remedy for past failures due to top-down approaches, and as such, has been enthusiastically endorsed by many governments, financial institutions, and bilateral donors (Koenig, 2002). However, experience suggests that effective participation means influencing decisions, not simply involvement in implementation; it is an essential component of political life (Koenig, 2002). In this context, education and training should focus less on delivering knowledge and more on helping people to learn how to find out for themselves (Bourner, 1998).

From the evidence presented so far, it is apparent that the physical capital (namely roads and other important economic infrastructure) has a dominant role in both the present and future development of the tilapia sector in the regional arena. The presence of hundreds of small-scale farmers in many rural and remote areas of the State represents a major obstacle to overcome. For instance, Finan et al. (2005) found that households that face lower transaction costs as measured by access to roads, garner a return to land that is two to three times as high as those without access to a road. The authors also found that access to only 1 ha of land can be sufficient to escape poverty for households living in villages with access to a paved road, in large part because Mexican farm households are engaged in off-farm activities that complement incomes derived from land. Since transport infrastructure allows the production and distribution of goods and services and because it is a "*sine qua non*" condition for the integration of the communities, it represents a national major economic and social issue to tackle (Jiménez Sánchez et al., 2001).

International labour markets are also an important part of the process of globalization and economic interdependency across countries and regions (Solimano, 2004). The increasing importance of remittances within the entire social and economic development of the country and the State has already been pointed out. Migration flows of people from rural areas of Veracruz to the North frontier of the country and beyond has increased in the last 10 years, resulting in many communities without enough local labour force and in a process of social erosion (Córdoba Plaza, 2003).

However, remittances generally have important effects on economic growth, trade, and the distribution of wealth in the recipient countries (Orozco, 2002). Evidence strongly indicates that the bulk of Mexican migrants to the United States are coming from the crisis of small land-holding and rain-fed agriculture (Arizpe, 1981). Moreover, Mexico-US migration developed in response to significant differentials in per capita income between the two countries sharing a common border (Solimano, 2004).

Migrants from Mexico to the United States are viewed very differently depending on which side of the border the migration phenomenon is observed and evaluated. In Mexico, these individuals are called “migrant workers”, and they are viewed in such a positive light that their family members are openly proud of their achievements. In the United States, they are called “illegal aliens” and are viewed in a very negative light, almost like a plague invading from outside and victimizing the citizens of the United States (Bustamante, 1997). In any case, although uprooting provokes loss of trust in governments and existing political leaders (Colson, 2003), remittances have grown to become an essential financial input to rural Mexican households with migrating members. Most importantly, remittances promote the development of human capital and growth of social and cultural capital stocks in local communities (Conway and Cohen, 2003).

The capitalist model of development is now clearly ascendant with its agenda of transformation toward modern industrial market economies, justified morally as the best means to combat poverty and raise standards of living on a global scale (Oliver-Smith, 2002). However, a state that does not act in the public interest cannot be expected to plan equitably (Koenig, 2002).

Policy development should not only depend on technical knowledge about aquatic resources management. It requires government investment and interventions in planning and implementing fair and equitable development strategies based on information about poor people in communities (STREAM Initiative, 2005).

The Bangkok Declaration acknowledges that further investments in education and training are essential to build the knowledge, skills and attitude of all people involved in the sector (NACA and FAO, 2000). Development plans and strategies for aquaculture are recent innovations and, in many cases, aquaculture has developed without clear legislative guidance (Hough and Bueno, 2003). After all, the ultimate source of conflict in most Mexican fisheries is the absence of clearly defined rights (Thorpe et al., 2000).

Mexico continues to struggle with water resources management problems resulting from a long period of unsustainable exploitation of both surface and ground water in various critical river basins and aquifers. The roots of these problems include over concession, unsustainable patterns of extraction, and the lack of measurement, regulation, and actions to enforce concession entitlements (Asad and Garduño, 2005).

Training on regulatory aspects governing aquaculture practice should also be provided to aquafarmers and their associations, to enable them to participate in the formulation and improvement of aquaculture-specific legislation (NACA and FAO, 2000). Policymakers in Mexico face a less favourable political environment to sustain the reform effort: reform fatigue and the complexity of forming reform-supportive coalitions limit the speed with which the reform process may advanced (Banco de México, 2004).

Despite the limited and discouraging results of many transfer initiatives, aquaculture should be pursued as an integral component of community development, contributing to sustainable livelihoods, for promoting human development and enhancing social well-being of poorer sectors. Aquaculture policies and regulations should promote practical and economically viable farming and management practices that are environmentally sustainable and socially acceptable (Subasinghe, 2003). Ultimately, any solution will necessarily involve a complex mixture of science, technology and of politics (Bromley, 2002).

Ultimately, after a great deal of initiatives promoted and implemented to achieve economic development within a multiple society with plural cultures such as Mexico, it seems that relevant answers to the following questions proposed fifty years ago by Nash (1957) are still necessary today:

- "What income-raising technology and knowledge will be adopted and how will these be fitted into the social system?
- What kind of persons will put into use the production-increasing innovations?

- What series of social and cultural changes will permit the innovators, together with their new forms of production, to restructure the society and reorient the culture, so that economic development becomes a built-in feature of the ordinary operation of the society?"

CHAPTER FIVE: TYPOLOGY OF TILAPIA FARMERS IN VERACRUZ

5.1 Introduction

As a rule, the development programs reviewed in the previous chapter and many other small-scale initiatives intended to promote or improve tilapia farming during the past forty years, have shared one key feature: they have considered tilapia farmers as a homogeneous group, with little or off differentiation of individuals. Until now, no serious attempts have been made to understand the fundamental characteristics of the tilapia sector and their protagonists.

It has been previously shown that tilapia in Veracruz is cultured under a wide range of methods and intensities, though this research excludes the stocked fisheries sector and focuses only on those farmers utilizing controlled systems, both water- and land-based. The primary assumption, as common elsewhere internationally is that this sector is the primary area from which future growth in production would be derived, and in which the quality and impact of support and capacity building will be significant. This survey included information of 142 tilapia farmers and their production units. This chapter intends to reflect the present situation of tilapia farming in Veracruz, keeping in mind the premise that the knowledge of farmers' typology should be a prerequisite at the moment of targeting groups during any development intervention.

5.2 General aspects

The age of producers ranged from 16 to 81 years old, with a median of 40 (Figure 5.1). Out of the total farmers interviewed, 25% were less than 31 years old, 50% between 31 and 53 years old, and the remaining 25% were older than 53.

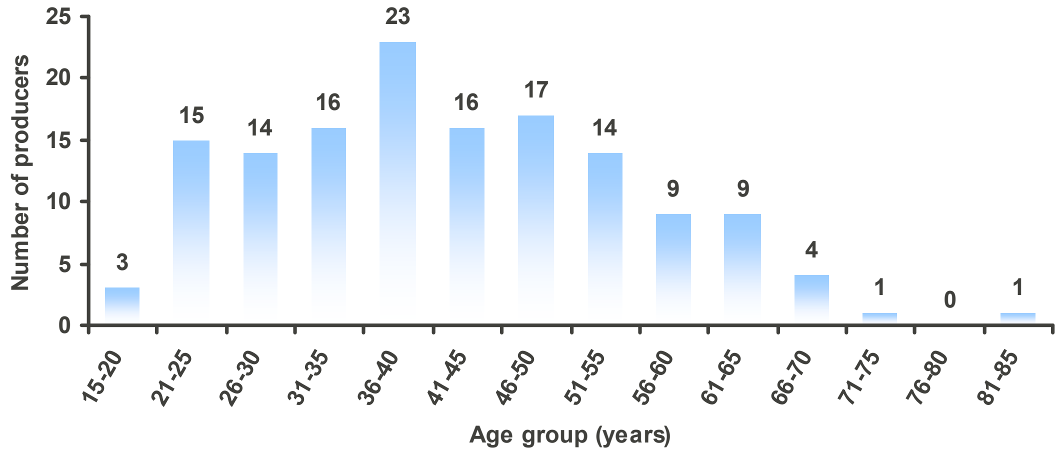


Figure 5.1. Age distribution of tilapia producers.

The formal education of farmers measured in terms of their attendance to school ranged from zero to 16 years (equivalent to professional studies), with a median of four years school attendance (Figure 5.2). Farmers' formal education within the sample was inferior to the national and state averages, which for that period corresponded to 7.8 and 6.8 years, respectively (SEP, 2003).

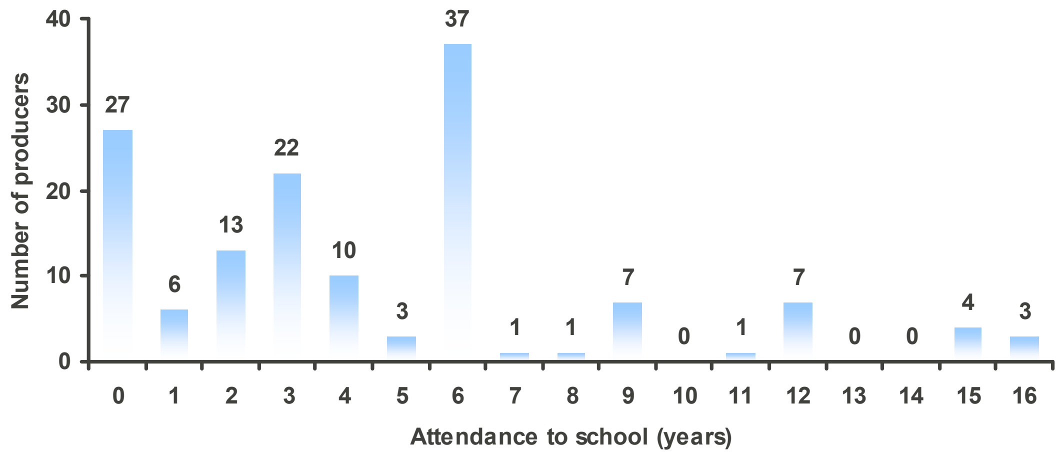


Figure 5.2. Schooling of tilapia producers.

Out of the total of farmers in the sample, 19% never attended school (illiterates). In fact, the illiteracy proportion of the sample was higher than both the national and state averages, which corresponded to 8.8 and 14.2%, respectively (SEP, 2003). Barely 25% of farmers studied beyond elementary school, which in Mexico corresponds to 6th grade and is supposed to be free and mandatory. Only three producers within the sample completed professional studies, two of them in areas related to agronomy or aquaculture.

5.3 Socioeconomic features

In Figure 5.3 can be observed that participation of women in the sector was very limited. Only 6% of production units were in charge of women, in which cases they were usually the main support of the family. However, in many other cases their involvement within the production processes was very intense, mainly in terms of feeding the fish, post-harvest activities and commercialization of the production at community level, apart from their traditional roles as housekeepers.

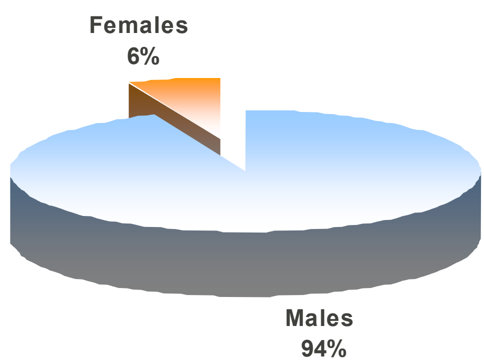


Figure 5.3. Gender distribution of tilapia producers.

The average land surface per farmer was 5.5 hectares and was sometimes simultaneously used for agricultural or livestock purposes. The land tenancy regime distribution can be seen in Figure 5.4. About 50% of tilapia farmers were *ejidatarios* (i.e. communal lands users); around 20% were possessors of their own land and included nearly all commercial farmers; the rest (almost 30%) were settlers (i.e. people without land that usually exploit a federal water body, rent a piece of land, or work for another owner). This last group is the least privileged in terms of availability of capital assets.

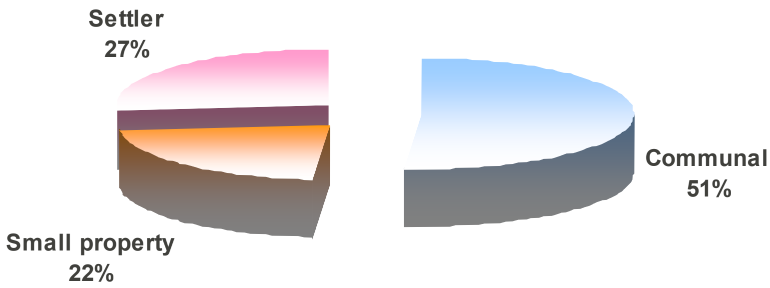


Figure 5.4. Land tenure regime among tilapia farmers.

The size of the farmers' family (or economic dependents of the farm) ranged from 2 to 10, 5 members being the average (Figure 5.5). In contrast, national and state average family size corresponded to 4.4 and 4.3 per household, respectively (INEGI, 2005b). More recent reductions in poverty levels in Mexico are associated with increases in educational levels and reductions in family size (Valero et al. 2006), which adds to the general picture of the tilapia farming groups being poorer, less economically and socially developed, though not necessarily different from equivalent rural populations.

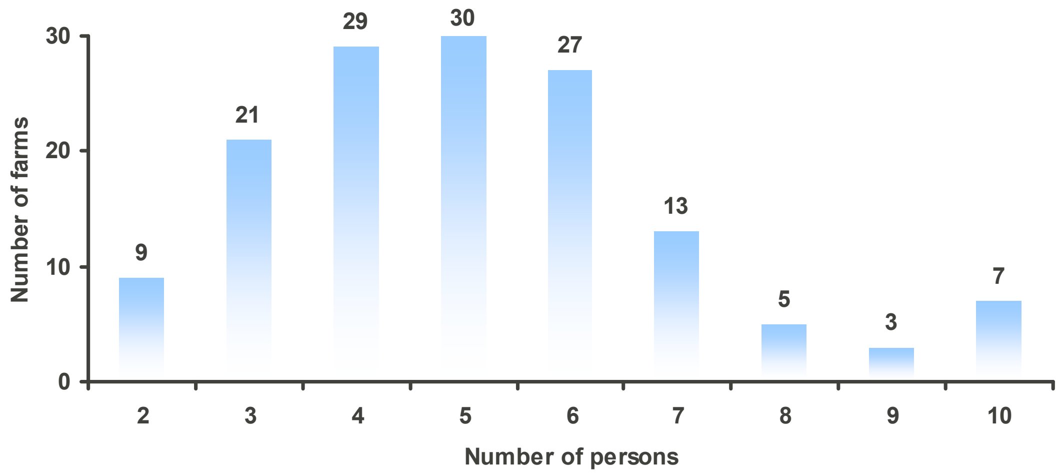


Figure 5.5. Members of the family dependent of the farm.

However, not all the members of the family participated in tilapia production activities (Figure 5.6). Approximately 30% of production units were managed by only one member of the family, usually the owner. The participation of two or three members of the family within the tilapia activities were around 30% in each case. Only in a few production units more than three household members regularly participated.

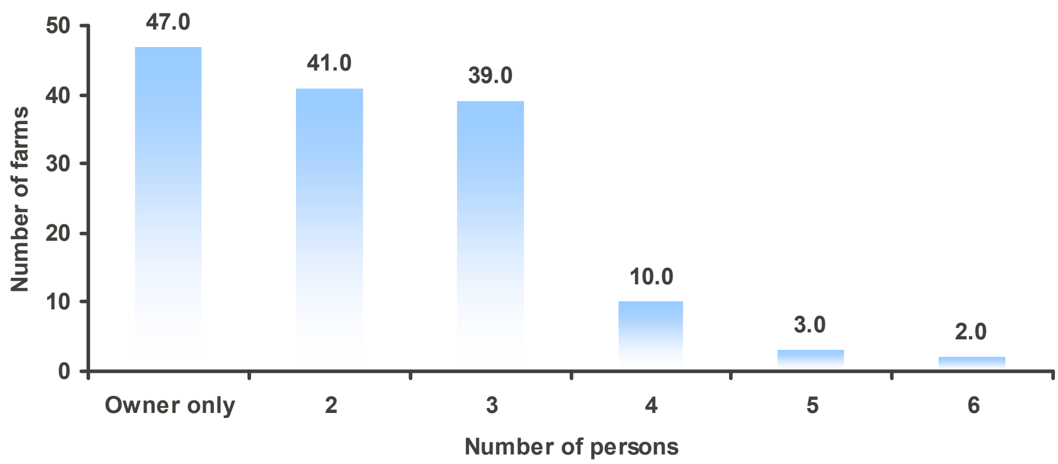


Figure 5.6. Members of the family working in the farm activities.

More than 90% of the surveyed farms were located within a range of 25 km from the major municipal centre (Figure 5.7), which in practical terms, in addition to market access, implied the possibility to exercise pressure to municipal authorities to obtain subsidies or technical advice.

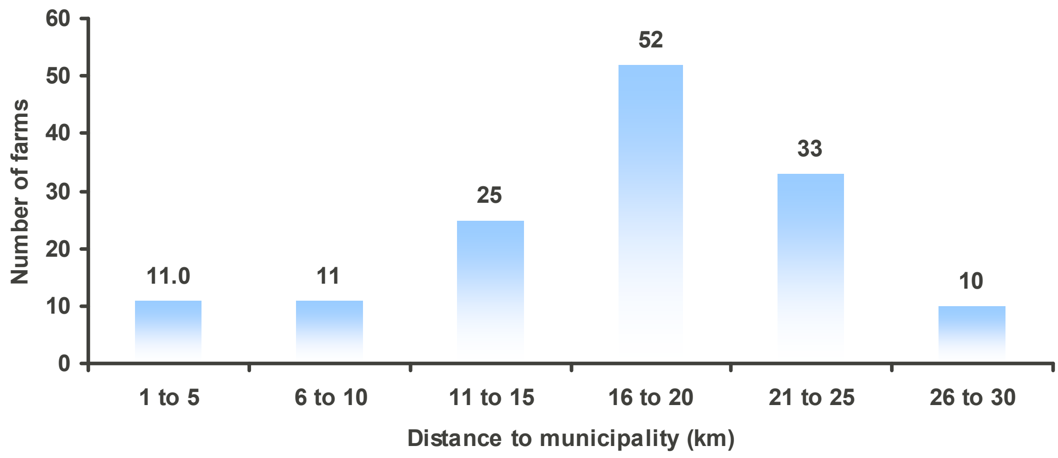


Figure 5.7. Distance of the tilapia farm to the municipality.

Most production units were situated within a range much closer to a town or village (Figure 5.8), which facilitated access to production inputs such as commercial feeds and to local markets. In fact, the largest farms (which corresponded to commercial units from the private sector) were in general situated near the largest urban centres. The impact of the local capital asset availability on the dissemination and adoption of tilapia farming technology will be examined further in the next chapter. However, access to more than 60% of production units was by non paved roads (Figure 5.9), which implied access problems during the rainy season. In some of the most isolated units, the only year round access was by means of domestic animals (i.e. horses or donkeys).

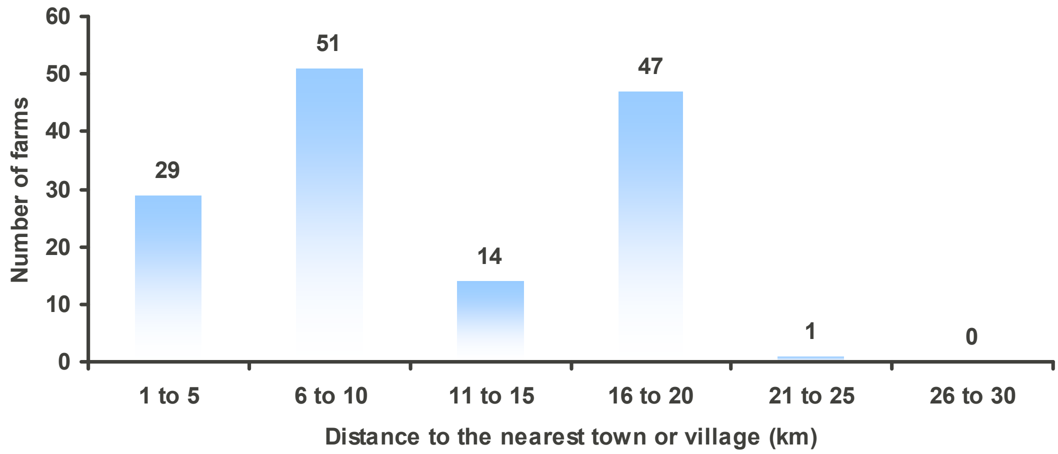


Figure 5.8. Distance of the tilapia farm to the nearest town or village.

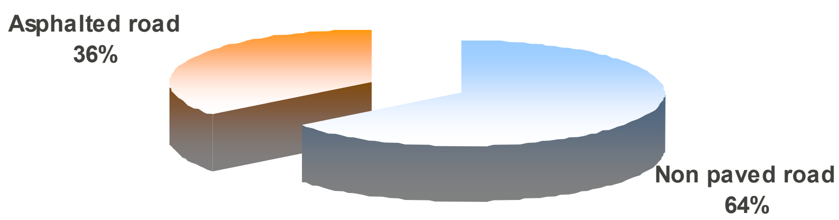


Figure 5.9. Type of road access to the production unit.

A summary of locally available services is provided in Figure 5.10. Despite the fact that most of production units were electrified, had relatively good communications and had access to elementary school services within the nearest town or community, some health related issues such as networked drainage, potable water or even access to health units reflected the unfavourable social environment still present in many rural areas.

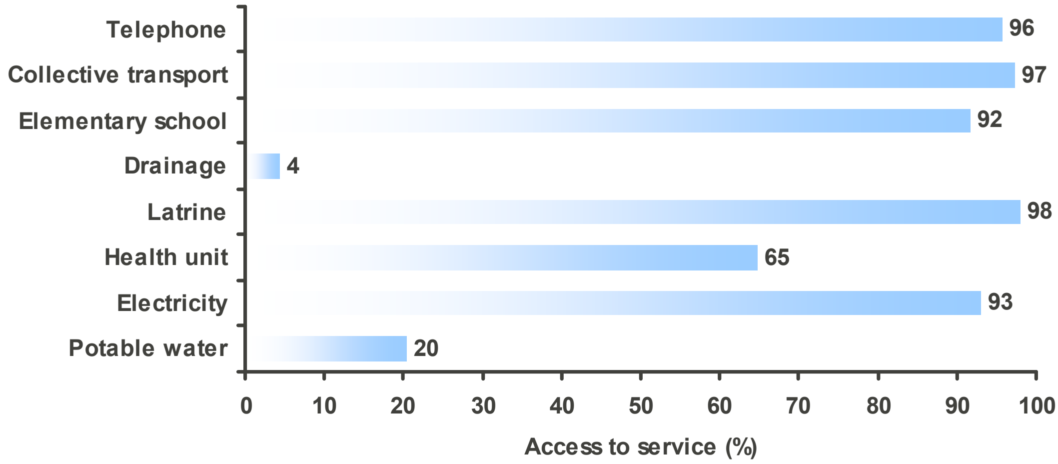


Figure 5.10. Access to services within the nearest town or community.

5.4 Management characteristics

The heterogeneity and diversity of tilapia farming systems in Veracruz are positively related to the number of management practices used. It is important to note that the number of water sources used for the different culture systems (Figure 5.11) were also related to the abundant water resources in the region. Lagoons (which represented nearly 30%) were almost exclusively used for water-based production systems, such as cages and enclosures. All other water sources were mainly employed in land-based systems such as ponds and tanks.

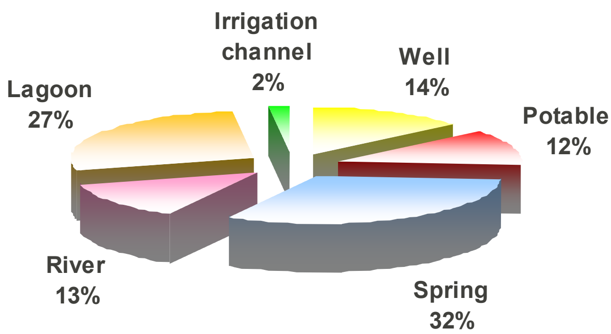


Figure 5.11. Water sources for tilapia farms.

All tilapia farms also used their water supply for domestic purposes (Figure 5.12), but only a small percentage used it for livestock (36.6%) or agricultural practices (10.6%).

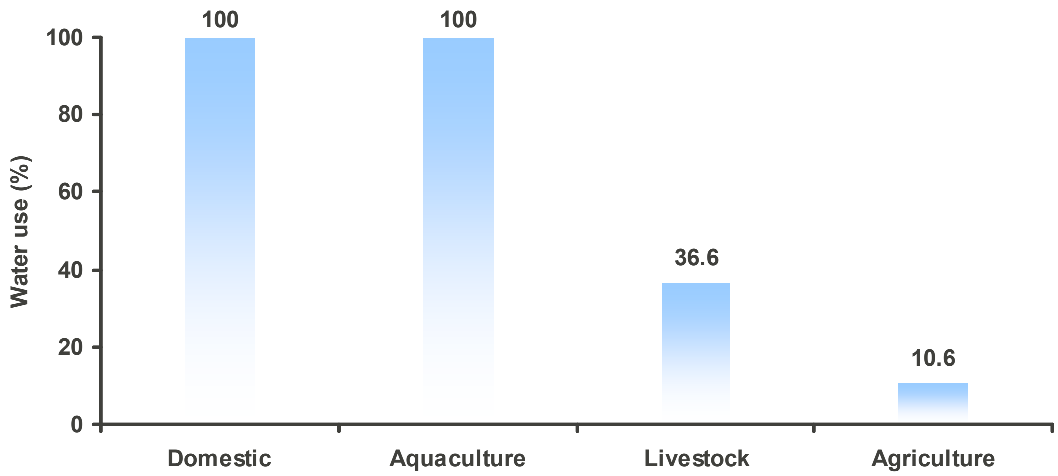


Figure 5.12. Different uses of water resources by tilapia farmers.

As shown earlier, tilapia farming is a relatively new economic activity in Veracruz. The experience of the farmer expressed by the number of years farming tilapia is presented in Figure 5.13. At the time of this survey, only one producer had more than 12 years experience in farming tilapia and was in fact one of the pioneer farmers in the State. In contrast, approximately 50% of the producers had one year of experience or less, which in part reflected a growing interest in the activity among new entrants but also appeared to be related to typical drop-out rates, with many people starting –often due to project initiatives–, then dropping out after initial support or subsidies stop. Nevertheless, all surveyed farmers remained producing during the entire research period.

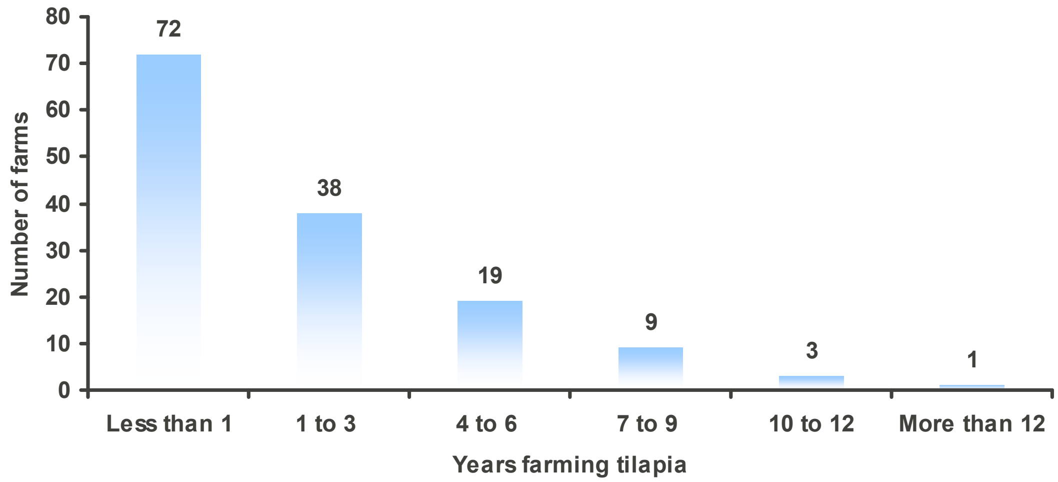


Figure 5.13. Experience in tilapia culture.

Moreover, the farmers' perception about the development of the industry, measured as the increase or decrease of production units within their area, also indicated a remarkable increasing trend (Figure 5.14). As indicated in the previous chapter, the perceptions of the different stakeholders involved in the regional tilapia industry –including farmers– greatly differed. Although the accuracy of the farmer's understanding of the sector seemed to correspond to their production level and socio-economic characteristics, the majority perceived an increasing demand at both local and regional levels. Moreover, because these perceptions were based on whether farmers think the industry is moving ahead or not, it has been an increasing motivating factor for new entrants, mainly from the private sector.

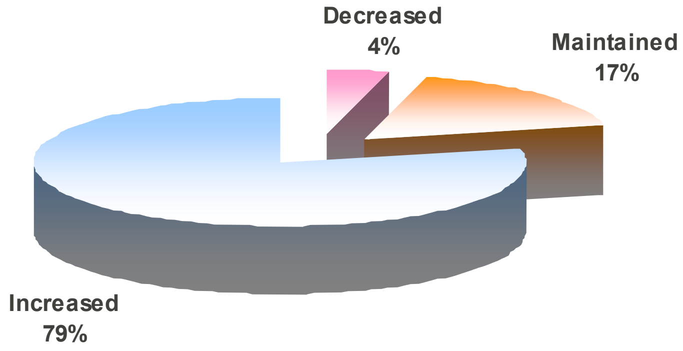


Figure 5.14. Farmers' perceptions about tilapia production in their region.

Out of the total farmers surveyed, almost 60% started their operations as a result of a governmental development initiative (Figure 5.15).

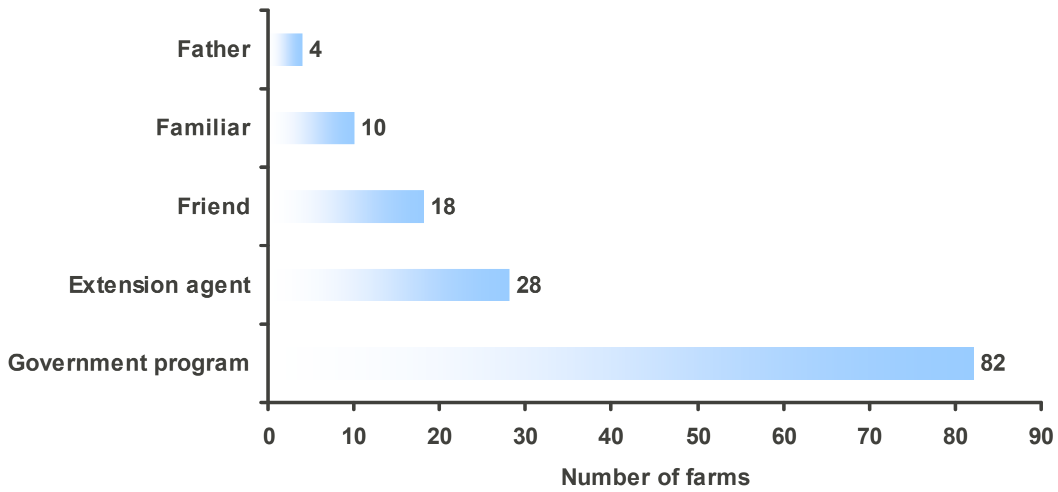


Figure 5.15. Initial source of stimulus to become involved in tilapia culture.

Abandonment rates in the region have been traditionally high. Unofficial estimates from the Veracruz Aquaculture Association (AVAC, 2007) reveal a drop out rate of nearly 50% of all new entrants induced by a development initiative. Other initial sources of motivation were the influence of an extension agent (usually a member of an NGO or an academic institution) and the rest because of friends, neighbours or relatives. Compared with other agricultural practices, the activity is so new in the State that only four farmers started cultivating tilapia following the teachings of their parents, which reflects a limited collective memory or capacity in tilapia farming.

According to their own perception, the main problems associated with tilapia production were defined and ranked (Figure 5.16). It is evident that the relative inexperience of the overall sample, as defined by years of involvement, must have strongly influenced the observed results. In general terms, however, the most experienced farmers (i.e. 100% of farmers with 7 or more years of experience or n=13) perceived the costs of production inputs as the major limiting factor. In contrast, issues such as technical assistance, culture and management practices, and availability and costs of inputs were the most important for the less experienced producers (for 95% of farmers with less than 6 years of experience).

Although for almost all farmers financial issues were ranked among the most important restrictions, commercialization issues, expressed as the possibility to find a suitable market for the product, was the aspect of least concern. Apparently, growing demand of tilapia at household level and for both local and regional markets makes the activity appear to be quite attractive. Lack of technical assistance and adequate training schemes can be easily identified as a major limiting factor (further implications of this will be addressed and discussed later). Moreover, the costs and availability of feeds, costs of infrastructure and production inputs, as well as organizational and managerial topics were also recognized as relevant problems. However, other issues such as availability of fingerlings, fish diseases or water quality management were of very little concern. This situation could simply reflect farmers' unawareness of how these topics relate to fish production.

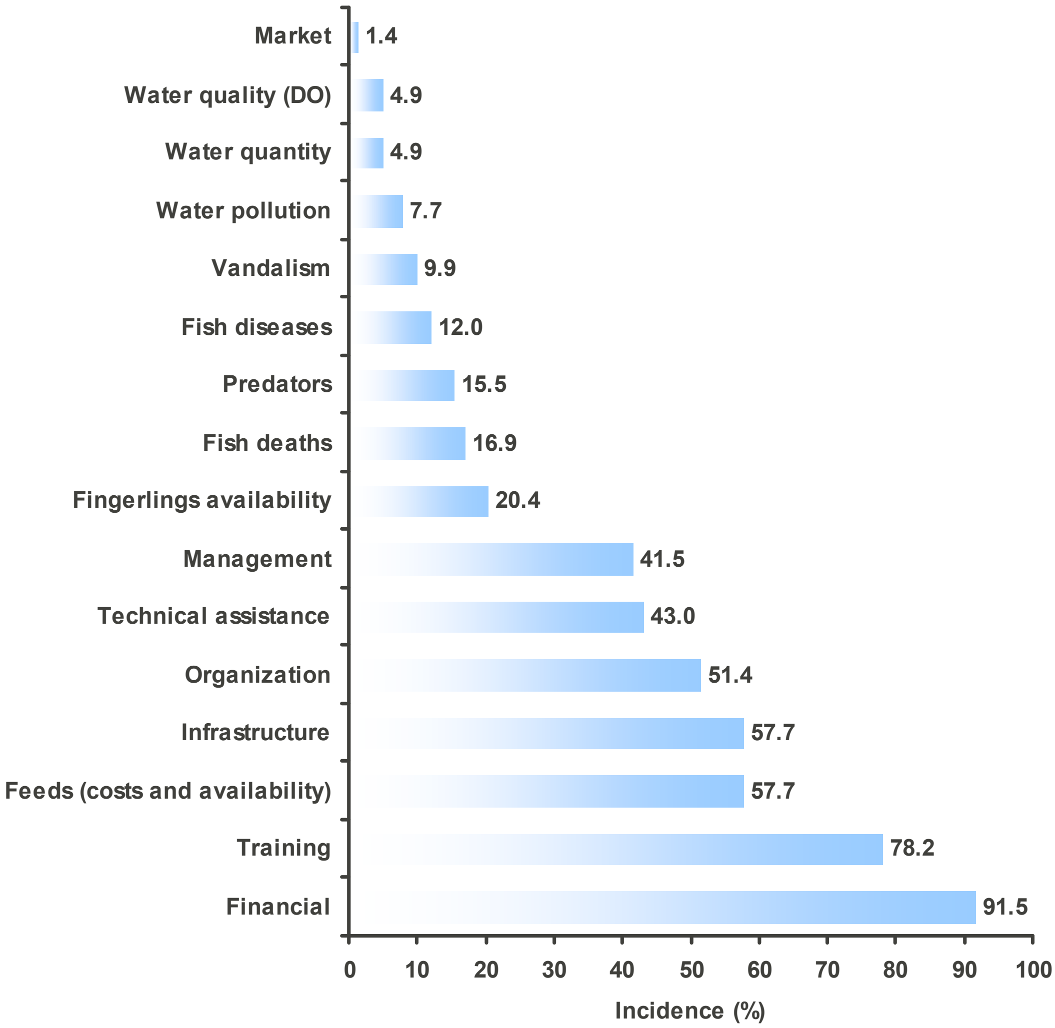


Figure 5.16. Farmers' perceptions about tilapia farming problems.

Tilapia undoubtedly plays a dual role in farmers' livelihoods: a food commodity and an income source (Figure 5.17). Only nine producers (6%) were fully market-oriented and these corresponded to the commercial farms. However, 94% stated that their production were both consumed and commercialized, even at a very small-scale. Apparently, none of the farmers produced tilapia exclusively for self consumption.

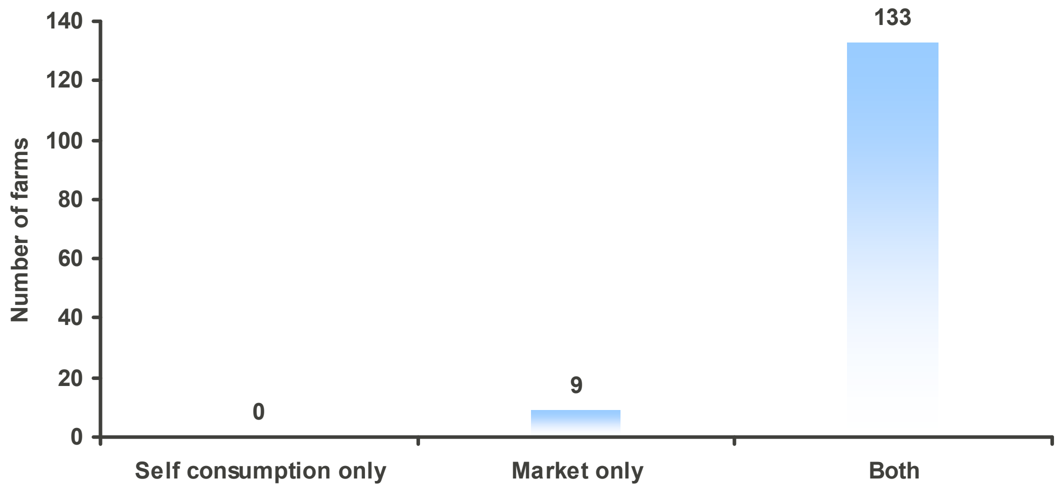


Figure 5.17. Purpose of tilapia production.

Most tilapia farmers are grouped and act collectively (Figure 5.18). This originated partially because of their tenancy regime (*ejidatarios* or settlers) and their traditional way of labour organization, but also because being constituted as cooperatives or another legally recognized organization facilitated their access to most subsidies and institutional aid programmes. Moreover, this collective way of working also allows them to combine their aquaculture activities with other sources of off-farm income.

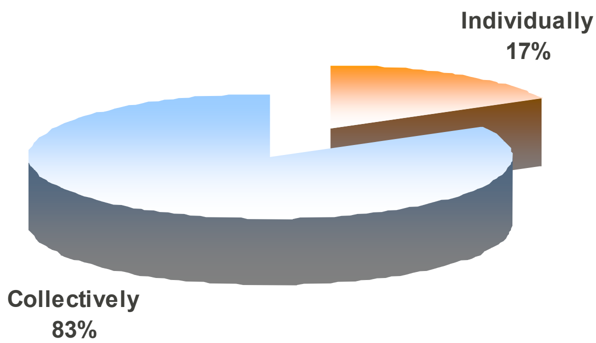


Figure 5.18. Type of organization within the production unit.

Seventeen percent of farmers operated their production units individually, which strongly corresponded to their land tenancy regime (small property). Additionally, this group comprised virtually all farmers who were primarily interested in commercialization. In fact, the most experienced farmers and the largest production units corresponded to this group, as well as most new entrants from the private sector.

As shown in Figure 5.19, the labour force in the production units individually operated was either family-based (14%) or remunerated (6%). However, in 80% of production units labour was provided by the own members of the groups.

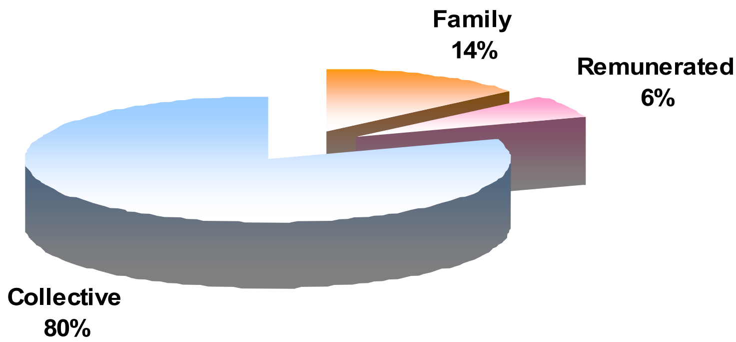


Figure 5.19. Type of labour within the production unit.

In fact, the farmers' perception about availability of labour force in the region is entirely divided, as presented in Figure 5.20, which partially corresponded to a continuous and progressive abandonment of some rural areas due to migration of the economically active population (to urban centres or to the United States) in search of better job opportunities and improvement of life conditions.

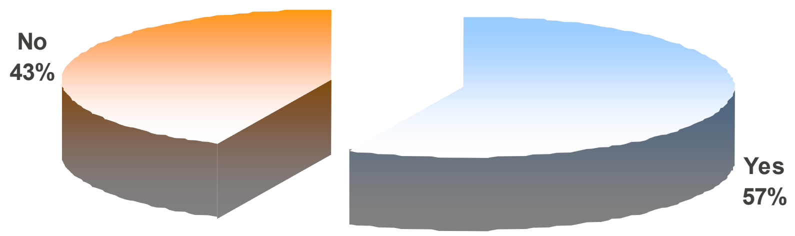


Figure 5.20. Farmers' perceptions about availability of manpower in the region.

According to the use of technology within their facilities, two main groups of almost the same size can be recognized (Figure 5.21):

- artisanal farmers (44%), comprised the most simple production units, usually based on earth ponds which depended mainly on primary productivity, and where the only practices were the stocking of fingerings (usually of mixed sexes) and in some cases the use of some agricultural sub-products as feeds or fertilizers. These farmers were in general the least experienced and most disadvantaged in terms of capital asset availability.
- more advanced farmers (56%), identified as farmers that made use of technology, comprised the rest of production units.

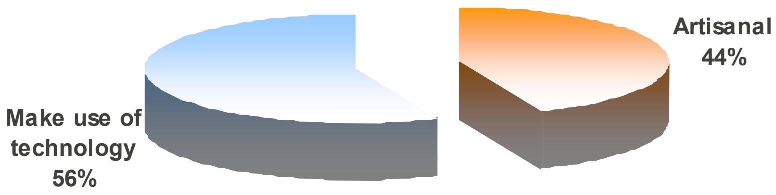


Figure 5.21. Production processes among tilapia farmers.

These artisanal farmers produced between 50 and 390 kg per year (median 210 kg), contributing with 13.4% of the entire production in the sample. In contrast, the more advanced farmers produced between 400 and 15 000 kg annually (median 5 000 kg), which comprised 86.5 % of the total production in the sample.

Land- and water-based systems were equally important for production purposes as shown in Figure 5.22. As noted earlier, however, water-based systems were mainly used by settlers or by farmers organized in groups.

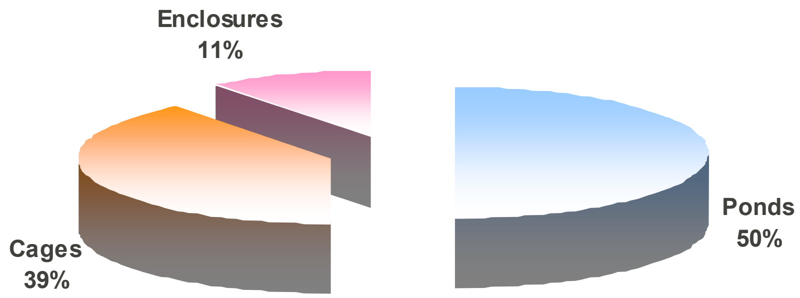


Figure 5.22. Culture systems used for tilapia production.

In relation to seed supply, only 8% of farms produced their own seed and corresponded to commercial farms which also produced fingerlings for sale (Figure 5.23).

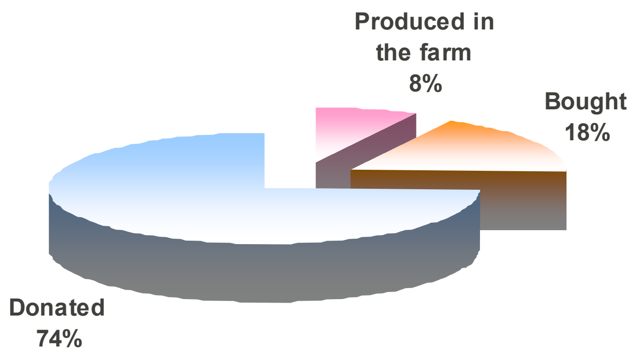


Figure 5.23. Sources of seed.

The great majority of farmers (74%), however, depended on seed donated as part of some kind of governmental or non-governmental program. These donated fingerlings were usually of mixed sexes and in many cases were part of a technological package which included inputs such as feeds, nets, pipes, etc., as well as some kind of technical assistance. Most fingerlings were produced in governmental hatcheries, although some were acquired by donor agencies from commercial farms. Only 18% of farmers could afford (or decided) to buy their seed from a commercial farm at a regular basis.

Nearly 90% of production units depended on commercial feeds (Figure 5.24). As described in Chapter 4, a number of commercial brands especially formulated for tilapia are regionally available, although distribution channels are very limited in many areas away from large cities. Only 12% of farmers produced their own feeds, which were usually based on agricultural products and sub-products.

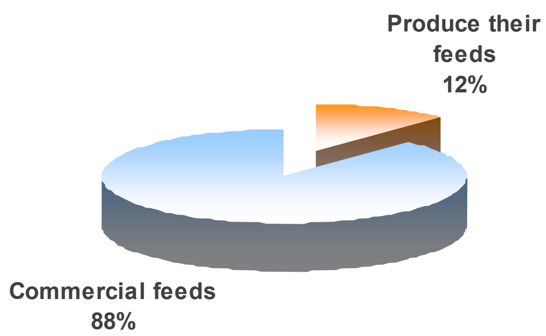


Figure 5.24. Feeding strategies among tilapia farmers.

5.5 Farm production and productivity

The vast diversity of production systems and technological approaches used by the sampled farmers generated a heterogeneous distribution of productivity, as shown in Figures 5.25, 5.26 and 5.27. Annual farm production ranged from 50 to 15 000 kg, with a median of 280 kg.

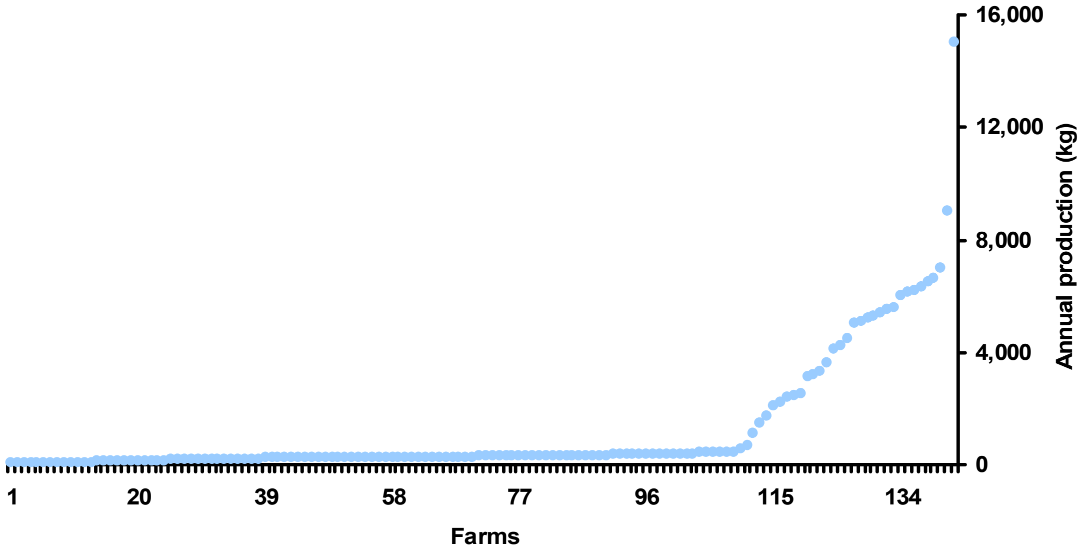


Figure 5.25. Annual farm production.

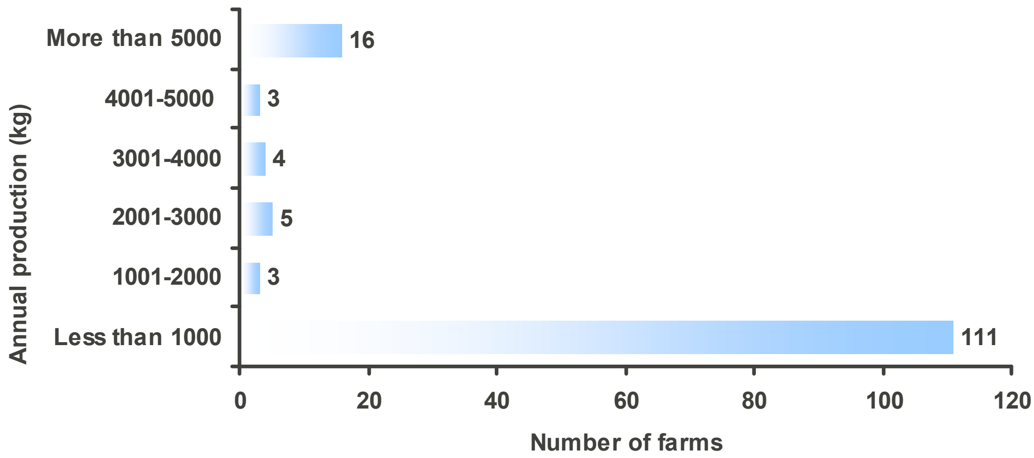


Figure 5.26. Identifiable groups according to farm's production.

Only 16 farms (11% of the sample) produced more than 5 000 kg annually. These units corresponded to the most experienced farmers; all belonged to the private sector, and their main purpose was the commercial grow-out as well as the production of fingerlings for sale. They relied on intensive (tanks and cages) and semi-intensive (earth ponds) systems. Moreover, all of these farms were situated near the most important development poles in the state.

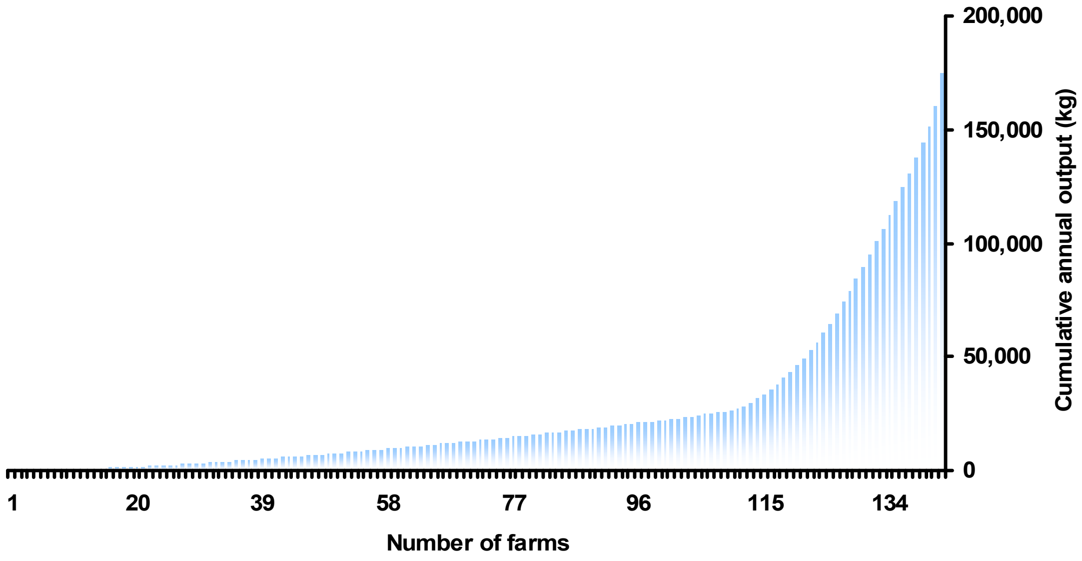


Figure 5.27. Cumulative output curve.

An intermediate group, which included 15 farms (around 10% of the sample), had annual production between 1 000 and 5 000 kg. Farmers of this group had more than four years of experience and also all corresponded to the private sector. Most used earth ponds for semi-intensive operations.

The final group was defined as those producing less than one metric tonne per year. This consisted of 111 farms (around 78% of the sample). These were in general new entrants (usually with less than three years of experience). Most of them corresponded to the social sector and were induced by a development agency. They used earth ponds, cages and enclosures. In general they were located in remote and less populated areas, and were the most deprived in terms of capital assets. Closer examination revealed that most of this group had an annual production of less than 400 kg (Figure 5.28).

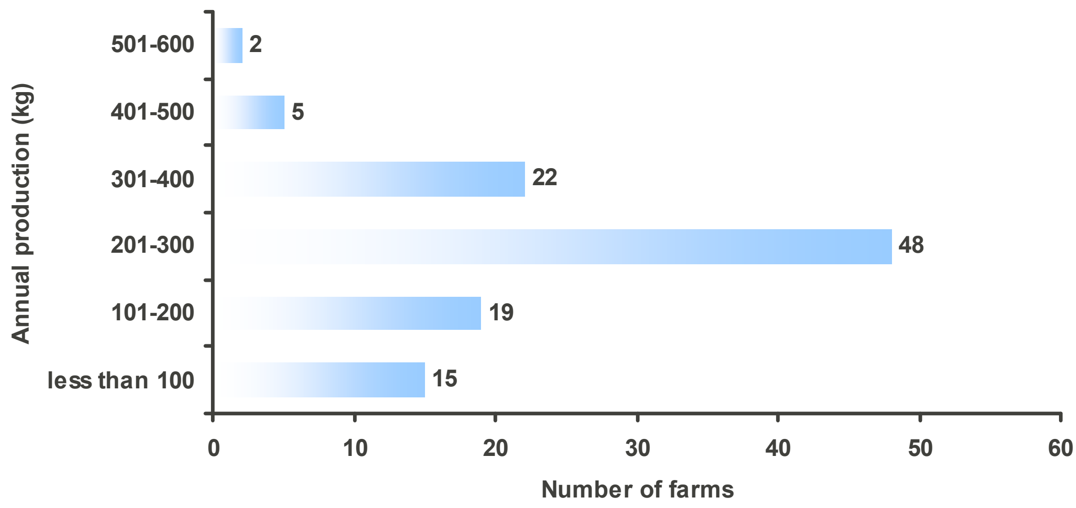


Figure 5.28. Tilapia production of small farmers.

A summary of the characteristics of the different surveyed systems in terms of dimensions, stocking densities and productivity is presented in Table 5.1.

Table 5.1. Characteristics of the main identified systems.

	Earth ponds	Tanks	Cages	Enclosures
Dimensions	25 – 90,000 m^2	15 – 1,400 m^3	1 – 50 m^3	25 m2 – 10 ha
Stoking densities	0.1 – 6 fish m^{-2}	1 – 60 fish m^{-3}	1 – 200 fish m^{-3}	0.2 – 2 fish m^{-2}
Productivity	200 – 3,500 kg ha^{-1}	0.5 – 30 kg m^{-3}	0.5 – 40 kg m^{-3}	100 – 600 kg ha^{-1}

In general, the largest farms were the most productive. Most of them used aerated ponds or tanks in intensive and semi-intensive operations. Furthermore, their owners were the most experienced and with more access to capital assets.

In Tables 5.2 to 5.4, results of nonparametric bivariate correlations between production, productivity and experience are presented. Positive significant correlations were detected in all cases.

Table 5.2. Nonparametric bivariate correlation between production and productivity (n=142).

	Production[1] (kg year^{-1})
Productivity (kg m^{-2})	**0.716**** 0.000

[1]Spearman's rho correlation coefficient (in bold) and two-tailed observed level of significance (below).
**Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.

Table 5.3. Nonparametric bivariate correlation between production and experience (n=142).

	Production[1] (kg year^{-1})
Experience (years)	**0.920**** 0.000

[1]Spearman's rho correlation coefficient (in bold) and two-tailed observed level of significance (below).
**Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.

Table 5.4. Nonparametric bivariate correlation between productivity and experience.

	Productivity[1] (kg m^{-2})
Experience (years)	**0.670**** 0.000

[1]Spearman's rho correlation coefficient (in bold) and two-tailed observed level of significance (below).
**Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.

5.6 Marketing strategies

Marketing strategies were also diverse. As noted earlier, many farmers produced tilapia for both self consumption and commercialization. During the research period (i.e. 2000 to 2004), retail prices at farm level remained relatively stable though ranged from 10 to 40 Mexican pesos per kg (US$ 1.00 to 4.00 per kg) depending on the geographic area. Highest prices usually corresponded to production near important urban centres, while lowest prices were mainly found in isolated farms or remote communities, where living standards and wages were also much lower. A notable increase both in price and demand was observed during Easter (Semana Santa), the only time of year when a large sector of the population traditionally consumes fish. This pattern is well perceived by most farmers (Figure 5.29). Nevertheless, tilapia in Veracruz is produced and consumed all year round.

Almost all tilapia is commercialized fresh, and the use of ice is the traditional method to preserve it. As shown in Figure 5.30, almost all commercialized product is distributed at local level (i.e. within the community or the nearest town), which confirms the high demand of fresh fish within the region.

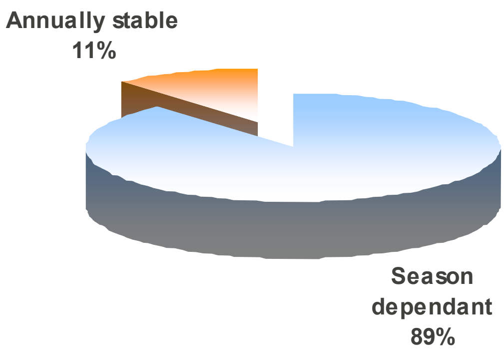


Figure 5.29. Farmers' perceptions about annual fluctuations of tilapia prices.

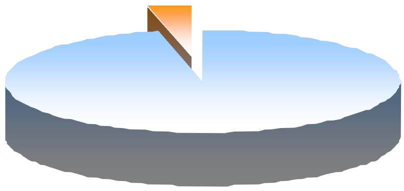


Figure 5.30. Destination of tilapia production.

Usually product is sold to the final consumer directly at the farm, although for larger producers, market intermediaries are usually also involved. Their role is usually to distribute production to restaurants or fish markets in small and middle size towns and villages. The markup margin ranges between 10 and 30% over the price paid to the farmer.

Only 4% of farmers (i.e. the big ones) sold the bulk of their production to a wholesaler, who usually distributed the product in big cities, mainly to the big supermarket chains. The wholesaler paid for the complete crop at a much lower price than that typically obtained at farm level. Because of this, most farmers chose to sell their production to local intermediaries and/or final consumers in the nearest villages.

As earlier noted, a widely observed problem according to farmers related to financial aspects. It had also been noted that many farmers, especially small ones, have depended from one time to another on some kind of subsidy. This strong dependence on subsidies, plus limited financial knowledge or accounting skills, determined that the great majority (95%) of farmers were unaware of the profitability of their farms (Figure 5.31).

Figure 5.31. Farmers' perception about the profitability of their production unit.

Tilapia farming is generally carried out together, though only exceptionally fully integrated with other agricultural practices in the same farm (Figures 5.32 and 5.33).

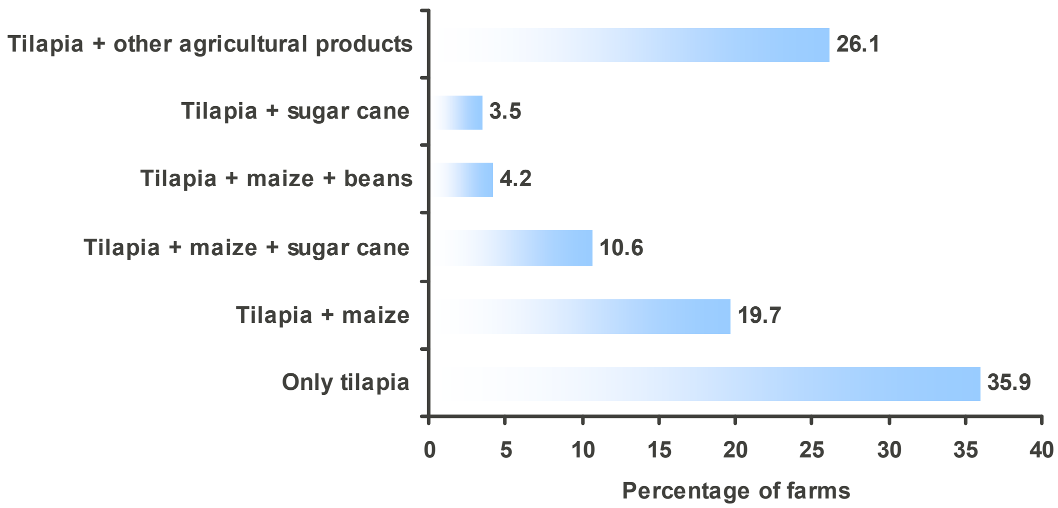


Figure 5.32. Agricultural production within the farm. Other species included watermelon, pasture, mango, tomato and banana.

In fact, many farmers have been dedicated to agricultural activities for years (or even generations) before tilapia was introduced. As previously indicated, in most cases tilapia farming has been proposed as an alternative to diversify existing production systems and as a means to improve protein supply and livelihoods in general.

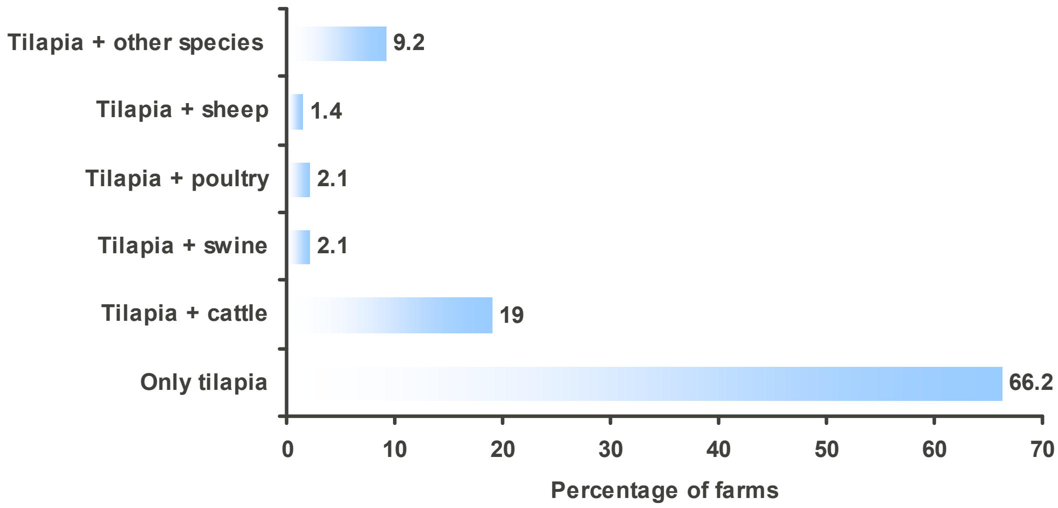


Figure 5.33. Livestock production within the farm. Other species included horses, turkeys, rabbits, ducks and gooses.

5.7 Closing remarks

This chapter has revealed the heterogeneity of the tilapia sector in Veracruz. Broadly also it identifies specific categories of producers, who are relatively sharply differentiated by production size, degree of commercialisation, experience in production, and access to assets. As with earlier initiatives described and analysed in the previous chapter, it would appear that much of the current sector, in numerical terms at least, is characterised by people who are induced to enter tilapia production for social development objectives, often in group associations, with significant levels of subsidy and technical support, and very little emerging sense of the financial realities of their operations. In this sense there appears to be no further prospect of these initiatives being any more successful than the previous rounds of development support, though a small encouragement might be found in the strong perception of local markets, and the apparent interest in further consumption of tilapia. However, as earlier noted, the growing international trade in tilapia, and the increasing entry of supply from Asia at highly competitive prices may limit even this potential incentive.

With respect to household supply and income it would appear that small scale producers, with 200-300kg production or less, could have useful contributions to household level food supply, which even at large household sizes and might typically represent no more than 100kg per year, while sales at a lower level price of $1 per kg with limited production costs could represent household income of $100-200 per annum. As a sole income source this would be insufficient for all but the very poorest of households, but as a contributor to more diversified livelihoods this could be a useful element. At the more commercial scale, however, the small size of even the larger farms suggests that margins and overall returns may be rather limited, and potentially discouraging, unless producers were able to expand and/or increase sales prices and production efficiency. Without this, the prospects for continuation may not be so clear, though the farms which are able to sell fry and fingerlings may make better returns on the available productive assets. Some of these issues, indicators and criteria will be further explored and utilized in the next chapter.

CHAPTER SIX: DISSEMINATION AND ADOPTION OF TILAPIA FARMING TECHNOLOGY

6.1 Introduction

This chapter is about the flow of technical information amongst tilapia producers. In the first section, some preliminary ideas are presented. Next, the flow of technical knowledge amongst farmers located in different geographic areas is analysed, in which group definitions and the methodological approach using quantitative indicators of technological change are addressed. Then, the spontaneous dissemination of an innovative practice among farmers was evaluated by the use of a sentinel technology. Finally, closing remarks regarding technological change are presented.

6.2 Preliminary thoughts

Within the regional context, the extension agents have limited material resources and skills to perform an efficient job. Although most of them have a background in biology or fisheries, their gaps in technical knowledge are quite notable. This is accentuated by limited knowledge regarding extension methodologies. The low wages offered by the development agencies (governmental and non-governmental) make extension an unattractive occupation for the better qualified technicians, whom prefer to work in commercial-scale enterprises. Nevertheless, they often represent the main source of information to most farmers.

Despite this situation, one important premise of the majority of interventions aimed at promoting semi-intensive and intensive tilapia farming in the region has been that the main source of technical knowledge for existing and new entrants derives from the extension agent. Should this be totally true (in view of the low productive status in the majority of the surveyed farms), the entire initiatives, including their extension programs, would deserve serious questioning. But the fact is that in the "real world", farmers use a number of different ways to acquire technical information. Even in the most remote areas, farmers are not totally isolated. Technical information (not always completely accurate) constantly flows from a number of formal or informal channels (e.g. mass media, friends, other farmers, service providers, extension agents, etc.). Ultimately, each farmer decides what elements to adopt according to his/her particular assets.

The prevailing debate about using perceptions as a means to assess most of the small-scale aquaculture interventions made by governmental or non-governmental entities in Veracruz during the past three decades can be exemplified with the following dialogue:

> "*The fact is*", said Rabbit, "*you're stuck*".
> "*It all comes*", said Pooh crossly, "*of not having front doors big enough*".
> "*It all comes*", said Rabbit sternly, "of *eating too much*"[1].

Without the adequate reference frameworks (and respective quantitative and qualitative indicators), the debate is no more than just an endless and sterile discussion. So, considering the present status of the regional tilapia industry, most interventions can be considered as successes or failures, depending on the angle from which they are analyzed. Certainly, most current small-scale farmers are mainly the result of a number of initiatives implemented in order to improve their livelihoods. In general, they seem to be "happy" with their overall achievements. However, it is also evident that the productivity of the majority of farms (both in technical and economic terms) appears to be remarkably low, and most farmers are still dependant on subsidies.

[1] Milne, A.A. 1926. *Winnie the Pooh*. Methuen and Co., London.

Accordingly, the overall effectiveness of the dominant technology transfer paradigm urgently demands the use of objective indicators in order to: *i*) assess the status of the technology used by individual farmers; *ii*) evaluate the adoption patterns of new technological practices; and *iii*) understand the mechanisms involved in the flow of technical knowledge. Eventually, this information could be translated into better use of the available human and material resources, and thus into improving the outcomes of future interventions.

The typology of the 142 studied farmers, in depth examined in the previous chapter, revealed a remarkable heterogeneity of their production systems. Six key features are important to bear in mind: *i*) most producers became so as the result of a development initiative (namely governmental or non-governmental); *ii*) they were geographically dispersed within fifteen municipalities dissimilar in terms of capital assets availability; *iii*) they had in general little experience in tilapia farming; *iv*) the productivity of most production units was remarkably low; *v*) most farmers were mature and aged people; and *vi*) their overall level of formal education was very low.

6.3 On the dynamics of technological change

6.3.1 Overall results

Technology Level Indices[2] (*TLIs*) as described in Chapter 3 were used to describe the level of knowledge and application before and after technology change interventions. These were calculated for each farm during the periods 2001-2002 (initial) and 2003-2004 (final), as well as Technological Change[3] figures for all 142 farms are presented in Appendix 5. A summary of results is provided in Figure 6.1. A summary of the overall

[2] As previously indicated, numerical values of Technological Level Indices range from zero to 100.
[3] Technological Change values are expressed in percentage (see Chapter 3).

results of *TLI*s and Technological Change is presented in Table 6.1, where a remarkable heterogeneity of production units in terms of the typology of farmer and background development indicators can also be noted. Within the study period, the overall values of Technological Change ranged from zero to 283.33%, with a median value of 82.35%, which confirmed a progressive tendency towards technological development.

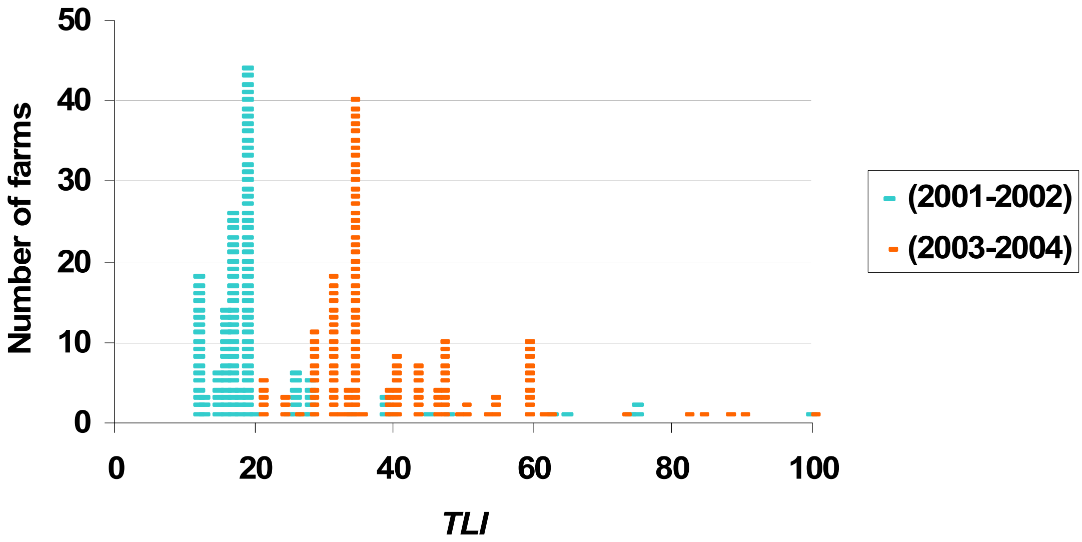


Figure 6.1. Graphic representation of *TLI*s for all farms during the research period.

Table 6.1. Summary of overall results (N = 142).

	HDI[1]	Initial *TLI*	Final *TLI*	Tech. Change	Experience[2] (years)	Farmer age[2] (years)	Schooling[2] (years)	Distance to municipality[3] (km)
Median	0.69	18.5	34	82.35	1	40.5	4	4
Std. Dev.	0.06	13.23	13.84	52.96	1.08	26.86	4.07	6.29
Min.	0.59	12	21	0	1	15	0	1
Max.	0.85	100	100	283.33	more than 12	85	17	30

[1]**Human Development Index of the municipality (PNUD, 2004).**
[2]**Registered during the year 2001.**
[3]**Distance from the production unit to the municipality head.**

Some initial points are worthy of remark:

- The time interval in which *TLI*s were calculated was considered enough to detect changes in adoption patterns.

- The overall initial *TLI*s were remarkably dissimilar, ranging between 12 and 100, with a median value of 18.5, which revealed an extremely low application of elements of tilapia culture technology amongst most farmers.
- The overall final *TLI*s, although still dissimilar, showed a general increment, ranging from 21 to 100, with a median value of 34, which represented a progressive trend towards the adoption of elements of tilapia culture technology.

6.3.2 Group characterization and initial findings

The 142 farmers were sorted into six groups according to geographic criteria (Table 6.2). Remote locations and less populated areas were expected to have different characteristics because of knowledge flow limitations. Table 6.2 also indicates the remarkable disparities between municipalities according to their Human Development Indices (HDIs), which reflect the conditions of inequality and poverty of some areas.

As expected, the nature of every group was extremely diverse. Some of their key features are summarized in Table 6.3. In general terms, farmers of Groups 1 and 2 represented those who were more advantaged in terms of capital asset availability, while farmers of Groups 5 and 6 were amongst the most deprived and isolated. The largest numbers, in Group 4, were also relatively poorly resourced, but not to the same degree.

Table 6.2. Group definitions.

Group	Municipality	Farmers	HDI[1]
1	Emiliano Zapata	1	0.7529
	Puente Nacional	1	0.7581
	Paso de Ovejas	6	0.7425
	Ursulo Galván	8	0.7957
2	La Antigua	1	0.7910
	Veracruz	12	0.8369
	Boca del Río	1	0.8456
	Medellín de Bravo	1	0.7474
3	Tlalixcoyan	2	0.7080
	Tierra Blanca	10	0.7417
4	Angel R. Cabada	63	0.6929
5	Catemaco	13	0.7005
6	Tatahuicapan de Juárez	5	0.6234
	Mecayapan	14	0.6027
	Pajapan	4	0.5934

[1]**Human Development Index of the municipality (PNUD, 2004).**

Table 6.3. Relevant features of the groups.

Group	Farmers	Main features
1	16	Small-scale farmers using mainly ponds. Located between two development poles (the cities of Veracruz and Xalapa). Most of them from the private sector. Some of their main sources of information were COLPOS (a research institution) and the DOAs.
2	15	Small-scale and commercial-scale farmers using ponds and cages. Located near one important development pole (the city of Veracruz). Multiple sources of information.
3	12	Two commercial-scale farms and 10 organized small-scale farmers. All used ponds. Their main sources of information were CODEPAP and the DOAs.
4	63	Small-scale farmers using ponds and cages. Some of them in remote areas. Their main sources of information were the municipal extension department and the DOAs.
5	13	Small-scale farmers using ponds and located within a remote protected area. Some of them indigenous Nahuas. Induced mainly by “Los Tuxtlas Biosphere Reserve” (an NGO with governmental support), which also provided extension.
6	23	Small-scale farmers using ponds. Most of them indigenous Nahuas and Popolucas located in a remote area. Induced mainly by “Proyecto Sierra de Santa Marta” (an NGO), which also represented their main source of information.

The initial assessment using *TLI*s confirmed an enormous heterogeneity amongst groups, as revealed in Table 6.4. Significant differences ($P<0.01$) amongst groups were found (Table 6.5). The contrast between Groups 2 and 6 was particularly notable.

Table 6.4. Summary of initial *TLI*s of different groups.

Group	N	Mean	Median	Min.	Max.	Std. Dev.
1	16	22.69	16	12	63	14.50
2	15	36.33	28	19	100	25.21
3	12	27.50	19	19	75	19.97
4	63	19.84	19	12	48	6.34
5	13	15.69	16	15	17	0.63
6	23	14.39	12	12	19	3.14
Total	142	21.29	18.5	12	100	13.23

As previously indicated, during the research period (2001-2004) all individual farmers were exposed to a number of different sources of information, both formal and informal. Table 6.6 reveals the final *TLI*s for all groups. In general, all farms showed an important increment in terms of adoption of technological elements, although they were still statistically different (P<0.01) (Table 6.7). It was interesting to note that Group 6, which was the most isolated and had limited access to technical sources, showed the lowest variability.

Table 6.5. Median test summary for initial *TLI*s.

Frequencies of farms above and below the median						
	Group					
	1	2	3	4	5	6
Initial *TLI* > Median	5	15	12	35	0	4
Initial *TLI* <= Median	11	0	0	28	13	19

Test Statistics	
N	142
Median	18.5
Chi-Square	52.81
df	5
Asymp. Sig.	3.67 E^{-10}

Table 6.6. Summary of final *TLI*s of different groups.

Group	N	Mean	Median	Min.	Max.	Std. Dev.
1	16	46.06	43	26	73	10.34
2	15	57.60	59	39	100	20.15
3	12	53.00	47	47	84	14.02
4	63	35.38	34	24	62	9.59
5	13	33.46	40	21	50	10.60
6	23	32.70	34	28	34	2.27
Total	142	39.81	34	21	100	13.84

Table 6.7. Median test summary for final *TLI*s.

Frequencies of farms above and below the median						
	Group					
	1	2	3	4	5	6
Final *TLI* > Median	15	15	12	9	8	0
Final *TLI* <= Median	1	0	0	54	5	23

Test Statistics	
N	142
Median	34
Chi-Square	93.71
df	5
Asymp. Sig.	$1.12E^{-18}$

The values for overall Technological Change also revealed a significant difference ($P<0.01$) amongst groups, as indicated in Tables 6.8 and 6.9. It is notable that Group 6, having the lowest initial *TLI*, achieved the highest Technological Change value.

Table 6.8. Summary of Technological Change of different groups.

Group	N	Mean	Median	Min.	Max.	Std. Dev.
1	16	142.86	168.75	15.87	283.33	83.82
2	15	82.31	105.26	0.00	110.71	40.19
3	12	126.02	147.37	9.33	147.37	50.04
4	63	80.43	78.95	29.17	126.92	18.72
5	13	111.09	150.00	40.00	194.12	59.69
6	23	139.25	183.33	47.37	183.33	58.06
Total	142	103.85	82.35	0.00	283.33	52.96

Table 6.9. Median test summary for Technological Change.

Frequencies of farms above and below the median						
	Group					
	1	2	3	4	5	6
Technological Change > Median	12	10	10	8	8	19
Technological Change <= Median	4	5	2	55	5	4

Test Statistics	
N	142
Median	82.35
Chi-Square	56.27
df	5
Asymp. Sig.	$7.16\ E^{-11}$

6.3.3 The dynamics of technological knowledge flow within groups

Data for each group is examined in turn, to describe and assess the factors contributing to their relative access and response to technical inputs. Key issues examined are age, experience, education, and distance to municipality (as a proxy for access to services).

Group one

This comprised 16 small-scale farmers in four municipalities. Practically all used ponds and tanks as culture facilities. Their main results are summarized in Table 6.10.

Table 6.10. Summary of results for Group 1 (N = 16 farmers).

Group 1	HDI	Initial *TLI*	Final *TLI*	Tech. Change	Experience (years)	Farmer age (years)	Schooling (years)	Distance to municipality (km)
Median	0.78	16	43	168.75	2	45.5	3.5	8
Std. Dev.	0.03	14.50	10.34	83.82	0.57	25.68	3.92	0.91
Min.	0.74	12	26	15.87	1	26	0	1
Max.	0.80	63	73	283.33	6	75	12	20

Farmers of this group had little experience in tilapia farming, and most commenced their operations at their own initiative and with their own economic resources. Many farmers were previously involved in agriculture and some had access of remittances from relatives working in the US. Farms of this group were located between two development poles[4] (the cities of Veracruz and Xalapa, the State capital). The local year-round high demand at elevated prices of fresh tilapia in the 100 km long Veracruz-Xalapa corridor was the main incentive for most farmers to become involved in the activity.

Although their general level of formal education was low (median of 3.5 years), they had relatively easy access to research and academic sources, as well as to commercial

[4] Areas with relatively easy access to markets and production inputs, as reflected in the municipal HDIs.

farms (where most of them usually acquired fingerlings). Two farmers regularly attended the weekly meetings of the Veracruz Aquaculture Association (AVAC) in the city of Veracruz and most were involved in the GCPS research project. A few others had sporadic advice from the DOAs and CODEPAP.

At the beginning of the research, the overall use of elements of tilapia farming technology in this group was remarkably low (*TLI*s from 12 to 63, with a median of 16). Moreover, the use of technological elements amongst farmers was remarkably heterogeneous, as revealed in the farms' dissimilarity in terms of *TLI*s (Figure 6.2a). At this point, only three farmers produced their own fingerlings (ID numbers 1, 4 and 126), while the remainder depended on commercial farms for their supply.

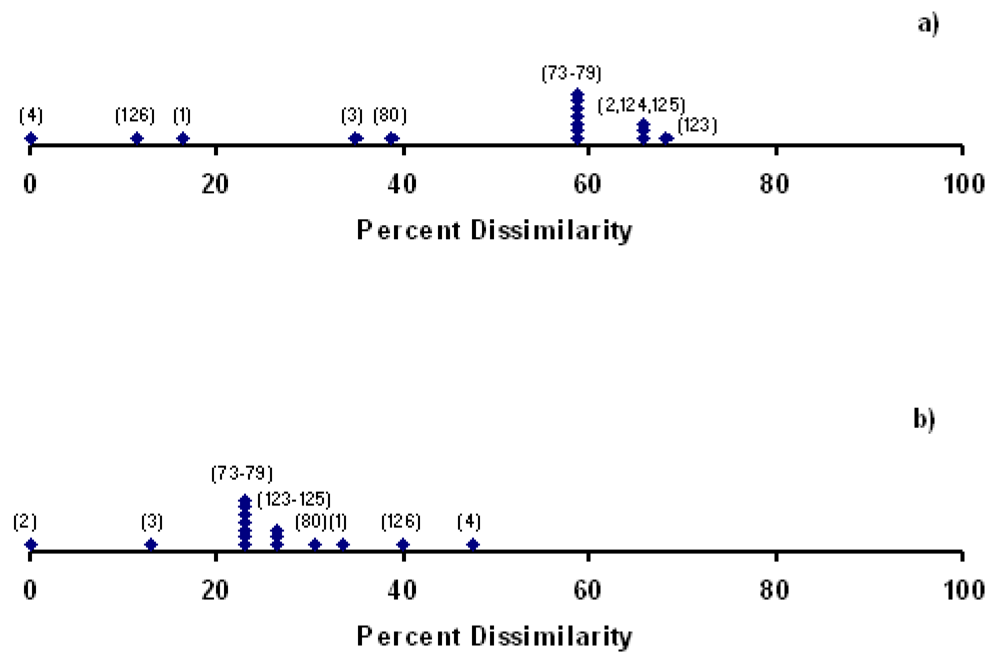


Figure 6.2. Single-axis Bray-Curtis polar ordination for farms in Group 1.

During the final assessments, *TLI*s ranged from 26 to 73 (median = 43). Out of the total 16 farmers of the group, 14 were already producing their own fingerlings (i.e. all except farms 2 and 3). Overall Technological Change showed a median increase of 168.8%, ranging from 15.9 to 283.3%. The technological gap amongst farms also showed a remarkable reduction, as indicated in Figure 6.2b.

The local availability of capital assets (indirectly measured by the HDIs of the municipalities) and the distance of production units to the municipality heads (also related to markets and production inputs) were undoubtedly important contributing factors of the observed results. Moreover, the constant interaction of farmers promoted by the GCPS project seemed to effectively help reducing the technological disparity.

Group two

This group included 15 farmers within four municipalities. Their main characteristics are summarised in Table 6.11. These farms were located near one of the most important development poles of the State and thus were privileged in terms of capital asset availability, as revealed by the municipal HDIs and their distance to municipality heads.

Table 6.11. Summary of results for Group 2 (N = 15 farmers).

Group 2	HDI	Initial *TLI*	Final *TLI*	Tech. Change	Experience (years)	Farmer age (years)	Schooling (years)	Distance to municipality (km)
Median	0.84	28	59	105.26	5	53	4	13
Std. Dev.	.03	25.21	20.14	40.19	1.30	24.04	6.36	0.83
Min.	0.75	19	39	0	1	21	0	1
Max.	0.85	100	100	110.71	more than 12	70	17	15

The group was remarkably heterogeneous. It included three commercial farms of the private sector (farms 112, 107 and 140, the best in terms of *TLI*s within the whole sample), which were involved in commercial fingerling production and ongrowing operations. Apart from years of experience, these three farms had regular access to financial resources and qualified managers. The group also included 12 small-scale farmers of the *ejido* sector involved in cage farming. These farmers were induced by the DOAs through the Cages and Enclosures project and, although they had been involved in tilapia farming for many years, most were still dependant on subsidies. During the initial assessment, only one of these small-scale farmers produced his own fingerlings.

The relation of all farmers of Group 2 with local academic and research bodies has been traditionally close. Additionally, all three commercial-scale farmers and two small-scale farmers of the *ejido* sector regularly attended weekly meetings of the AVAC in the city of Veracruz. During the period, the small-scale farmers also had sporadic support from the DOAs and the Agriculture Department of the municipality of Veracruz.

The initial *TLI*s of farms in this group ranged from 19 to 100 (median = 28). At that point, their dissimilarity in terms of use of elements of tilapia farming technology was also remarkably high (Figure 6.3a). As previously indicated, the endpoint farms on the axis represented the best and the worst in terms of *TLI*s. The three commercial farms, however, showed much less dissimilarity in terms of *TLI*s, while the gap between these and the small-scale farms (which also showed a high degree of similarity amongst them) was notable.

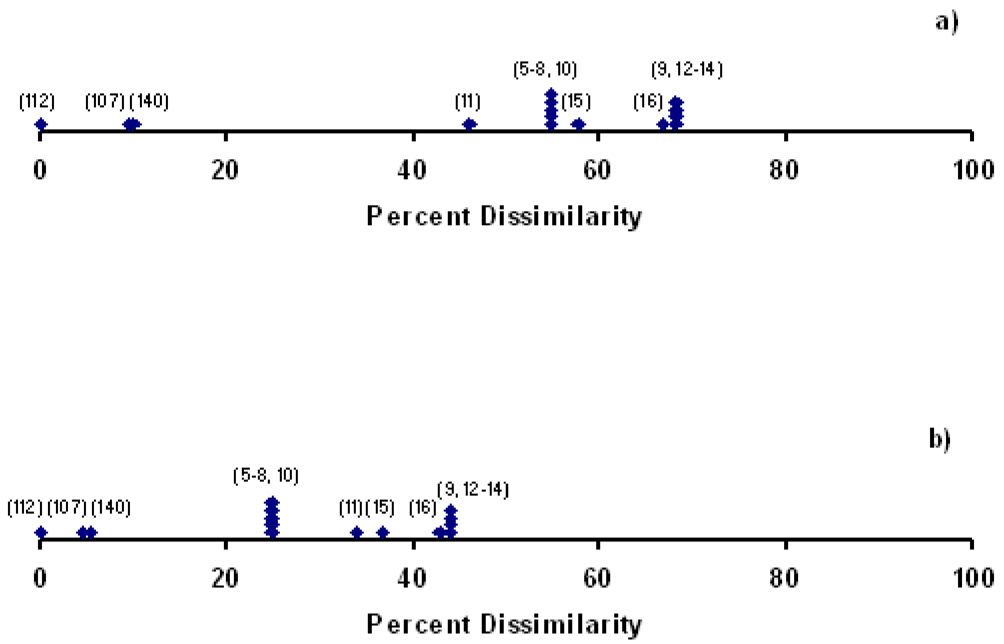


Figure 6.3. Polar ordination for farms in Group 2.

The final assessment still revealed a clear distinction between the commercial and small-scale farms (Figure 6.3b), although a notable reduction in their technological gap was also evident. Final *TLI*s ranged from 39 to 100 (median = 59) and, although the overall Technological Change within the group reached a median value of 105.3%, the highest figures corresponded to the small-scale farmers. The high levels of technology used by the three commercial farms appeared to be pulling the small ones (which regularly interacted with the commercial farmers in the AVAC meetings or visited the commercial farms in order to acquire fingerlings), towards a better technological scenario.

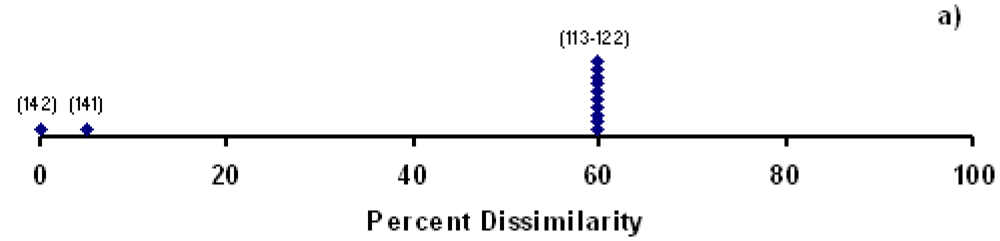
Group three

This group included 12 production units and its main results are presented in Table 6.12. It comprised two experienced commercial farmers of the private sector (farms 141 and 142), both involved in complete cycle operations, and 10 organized small-scale farmers of the *ejido* sector. The latter were beginner entrants induced by CODEPAP and the DOAs, which were their main (although sporadic) sources of technical advice.

Table 6.12. Summary of results for Group 3 (N = 12 farmers).

Group 3	HDI	Initial *TLI*	Final *TLI*	Tech. Change	Experience (years)	Farmer age (years)	Schooling (years)	Distance to municipality (km)
Median	0.74	19	47	147.37	5	43	4	28
Std. Dev.	0.01	19.97	14.02	50.03	0.52	32.6	4.0	6.76
Min.	0.71	19	47	9.33	4	21	0	1
Max.	0.74	75	84	147.37	9	85	15	30

Initial *TLI*s were remarkably low and heterogeneous, ranging from 19 to 75 (median = 19). Figure 6.4a also illustrates the high technology gap between the commercial farmers and the small-scale producers. At this initial point, none of the small-scale farmers produced their own fingerlings. The final assessment revealed an increase in *TLI*s (ranging from 47 to 84, median of 47) and an increment of Technology Change (median = 147.4%), achieved mainly by the small-scale producers. The technology gap between commercial and small-scale farms also showed a remarkable reduction (Figure 6.4b). At the final stage, all small-scale farmers were producing their own fingerlings. Since the beginning, they seemed to work in a well organized manner, and their *TLI*s were identical in both assessments. After their initial governmental support, they started reinvesting their profits and remained working in an organized way. Most farmers regularly visited the commercial farms within their geographic area and eventually attended the AVAC meetings.



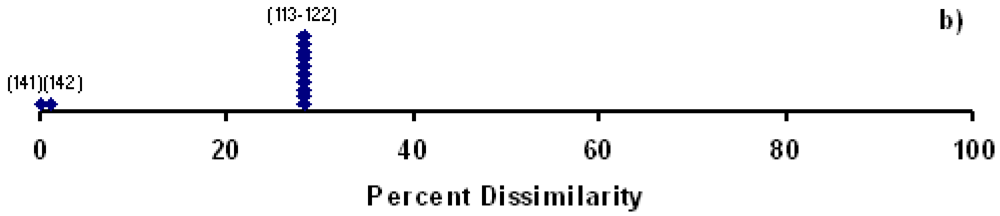


Figure 6.4. Polar ordination for farms in Group 3.

Group four

The largest in the sample, Group 4 included 63 farmers in only one municipality. Its relevant features and results are presented in Table 3.13.

Table 6.13. Summary of results for Group 4 (N = 63 farmers).

Group 4	HDI	Initial *TLI*	Final *TLI*	Tech. Change	Experience (years)	Farmer age (years)	Schooling (years)	Distance to municipality (km)
Median	0.69	19	34	78.95	1	38	3	18
Std. Dev.	0.00	6.34	9.59	18.72	0.74	25.22	3.65	0.65
Min.	0.69	12	24	29.17	1	21	0	6
Max.	0.69	48	62	126.92	9	70	15	25

The group comprised one experienced small-scale farmer of the private sector (farm No. 61) and five organized sub-groups of people from the *ejido* sector, most of them new entrants using cages and enclosures. Some farmers of this group were previously involved in the MIRNZB initiative and were thus familiar with tilapia farming. Many were also involved in agriculture and other off-farm activities. During the research period, practically all farmers had some kind of support (such as infrastructure, fingerlings, commercial feeds and some advice) from the DOAs, CODEPAP and the municipal Department of Agriculture. Additionally, most farmers actively participated in the GCPS project. During the initial assessment, *TLI*s were low, ranging from 12 to 48, with a median of 19. Only four farmers produced their own fingerlings (No. 61, 65, 66 and 67), and were also the ones with highest *TLI*s (Figure 6.5a).

The final assessment showed a small increase of *TLI*s, ranging from 24 to 62, with a median of 34. The overall Technological Change of the group was only of 79.0% (the smallest in the whole sample), and although the technological gap decreased, the pattern of all sub-groups remained very similar (Figure 6.5b). Apart from the four previously mentioned farms, only five other farmers started to produce their own fingerlings (farms No. 68-72). The majority of the farmers, however, remained dependant on input subsidies (namely commercial feeds and fingerlings) during the entire research period.

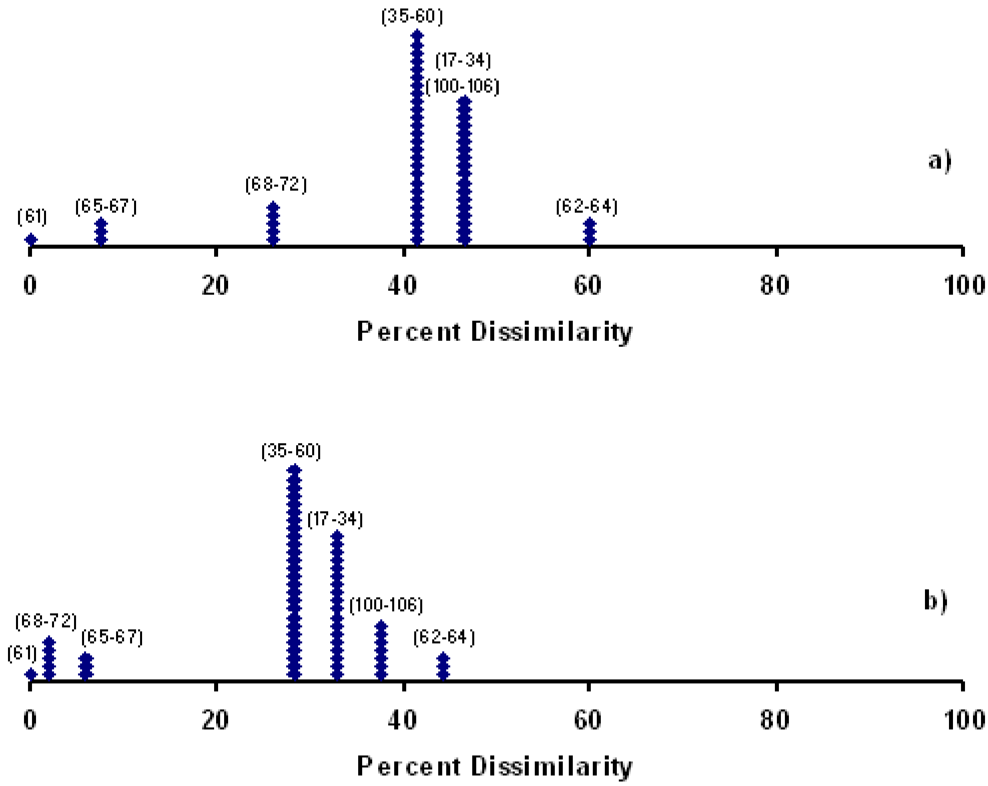


Figure 6.5. Polar ordination for farms in Group 4.

In general, the adoption pattern was very similar in all sub-groups, but extremely slow. The paternalistic nature of the governmental interventions, accentuated by a sense of insecurity amongst most farmers (mainly in terms of irregular incomes and land tenure status), appeared to have had a decisive impact in the observed adoption rates.

Group five

This included 13 small-scale farmers located within one municipality of relatively low HDI. Some were indigenous Nahuas and all were situated in a remote part of "Los Tuxtlas Biosphere Reserve", a rainforest natural protected area. All of them used ponds as farming facilities. The group's main characteristics and results are summarized in Table 6.14.

Table 6.14. Summary of results for Group 5 (N = 13 farmers).

Group 5	HDI	Initial *TLI*	Final *TLI*	Tech. Change	Experience (years)	Farmer age (years)	Schooling (years)	Distance to municipality (km)
Median	0.70	16	40	150	1	38	6	23
Std. Dev.	0.00	0.63	10.6	59.69	0.0	24.1	3.27	0.0
Min.	0.70	15	21	40	1	15	0	21
Max.	0.70	17	50	194.12	1	60	12	25

All farmers of this group were new entrants induced by the NGO in charge of managing the reserve, which operated with full governmental support. All farmers were *ejidatarios* previously involved in agricultural activities and started their operations using mainly their own resources (e.g. for their pond construction). However, during the entire research period they had regular technical advice from the NGO's extension agent based in the municipality head. Another two important sources of technical information were two governmental hatcheries located within the same municipality and operated by the Federal DOA. These hatcheries also supplied the initial stocks of fingerlings and were a constant source of support.

Farmers of the group showed very low initial *TLI*s, ranging from 15 to 17, with a median of 16. At that point, none of the farmers produced their own fingerlings. Moreover, all production units were very similar in terms of the use of elements of tilapia farming technology, as shown in Figure 6.6a.

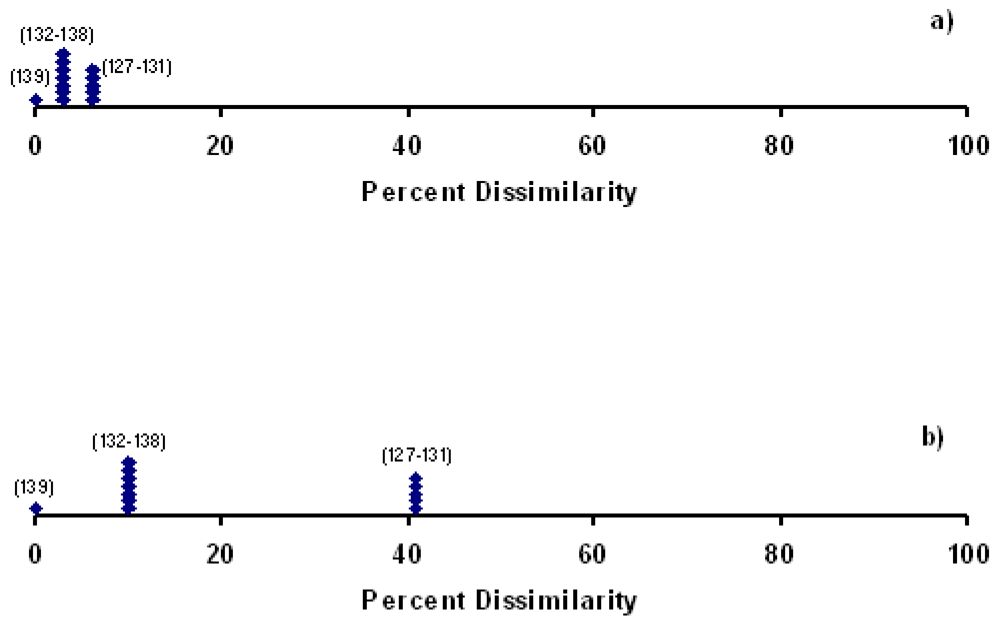


Figure 6.6. Polar ordination for farms in Group 5.

However, the final assessment revealed a remarkable rise in *TLI*s, ranging from 21 to 50, with a median of 40. This increment also produced a median Technological Change of 150% (ranging between 40 and 194.1). Although during the initial assessment all production units were relatively homogeneous in terms of the use of technological elements, the final assessment revealed a notable dissimilarity amongst farms (Figure 6.6b). At this point it was also notable that out of the total 13 farmers which comprised the group, eight were producing their own fingerlings. It was evident that, although practically all farmers were exposed to the same sources of information, their individual adoption capacity was different.

Group six

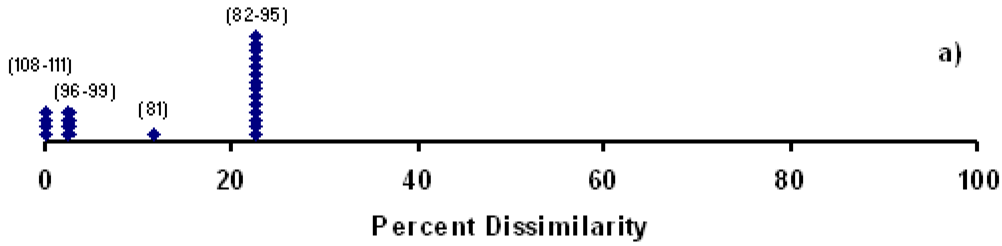
This included 23 small-scale farmers dispersed within three remote and deprived municipalities, as revealed by their low HDIs. Table 6.15 summarizes the group's main features and results.

Table 6.15. Summary of results for Group 6 (N = 23 farmers).

Group 6	HDI	Initial *TLI*	Final *TLI*	Tech. Change	Experience (years)	Farmer age (years)	Schooling (years)	Distance to municipality (km)
Median	0.60	12	34	183.33	2	33	3	23
Std. Dev.	0.01	3.14	2.27	58.06	0.54	20.77	2.78	0.79
Min.	0.59	12	28	47.37	1	15	0	11
Max.	0.62	19	34	183.33	6	60	9	25

Most farmers of this group were indigenous Nahuas and Popolucas, some of whom were illiterates and/or unable to understand Spanish. Practically all were involved in agricultural activities and most were introduced to tilapia culture by "Proyecto Sierra de Santa Marta", an NGO deeply involved in the area. All farmers used ponds as farming facilities and many of them initiated operations with their own limited resources. The NGO's extension agent was the main source of technical advice for most farmers. However, some of them had at some point the opportunity to attend training courses at COLPOS or to visit commercial farms, mainly for acquiring fingerlings.

Initial *TLI*s were very low, ranging from 12 to 19, with a median of 12. At that moment, their use of elements of tilapia farming technology was very similar (Figure 6.7a), and none of them produced their own fingerlings.



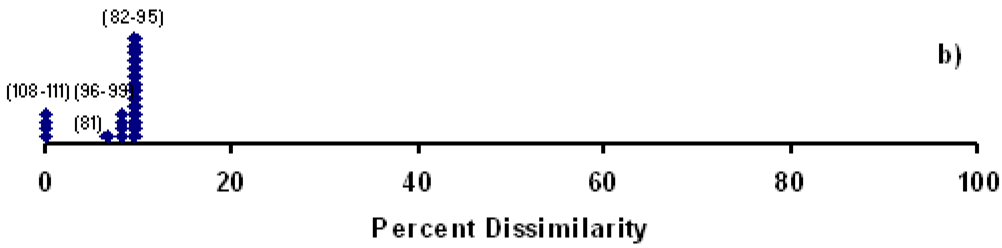


Figure 6.7. Polar ordination for farms in Group 6.

The final assessment showed an important increment in *TLI*s, ranging between 28 and 34, with a median of 34. The Technological Change was also remarkably high, reaching a median value of 183.3%. During this final stage, all 23 farmers were producing their own fingerlings. The constant presence of the extension agent and the intense interaction of farmers due to their isolated conditions seemed to facilitate a gradual and homogeneous adoption pattern of technological elements, as revealed in Figure 6.7b.

6.3.4 The influence of socio-economic variables and agricultural background

Putting together the data explored so far, some relationships between the use of elements of tilapia farming technology amongst farmers and certain explanatory variables have emerged (Table 6.16). For instance, strong linear relationships (P < 0.01) between final *TLI*s and human capital indicators (i.e. group affiliation, municipal development and farmer's experience) were evident. As hypothesised, *TLI*s seemed to relate closely to human capital availability.

Table 6.16. Nonparametric bivariate correlations between final *TLI*s and key socioeconomic variables.

	Technology Level Index[1] (for 2003-2004 period)
Group affiliation	**-0.531****
	0.000
Human Development of municipality	**0.564****
	0.000
Years of experience	**0.574****
	0.000
Age of farmer	**0.245****
	0.003
Distance of farm to municipality head	**-0.129**
	0.126
Formal education of farmer	**0.130**
	0.125

[1]Spearman's rho correlation coefficient (in bold) and two-tailed observed level of significance (below).
****Correlation is significant at the 0.01 level.**

Moreover, it has been previously indicated that tilapia culture was a relatively new practice for most farmers and that many were simultaneously involved in other agricultural practices. It was also hypothesized that previous experience in these activities could facilitate the adoption of tilapia farming technology. In fact, significant differences amongst farmers ($P<0.01$) were found when the presence of these other productive activities were considered (Table 6.17). A deeper scrutiny revealed that these differences appeared only when a distinction between agriculture and livestock husbandry was taken into account.

Table 6.17. Median test summary for final *TLI*s using agricultural background as grouping variable.

Frequencies of farms above and below the median				
	only tilapia	tilapia + agriculture	tilapia + livestock	tilapia + agriculture + livestock
Final TLI > Median	17	14	9	19
Final TLI <= Median	23	40	2	18

Test Statistics	
N	142
Median	34
Chi-Square	14.25
df	3
Asymp. Sig.	0.003

Accordingly, it seemed that the overall adoption and use of elements of tilapia farming technology (represented by the final *TLI*s) was not statistically related (P>0.05) to the agriculture experience of the farmer (Table 6.18).

Table 6.18. Median test summary for final *TLI*s using agricultural association as grouping variable.

Frequencies of farms above and below the median		
	only tilapia	tilapia + agriculture
Final *TLI* > Median	17	14
Final *TLI* <= Median	23	40

Test Statistics	
N	94
Median	34
Chi-Square	2.85
df	1
Asymp. Sig.	0.09

In contrast, involvement of the farmers engaged with livestock production showed statistical differences (P<0.01) when contrasted with producers only involved in tilapia farming (Tables 6.19). Apparently, adoption of elements of tilapia farming technology was facilitated by previous experience with other forms of animal husbandry. In this respect, it would appear that tilapia farming is but a sort of aquatic animal husbandry.

Table 6.19. Median test summary for final *TLI*s using livestock association as grouping variable.

Frequencies of farms above and below the median		
	only tilapia	tilapia + livestock
Final TLI > Median	17	9
Final TLI <= Median	23	2

Test Statistics	
N	51
Median	34
Chi-Square	12.63
df	1
Asymp. Sig.	0.002

These results suggest that technical practices regarding tilapia culture were adopted in more easily ($P<0.05$) by farmers previously involved with livestock rather than by those only involved in agriculture (i.e. crop production), as shown in Table 6.20.

Table 6.20. Mann-Whitney test summary for final *TLI*s using agricultural background as grouping variable.

Ranks of final TLI using agricultural background as grouping variable			
	N	Mean Rank	Sum of Ranks
tilapia + agriculture	54	30.42	1642.5
tilapia + livestock	11	45.68	502.5
Total	65		

Test Statistics	
Mann-Whitney U	157.5
Wilcoxon W	1642.5
Z	-2.52
Asymp. Sig. (2-tailed)	0.012

On the other hand, Technological Change was strongly related ($P < 0.01$) to the distance of the farm to the municipality head[5] (which positively related with access to markets, inputs and sources of information) and to the formal education of the farmer (which related to their capacity to acquire and process technical knowledge). Technological Change also showed a moderately strong positive relationship ($P < 0.05$) with the

[5] The main city within the municipality, where local government and administrative offices are located.

experience of the farmer and the *TLI* of the unit (Table 6.21). In contrast, poor relationships were found between Technological Change and the remaining variables.

Table 6.21. Nonparametric bivariate correlations between Technological Change and key socioeconomic variables.

	Technological Change[1]
Distance of farm to municipality head	**0.420****
	0.000
Formal education of farmer	**-0.221****
	0.008
Years of experience	**0.179***
	0.033
Technology Level Index	**0.211***
	0.012
Group affiliation	**0.084**
	0.323
Human Development of municipality	**0.007**
	0.935
Age of farmer	**-0.002**
	0.986

[1]Spearman's rho correlation coefficient (in bold) and two-tailed observed level of significance (below).
**Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.

Moreover, the Technological Change, defined as the ratio of the increase in *TLI* to the initial *TLI*, also seemed to be statistically different ($P<0.05$) when the previous experience of the farmer in both agricultural and livestock activities was taken into account (Table 6.22). In fact, farmers that combined tilapia with agriculture and livestock were more likely to achieve higher Technological Change values than those farmers without that agricultural background.

Table 6.22. Median test summary for technological change using agricultural background as grouping variable.

Frequencies of farms above and below the median				
	only tilapia	tilapia + agriculture	tilapia + livestock	tilapia + agriculture + livestock
Technological Change > Median	13	24	7	23
Technological Change <= Median	27	30	4	14

Test Statistics	
N	142
Median	82.35
Chi-Square	8.15
df	3
Asymp. Sig.	0.043

6.4 A case of spontaneous dissemination of an innovative practice

Until the late 1990s, the use of monosex tilapia fingerlings in ongrowing operations was not a widespread practice in the region. The ineffective and tedious method of manual sexing was the *avant-garde* practice, and none of the other practices used worldwide (e.g. sex reversal with hormone-treated feed, hybridisation, genetic manipulation, etc.) was regularly used. Despite the use of hormones was perceived by many farmers as an attractive and promising choice, the proved and widely used androgen *17-alpha-methyltestosterone* was not (and still is not) easily available within the national market.

In 2000, the validated protocol for using the synthetic hormone fluoximesterone[6] (Phelps et al. 1992) was suggested to one important producer of fingerlings in the region. Pioneer of tilapia culture in the area, this farmer had been an enthusiast promoter of the activity and was well-known amongst many farmers and extension agents. The benefits of using monosex fingerlings (and particularly this hormone) were

[6] Fluoximesterone (commercially known as Stenox®) is an effective, cheaper and locally available alternative to *17-alpha-methyltestosterone*. It is available in almost any local pharmacy and it is usually used at 2.5-5.0 mg kg^{-1} of feed (enough to revert between 2 500-4 000 fry during a 28 day period). When well used, its efficiency is superior to 95%. Although its popularity has increased greatly, its use in aquaculture has not been legally authorized in the country.

immediately recognized and adopted by him, who from 2001 onwards openly promoted it to clients and friends.

Within the region, the use of monosex fingerlings in ongrowing operations spread quickly (Figure 6.8). Out of the 142 farmers in the sample, 84 (59.1%) were using fluoximesterone sex-reverted fingerlings during the first 9 months after the hormone was adopted by the initial farmer. After 3 years, 114 farmers (80.2%) were using this kind of fingerlings in their production units.

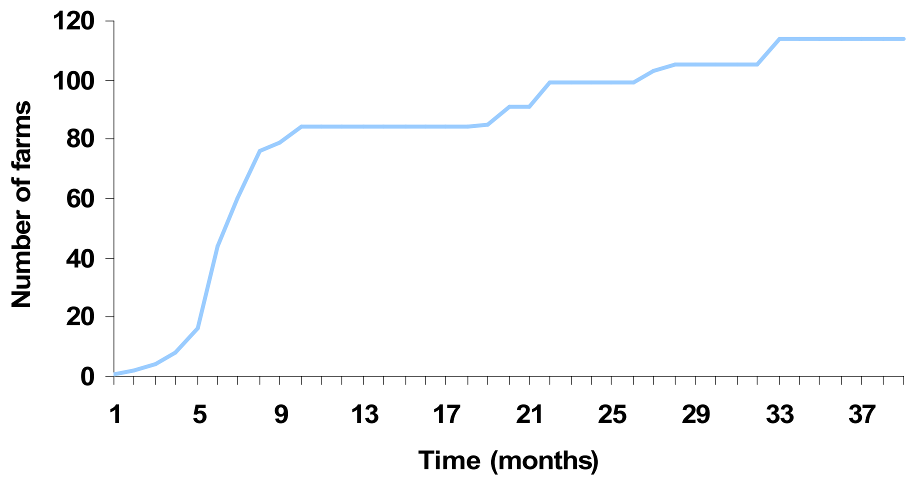


Figure 6.8. Cumulative use of sex-reverted tilapia fingerlings in ongrowing operations.

Apparently, the dissemination and adoption processes followed various simultaneous paths, mimicking a chain-reaction. The main sources of farmers' awareness about the benefits of using this type of monosex fingerlings are indicated in Table 6.23, where the fundamental participation of the private sector in general (nearly 75%), and farmers in particular (47%), can be appreciated. Clients of fingerlings were the fist to adopt and promote the use of these organisms amongst other farmers and friends. Fingerling producers were also immediately attracted to learn the sex-reversion process in order to remain competitive, and so they continued spreading reverted animals to their respective customers. During the entire dissemination process, service providers (23%) also played an important role, while extension agents (16%) and academics (10%) apparently did not.

Table 6.23. Farmers' initial sources of information about regional suppliers of sex-reverted fingerlings and the benefits of their use.

Initial source of information	Farmers	Percentage
Other farmer	54	47.4
Service provider	26	22.8
Extension agent	18	15.8
Academic or researcher	11	9.6
Other (friend, mass media, etc.)	5	4.4
Total	114	100.0

On the other hand, the adoption trend of fluoximesterone within hatchery operations is shown in Figure 6.9. Four years after its introduction, 77 farms were using it at regular basis. Out of this amount, however, only 25 farmers (32.5%) used the hormone adequately.

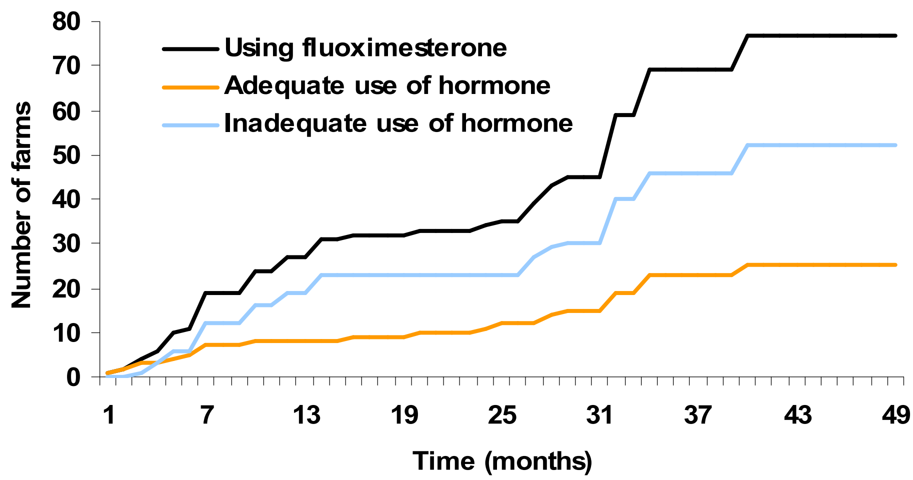


Figure 6.9. Use of fluoximesterone in hatchery operations.

The most common incidence of technology misuse observed in the remnant 52 farms was dose related, both during preparation (94%) and administration (89%). Because many of these farmers did not receive an adequate training, they –logically still wrongly– assumed that the reversion results might improve if the dose was increased.

Other problems such as improper storage of treated feed (68%) and human health risks associated to drug handling (59%) were also notable. As shown in Table 6.24, farmers which were introduced into this technology by extension agents, academics or researchers were those that –from the beginning– made an adequate use of the protocol. In contrast, farmers introduced by other farmers (usually by imitation) and service providers showed the highest incidence of mistakes during its initial use. Once an inadequate case was detected by extension agents or academics, corrective recommendations were regularly suggested and, in some cases, implemented and adopted.

Table 6.24. Adequate and inadequate use of fluoximesterone at farm-level (N = 77).

Initial source of information	Adequate use		Inadequate use	
	Farmers	Percentage	Farmers	Percentage
Other farmer	3	3.9	25	32.5
Service provider	0	0.0	21	27.3
Extension agent	9	11.7	3	3.9
Academic or researcher	13	16.9	1	1.3
Other (friend, media, etc.)	0	0.0	2	2.6
Total	25	32.5	52	67.5

Although it is generally accepted that the main objective of dissemination is to increase the level and speed of uptake (Garforth, 1998), dissemination *per se* does not guarantee that the quality of information reaches the end-user as intended, as a number of distortions are likely to occur during the communication process. In the present case, the role of farmers and service providers proved to be a good mechanism to deliver information to individual farmers (i.e. the use of monosex fingerlings), although it was not so good when the practice needed a specific training process (i.e. the manipulation of fluoximesterone).

These sorts of distortions have been detected elsewhere. For example, the experience of maize-mucuna in northern Honduras described by Neill and Lee (2001) suggested that spontaneous diffusion of sustainable agricultural practices could be a mixed blessing at best. Their findings revealed that many farmers adopted the maize-mucuna system after they observed the improved harvests of their neighbours. However, spontaneous diffusion did not necessarily provide farmers with an understanding of system dynamics, which may prove critical for system sustainability.

Ultimately, it seems evident that some practices are more easily adopted than others. In the case presented in this section, the choice of adequate *detonators* (or what Gillespie (2004) defined as *triggers*, *catalysts* or *sparks*), proved to be important in the observed uptake rates. Accordingly, the identification and exploitation of these *detonators* (which in the exposed case were an innovative/useful practice, the timing for introducing it, and the initial farmer) might result helpful when planning and conducting future dissemination interventions.

6.5 Closing remarks

> "*It is almost impossible for any one in the United States to realize the emptiness of the lives of the Mexican lower class, which comprises about nine millions of a nation of ten millions of people. Most of them can neither read nor write. They have no books nor paper. My servants do not know their own ages, and actually cannot count up to twenty-five. A man or woman who has been to Tampico, or Monterey, or the City of Mexico, is a much-travelled person. Most of the peasants die with but a limited knowledge of the country around them for a radius of thirty miles. All beyond that is as vague to them as is Matabel Land to us; more so, for they have no idea of a map, nor of anything not Mexican*."

V. A. Lucier, 1897.

It could be argued that the eloquent perceptions of Mrs. Lucier, the companion American wife of a businessman that spent five years amongst the peasantry of Mexico, were completely biased, subjective, lacked of the minimum scientific evidence, non-representative or even racist. Nevertheless, as history confirmed, her words proved to be not but a sad and inconvenient truth. Thirteen years after *The Journal of American Folklore* published her opinions, the Mexican Revolution began.

More than a century later, and despite achievements in many sectors of the national economy, that pre-revolutionary panorama seems to be re-emerging. As previously indicated, tens of millions, particularly in rural areas, remain poor. The evidence revealed so far, although restricted to a small region, has confirmed acute differences in terms of capital asset availability.

In the regional crusade against poverty, during the past four decades most development agencies have seen in tilapia culture a glimpse of hope. Although its precise impact in improving the livelihoods of many poor and disadvantaged groups still remains unclear, the findings presented until now have revealed a gradual increase in the adoption of culture practices amongst most new entrants and, consequently, a rise in technological change and productivity. The future of the industry, both at small and commercial scale, seems to be promising.

So far, the overall results appear to confirm the hypothesis that local knowledge effectively enhances and stimulates the dissemination and adoption of tilapia farming technology, and hence human capital. So, from the gathered evidence, some preliminary conclusions can be derived.

In a very simplified algebraic way, if *ETL* is defined as the expected technological level achieved by an individual farmer in any particular geographic area. So,

(Eq. 6.1) $ETL = f(X_1 + X_2 + X_3 + Z)$ where *ETL* was defined above and

X_1 is the regional development level (as measured by the HDI)
X_2 is the local availability of technical information sources
X_3 is the farmer's experience in animal husbandry practices
Z corresponds to other variables and externalities

As previously indicated, the local availability of technical knowledge can be positively related to the municipal HDI and to the presence of commercial farms within the area, as well as the constant presence of extension agents. External variables include markets, regulatory policies, farmer's managerial skills, extension agent's competence, etc. More specifically, the likelihood of an individual farmer to adopt new elements of tilapia farming technology (*ATL*) can be defined by the function:

(Eq. 6.2) $ATL = f(Y_1 + Y_2 + Y_3 + Z)$ where ATL was defined above and

Y_1 is the farmer's access to information sources (which also relates to HDI)

Y_2 is the farmer's educational background

Y_3 is the farmer's experience in animal husbandry practices

Z corresponds to other variables and externalities

In this sense it may be possible to assemble a clearer view of the prospects for development of general or specific cases. Here of course the *ETL* and *ATL* refer to only one technology, in this case tilapia farming, and as noted in the earlier stages, they does not in itself confer success in this endeavour. Nor does success in tilapia farming, unless developed to a sufficient scale and/or with sufficient profitability, result in significant economic gain, let alone the potential for broader change of the type reflected in HDI criteria.

Technology is a motor for human development (UNDP, 2003). Moreover, it is part of a much larger phenomenon and like many other endeavours, is the result of thought, intention, and action, all of which are related to choice (Rivers, 2005). In macroeconomic terms, it plays a major part in the steady accumulation of capital which is necessary to increase living standards in the long run (Bretschger, 2005).

Technological change is a principal source of sustained growth in living standards and is essential for transformation and modernization of economic structures (Maskus, 2004). In the world at large, technological change is driven by the need to squeeze ever greater yields from the same plot of land. In all such arguments, knowledge is the ultimate decider, balanced by economic considerations (Trewavas, 2002). It responds to market forces, but new technologies and new markets are also created in response to new technological opportunities, and these can be unpredictable (Clarke et al. 2006).

Technological change is multi-faceted and complex. It arises from a variety of interacting activities, including public and private funded R&D, and learning-by doing (Clarke et al. 2006). The common denominator to all growth and diffusion phenomena in the living world is the transmission of information, whose continuing evolutionary process conduces to increasingly complex systems (Devezas, 2005). Technological evolution is not an independent evolutionary process, but it is the fastest and more energetic among a broad innovation-driven and co-evolutionary set of processes, composing the whole of the world system (Devezas, 2005). A natural and theoretically important distinction should be made between determinants affecting the supply of innovations and determinants influencing the demand for innovations (Bretschger, 2005). Although it is generally accepted that the diffusion of knowledge is costly (Vollebergh and Kemfert, 2005), the potential for technological change may be directly related to different kinds of capital employed in the sector (Herr, 1966).

Technological change can be defined as a change in the parameters of a production function resulting directly from the use of new knowledge (Stout and Ruttan, 1958). Its measurement and interpretation, however, have long been a problem (Scott, 1964), due to the variables involved (Coccia, 2004). Traditionally, the measure of technological change has been interpreted as the changes in output per unit of total input between two periods (Jensen, 1957; Stout and Ruttan, 1958). However, the quality of both inputs and outputs changes over time, and outputs rarely increase in strict proportion to inputs increments. So, this measure tends to obscure and underestimate technological change (Lave, 1962). Alternative nonparametric tests of technological change have been promoted and motivated as being free of bias, which may be caused by an incorrect parametric specification of the objective function (Bar-Shira and Finkelshtain, 1999). In this work, technological change was evaluated via the improvement of technological practices at farm level, in the assumption that this increases the overall farm performance and hence the social benefits. As previously indicated, this approach appeared to be useful in the achievement of the proposed goals.

CHAPTER SEVEN: CASE STUDIES AT FARM LEVEL

7.1 Introduction

Following the development of the research aims and strategy, and in order to illustrate the role of tilapia within the livelihoods of representative small-scale farmers, six agroecosystems were selected to conduct study cases, trying to expand and complement the key findings examined in the previous chapter. According to HDI values, six dissimilar municipalities were selected (0.6027; 0.6929; 0.7005; 0.7425; 0.7529; and 0.8369), representing the whole spectrum in the sample. Within each municipality, one farmer was selected according to its median value of Initial TLI. In the final section, key processes by which technical knowledge is disseminated and taken up are presented.

7.1.1 Study case one (farmer No. 4)

This pond-based, small-scale farm was located in the municipality of Emiliano Zapata (HDI = 0.7529), within Group 1. The farm was also the household residence and was situated at approximately 16 km of the municipality head by asphalted road. The four hectares small property had access to services such as potable water, electricity and latrine. In the nearest town (at approximately 2.5 km) there was a health unit, an elementary school, public telephone and frequent collective transport.

The family head was a 35 year-old man with 12 years of formal education (equivalent to completed high school) and five years experience in tilapia culture. He inherited the farm from his father but started cultivating tilapia using his own resources, motivated by the elevated demand of fresh fish in the Veracruz-Xalapa corridor all-year round. His brother and associate, who inhabited in the farm part of the year, also worked intermittently as illegal immigrant in the US. The remittances represented an important source of external income for the household and were also used to initiate the tilapia subsystem. Out of the seven members that comprised the family nucleus, two were fully involved in the tilapia subsystem.

The fish production unit used river water and included two nursery ponds and two grow-out ponds used in semi-intensive operations. The farmer produced his own fingerlings and used commercial feeds for both hatchery and grow-out operations. His yearly production capacity was of approximately 15 000 fingerlings (that was also partially commercialised) and between 2 and 3 tonnes of market-size tilapia. Most production was commercialized locally, but fish was also consumed by the family on a regular basis.

The farmer was also involved in the production of sheep and fruit, namely mango (*Mangifera indica*) and zapote chico (*Manilkara zapota*). Although all fruit production (obtained from 350 trees) was bound for the national market, the by-products were usually integrated into the sheep subsystem. Besides, sheep manure was frequently used as tree fertilizer. The livestock subsystem was a herd of 14 sheep, used mainly for family consumption, although most lambs were generally sold locally. Figure 7.1 shows the main qualitative relationships of the different subsystems within the agroecosystem.

During the research period, the farmer got sporadic support and advice from the DOAs, which represented his main sources of technical information. However, he had the opportunity and resources to visit many of the commercial farms within the area, from where he obtained ideas and technical information.

Observed *TLI*s and Technological Change values for this farm are presented in Table 7.1. As can be noted, during the research period his total *TLI* varied from 63 to 73, which was the highest observed within Group one. In fact, the farm represented an important source of inspiration and information for many other small-scale farmers of that area. In contrast, the farm achieved a Technological Change of only 15.9%, the lowest observed in the whole group.

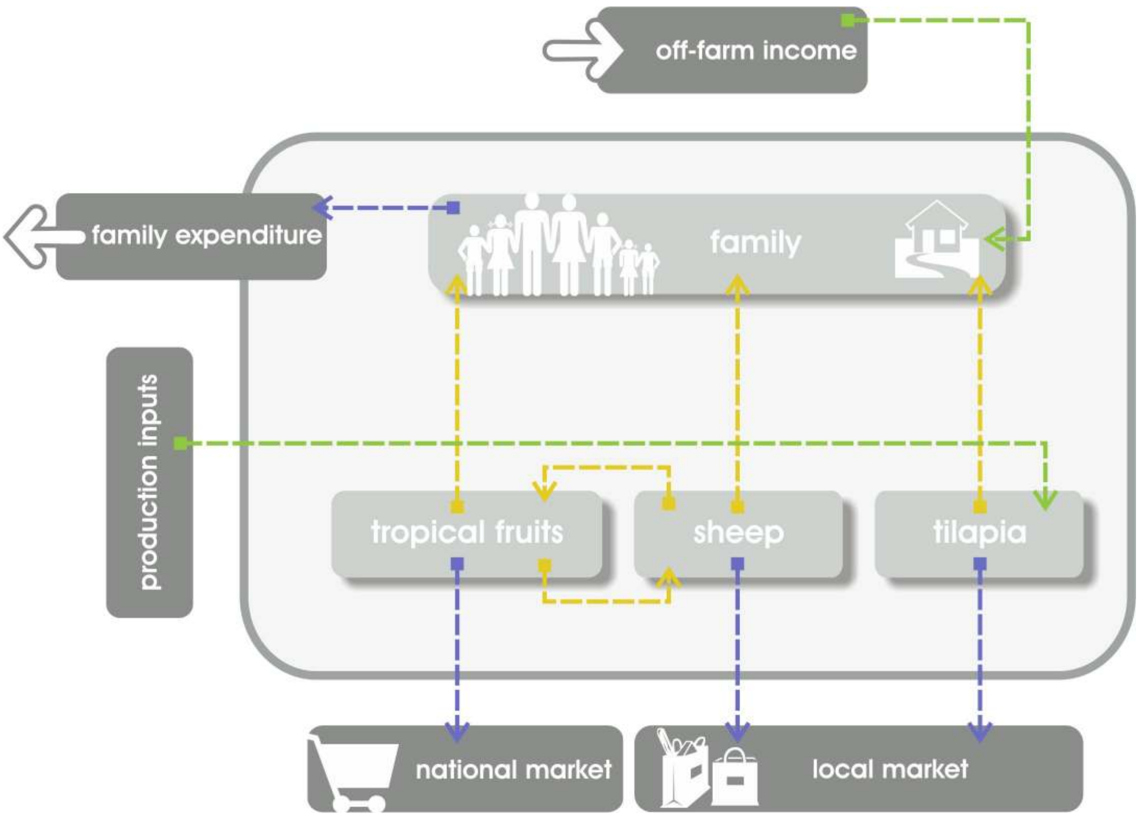


Figure 7.1. Schematic representation of the input and output flows for the agroecosystem No. 4.

Table 7.1. Summary of results for farmer No. 4.

Initial *TLI* (2001-2002)				Final *TLI* (2003-2004)				Technological Change
Hatchery	Grow-out	Post-harvest	Total	Hatchery	Grow-out	Post-harvest	Total	(Percentage)
70.0	57.5	60.0	63.0	77.5	70.0	70.0	73.0	15.87

An economic evaluation of the different subsystems within the entire agroecosystem revealed that the tilapia subsystem represented up to 68% of the yearly net income of the household (without taking into account the periodic remittances), whereas tropical fruit and sheep represented 31 and 1%, respectively. Annual earnings per farmer have doubled since the introduction of tilapia into the farm, and also the cash flow has increased. Moreover, auto-consumption of tilapia (two times per week in average) represented an important source of animal protein for the family (this consumption rate remained constant during the research period). As the local demand for fresh fish increased, the people involved have expectations for increasing their number of ponds in the short term.

7.1.2 Study case two (farmer No. 3)

This production unit was located within the Veracruz-Xalapa corridor, in the municipality of Paso de Ovejas (HDI = 0.7425) and also in Group one. The 0.75 ha farm was a small property connected to the municipality head by 12 km of asphalted road. It had access to potable water, electricity and sanitation. The nearest town, actually the municipality head, had a health unit, elementary school, telephone and public transport.

The household was comprised of the 37 year-old owner and three other members. The farmer had 12 years of formal education (i.e. completed high school) and only one year of experience in tilapia farming. He started at his own initiative and with his own resources, motivated mainly by the local demand for fresh fish. Two members of the household were actively involved in tilapia culture, which represented the only productive activity of the farm and the main source of income for the family. Sporadic off-farm work complemented the household income (Figure 7.2).

The semi-intensive fish farming unit used water from an irrigation channel and included two earth ponds of approximately 0.25 ha each. The farm was dedicated only to grow-out operations. The production depended on fingerlings acquired in commercial farms and on commercial feeds. The farmer started his business without any previous knowledge in fish farming or any technical advice. At the moment of the initial assessment of this research, he was just completing his first production cycle. At that point he was using few elements of tilapia farming technology (Table 7.2) and harvested only 100 kg of market-size fish. Nevertheless, he sold the production and enthusiastically persevered.

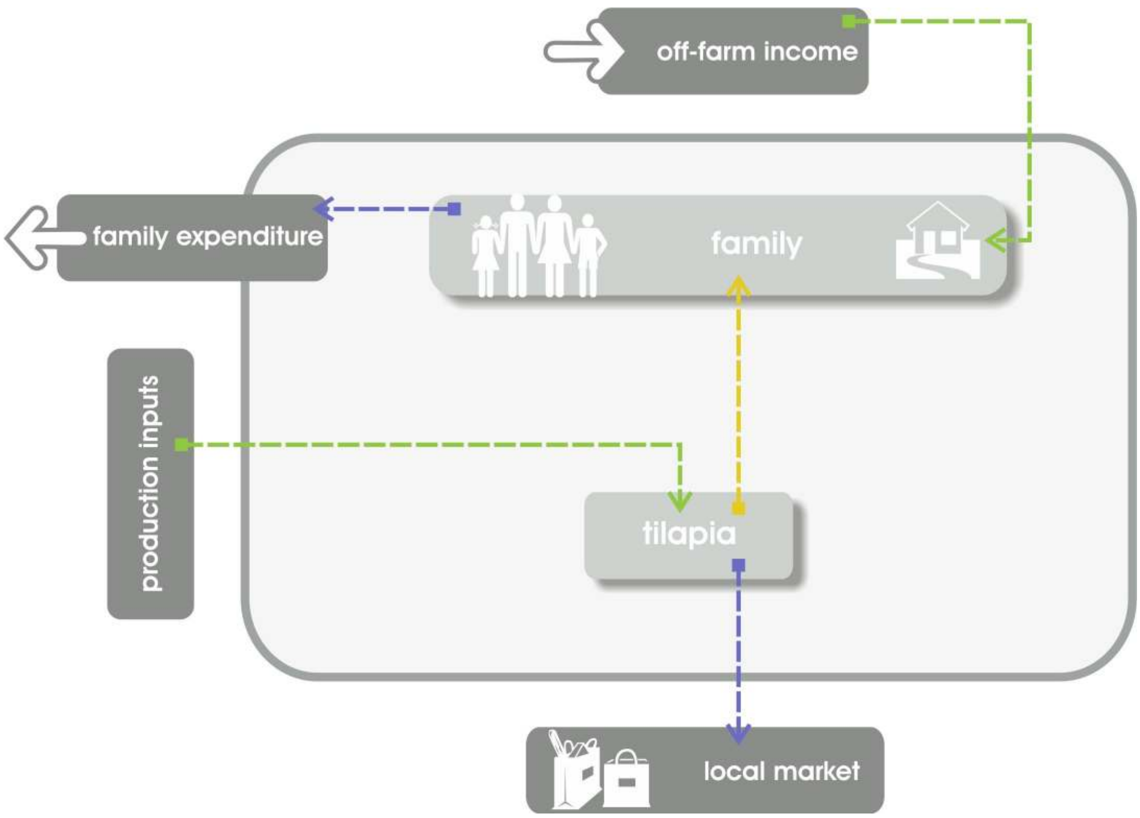


Figure 7.2. Schematic representation of the input and output flows for the agroecosystem No. 3.

Table 7.2. Summary of results for farmer No. 3.

Initial *TLI* (2001-2002)				Final *TLI* (2003-2004)				Technological Change
Hatchery	Grow-out	Post-harvest	Total	Hatchery	Grow-out	Post-harvest	Total	(Percentage)
0.0	47.5	40.0	27.0	0.0	60.0	55.0	35.0	29.63

He decided to look for advice at COLPOS, a nearby academic and research institution situated less than 15 km away. Ever since, he regularly attended weekly meetings of AVAC in the city of Veracruz and actively participated in the GCPS project. This allowed him to be in contact with many other farmers and reliable sources of information. Moreover, in order to restart operating, he managed to get support from the DOAs in terms of commercial feeds and fingerlings for a second production cycle. After that, he continued operating with his own resources. During the final assessment, the farm was producing approximately 1.33 tonnes annually. Production was destined mainly for the local market, but fish was also regular part of the household diet. Table 6.24 reveals a narrow overall increase in *TLI*, which represented a Technological Change of nearly 30% during the research period.

Fish consumption by the household increased in nearly 200% and although its income hasn't rise at the same proportion, still represents a better alternative to off-farm job. Observed low change in TLI might be due to lack of capital to invest.

7.1.3 Study case three (producer No. 13)

This small-scale producer of the *ejido* sector (i.e. communal regime of land tenure) had a land parcel of 5 ha, mainly used for maize production and sheep grazing. However, he used an adjacent federal and highly-eutrophic water body to produce tilapia in floating cages. The production unit was located within Group two in the municipality of Veracruz (HDI = 0.8369), the most important development pole in the State, where many sources of aid and information were available. The farm was located at approximately 15 km of the municipality head by asphalted road, and at less than 1 km of the nearest town, which contained basic services such as electricity, sanitation, telephone, health unit, elementary school and public transport.

The household included 6 members, the 66 year-old farmer being the head of the family. Although his sons participated in different agriculture activities in the same farm, he was the only one involved in tilapia production. He had 6 years of formal education (equivalent to elementary school) but 11 years involved in cage culture of tilapia. He was introduced to tilapia culture by the DOAs through the Cages and Enclosures project. During all those years, he had regular support (construction materials, fingerlings, feeds and advice) from the DOAs and from the Agriculture Department of the municipality of Veracruz.

During more than a decade and until the initial assessment of this research, he mainly relied on donations of commercial feeds and/or fingerlings from the government development agencies, namely the DOAs. Although his installed capacity (mainly in terms of infrastructure and production inputs) was projected to allow him to produce between 2 and 3 tonnes per year, at the time of the initial assessment his regular annual production was of less than 300 kg of market-size tilapia. Most production was commercialized locally and fish was an important part of the household diet. At that point he decided to start producing his own fingerlings.

Apart from fish farming, the farmer also dedicated around 1 ha to produce maize, which was also frequently subsidized through governmental aid programmes such as PROCAMPO. Corn was mainly used for self consumption. The by-products were mainly reused in the maize fields and as feeding supplement for his small herd of 6 beef cattle, which depended mostly on grazing and was also commercialized locally. Sporadic off-farm labour complemented the household income (Figure 7.3).

Even though the farmer had for many years been involved in cage farming with regular governmental support, the initial assessment revealed an extremely low use of elements of tilapia farming technology (Table 7.3).

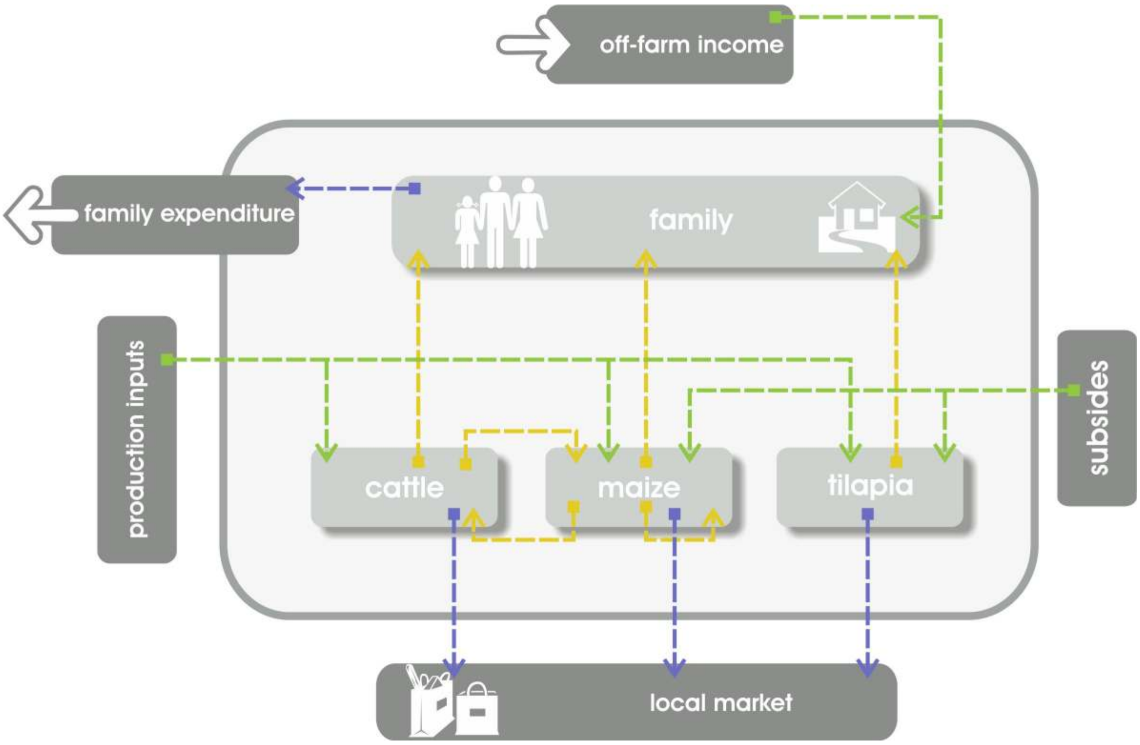


Figure 7.3. Schematic representation of the input and output flows for the agroecosystem No. 13.

Table 7.3. Summary of results for farmer No. 13.

Initial *TLI* (2001-2002)				Final *TLI* (2003-2004)				Technological Change
Hatchery	Grow-out	Post-harvest	Total	Hatchery	Grow-out	Post-harvest	Total	(Percentage)
0.0	37.5	20.0	19.0	25.0	47.5	50.0	39.0	105.26

During the research period, the farmer continued having sporadic support from the extension agent of the municipal Department of Agriculture. He also intermittently attended the AVAC meetings and had the opportunity to visit many commercial and small-scale farms in the area. At the time of the final assessment, he was already producing his own fingerlings and harvesting between 500 and 600 kg per year of market-size fish. His final *TLI* almost doubled, producing a Technological Change of 105.3%.

Due to the proximity to the city of Veracruz, land prices have rocketed high; it is expected that in the short term, the vocation of the site will change into ecotourism or a conservation reserve. It appears to be the case (quite common in the region) of a farmer that will remain active as long as the subsidies continue. Despite being one of the pioneer farmers in the area, the younger members of his family seem not to share his interest and are eager to migrate to urban areas.

7.1.4 Study case four (producer No. 59)

This small-scale 53 year-old *ejidatario* had a land parcel of 7.5 ha. His farm was situated in the municipality of Angel R. Cabada (HDI = 0.6929), within Group four. Although he was simultaneously involved in productive activities such as maize, sugar cane[1] and beef cattle, he started exploiting an adjacent federal water body for cage farming of tilapia. He was introduced to this by CODEPAP, which provided seed

[1] Within the regional context, sugar cane is one of the most important industrial crops. Out of the total 142 surveyed farmers, twenty-six (nearly 20% of the sample) were involved in its production. Although sugar cane's profitability is in general low, most small-scale farmers are involved in its production in order to have access to the national Social Security system (i.e. health services, pensions, credits, maternity and nursery care). In legal and practical terms, the farmer becomes an employee of the sugar refinery, which usually provides credit for inputs and purchases all production. The refinery also administers the social security fees.

capital for an initial production cycle, together with other sixty new entrants of the municipality. The aid basically consisted of cage (or enclosure) construction materials, fingerlings and commercial feeds. On average, each farmer received the equivalent of one 18 m^3 cage intended to individually produce 250 kg of market-size tilapia per year[2]. CODEPAP also provided initial and sporadic technical advice. At the time of the initial assessment, most of these new entrants were about to complete their first production cycle.

The production unit (and household residence) was situated at approximately 20 km of the municipality head, by non-paved road. On-farm services included electricity and sanitation. In the nearest town, at around 10 km by unpaved road, there was a health unit, elementary school, telephone and sporadic collective transport. The household was composed of 5 members. The farmer, who was the family head, had three years of formal education and was the only member involved in the tilapia subsystem. However, the entire family participated in the livestock and agriculture subsystems. Sporadic off-farm labour complemented the household income (Figure 7.4).

[2] Out of the 63 farmers that comprised Group four, 24 were landless and unemployed. For most of them, cage farming represented their main (and often only) source of livelihoods during the research period.

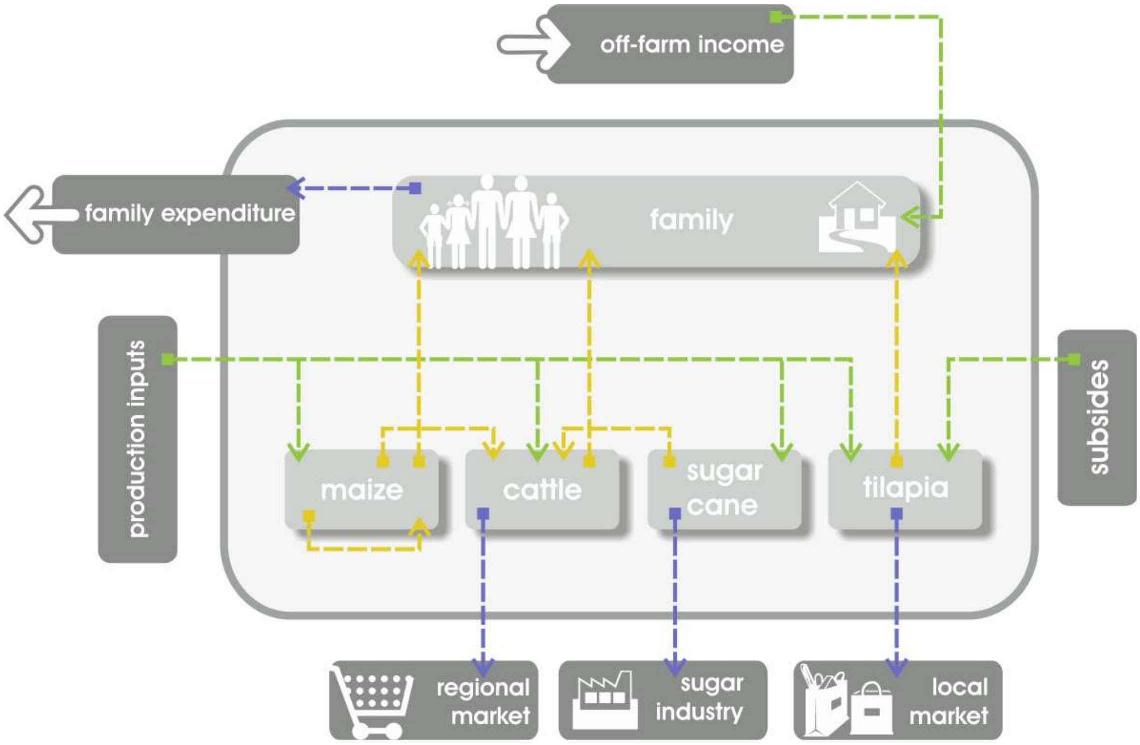


Figure 7.4. Schematic representation of the input and output flows for the agroecosystem No. 59.

As previously indicated, the farmer was simultaneously involved in agriculture. He used 2 ha of his land for sugar cane production (@ 70 tonnes ha^{-1} year^{-1}, which generated a net income of $US 150 ha^{-1} year^{-1}). Apart from the Social Security benefits, this crop represented more than 80% of the regular income of the household. The farmer also used 0.5 ha for maize production, for which he also depended on some external inputs (namely seed and fertilizers), and was mainly used for family consumption. Additionally, he utilized 4 ha for dairy cattle grazing. His herd of 8 cows provided milk for the family and for the regional market. During the dry season, supplementary feeds (farm derived or locally purchased agricultural by-products) were often required.

During the research period, the farmer had sporadic advice from CODEPAP and the municipal Department of Agriculture. He also participated in some meetings of the GCPS research project. Once the initial harvest of approximately 200 kg was successfully commercialized, the farmer decided to remain in business[3]. Together with a few others, he reinvested in commercial feeds and fingerlings (which after the first donation were regularly acquired in commercial farms).

During the research period, his total *TLI* varied from 19 to 34, producing a Technological Change of nearly 80% (Table 7.4). At the time of the final assessment, he was still producing without additional subsidies.

Table 7.4. Summary of results for farmer No. 59.

Initial *TLI* (2001-2002)				Final *TLI* (2003-2004)				Technological Change
Hatchery	Grow-out	Post-harvest	Total	Hatchery	Grow-out	Post-harvest	Total	(Percentage)
0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95

7.1.5 Study case five (producer No. 137)

The production unit of this 50 year-old *ejidatario* was located in the municipality of Catemaco (HDI = 0.7005), within the national protected area of “Los Tuxtlas”. He was introduced into pond-based tilapia culture by the Federal DOA, which provided initial advice and fingerlings, together with 12 other farmers. However, most of his technical support was provided by the NGO’s extension agent. The 38 ha production unit was located in a remote tropical rainforest area, 25 km from the municipality head by non-paved road, and at 10 km from the nearest town by rural footpath. This nearest town, which was also the household residence, had access to services such as electricity, sanitation, health unit, elementary school, telephone, and sporadic collective transport. The farmer had 6 years of formal education and at the time of the initial assessment he had only one year of experience in tilapia farming. All members of the household were

[3] At the moment of the final assessment, practically all new entrants of this group were still in business. However, most of them still depended on subsidies (i.e. feeds and fingerlings). In general terms they improved some technical practices, although their overall adoption rates were slow (as indicated in Section 6.3.3.4).

involved in the different farm activities and sporadic off-farm labour complemented the household income (Figure 7.5).

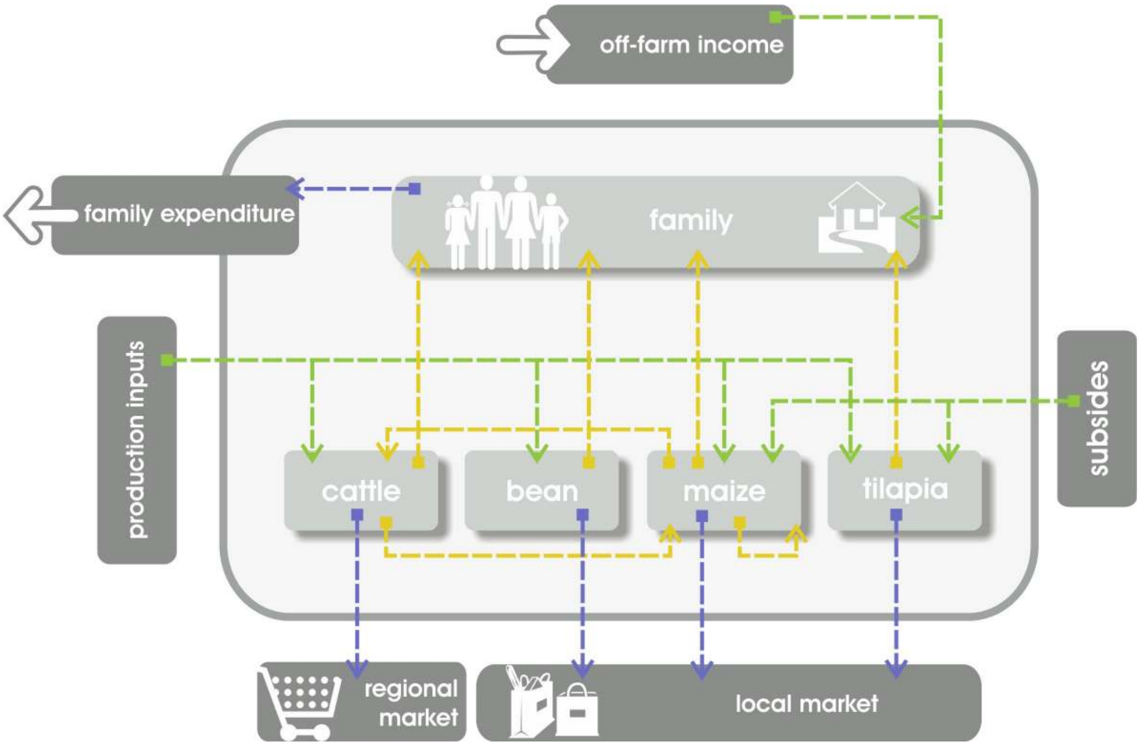


Figure 7.5. Schematic representation of the input and output flows for the agroecosystem No. 137.

The farmer and his family were simultaneously involved in other agricultural activities. For instance, he used 33 ha for extensive dairy and beef cattle grazing. His 40 animal herd provided the main income to the household. Milk, cheese and calves were mainly commercialized in the regional market, but were also consumed at regular basis. Additionally, he used 3 ha for maize production (often subsidized by PROCAMPO) and mainly destined for family consumption and for the local market. He also used 0.75 ha for bean production, which was also consumed by the household or commercialized locally. Most by-products were generally recycled.

He used river water to fill his 200 m^2 earth pond. Agricultural by-products were the main food sources, although commercial feeds as supplement were sporadically used. At the end of his first cycle he harvested approximately 150 kg of tilapia, which were essentially commercialized locally. At that point, his use of elements of tilapia farming technology was extremely low (Table 7.5).

Table 7.5. Summary of results for farmer No. 137.

Initial *TLI* (2001-2002)				Final *TLI* (2003-2004)				Technological Change
Hatchery	Grow-out	Post-harvest	Total	Hatchery	Grow-out	Post-harvest	Total	(Percentage)
0.0	40.0	0.0	16.0	40.0	45.0	30.0	40.0	150.00

During the research period, he had constant advice from the NGO's extension agent, who was his main source of technical information. Together with the other 12 farmers of the area, he was actively involved in the GCPS project and also had the opportunity to interact with the workers and managers of the two nearby governmental hatcheries (which regularly provided fingerlings and advice).

At the time of final assessment, he was producing his own monosex fingerlings and harvesting approximately 350 kg of market-size tilapia per year, which, apart from providing additional income, represented a regular source of fish in the household diet. Over the research period, his *TLI* varied from 16 to 40, a Technological Change of 150%.

7.1.6 Study case six (producer No. 82)

This 30 year-old *ejidatario* was an indigenous Nahuatl from the remote municipality of Mecayapan (HDI = 0.6027). He had 15 ha of land, partially covered by tropical rainforest, and was part of Group six. His production unit (and household residence) was situated 25 km from the municipality head by non-paved road. The farm had access to electricity and sanitation. In the nearest town, at 10 km by unpaved road, elementary school and public telephone were available, as well as sporadic collective transport.

The farmer was illiterate and never had the opportunity to receive any formal education. Although Nahuatl was his mother tongue, he was fluent in Spanish. His household included five members, all involved in agriculture (1 ha of maize and 0.25 ha of bean), which were entirely destined for family consumption. The rental of 10 ha of his land to neighbour farmers for cattle grazing represented his main earnings. However, sporadic off-farm labour complemented the household income (Figure 7.6).

A few months before the initial assessment, he was introduced to tilapia farming by "Proyecto Sierra de Santa Marta", an NGO deeply involved in the area. Following the initial advice of the bilingual extension agent, he decided to build a small earth pond of approximately 25 m^2, where he stocked 350 fingerlings provided also by the NGO. He used spring water to fill his pond and agricultural by-products as feeds and fertilizers. During that first production cycle he suffered mortalities and predation, and as a result he only harvested 5 kg, which were consumed by the family.

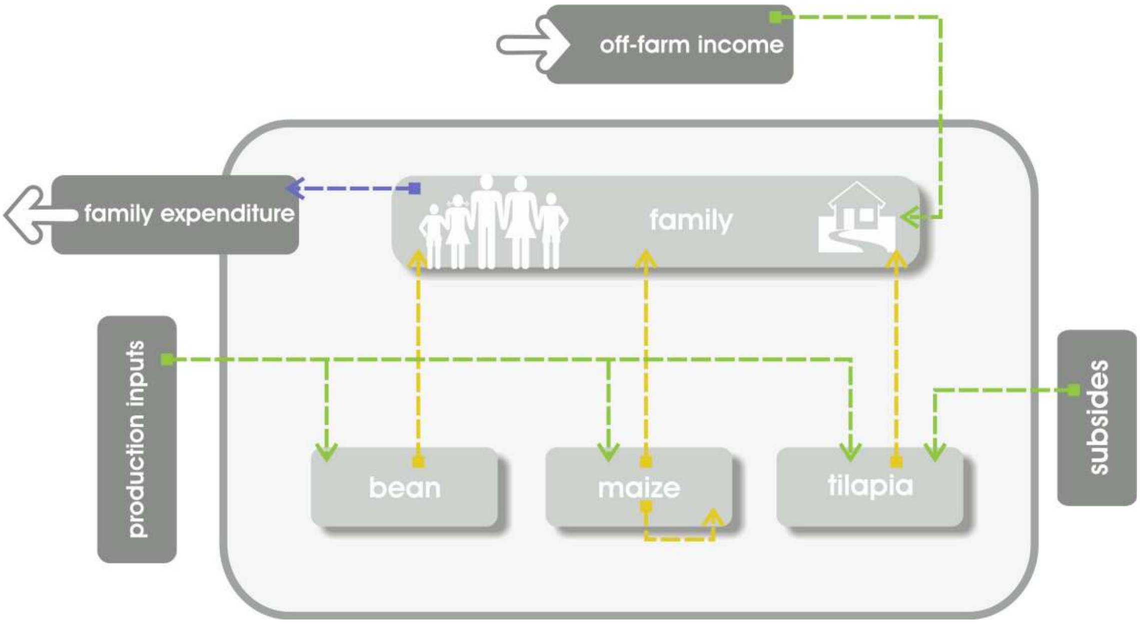


Figure 7.6. Schematic representation of the input and output flows for the agroecosystem No. 82.

At that point, his use of elements of tilapia farming technology was extremely low (Table 7.6). However, the constant motivation of the extension agent, together with his own perseverance and enthusiasm, made him try once more. So, he was invited to participate in the GCPS project, which in turn allowed him to visit many farms and interact with more experienced producers.

Table 7.6. Summary of results for farmer No. 82.

Initial *TLI* (2001-2002)				Final *TLI* (2003-2004)				Technological Change
Hatchery	Grow-out	Post-harvest	Total	Hatchery	Grow-out	Post-harvest	Total	(Percentage)
0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33

During the research period, the NGO continued supporting him with constant advice and fingerlings. At the time of the final assessment, he was producing his own fingerlings and harvesting between 100 and 150 kg per year, which were partially consumed by his family and partially commercialized locally. Within his social context, he was seen as an entrepreneur, and some of his neighbours started to imitate him. His *TLI* rose from 12 to 34, which represented a Technology Change of more than 180%.

7.2 Closing remarks

In general, it seems clear that the livelihoods of the surveyed farmers reflect the seasonality in opportunities and constraints available in the State. For all of them, tilapia not only represented an alternative source of income, but also a real and important way to improve their diet through self-consumption. Evidence on social mobility arising from tilapia farming suggests that farmer's livelihoods might be improving, after all.

As official and non-official statistics reveal, tilapia culture in the area (both small-scale and commercial) is growing. New entrants have now better conditions to start and developing agencies are learning from past experiences. NGOs and organised farmers continue pushing the industry towards more sustainable and productive scenarios.

The study cases have also revealed a generalised and gradual rise in TLI amongst farmers. However, a specific TLI was not always necessary to achieve a good level of effectiveness, evident among farmers with a very low TLI that enter into the activity, remained producing and gradually prospered. Nevertheless, it also seems clear that an increase in TLI closely relates to a rise in productivity. The rate of change, being a multifactor and complex process, is not always easy to control. How to accelerate this change will remain a challenge for development agencies in the years to come.

ETL (empirically defined at the end of the previous chapter as the Expected Technological Level achieved by an individual farmer in any particular geographic area) appeared to be a good indicator of effectiveness of activity in the sector, and hence of development potential. Moreover, the likelihood of an individual farmer to adopt new elements of tilapia farming technology (previously defined as ATL) offered good perspectives as a planning tool in future interventions.

Although much remains unknown about the effectiveness of specific types of intervention, it seems that targeting strategies have played a fundamental role in the observed outcomes. The analysis of more than four decades of aquaculture technology transfer interventions in the area has revealed a manifold of outcomes from an equally diverse spectrum of dissemination paradigms. For instance, a top-down approach like the one used by the Papaloapan Commission produced a massive impact, while a participative approach like the MIRNZB initiative generated only very modest results. A primary logical conclusion could be that a well conceived and implemented top-down intervention is better than a badly executed participative one.

It is quite clear that every approach has its own value and, according to the particular circumstances, the appropriate modifications and tunings should be conducted. In fact, the detailed scrutiny of the 142 farmers confirmed that the local availability of human capital produced greater impact in the adoption of cultural practices than the approaches used for the dissemination of this technical knowledge. In this process, the municipal UN’s Human Development Indices proved to be useful assessment indicators.

The additional underlying critical factors to facilitate technological change found in this research have also been detected by other authors. These include farmers’ educational background (Herr, 1966; Gao, 1994), farmer’s age (Ayuk, 1997), links between technology users and independent suppliers (Dupuy, 1997), management ability (Klinefelter, 1988), rural–urban disparity (FAO, 2005), psychological constraints (Waggoner, 2004), prices (Hazell and Wood, 2000), and so forth. However, beyond the "good" intentions or approaches followed by whatever development body, the relative economic performance of the activity is expected to remain the primary determinant of uptake and expansion, influenced by regulatory policies and consumer preferences (Muir, 2005).

SECTION THREE: FINAL REMARKS AND CONCLUSIONS

CHAPTER EIGHT: FINAL CONSIDERATIONS

8.1 Overview and lessons learned

Despite the number of failures and the range of obstacles that diminish its productive expansion, tilapia culture in Veracruz has been an element of many development interventions during the past forty years. After a mix of planned and fortuitous events, tilapia farming is nowadays an industry struggling to compete with other primary sector activities in a rather complex environment, still remaining uncertain its long-term financial viability. Because tilapia farming is a new economic activity, most rural farmers have started their operation with a limited knowledge of the required technology and its associated risks. In contrast with other agricultural practices, the collective memory of its exercise is barely minimum. Nonetheless, evidence appears to confirm a gradual adoption and use of different elements of tilapia farming technology.

Regional experiences aimed to promote tilapia culture are the result of a number of technology transfer paradigms generated in the agriculture sector under completely different circumstances and contexts. This situation, along with a national institutional instability and frequent improvised extension approaches based on trial-and-error, has limited the long-term impact of the majority of interventions. In fact, tilapia culture in Veracruz appears to replicate ineffective experiences reported elsewhere: adoption following promotion by outsiders, inappropriate targeting strategies and elevated abandonment rates.

Apparently, the different stakeholders have divergent expectations regarding the industry, its direction and future. Partially at least, this has limited the possibilities to reach agreements and consensus, essential in the development of organized joint initiatives. Moreover, the over-regulated legal framework of aquaculture seems to be restraining its expansion.

The study has also confirmed the presence of remarkable disparities in terms of capital assets amongst farmers, which has generated a wide spectrum of production strategies, intensities and productivity. It would appear that most entrants have been the result of social development interventions with significant level of subsidy, which often resulted in low levels of productivity and high abandonment rates. However, for the most vulnerable groups, tilapia culture has apparently provided a way to diversify their livelihood portfolio.

On the other hand, the availability of sources of technical knowledge and expertise appears to have enhanced and stimulated the dissemination and adoption of tilapia farming technology, and hence human capital. In this context, the use of participatory and people-centred approaches has started to spread. While most technology transfer interventions based on top-down approaches and oriented to small-scale farmers have produced limited impacts, community-based experiences promoted and conducted mainly by regional NGOs have induced modest yet promising results. Farmer-to-farmer extension showed to be an effective mechanism in disseminating technical know-how that needs to be further exploited.

Parallel to the social role of tilapia encouraged by development bodies, the private sector appears to be having and increasing and decisive role in the expansion of the industry. Apart from being responsible of introducing technological innovations and knowledge into the region, this faction has started to lead the processes of social capital building. The resulting structures appear to be gradually filling a number of institutional vacuums. Although its long-term impact still remains unclear, it has provided a much more positive outlook for the sector.

The manner in which technical knowledge flows amongst farmers appears to be rather complex, and depends upon a number of exogenous and endogenous factors simultaneously interacting. As earlier noted, most technical knowledge regarding tilapia culture has been recently introduced. Much of that knowledge was born, nourished and co-evolved with social groups under a completely different umbrella of cultural and environmental circumstances. Like the poet once said, it is not but a same plant growing in different soil. Accordingly, differences in performance are likely to occur. In contrast with crop farming which has more than 5 000 years co-evolving in the region, tilapia farming has only 40. Nevertheless, findings show that when adequately targeted and delivered, most technologic elements can be easily adopted.

The simultaneous use of qualitative and quantitative tools proved to be useful in the assessment of impacts. Particularly, the development and use of technology change indices proved useful in measuring adoption rates and offered an alternative method of assessment. Besides, the SLA framework offered a different approach to the problems and opportunities of the poor compared to what has tended to be the practice in the past, especially on the part of local level government agencies.

A number of study cases on the application of the livelihoods approach in different projects/programmes in Africa and Asia have generated lessons about how rural livelihoods affect and are affected by natural resource management. In general terms, the SLA added value to the project design processes.

Like in many other geographic and socioeconomic contexts (Warner, 2000; Foster and Fozzard, 2000; Foster, 2000; Shah and Gupta, 2000; Nicol, 2000; Hobley and Shields, 2000; Ashley and Hussein, 2000; Baumann, 2000a; Turton, 2000a; Ashley, 2000a; Baumann, 2000b; Turton, 2000b; Ashley, 2000b; Turton, 2000c; Brown et al. 2001), the use of the SLA encouraged a more holistic understanding of the needs and priorities of the poor and also drew attention to the importance of policy and institutional structures. The evidence provided the basis for identifying useful strategies to enhance impacts, but further work was considered to be required to identify the most effective ways of implementing recommendations, the circumstances under which each is most appropriate, and contingent requirements at national and international levels.

A number of studies have highlighted the dynamic and complex nature of rural livelihoods, rural/urban and poverty/environment linkages and the importance of rural non-farm economic activities (DFID, 2002a). In fact, spending large sums of public money disseminating agricultural technologies designed to increase production may actually increase inequalities in rural areas and be of little use to poorer households who do not own or have access to the necessary resources (i.e. land) to make use of these public investments and interventions (Rigg, 2005).

It is evident, however, that many questions remain unanswered about the practical complexities and contradictions of the sustainable livelihoods approach. Ultimately, the continuing evolution of the approach will need to take into account ideas about what development means and what its purpose is (Toner, 2002).

8.2 Further work

The scrutiny of the sector, its actors and its dynamics opened the Pandora's Box. Specific action lines that deserve further scrutiny include:

- **Gender issues**. Although women have been increasingly seen as an important target group, promoting and implementing organizations are male dominated to a great extent. Moreover, the number of specialist women working in extension programmes, particularly in aquaculture-related topics, it minor. As such, the inclusion of gender issues in research and development agendas would appear to be key element if the benefits of the activity are expected to be widespread.
- **Diffusion of international knowledge**. Topics such as people-centred approaches (i.e. SLA) are still practically unknown by most stakeholders in the region, while others, like animal welfare, remain taboo. Actually, most regional stakeholders appeared to be totally unaware and careless about the latter, which partially reflects an ignorant society in the matter of animal care. Moreover, many published lessons are unavailable to local people due to language and costs barriers. Donor organizations might promote their dissemination and maximize their impact by placing them at reach of people through language translations and/or R&D interventions.
- **Exploitation of mass media**. The use and evaluation of mass media in the entire technology transfer processes is a promising line of action, practically unexplored.

- **Networks**. From local groups to international structures, the building of social capital and its role on the expansion of the sector is one of the most promising development detonators. Existing structures –yet unexploited– such as the Municipal Development Councils are likely to play a decisive role in the future of the extension services.
- **Tool validation**. Tools such as *TLI* and Technological Change need to be validated as objective indicators in assessing the status of the technology used by other individual farmers and the adoption patterns of new technological practices.

8.3 Conclusions

The work provided a better understanding of the different processes involved in dissemination and adoption of tilapia farming technology in Veracruz. It was clear that:

- The tilapia sector is diverse and immersed in a rather complex arena, where policy and finance issues, and the role of demand, linked in with market chains and their functioning are major determinants of further expansion.
- Farm producers are sharply differentiated by production size, degree of commercialisation, experience in production, and access to assets.
- Most entrants were the result of social development interventions with significant level of subsidy, which often resulted in low levels of productivity and high abandonment rates.
- For the most vulnerable groups, tilapia culture has apparently provided a way to diversify their livelihood portfolio.

- Availability of local knowledge and expertise appears to have enhanced and stimulated the dissemination and adoption of tilapia farming technology, and hence human capital.
- Private sector and collective action are likely to play an increasing and decisive role in the direction of the industry.
- TLI proved to be useful in the quantification and evaluation of technological change.
- Lessons learned may be taken into account during the process of planning and conducting similar interventions in other areas of the country and Latin America.

REFERENCES

Aarset, B., 1999. Aquacultural development, institution building and research and development policy: Norwegian salmon and Arctic char farming as cases. *Aquaculture Economics and Management,* 3: 177-191.

Abella, T.A., 2006. The role of public sector in genetics research and its partnership with private sector in Philippines. pp. 10-15 In: B.O. Acosta, R.C. Sevilleja and M.V. Gupta (eds.) Public and private partnerships in aquaculture: a case study on tilapia research and development. WorldFish Center Conf. Proc. 72, 72 pp.

Acosta, B.O., Sevilleja, R.C. and Gupta, M.V., 2006a. Public and private partnerships in aquaculture: a case study on tilapia research and development. WorldFish Center Conf. Proc. 72, 72 pp.

Acosta, B.O., Sevilleja, R.C., Gupta, M.V., Rodriguez, B.M., Abella, T. and Tayamen, M., 2006b. Public and private partnerships in tilapia research and development: an overview of Philippine experience. pp. 1-9 In: B.O. Acosta, R.C. Sevilleja and M.V. Gupta (eds.) Public and private partnerships in aquaculture: a case study on tilapia research and development. WorldFish Center Conf. Proc. 72, 72 pp.

Adato, M. and Meinzen-Dick, R., 2002. Assessing the impact of agricultural research on poverty using the sustainable livelihoods framework. FCND discussion paper 128; EPTD discussion paper 89. International Food Policy Research Institute, Wasington, D.C. 57 pp.

ADB, 2004. Special evaluation study on small-scale freswater rural aquaculture development for poverty reduction. Operations Evaluation Department, Asian Development Bank. 67 pp.

ADB, 2005. An evaluation of small-scale freshwater rural aquaculture development for poverty reduction. Operations Evaluation Department. Asian Development Bank. 178 pp.

Aguilar S., A.M., 2005. Aprovechamiento sustentable de los acahuales con el cultivo de palma camedor en Pajapan, Veracruz. Proceso y evolución. Memorias 1er. Congreso Internacional de Casos Exitosos de Desarrollo Sostenible del Trópico. Universidad Veracruzana - Centro de Investigaciones Tropicales. Boca del Río, Veracruz, México. 10 pp.

Ahmed, M. and Lorica, M.H., 2002. Improving developing country food security through aquaculture development--lessons from Asia. *Food Policy,* 27: 125-141.

Alam, M.F. and Thomson, K.J., 2001. Current constraints and future possibilities for Bangladesh fisheries. *Food Policy,* 26: 297-313.

Alemán S., T., 1998. Investigación participativa para el desarrollo rural. La experiencia de Ecosur en los Altos de Chiapas. *Serie Estudios de Caso sobre Participación Campesina en Generación, Validación y Transferencia de Tecnología,* Red de Gestión de Recursos Naturales y Fundación Rockefeller. México.

Alex, G., Byerlee, D., Helene-Collion, M. and Rivera, W., 2004. Extension and rural development. Converging views on institutional approaches? Agriculture and Rural

Development Discussion Paper 4. The International Bank for Reconstruction and Development / The World Bank. Washington, DC. 23 pp.

Allison, E.H. and Ellis, F., 2001. The livelihoods approach and management of small-scale fisheries. *Marine Policy,* 25: 377-388.

Alonge, A.J., 2002. Traditional institutions, social capital, and multi-institutional partnerships for agricultural development: implications for a new extension paradigm. pp. 1-8 In: Proceedings of the 18th Annual Conference of the Association for International Agricultural and Extension Education. May 26-30, 2002, Durban, South Africa.

Alonso, E.S., 1995. El campesinado de Tres Zapotes: diagnóstico de sus principales características socioeconómicas. Colegio de Postgraduados, Campus Veracruz, México. Mimeog. 45 pp.

Altieri, M. and Nicholls, C.I., 2000. *Agroecología. Teoría y práctica para una agricultura sustentable*. Serie Textos Básicos para la Formación Ambiental 4. Programa de las Naciones Unidas para el Medio Ambiente y Red de Formación Ambiental para América Latina y el Caribe. México. 250 pp.

Aluja, A. and Blanch, A., 2004. Replicability of first-order 16PF-5 factors: an analysis of three parcelling methods. *Personality and Individual Differences,* 37: 667-677.

Alvarez-Arrojo, N., 2006. Intensive tilapia production in circular concrete ponds with the utilization of pure oxygen. *Panorama Acuícola Magazine,* 6: 10-13.

Alvarez-Avila, M.C., Olguín Palacios, C., Asiain Hoyos, A., Alcántar González, G. and Castillo Morales, A., 2001. Biotecnificación de solares familiares de las zonas bajas tropicales. *Terra,* 19: 37-46.

Alvial, A. and Manríquez, J., 1999. Diversification of flatfish culture in Chile. *Aquaculture,* 176: 65-73.

Amador del Ángel, L.E., Córdoba R., C.M., Gómez V., J., Villarreal L., C., Valdez M., S. and Cabrera R., P., 2006. Diagnóstico de las unidades femeniles de producción rural (UFPR) de Mojarra Tilapia (*Oreochromis* spp) en la Península de Atasta, Campeche (México). Pages 907-915 In: Memorias del IV Congreso Iberoamericano Virtual de Acuicultura CIVA 2006 (http://www.civa2002.org).

Amilhat, E., Morales, E., Immink, A., Little, D., Lorenzen, K., Ul Islam, F. and Karapanagiotidis, I., 2005. Self-Recruiting Species (SRS) from farmer managed aquatic systems: their role in rural livelihoods. DFID summary report. 12 pp.

Amudavi, D.M., Kroma, M.M. and Davis, K., 2006. Understanding effects of institutional partnerships on rural groups in improving livelihoods in Kenya. pp. 24-35 In: Proceedings of the 22nd Annual Conference of the Association for International Agricultural and Extension Education. May 14-19, 2006, Clearwater Beach, Florida, USA.

Anderson, J.L., 2002. Aquaculture and the future: why fisheries economists should care. *Marine Resource Economics,* 17: 133-151.

Anderson, J.R. and Feder, G., 2003. *Rural extension services*. World Bank Policy Research Working Paper 2976, 33 pp.

Anderson, J.R. and Feder, G., 2004. Agricultural extension: good intentions and hard realities.

The World Bank Research Observer, 19: 41-60.

Anonymous, 2006. Conference report: The Seventh International Symposium on Tilapia in Aquaculture. Boca del Río, Veracruz, México. 3-5 September 2006. *Panorama Acuícola Magazine,* 6: 42-46.

Arizpe, L., 1981. The rural exodus in Mexico and Mexican migration to the United States. *International Migration Review,* 15: 626-649.

Aroca, P. and Maloney, W.F., 2005. Migration, trade, and foreign direct investment in Mexico. *The World Bank Economic Review,* 19: 449-472.

Asad, M. and Garduńo, H., 2005. Water resources management in Mexico: the role of the Water Rights Adjustement Program (WRAP) in water sustainability and rural development. Sustainable Development Working Paper No. 24. The World Bank, Washington, D.C. 60 pp.

Asche, F., Guttormsen, A.G. and Tveterĺs, R., 1999. Environmental problems, productivity and innovations in Norwegian salmon aquaculture. *Aquaculture Economics and Management,* 3: 19-29.

Asche, F. and Khatun, F., 2006. Aquaculture: issues and opportunities for a sustainable production and trade. Issue Paper No. 5. ICTSD Natural Resources, International Trade and Sustainable Development Series. International Centre for Trade and Sustainable Development (ICTSD). Geneva, Switzerland. 52 pp.

Ashley, C., 2000a. Applying livelihood approaches to natural resource management initiatives: experiences in Namibia and Kenya. *Sustainable Livelihoods.,* Working Paper 134. London: ODI

Ashley, C., 2000b. The impacts of tourism on rural livelihoods: Namibia's experience. *Sustainable Livelihoods.,* Working Paper 128. London: ODI

Ashley, C. and Hussein, K., 2000. Developing methodologies for livelihood impact assessment: experience of the African Wildlife Foundation in East Africa. *Sustainable Livelihoods.,* Working Paper 129. London: ODI

Asiain, A. and Olguín, C., 1995. Evaluation of water spinach (*Ipomoea aquatica*) as feed for apple snail (*Pomacea patula*). pp. 51-52 In: Book of Abstracts. World Aquaculture ´95 Conference. 1-4 February 1995, San Diego, California, USA.

Athreye, S. and Kapur, S., 2001. Private foreign investment in India: pain or panacea? *The World Economy,* 24: 399-424.

AVAC, 2007. Internal statistics. Unpublished. Acuacultores Veracruzanos, AC. Veracruz, México. [online] URL: http://www.avac-enlinea.com.

Aveldańo, R., Tapia N., A. and Espinosa C., A., 1999. Generación y transferencia de tecnología en el INIFAP, para el desarrollo de la agricultura mexicana. *Terra,* 17: 265-270.

Axinn, G.H., 1988. *Guide on alternative extension approaches* . FAO, Rome. 149 pp.

Ayuk, E.T., 1997. Adoption of agroforestry technology: the case of live hedges in the central plateau of Burkina Faso. *Agricultural Systems,* 54: 189-206.

Ayyappan, S., Bueno, P. and Haylor, G., 2003. Farmer Associations. Experiences in poverty alleviation from Eastern India. A presentation to the Sub-committee on Aquaculture of the Committee on Fisheries of the Food and Agriculture Organisation of the UN, August 2003, Trondhiem, Norway. 3 pp.

Backer, T.E., 2000. The failure of success: challenges of disseminating effective substance abuse prevention programs. *Journal of Community Psychology,* 28: 363-373.

Banco de México, 2004 . The outlook for Latin America. México. 22 pp.

Banco de México, 2005a. Annual Report 2004. México. 193 pp.

Banco de México, 2005b. Evolución y perspectivas de la economía mexicana. México. 29 pp.

Banco de México, 2006 . Informe anual 2005. México. 175 pp.

Bar-Shira, Z. and Finkelshtain, I., 1999. Simple nonparametric tests of technological change: theory and application to U.S. agriculture. *American Journal of Agricultural Economics,* 81: 850-864.

Barabas, A.M. and Bartolomé, M.A., 1992. Antropología y relocalizaciones. *Alteridades,* 2: 5-15.

Barbier, E.B., 2000. Links between economic liberalization and rural resource degradation in the developing regions. *Agricultural Economics,* 23: 299-310.

Barrett, C. and Swallow, B.M., 2003. Chapter 2: Dynamic poverty traps and rural livelihoods. Working Paper 2003-44. Department of Applied Economics and Management. Cornell University, Ithaca, New York. 21 pp.

Barriga-Sosa, I.D.L.A., Jiménez-Badillo, M.D.L., Ibáñez, A.L. and Arredondo-Figueroa, J.L., 2004. Variability of tilapias (*Oreochromis* spp.) introduced in Mexico: morphometric, meristic and genetic characters. *Journal of Applied Ichthyology,* 20: 7-14.

Bartolomé, M.A., 1992. Presas y relocalizaciones de indígenas en América Latina. *Alteridades,* 2: 17-28.

Baumann, P., 2000a. Equity and efficiency in contract farming schemes: the experience of agricultural tree crops. Working Paper 139. London: ODI

Baumann, P., 2000b. Sustainable livelihoods and political capital: arguments and evidence from decentralisation and natural resource management in India. Working Paper 136. London: ODI

Baumann, P., 2002. Improving access to natural resources for the rural poor. A critical analysis of central concepts and emerging trends from a sustainable livelihoods perspective. LSP Working Paper 1. Livelihood Support Programme, FAO, Rome. 50 pp.

Beals, E.W., 1965. Ordination of some corticolours cryptogamic communities of south-central Wisconsin. *Oikos,* 16: 1-8.

Beltrán, C.S., 2006. Implications of Mexico's rural development strategy for aquaculture and wild fisheries. Organisation for Economic Co-operation and Development (OECD). 13 pp.

Bingen, J., Serrano, A. and Howard, J., 2003. Linking farmers to markets: different approaches to human capital development. *Food Policy,* 28: 405-419.

Blanco R., J.L., 1998. El proyecto Sierra de Santa Marta. *Serie Estudios de Caso sobre Participación Campesina en Generación, Validación y Transferencia de Tecnología,* Red de Gestión de Recursos Naturales y Fundación Rockefeller. México.

Blench, R., 1999. Seasonal climatic forecasting: who can use it and how should it be disseminated? *Natural Resource Perspectives.,* Paper No. 47. London: ODI

Boahene, K., Snijders, T.A.B. and Folmer, H., 1999. An integrated socioeconomic analysis of innovation adoption: the case of hybrid cocoa in Ghana. *Journal of Policy Modelling,* 21: 167-184.

Booz, R.J. and Lewis, L.K., 1997. Facilitating technology transfer among organizations: an applied communication strategy concept for organizational boundary spanners. *Journal of Technology Transfer,* 22: 35-46.

Bourgeon, J.-M. and Chambers, R.G., 2000. Stop-and-go agricultural policies. *American Journal of Agricultural Economics,* 82: 1-13.

Bourner, T., 1998. More knowledge, new knowledge: the impact on education and training. *Education + Training,* 40: 11-14.

Boz, I., 2002. Does early adoption affect farmers' use of the extension service? *Journal of International Agricultural and Extension Education,* 9: 77-82.

Bozionelos, N., 2004. The big five of personality and work involvement. *Journal of Managerial Psychology,* 19: 69-81.

Bradley, J.H. and Hebert, F.J., 1997. The effect of personality type on team performance. *Journal of Management Development,* 16: 337-353.

Bray, J.R. and Curtis, J.T., 1957. An ordination of the upland forest communities of southern Wisconsin. *Ecological Monographs,* 27: 325-349.

Bretschger, L., 2005. Economics of technological change and the natural environment: how effective are innovations as a remedy for resource scarcity? *Ecological Economics,* 54: 148-163.

Bromley, D.A., 2002. Science, technology, and politics. *Technology in Society,* 24: 9-26.

Brown, A., Foster, M., Norton, A. and Naschold, F., 2001. The status of sector wide approaches. Working Paper 142. London: ODI

Brummett, R.E. and Williams, M.J., 2000. The evolution of aquaculture in African rural and economic development. *Ecological Economics,* 33: 193-203.

Buckles, D. and Erenstein, O., 1996. Intensifying maize-based cropping systems in the Sierra de Santa Marta, Veracruz. NRG Paper 96-07. International Maize and Wheat Improvement Center (CIMMYT), México. 56 pp.

Bueno, G.M., 1986. Alternative forms, fashions and politics for technology transfer: a Mexican perspective. *Mexican Studies / Estudios Mexicanos,* 2: 235-252.

Bush, R. and Sabri, A., 2000. Mining for fish: privatization of the "commons" along Egypt's northern coastline. *Middle East Report,*

Bustamante, J.A., 1997. Mexico-United States labor migration flows. *International Migration*

Review, 31: 1112-1121.

Byrd, T., Cohn, L.D., Gonzalez, E., Parada, M. and Cortes, M., 1999. Seatbelt use and belif in destiny among Hispanic and non-Hispanic drivers. *Accident Analysis and Prevention,* 31: 63-65.

Cabrera, A., Incháustegui, C., García, A. and Toledo, V., 2001. Etnoecología mazateca: una aproximación al complejo *cosmos-corpus-praxis*. *Etnoecológica,* 6: 61-83.

Campos-Arriaga, L., 2003 . Renewable energy technology transfer in Mexico: actors, barriers and perspectives. M.Sc. Thesis. Institute of Building Technology. University of Nottingham, UK. 82 pp.

Cardoso, I.M., Guijt, I., Franco, F.S., Carvalho, A.F. and Ferreira Neto, P.S., 2001. Continual learning for agroforestry system design: university, NGO and farmer partnership in Minas Gerais, Brazil. *Agricultural Systems,* 69: 235-257.

Carney, D., 1999. Approaches to sustainable livelihoods for the rural poor. *Poverty Briefing,* Paper No. 2. London: ODI

Carney, D., Drinkwater, M., Rusinow, T., Neefjes, K., Wanmali, S. and Singh, N., 1999. Livelihood approaches compared. A brief comparison of the livelihoods approaches of the UK Department for International Development (DFID), CARE, Oxfam and the United Nations Development Programme (UNDP). Sustainable Livelihoods Learning Platform, DFID. 19 pp.

Carter, M.R., 2001. Researching the agroecosystem/environmental interfase. *Agriculture, Ecosystems and Environment,* 83: 3-9.

Castelán, E., 2002. Role of large dams in the socio-economic development of Mexico. *International Journal of Water Resources Development,* 18: 163-177.

Cattell, R.B., Cattell, A.K. and Cattell, H.E.P., 1993. *Sixteen Personality Factor Questionnaire* (fifth ed.). Institute for Personality and Ability Testing. Champaign, IL.

CEPAL, 1994. Políticas públicas para el desarrollo sustentable: la gestión integrada de cuencas. Comisión Económica para América Latina y el Caribe, División de Recursos Naturales y Energía. Documento presentado en el Segundo Congreso Latinoamericano de Cuencas Hidrográficas, Mérida, Venezuela, 6-10 noviembre 1994. 238 pp.

CETRA, 2006. Center for Aquaculture Technology Transfer. Tabasco, México. [online] URL: http://www.cetra.org.mx.

Chambers, R. and Conway, G.R., 1991. Sustainable rural livelihoods: practical concepts for the 21st century. IDS Discussion Paper 296. Institute of Development Studies. Brighton, UK. 33 pp.

Chan, G.L., 1985. Integrated farming system. *Landscape and Planning,* 12: 257-266.

Chan, R. and Joseph, S., 2000. Dimensions of personality, domains of aspiration, and subjective well-being. *Personality and Individual Differences,* 28: 347-354.

Chong Carrillo, O. and Vega Villasante, F., 2002. La terminología como solución comunicativa en la acuicultura. Pages 969-973 In: Memorias del I Congreso Iberoamericano Virtual de Acuicultura CIVA 2002 (http://www.civa2002.org).

Christiansen, I. and Hunt, R., 2000. Research, extension and industry - working together can achieve results. *Marine Pollution Bulletin,* 41: 310-318.

Cifuentes-Lemus, J.L., Torres-García, M.d.P. and Frías-Mondragón, M., 1990. El océano y sus recursos. XI. Acuicultura. Fondo de Cultura Económica, México.

Claar, J., 1957. How to keep extension resources properly allocated to a dynamic agriculture. *Journal of Farm Economics,* 39: 1387-1398.

Clarke, L., Weyant, J. and Birky, A., 2006. On the sources of technological change: assessing the evidence. *Energy Economics,* 28: 579-595.

Cleary, D., 2003. People-centred approaches. A brief literature review and comparison of types. LSP Working Paper 5. Livelihood Support Programme, FAO, Rome. 74 pp.

CNA, 2004. Statistics on water in Mexico. Comisión Nacional del Agua, México. 142 pp.

Coccia, M., 2004. Theoretical analysis of the technological change: measuring and classifying the economic impact. Paper presented at the Canadian Economic Theory Conference, Montreal, Canada, May 7-8, 2004. 39 pp.

CODEPAP, 2006. Desarrollo acuícola sustentable en la Cuenca del Papaloapan. Consejo de Desarrollo del Papaloapan. Gobierno del Estado de Veracruz de Ignacio de la Llave, México. 23 pp.

Colchester, M., 2000. Forest Peoples Programme: *dams, indigenous peoples and ethnic minorities*. Thematic Review I.2 prepared as an input to the World Commission on Dams, Cape Town, South Africa. 98 pp.

Colson, E., 2003. Forced migration and the anthropological response. *Journal of Refugee Studies,* 16: 1-18.

COMEPESCA, 2006. Creando una cultura en el consumo de pescados y mariscos a través de la publicidad. *Seafood Today,* 2: 34-36.

COMEPESCA, 2007. Consejo Mexicano de Promoción de los Productos Pesqueros y Acuícolas. México. [online] URL: http://www.comepesca.com.mx/

CONAPESCA, 2003. *Anuario estadístico de pesca 2003*. Comisión Nacional de Acuacultura y Pesca. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. México. 256 pp.

CONAPESCA, 2004. Registro Nacional de Pesca en aguas continentales. Comisión Nacional de Acuacultura y Pesca. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. México.

CONAPO, 2003. La situación demográfica de México 2003. Consejo Nacional de Población. México. 179 pp.

Contreras-Moreno, N., 2004. Agricultural technology transfer experiences in Mexico: lessons and options. Working Paper No. 107. United Nations University/Institute of Advanced Studies. 46 pp. [online] URL: http://www.ias.unu.edu/binaries2/IASWorkingPaper107.doc

Conway, D. and Cohen, J.H., 2003. Local dynamics in multi-local, transnational spaces of rural Mexico: Oaxacan experiences. *International Journal of Population Geography,* 9: 141-

161.

Cord, L. and Wodon, Q., 2001. Do agricultural programs in Mexico alleviate poverty? Evidence from the ejido sector. *Cuadernos de Economía,* 38: 239-256.

Córdoba Plaza, R., 2003. *Migración internacional y medio rural del centro de Veracruz*. Cuadernos de Trabajo. Instituto de Investigaciones Histórico-Sociales. Universidad Veracruzana, México. 70 pp.

COSAP, 2007. Comité de Sanidad Acuícola y Pesquero Veracruzano, A.C. México. [online] URL: http://www.cosap.org.mx

Costa-Pierce, B., 1997. From farmers to fishers. Developing reservoir aquaculture for people displaced by dams. Technical Paper No. 369. The World Bank, Washington, D.C. 60 pp.

Cotula, L., 2002. Improving access to natural resources for the rural poor. The experience of FAO and of other key organizations from a sustainable livelihood perspective. LSP Working Paper 2. Livelihood Support Programme, FAO, Rome. 73 pp.

Cramb, R.A., Purcell, T. and Ho, T.C.S., 2004. Participatory assessment of rural livelihoods in the Central Highlands of Vietnam. *Agricultural Systems,* 81: 255-272.

Crossley, C.D. and Highhouse, S., 2005. Relation of job search and choice process with subsequent satisfaction. *Journal of Economic Psychology,* 26: 255-268.

Cunningham, L., 2005. Assesing the contribution of aquaculture to food security: a survey of methodologies. Fisheries Circular No. 1010. FAO, Rome. 25 pp.

David, M.B.A., Dirven, M. and Vogelgesang, F., 2000. The impact of the new economic model on Latin America's agriculture. *World Development,* 28: 1673-1688.

De Silva, S.S., Moehl, J., Satia, B., Bartley, D. and Subasinghe, R., 2003. Inland fisheries and aquaculture: a synergy for sustainable food fish production. Pages 37-46. *In*: FAO Fisheries Circular No. 886, Rev. 2. Review of the state of world aquaculture. FAO, Rome. 95 pp.

del Giudice, P., Dellamonica, P., Durant, J., Rahelinrina, V., Grobusch, M.P., Janitschke, K., Dahan-Guedj, A. and Le Fichoux, Y., 2001. A case of gnathostomiasis in a European traveller returning from Mexico. *British Journal of Dermatology,* 145: 487-489.

Deugd, M., Röling, N. and Smaling, E.M.A., 1998. A new praxeology for integrated nutrient management, facilitating innovation with and by farmers. *Agriculture, Ecosystems and Environment,* 71: 269-283.

Devezas, T.C., 2005. Evolutionary theory of technological change: state-of-the-art and new approaches. *Technological Forecasting and Social Change,* 72: 1137-1152.

DeWalt, B.R., Ramírez Zavala, J.R., Noriega, L. and González, R.E., 2002. Shrimp aquaculture, people and the environment in coastal Mexico. Report prepared under the World Bank, NACA, WWF and FAO Consortium Program on Shrrimp Farming and the Environment. Work in Progress for Public Discussion. Published by the Consortium. 73 pp.

Dewees, P.A., 1995. Trees on farms in Malawi: private investment, public policy, and farmers choice. *World Development,* 23: 1085-1102.

DFID, 2002a. Better livelihoods for poor people: the role of land policy. Consultation document. London: Department for International Development (DFID). 22p.

DFID, 2002b. A review of DFID´s country strategy for Bangladesh. CSP 1998-2002. DFID Bangladesh, 56 pp.

DGECTM, 2007. Centros de Estudios Tecnológicos del Mar (CETMAR) y Centros de Estudios Tecnológicos en Aguas Continentales (CETAC). Dirección General de Educación en Ciencia y Tecnología del Mar (DGECTM). Secretaría de Educación Pública, México. [online] URL: http://uecytm.sep.gob.mx/.

Díaz-Bautista, A. and Díaz-Domínguez, M., 2003. Capital humano y crecimiento económico en México (1970-2000). *Revista Comercio Exterior, Bancomext,* 53: 1012-1023.

Díaz-Camacho, S.-P., Zazueta-Ramos, M., Ponce-Torrecillas, E., Osuna-Ramírez, I., Castro-Velazquez, R., Flores-Gaxiola, A., Baquera-Heredia, J., Willms, K., Akahane, H., Ogata, K. and Nawa, Y., 1998. Clinical manifestations and immunodiagnosis of gnathostomiasis in Culiacán, México. *American Journal of Tropical Medicine and Hygiene,* 59: 908-915.

Dinar, A., 1996. Extension commercialization: how much to charge for extension services. *American Journal of Agricultural Economics,* 78: 1-12.

Dollar, D., 2005. Globalization, poverty, and inequality since 1980. *The World Bank Research Observer,* 20: 145-175.

Donovan, P.A., 1995. The management, funding and organisational structure of agricultural R & D in Zimbabwe, Malawi and South Africa. Part II - Organisational structure. *Agricultural Systems,* 47: 273-290.

Dorward, A., Anderson, S., Clark, S., Keane, B. and Moguel, J., 2001. Asset functions and livelihood strategies: a framework for pro-poor analysis, policy and practice. Contributed paper to EAAE seminar on livelihoods and rural poverty, September 2001. 15 pp.

Douglas, H.E. and Basiuk, V., 1986. The private sector and technology transfer to Mexico. *Mexican Studies / Estudios Mexicanos,* 2: 253-273.

Dozier, C.L., 1965. Book Review. The Papaloapan Project: agricultural development in the Mexican tropics. By Thomas T. Poleman. Stanford University Press, Stanford, California, 1964. 167 pp. *Geographical Review,* 55: 444-445.

Dupuy, D., 1997. Technological change and environmental policy: the diffusion of environmental technology. *Growth and Change,* 28: 49-66.

Durand, J., Parrado, E.A. and Massey, D.S., 1996. Migradollars and development: a reconsideration of the Mexican case. *International Migration Review,* 30: 423-444.

Durand, L. and Lazos, E., 2004. Colonization and tropical deforestation in the Sierra Santa Marta, Southern Mexico. *Environmental Conservation,* 31: 11-21.

ECLAC, 2004. *Social panorama of Latin America 2002-2003*. Economic Commission for Latin America and the Caribbean. United Nations publication LC/G.2209-P. Santiago, Chile. 348 pp.

ECON, 2005. Business opportunities for Canadian fish and seafood products in the Mexican market. ECON Consultores Asociados. Document prepared for the Canadian Embassy in Mexico. Unpublished. 44 pp.

Edwards, P., 1999. Towards increased impact of rural aquaculture. A Discussion Paper prepared for the First Meeting of the APFIC Ad Hoc Working Group of Experts on Rural Aquaculture. 20-22 October 1999, Bangkok, Thailand. FAO Regional Office for Asia and the Pacific (RAP). 52 pp.

Edwards, P., 2000. Aquaculture, poverty impacts and livelihoods. *Natural Resource Perspectives.,* Paper No. 56. London: ODI

Edwards, P., 2002a. Aquaculture for poverty alleviation and food security. *Aquaculture Asia,* 7: 53-56.

Edwards, P., 2002b. Aquaculture for poverty alleviation and food security - Part II. *Aquaculture Asia,* 7: 26-28.

Eiser, C., Eiser, J.R. and Havermans, T., 1995. The measurement of self-esteem: practical and theoretical considerations. *Personality and Individual Differences,* 18: 429-432.

El-Sayed, A.-F.M., 2006. Chapter 1. Current state and future potential. pp. 1-24 In: Tilapia culture. CABI Publishing. 275 pp.

Ellis, F., 1999. Rural livelihood diversity in developing countries: evidence and policy implications. *Natural Resource Perspectives,* No. 40. ODI, London.

Emmerich, W., Rock, D.A. and Trapani, C.S., 2006. Personality in relation to occupational outcomes among established teachers. *Journal of Research in Personality,* 40: 501-528.

Engle, C.R. and Stone, N.M., 1990. *A review of extension methodologies in aquaculture*. FAO Aquaculture Development and Coordination Programme. ADCP/REP/89-44. FAO, Rome. 65 pp.

Escobar C., J.F., Andrade-Escobar, K., Figueroa-Peña, A., Gómez-Marín, F.J., Arceo-Castro, G. and González-Azuara, J.A., 2005. El caso de la Reserva de la Biósfera de Los Tuxtlas. Proyecto MIE-PNUD. Memorias 1er. Congreso Internacional de Casos Exitosos de Desarrollo Sostenible del Tropico. Universidad Veracruzana - Centro de Investigaciones Tropicales. Boca del Río, Veracruz, México. 11 pp.

Esquivel Obregón, T., 1919. Factors in the historical evolution of Mexico. *The Hispanic American Historical Review,* 2: 135-172.

Evenson, R.E. and Mwabu, G., 2001. The effect of agricultural extension on farm yields in Kenya. *African Development Review,* 13: 1-23.

FAO, 1997. *Aquaculture development*. Technical Guidelines for Responsible Fisheries, No. 5. FAO, Rome. 40 pp.

FAO, 2002. FISHSTAT Plus. Universal software for fishery statistical time series, Version 2.3. FAO, Rome.

FAO, 2004. *The state of world fisheries and aquaculture, 2004 (SOFIA)*. FAO Fisheries Department. FAO, Rome. 161 pp.

FAO, 2005. *The State of Food and Agriculture 2005*. Agriculture Series No. 36. FAO, Rome. 198 pp.

FAO, 2007. *Aquaculture development. 2. Health management for responsible movement of live aquatic animals*. Technical Guidelines for Responsible Fisheries, No. 5 , Suppl. 2. FAO, Rome. 31 pp.

FAO/RAP, 2007. Integrating fisheries into the development discourse. RAP Publication 2007-03. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand. 23 pp.

Farrington, J., 1995. The changing public role in agricultural extension. *Food Policy,* 20: 537-544.

Farrington, J., Christoplos, I., Kidd, A.D. and Beckman, M., 2002. Can extension contribute to rural poverty reduction? Synthesis of a six-country study. *ODI Agricultural Research and Extension Network Paper,* No. 123. Overseas Development Institute, London.

Finan, F., Sadoulet, E. and de Janvry, A., 2005. Measuring the poverty reduction potential of land in rural Mexico. *Journal of Development Economics,* 77: 27-51.

Fitzsimmons, K., 2000a. Tilapia aquaculture in Mexico. pp. 171-183 In: Costa-Pierce, B.A. and J.E. Rakocy (eds.) *Tilapia Aquaculture in the Americas*, *Vol. 2*. The World Aquaculture Society, Baton Rouge, Louisiana, United States.

Fitzsimmons, K., 2000b. Future trends of tilapia aquaculture in the Americas. pp. 252-264 In: Costa-Pierce, B.A. and J.E. Rakocy (eds.). *Tilapia Aquaculture in the Americas*, *Vol. 2*. The World Aquaculture Society, Baton Rouge, Louisiana, United States.

Foster, M., 2000. New approaches to development co-operation: what can we learn from experience with implementing sector wide approaches? Working Paper 140. London: ODI

Foster, M. and Fozzard, A., 2000. Aid and public expenditure: a guide. Working Paper 141. London: ODI

Frank, B.R., 1997. Adoption of innovations in the north Queensland beef industry. III: Implications for extension management. *Agricultural Systems,* 55: 347-358.

Fraser, C. and Restrepo Estrada, S., 1996. *Communication for rural development in Mexico: in good times and in bad*. FAO, Rome. 120 pp.

Freebairn, D.K., 1995. Did the green revolution concentrate incomes? A quantitative study of research reports. *World Development,* 23: 265-279.

Freebairn, D.K., 1969. The dichotomy of prosperity and poverty in Mexican agriculture. *Land Economics,* 45: 31-42.

Fuentes, R. and Montes, A., 2003. *Mexico: country case study towards the Millenium Development Goals at the sub-national level*. United Nations Development Programme. Background paper for Human Development Report. 43 pp.

Fuller, R., 2003. Livestock and the livelihoods of the urban poor: a background document. Livestock Development Group, University of Reading, UK. 76 pp.

Furnham, A., Forde, L. and Ferrari, K., 1999. Personality and work motivation. *Personality and Individual Differences,* 26: 1035-1043.

Furnham, A., Petrides, K.V., Jackson, C.J. and Cotter, T., 2002. Do personality factors predict job satisfaction? *Personality and Individual Differences,* 33: 1325-1342.

Furnham, A. and Zacherl, M., 1986. Personality and job satisfaction. *Personality and Individual Differences,* 7: 453-459.

Gafsi, M., 1999. A management approach to change on farms. *Agricultural Systems,* 61: 179-189.

Gao, X.M., 1994. Measuring technological change using a latent variable approach. *European Review of Agricultural Economics,* 21: 113-129.

García A., S., Eloy-Trejo, L. and Cárdenas-Zacarías, O., 1998. Desarrollo autogestivo en comunidades indígenas del Valle del Mezquital. La experiencia de SEDAC-COVAC. *Serie Estudios de Caso sobre Participación Campesina en Generación, Validación y Transferencia de Tecnología,* Red de Gestión de Recursos Naturales y Fundación Rockefeller. México.

García, L.E., 2001. Review of the role of river basin organizations in Latin America. Working paper of the World Commission on Dams. Prepared for thematic review V.3: River basins-institutional frameworks and management options. Cape Town, South Africa. 9 pp.

Garforth, C., 1998. Dissemination pathways for RNR research. *Socio-economic Methodologies. Best Practice Guidelines (BPG1)* . Chatham, UK: Natural Resources Institute. 12 pp.

Garforth, C., McKemey, K., Rehman, T., Tranter, R., Cooke, R., Park, J., Dorward, P. and Yates, C., 2006. Farmers' attitudes towards techniques for improving oestrus detection in dairy herds in South West England. *Livestock Science,* 103: 158-168.

Garforth, C. and Lawrence, A., 1997. Supporting sustainable agriculture through extension in Asia. *Natural Resource Perspectives,* Paper No. 21. London: ODI

Garrison, D.J., 1950. Reclamation project of the Papaloapan river basin in Mexico. *Economic Geography,* 26: 59-64.

Gegner, L., 2006. Aquaculture enterprises: considerations and strategies. Appropriate Technology Transfer for Rural Areas (ATTRA) - National Sustainable Agriculture Information Service. 16 pp. [online] URL: http://www.attra.ncat.org

Gelissen, J. and de Graaf, P.M., 2006. Personality, social background, and occupational career success. *Social Science Research,* 35: 702-726.

Gellatly, I.R., Paunonen, S.V., Meyer, J.P., Jackson, D.N. and Goffin, R.D., 1991. Personality, vocational interest, and cognitive predictors of managerial job performance and satisfaction. *Personality and Individual Differences,* 12: 221-231.

Gerpacio, R.V., 2003. The roles of public sector versus private sector in R&D and technology generation: the case of maize in Asia. *Agricultural Economics,* 29: 319-330.

Gerpacio, R.V., 2006. Roles of public and private sectors in maize research and development and technology dissemination in Asia. pp. 53-58 In: B.O. Acosta, R.C. Sevilleja and M.V. Gupta (eds.) Public and private partnerships in aquaculture: a case study on tilapia research and development. WorldFish Center Conf. Proc. 72, 72 pp.

Gillespie, S., 2004. Scaling up community-driven development: a synthesis of experience. FCND Discussion Paper No. 181. International Food Policy Research Institute, Washington, D.C. 66 pp.

Gisselquist, D., Nash, J. and Pray, C., 2002. Deregulating the transfer of agricultural technology: lessons from Bangladesh, India, Turkey, and Zimbabwe. *The World Bank Research Observer,* 17: 237-265.

Gobierno de la República, 2006. Producto interno bruto, empleo, sector externo y financiamiento del sector agropecuario. pp. 387 *En*: Fox-Quesada, Vicente. 2006. Sexto Informe de Gobierno. Presidencia de la República, México. [online] URL: http://sexto.informe.fox.presidencia.gob.mx/docs/anexo/pdf/P387.pdf.

Gobierno del Estado de Veracruz, 2000. *Programa de desarrollo regional de sotavento*. Gobierno del Estado de Veracruz, Mexico. 306 pp.

Gobierno del Estado de Veracruz, 2005. Plan Veracruzano de Desarrollo 2005-2010. Gobierno del Estado de Veracruz, Mexico. 163 pp. [online] URL: http://www.veracruz.gob.mx.

Gomez Tovar, L., Martin, L., Gomez Cruz, M.A. and Mutersbaugh, T., 2005. Certified organic agriculture in Mexico: market connections and certification practices in large and small producers. *Journal of Rural Studies,* 21: 461-474.

González-Oropeza, M. and Garita-Alonso, M.A., 1994. *El régimen jurídico de la pesca en México*. Instituto de Investigaciones Jurídicas. Universidad Nacional Autónoma de México. México. 603 pp.

Guzmán, A.M. and Zarza, E.M., 1996. La educación pesquera y acuícola en México. Comités Interinstitucionales para la Evaluación de la Educación Superior. Secretaría de Educación Pública, México. 54 pp.

Haenn, N., 2006. The changing and enduring ejido: a state and regional examination of Mexico's land tenure counter-reforms. *Land Use Policy,* 23: 136-146.

Hagmann, J., Chuma, E., Murwira, K. and Connolly, M., 1999. Putting process into practice: operationalising participatory extension. *ODI Agricultural Research and Extension Network Paper,* No. 94. Overseas Development Institute , London. 18pp.

Halwart, M., 2005. The role of aquaculture in rural development. *Agriculture and Rural Development,* 2: 41-44.

Halwart, M., Funge-Smith, S. and Moehl, J., 2003. The role of aquaculture in rural development. Pages 47-58. *In*: FAO Fisheries Circular No. 886, Rev. 2. Review of the state of world aquaculture. FAO, Rome. 95 pp.

Harrison, E., 1993. "My pond has no fish": aquaculture development in Luapula Province, Zambia. Field-work findings from Luapula Province, Zambia. ODA unpublished report. 300 pp.

Harrison, E., 1996. Rethinking "failure": fish ponds and projects in sub-Saharan Africa. ODA project report. Unpublished. 53 pp.

Harrison, E., Stewart, J.A., Stirrat, R.L. and Muir, J.F., 1994. Fish farming in Africa: what's the catch? Summary report of ODA-supported research project and policy recommendations. University of Sussex, Brighton, UK. 51 pp.

Hartley-Alcocer, A.G., Muir, J.F. and Young, J.A., 2006. Tilapia as a global commodity: a potential role for Mexico? Paper presented in the 7th International Symposium on Tilapia in Aquaculture. Boca del Río, Veracruz, México. 3-5 September 2006, 11 pp.

Harvey, D.J., 2005. Aquaculture outlook. Report LDP-AQS-21. Economic Research Service, United States Department of Agriculture. 27 pp.

Hawker, P., 2000. A review of the role of dams in flood management. Working paper of the World Commission on Dams. Prepared for thematic review IV.4: Assessment of flood control and management options. Cape Town, South Africa. 43 pp.

Hazell, P. and Wood, S., 2000. From science to technology adoption: the role of policy research in improving natural resource management. *Agriculture, Ecosystems and Environment,* 82: 385-393.

Hernández-Mogica, M., Reta Mendiola, J.L., Gallardo López, F. and Nava Tablada, M.E., 2002. Tipología de productores de mojarra tilapia (*Oreochromis* spp.): base para la formación de grupos de crecimiento productivo simultaneo (GCPS) en el estado de Veracruz, México. *Tropical and Subtropical Agroecosystems,* 1: 12-19.

Hernández-Mojica, M., 2002. Tipología de productores de tilapia: base para la formación de Grupos de Crecimiento Productivo Simultáneo (GCPS) en el Estado de Veracruz. Tesis de Maestría. Programa de Agroecosistemas Tropicales, Colegio de Postgraduados, México.

Herr, W.M., 1966. Technological change in the agriculture of the United States and Australia. *Journal of Farm Economics,* 48: 264-271.

Hill, T. and Westbrook, R., 1997. SWOT analysis: it's time for a product recall. *Long Range Planning,* 30: 46-52.

Hishamunda, N. and Ridler, N.B., 2006. Farming fish for profits: a small step towards food security in sub-Saharan Africa. *Food Policy,* 31: 401-414.

Hobley, M. and Shields, D., 2000. The reality of trying to transform structures and processes: forestry in rural livelihoods. *Sustainable Livelihoods.,* Working Paper 132. London: ODI

Holland, G.L., 1998. The role of intergovernmental organizations in coastal zone management. *Ocean and Coastal Management,* 39: 25-31.

Houben, G., Lenie, K. and Vanhoof, K., 1999. A knowledge-based SWOT-analysis system as an instrument for strategic planning in small and medium sized enterprises. *Decision Support Systems,* 26: 125-135.

Hough, C., 2002. Organising and operating a regional federation of aquaculture producers. *Aquaculture Asia,* 7: 36-39.

Hough, C. and Bueno, P., 2003. Producer associations and farmer societies: support to sustainable development and management of aquaculture. Pages 75-95. *In*: FAO Fisheries Circular No. 886, Rev. 2. Review of the state of world aquaculture. FAO, Rome. 95 pp.

Hubbell, B.J., Marra, M.C. and Carlson, G.A., 2000. Estimating the demand for a new technology: Bt cotton and insecticide policies. *American Journal of Agricultural Economics,* 82: 118-132.

Huisman, K.J.M. and Kort, P.M., 2004. Strategic technology adoption taking into account future technological improvements: a real options approach. *European Journal of Operational Research,* 159: 705-728.

Hussein, K. and Nelson, J., 1998. Sustainable livelihoods and livelihood diversification. IDS Working Paper 69. Institute of Development Studies. Brighton, UK. 32 pp.

ICID, 2000. Country profile: Mexico. International Commission on Irrigation and Drainage. New Delhi, India. 7 pp.

Idyll, C.P., 1974. Capacitación en acuicultura: México. Contribuciones al estudio de las pesquerías de México 12. Programa de Investigación y Fomento Pesquero/PNUD/FAO. 49 pp.

Ilies, R. and Judge, T.A., 2002. Understanding the dynamic relationships among personality, mood, and job satisfaction: a field experience sampling study. *Organizational Behavior and Human Decision Processes,* 89: 1119-1139.

INCMNSZ, 2003. *Cambios en la situación nutricional de México de 1990 a 2000 a través de un índice de riesgo nutricional por municipio*. Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán. Sociedad Latinoamericana de Nutrición. México. 441 pp.

INE, 2000. *Indicadores para la evaluación del desempeño ambiental*. Instituto Nacional de Ecología. Secretaría de Medio Ambiente y Recursos Naturales. México. 184 pp.

INEGI, 2000. XII Censo General de Población y Vivienda. Instituto Nacional de Estadística, Geografía e Informática , México. [online] URL: http://www.inegi.gob.mx.

INEGI, 2005a. El sector alimentario en México. Serie de Estadísticas Sectoriales. Instituto Nacional de Estadística, Geografía e Informática, México. 301 pp. [online] URL: http://www.inegi.gob.mx.

INEGI, 2005b. *Perspectiva estadística. Veracruz de Ignacio de la Llave*. Instituto Nacional de Estadística, Geografía e Informática, México. 83 pp. [online] URL: http://www.inegi.gob.mx.

INEGI, 2006. Producto Interno Bruto por entidad federativa 1999-2004. Sistema de Cuentas Nacionales de México. Instituto Nacional de Estadística, Geografía e Informática, México. 222 pp. [online] URL: http://www.inegi.gob.mx.

INEGI, 2007a. Producto Interno Bruto trimestral. Estadísticas Económicas, febrero 2007. Instituto Nacional de Estadística, Geografía e Informática, México. 60 pp. [online] URL: http://www.inegi.gob.mx.

INEGI, 2007b. Instituciones de educación en ciencias del mar. Instituto Nacional de Estadística, Geografía e Informática, México. [online] URL: http://mapserver.inegi.gob.mx/dsist/oceanografia/.

INIFAP, 2005. *Contribuciones del modelo GGAVATT al desarrollo de la ganadería. Testimonios*. Publicación Especial No.1. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, México.

INP, 2003. 1^er^ Foro Internacional de Acuicultura: un encuentro con el mercado. Instituto Nacional de la Pesca, SAGARPA, México. Memorias de la reunión nacional de tilapia, 19-21 de marzo del 2003, Cámara de Comercio de Guadalajara , Jalisco, México. 263 pp.

INP, 2006. *Sustentabilidad y pesca responsable en México: evaluación y manejo*. Instituto Nacional de la Pesca, México. 544 pp.

IPCC, 2000. Cuestiones metodológicas y tecnológicas en la transferencia de tecnología. Resumen para responsables de políticas. Informe Especial del Grupo Intergubernamental de Expertos sobre el Cambio Climático (IPCC). Organización Meteorológica Mundial (OMM) - Programa de las Naciones Unidas para el Medio Ambiente (PNUMA). 16p.

Ison, R.L., Maitenv, P.T. and Carr, S., 1997. Systems methodologies for sustainable natural resources research and development. *Agricultural Systems,* 55: 257-272.

ITBOCA, 2007. Reseńa histórica. Instituto Tecnológico de Boca del Río (ITBOCA) . Boca del Río, Ver., México. [online] URL: http://www.itboca.edu.mx/.

Jensen, H.R., 1957. Discussion: differential rates of change in output per unit of input. *Journal of Farm Economics,* 39: 1561-1565.

Jia, J., Wijkstrom, U., Subasinghe, R.P. and Barg, U., 2001. Aquaculture development beyond 2000: global prospects. Keynote Address II. pp. 9-12 In: R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery and J.R. Arthur (Eds.) *Aquaculture in the Third Millennium*. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. NACA, Bangkok and FAO, Rome. 471 pp.

Jiménez, J.J., Kak-Moo, M., Sohn, I., López, A., Ancona, F., Mendoza, A., Xuluc, F., Cámara, R. and Nelson, K., 1998. Investigación en Sahcabá, Yucatán. La experiencia de PROTROPICO-FMVZ-UADY. *Serie Estudios de Caso sobre Participación Campesina en Generación, Validación y Transferencia de Tecnología,* Red de Gestión de Recursos Naturales y Fundación Rockefeller. México.

Jiménez Sánchez, J.E., Islas Rivera, V.M., Hernández García, S. and Pérez Sánchez, J.A., 2001. El transporte regional en el sureste mexicano. Publicación Técnica No. 174. Instituto Mexicano del Transporte. Secretaría de Comunicaciones y Transportes, México. 264 pp.

Jones, G.E. and Garforth, C., 1997. The history, development, and future of agricultural extension. pp. 3-13 (Chapter 1) In: Swanson, B.E., R.P. Bentz and A.J. Sofranko (Eds.). *Improving agricultural extension. A reference manual.* FAO, Rome. 220 pp.

Jones, R.C., 2001. Maquiladoras and U.S.-bound migration in central Mexico. *Growth and Change,* 32: 193-216.

Kapetsky, J.M. and Nath, S.S., 1997. A strategic assessment of the potential for freshwater fish farming in Latin America. COPESCAL Technical Paper, No. 10. FAO, Rome. 128 pp.

Karmokolias, I., 1997. Aquaculture de la Mahajamba. Pp. 35-46 In: The private sector and development: five case studies. Publication 23470. The World Bank and International Finance Corporation, Washington, D.C. 60 pp.

Keefer, P. and Khemani, S., 2005. Democracy, public expenditures, and the poor: understanding political incentives for providing public services. *The World Bank Research Observer,* 20: 1-27.

Kellogg, W.A., 1999. Community-based organizations and neighbourhood environmental problem solving: a framework for adoption of information technologies. *Journal of Environmental Planning and Management,* 42: 445-469.

Khan, S.A., Lyla, P., Veerappan, N. and Rajagopal, S., 2000. Aquaculture vis-à-vis agriculture.

Naga, The ICLARM Quarterly, 23: 10-12.

Klinefelter, D.A., 1988. Characteristics of farmers who have failed. Texas Agricultural Extension Service, Texas A&M University. 3 pp.

Klooster, D. and Masera, O., 2000. Community forest management in Mexico: carbon mitigation and biodiversity conservation through rural development. *Global Environmental Change,* 10: 259-272.

Knickel, K. and Renting, H., 2000. Methodological and conceptual issues in the study of multifunctionality and rural development. *Sociologia Ruralis,* 40: 512-528.

Knuston, R.D., 1986. Restructuring agricultural economics extension to meet changing needs. *American Journal of Agricultural Economics,* 68: 1297-1306.

Koenig, D., 2002. Toward local development and mitigating impoverishment in development-induced displacement and resettlement. Refugee Studies Centre Working Paper No. 8. Queen Elizabeth House, International Development Centre, University of Oxford, UK. 65 pp.

Koffi, C., Oswald, M. and Lazard, J., 1996. Rural development of tilapia culture in Africa: from myth to reality. pp. 505-514. In R.S.V. Pullin, J. Lazard, M. Legendre, J.B. Amon Kothias and D. Pauly (eds.). The Third International Symposium on Tilapia in Aquaculture. ICLARM Conf. Proc. 41, 575 pp.

Kydd, J., 2002. Agriculture and rural livelihoods: is globalisation opening or blocking paths out of rural poverty? *ODI Agricultural Research and Extension Network Paper,* No. 121. Overseas Development Institute, London.

Lau, V.P. and Shaffer, M.A., 1999. Career success: the effects of personality. *Career Development International,* 4: 225-230.

Lave, L.B., 1962. Empirical estimates of technological change in United States agriculture, 1850-1958. *Journal of Farm Economics,* 44: 941-952.

Lawrence, P.G., Sanders, J.H. and Ramaswamy, S., 1999. The impact of agricultural and household technologies on women: a conceptual and quantitative analysis in Burkina Faso. *Agricultural Economics,* 20: 203-214.

Lazard, J., 1996. Which research for which development of tilapia aquaculture in subSaharan Africa? pp. 515-524. In R.S.V. Pullin, J. Lazard, M. Legendre, J.B. Amon Kothias and D. Pauly (eds.). The Third International Symposium on Tilapia in Aquaculture. ICLARM Conf. Proc. 41, 575 pp.

Leeuwis, C. and Van den Ban, A.W., 2004. *Communication for rural innovation: rethinking agricultural extension*. Third Edition. Blackwell Science, Oxford. 412 pp.

Lefroy, R.D.B., Bechstedt, H.-D. and Rais, M., 2000. Indicators for sustainable land management based on farmer surveys in Vietnam, Indonesia, and Thailand. *Agriculture, Ecosystems and Environment,* 81: 137-146.

Lerer, L.B. and Scudder, T., 1999. Health impacts of large dams. *Environmental Impact Assessment Review,* 19: 113-123.

Levy, S., 1991. Poverty alleviation in Mexico. World Bank Working Paper Series No. 679. 113 pp.

Lewis, D.J., 1997. NGOs, donors, and the State in Bangladesh. *Annals of the American Academy of Political and Social Science,* 554: 33-45.

Lichtkoppler, F.R. and Passewitz, G.R., 1992. Starting new producer organizations. *Journal of Extension,* 30: [online] URL: http://www.joe.org/joe/1992spring/iw4.html

Little, D.C. and Edwards, P., 2003. *Integrated livestock-fish farming systems*. Inland Water Resources and Aquaculture Service. Animal Production Service. FAO, Rome. 184 pp.

Little, D.C. and Muir, J.F., 1987. *Integrated warm water aquaculture*. Pisces Press, Stirling. 238 pp.

Little, D.C. and Muir, J.F. (2003) Integrated agri-aquaculture systems - the Asian experience. Pages 24-36. In: Gooley, G.J. and Gavine, F.M., (Eds.) *Integrated agri-aquaculture systems. A resource handbook for Australian industry development*, Rural Industries Research and Development Corporation:

Liu, J. and Cai, Q., 1998. Integrated aquaculture in Chinese lakes and paddy fields. *Ecological Engineering,* 11: 49-59.

Loader, R. and Amartya, L., 1999. Participatory Rural Appraisal: extending the research methods base. *Agricultural Systems,* 62: 73-85.

Londner, S. and Mulholland, M.E., 2002. Working with the private sector to create rural economic growth: two case studies. pp. 176-182 In: Breth, S.A. (Editor). *Food security in a changing Africa*. Proceedings of the workshop on Africa food security in a changing environment: sharing good practices and experiences. Kampala, Uganda, June 6-9, 2001. Centre for Applied Studies in International Negotiations, Geneva. 219 pp.

López-Cortés, E., 1992. Construcción de presas hidroeléctricas y estructuras axiales estatales. *Alteridades,* 2: 111-116.

Lopez-Feldman, A., Mora, J. and Taylor, J.E., 2006. Does natural resource extraction mitigate poverty and inequality? Evidence from rural Mexico. Paper presented at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006. 17 pp.

Lounsbury, J.W., Gibson, L.W., Steel, R.P., Sundstrom, E.D. and Loveland, J.L., 2004. An investigation of intelligence and personality in relation to career satisfaction. *Personality and Individual Differences,* 37: 181-189.

Lucier, V.A., 1897. Mexican superstitions relating to maternity. *The Journal of American Folklore,* 10: 108

Ludwig, J.A. and Reynolds, J.F., 1988. *Statistical ecology. A primer on methods and computing.* John Wiley & Sons. 337 pp.

Marsh, S.P., Pannell, D.J. and Lindner, R.K., 2004. Does agricultural extension pay?: A case study for a new crop, lupins, in Western Australia. *Agricultural Economics,* 30: 17-30.

Martin, A. and Sherington, J., 1997. Participatory research methods - Implementation, efectiveness and institutional context. *Agricultural Systems,* 55: 195-216.

Martínez Dávila, J.P., 2001. El Colegio de Postgraduados en Veracruz: veinte años de experiencia (1979-1999). Decima cuarta reunión científica-tecnológica forestal y agropecuaria. Veracruz, México.

Martínez-Espinosa, M., 2000. Participatory approaches in aquaculture. Report of the Workshop on Participatory Approaches in Aquaculture (unpublished), held in Bangkok, Thailand, 28th February - 1st March, 2000. [online] URL: http://www.fao.org/Participation/aquaculture-lessons.html.

Martínez, P.R., Molnar, J., Trejos, E., Meyer, D., Meyer, S.T. and Tollner, W., 2004. Cluster memberhip as a competitive advantage in aquacultural development: case study of tilapia producers in Olancho, Honduras. *Aquaculture Economics and Management,* 8: 281-294.

Marvasti, A., 1998. An assessment of the international technology transfer system and the new Law of the Sea. *Ocean and Coastal Management,* 39: 197-210.

Maskus, K.E., 2004. Encouraging international technology transfer. Issue Paper No. 7. ICTSD Intellectual Property Rights and Sustainable Development Series. International Centre for Trade and Sustainable Development (ICTSD) and United Nations Conference on Trade and Development (UNCTAD). Geneva, Switzerland. 49 pp.

Massey, D.S. and Espinosa, K.E., 1997. What's driving Mexico-U.S. migration? A theoretical, empirical, and policy analysis. *The American Journal of Sociology,* 102: 939-999.

Mayoux, L. and Chambers, R., 2005. Reversing the paradigm: quantification, participatory methods and pro-poor impact assessment. *Journal of International Development,* 17: 271-298.

McCarthy, N., Dutilly-Diane, C. and Drabo, B., 2004. Cooperation, collective action and natural resources management in Burkina Faso. *Agricultural Systems,* 82: 233-255.

Mckinley, T. and Alarcon, D., 1995. The prevalence of rural poverty in Mexico. *World Development,* 23: 1575-1585.

Mendoza, M.A., Fajardo, J.J. and Zepeta, J., 2005. Landscape based forest management, a real world case study from Mexico. *Forest Ecology and Management,* 209: 19-26.

Millington, P., 2000. *River basin management: its role in major water infrastructure projects*. Thematic Review V.3 prepared as an input to the World Commission on Dams, Cape Town, South Africa. 166 pp.

Milne, A.A., 1926. *Winnie the Pooh*. Methuen and Co., London.

Molina-Ramos, E., 1992. Faccionalismo y poder en Arroyo Tambor: el impacto de la presa "Miguel de la Madrid Hurtado" sobre un microproceso político. *Alteridades,* 2: 67-75.

Mondal, A.H., 2000. Social capital formation: the role of NGO rural development-áprograms in Bangladesh. *Policy Sciences,* 33: 459-475.

Moore, P., 2002. *The sky at night*. Philip's Publishing, UK. 256 pp.

Morales-Díaz, A., 1991. *La tilapia en México: biología, cultivo y pesquerías*. AGT Editor, México. 190 pp.

Morales Morales, M., Martínez Dávila, J.P., Torres Hernández, G. and Pacheco Velasco, J.E., 2004. Evaluación del potencial para la producción ovina con el enfoque de agroecosistemas en un ejido de Veracruz, México. *Técnica Pecuaria en México,* 42: 347-359.

Morales Q., V.V. and Morales R., R., 2006. Regional review on aquaculture development. 1. Latin America and the Caribbean - 2005. FAO Fisheries Circular No. 1017-1. FAO, Rome. 177 pp.

Morris, C. and Winter, M., 1999. Integrated farming systems: the third way for European agriculture? *Land Use Policy,* 16: 193-205.

Moxley, R.L. and Lang, K.B., 2006. The importance of social context influences on new farm technology sustainability: community and sub-community characteristics in Jamaica. *Technology in Society,* 28: 393-406.

Muir, J.F., 1999. Aquaculture and poverty: full baskets or empty promises? Perspectives from the DFID Aquaculture Research Programme. Contributed paper. Fifth Fisheries Development Donor Consultation. 22-24 February 1999, FAO, Rome. 7 pp.

Muir, J.F., 2002. DFID Aquaculture and Fish Genetics Research Programme. Annual Report 2001-02, Part I. Institute of Aquaculture, University of Stirling. 45 pp.

Muir, J.F., 2005. Managing to harvest? Perspectives on the potential of aquaculture. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences,* 360: 191-218.

Murillo-Licea, D., 2003. La cuenca del Papaloapan, México: un caso de baja gobernabilidad del agua. *In*: Memorias del Simposio "El acceso al agua: un problema histórico y actual", 14-18 de Julio del 2003, Santiago, Chile. 18 pp.

Murray, P., 2000. Agricultural extension and rural development: breaking out of traditions. Book review. *Agriculture, Ecosystems and Environment,* 79: 281-282.

Murrell, K.D., 1996. Communications: technology transfer in the developed world. *Veterinary Parasitology,* 64: 107-120.

Nabudere, D.W., 1997. Beyond modernization and development, or why the poor reject development. *Geografiska Annaler,* 79B: 203-215.

NACA and FAO, 2000. Aquaculture development beyond 2000: the Bangkok declaration and strategy. Conference on Aquaculture in the Third Millennium, 20-25 February 2000, Bangkok, Thailand. NACA, Bangkok and FAO, Rome. 27 pp.

Nadvi, K. and Barrientos, S., 2004. Small firm clusters: working to reduce poverty. IDS Policy Briefing No. 21. Institute of Development Studies, Brighton, UK.

Narayanan, V.K. and Fahey, L., 2006. Institutional evolution as an emerging focus in scenario planning. *Futures,* 38: 972-992.

Nash, C.E., 2004. Achieving policy objectives to increase the value of the seafood industry in the United States: the technical feasibility and associated constraints. *Food Policy,* 29: 621-641.

Nash, M., 1957. The multiple society in economic development: Mexico and Guatemala. *American Anthropologist,* 59: 825-833.

Nederveen Pieterse, J., 1998. My paradigm or yours? Alternative development, post-development, reflexive development. *Development and Change,* 29: 343-373.

Neill, S.P. and Lee, D.R., 2001. Explaining the adoption and disadoption of sustainable agriculture: the case of cover crops in Northern Honduras. *Economic Development and Cultural Change,* 49: 793-820.

Nicol, A., 2000. Adopting sustainable livelihoods approach to water projects: implications for policy and practice. *Sustainable Livelihoods.,* Working Paper 133. London: ODI

Nong, K. and Marschke, M., 2006. Building networks of support for community-based coastal resource management in Cambodia. Chapter 8 *In*: Tyler, S.R. (Editor). *Communities, livelihoods and natural resources: action research and policy change in Asia*. Practical Action Publishing/IDRC. 456 pp.

Noriega, J.S., 1947. Control del río Papaloapan: preparación del plan de estudios definitivos y programas de construcción de obras. *Ingeniería Hidráulica en México,* 1: abril-junio y julio-septiembre.

Normann, A.K., 2005. Creation of a cluster? Pull-factors and obstacles in the establishment of a formalised network. The case of the marine biotechnology industry in North Norway. Rapport nr 12-2005. NORUT Samfunnsforskning AS, Norway. 37 pp.

Norrish, P., Lloyd-Morgan, K. and Myers, M., 2001. Improved communication strategies for renewable natural resource research outputs. *Socio-economic Methodologies. Best Practice Guidelines (BPG8)*. Chatham, UK: Natural Resources Institute. 17 pp.

Norrish, P., 2006. Communication for research uptake promotion: learning from practice. NRSP Brief. DFID Natural Resources Systems Programme. 6 pp.

Norse, D. and Tschirley, J.B., 2000. Links between science and policy making. *Agriculture, Ecosystems and Environment,* 82: 15-26.

ODI, 1999a. Agricultural extension. *Key Sheets for Sustainable Livelihoods,* Overseas Development Institute. Service Delivery No. 2. London.

ODI, 1999b. Aquaculture. *Key Sheets for Sustainable Livelihoods,* Overseas Development Institute. Resource Management No. 4. London.

OECD, 2006. Política agropecuaria y pesquera en México: logros recientes, continuación de las reformas. (Extractos). Organisation for Economic Co-operation and Development (OECD). 42 pp.

OEIDRUS, 2007. Granjas acuícolas registradas en el Estado de Veracruz. Oficina Estatal de Información para el Desarrollo Rural Sustentable (OEIDERUS). Gobierno del Estado de Veracruz, México. [online] URL: http://www.snidrusver.gob.mx/estadisticas/granjaacui.htm.

Oficina de Pesca en Veracruz, 1997. Sistema Veracruzano de encierros. Resultados de proyecto no publicados (unpublished project results). Delegación Federal de Pesca en Veracruz. Secretaría del Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP), México.

Ogata, K., Nawa, Y., Akahane, H., Díaz-Camacho, S.P., Lamothe-Argumedo, R. and Cruz-Reyes, A., 1998. Gnathostomiasis in Mexico. *American Journal of Tropical Medicine and Hygiene,* 58: 316-318.

Olguín, C., Alvarez, M.C., Asiain, A. and Reta, J.L., 1993. Conceptos básicos de la teoría de sistemas aplicados al manejo integral de los recursos naturales de las zonas bajas del trópico húmedo mexicano. pp. 343-351 En: Sistemas de Producción y Desarrollo Agrícola. ORSTOM-CONACYT-CP. Montecillo, Edo. de México, México.

Olguín, C. and Asiain, A., 1994. Water table management in temporary flooded areas for food production in tropical Mexico. *Transactions of the 15th World Congress of Soil Science,* 7: 23-24.

Olguín, C., 1999. Fertigación orgánica: investigación y transferencia. *Terra,* 17: 175-178.

Olguín, C., Alvarez A., M.C. and Asiain H., A., 1999. Tecnología agroacuícola en la cuenca baja del río Papaloapan. La experiencia del Campus Veracruz del Colegio de Postgraduados. *Serie Estudios de Caso sobre Participación Campesina en Generación, Validación y Transferencia de Tecnología,* Red de Gestión de Recursos Naturales y Fundación Rockefeller. México. 108p.

Olguín, C. and Alvarez, M.C., 1980. Generación de técnicas de producción de cultivos flotantes sub-irrigados, como factor tecnológico central en la explotación integral de ecosistemas acuáticos del trópico húmedo. Proyecto de investigación financiado por CONACYT, México. No publicado.

Olguín, C. and Asiain, A., 2001. Utilización y manejo integral de acahuales con cultivos de sombra. pp. 49-54 En: G.A. Narváez R., R. Ríos R. y S. Quintero S. (Eds). 2001. Memoria del Segundo Foro Internacional sobre los Aprovechamientos Forestales en Selvas y su Relación con el Ambiente. Veracruz, México. 2-5 diciembre 1997. SEMARNAP, SDAP, COFAN-FAO.

Oliver-Smith, A., 2002. Displacement, resistance and the critique of development: from the grass-roots to the global. Refugee Studies Centre Working Paper No. 9. Queen Elizabeth House, International Development Centre, University of Oxford, UK. 68 pp.

Olivo, M., Alarcón-Cháires, P. and Solis, L., 2001. Los pueblos del maiz. Nomenclatura indígena de una planta sagrada. *Etnoecológica,* 6: 103-106.

Orozco, M., 2002. Globalization and migration: the impact of family remittances in Latin America. *Latin American Politics and Society,* 44: 41-67.

Ortiz-Ferrara, G., Joshi, A.K., Chand, R., Bhatta, M.R., Mudwari, A., Thapa, D.B., Sufian, M.A., Saikia, T.P., Chatrath, R., Witcombe, J.R., Virk, D.S. and Sharma, R.C., 2007. Partnering with farmers to accelerate adoption of new technologies in South Asia to improve wheat productivity. *Euphytica,* 157: 399-407.

Osti, G., 2000. LEADER and partnerships: the case of Italy. *Sociologia Ruralis,* 40: 172-180.

Paz, O., 1991. La búsqueda del presente (In search of the present). Nobel Lecture, 1990. *In*: Frängsmyr, T. (Editor) 1991. *The Nobel Prizes 1990*. Stockholm, Sweden. [online] URL: http://nobelprize.org/nobel_prizes/literature/laureates/1990/paz-lecture-e.html.

Pérez-Alemán, P., 2005. Cluster formation, institutions and learning: the emergence of clusters and development in Chile. *Industrial and Corporate Change,* 14: 1-27.

Pérezgrovas, V., López, M., Anzueto, W., Rodríguez, F. and Gómez, E., 1998. El cultivo de café orgánico en la Unión Majomut. Un proceso de rescate, sistematización, evaluación y divulgación de tecnología agrícola. *Serie Estudios de Caso sobre Participación Campesina en Generación, Validación y Transferencia de Tecnología,* Red de Gestión de Recursos Naturales y Fundación Rockefeller. México.

Perez-Sanchez, E. and Muir, J.F., 2003. Fishermen perception on resources management and aquaculture development in the Mecoacan estuary, Tabasco, Mexico. *Ocean and Coastal Management,* 46: 681-700.

Peña, F., 2004. Pueblos indígenas y manejo de recursos hídricos en México. *Revista Mad,* 11: Departamento de Antropología. Universidad de Chile. 10 pp. [online] URL: http://www.revistamad.uchile.cl/11/paper03.pdf

Phelps, R.P., Cole, W. and Katz, T., 1992. Effect of fluoximesterone on sex ratio and growth of Nile tilapia, *Oreochromis niloticus* (L.). *Aquaculture and Fisheries Management,* 23: 405-410.

Picciotto, R. and Anderson, J.R., 1997. Reconsidering agricultural extension. *The World Bank Research Observer,* 12: 249-259.

Pinkerton, J.R. and Glazier, J.D., 1993. Extending information resources in rural areas. *Journal of Extension,* 31: [online] URL: http://www.joe.org/joe/1993summer/a3.html

Place, F., Kariuki, G., Wangila, J., Kristjanson, P., Makauki, A. and Ndubi, J., 2004. Assessing the factors underlying differences in achievements of farmer groups: methodological issues and empirical findings from the highlands of Central Kenya. *Agricultural Systems,* 82: 257-272.

PNUD, 2003. *Informe sobre desarrollo humano México 2002*. Programa de las Naciones Unidas para el Desarrollo. Mundi-Prensa, México. 160 pp.

PNUD, 2004. Indice de Desarrollo Humano Municipal en México. CD-ROM. Programa de las Naciones Unidas para el Desarrollo, México. [online] URL: http://saul.nueve.com.mx/disco/index.html.

Poleman, T.T., 1964. *The Papaloapan project*. Stanford University Press, Stanford, California.

Pomeroy, R.S., Pollnac, R.B., Katon, B.M. and Predo, C.D., 1997. Evaluating factors contributing to the success of community-based coastal resource management: the Central Visayas Regional Project-1, Philippines. *Ocean and Coastal Management,* 36: 97-120.

Poteete, A.R. and Ostrom, E., 2004. In pursuit of comparable concepts and data about collective action. *Agricultural Systems,* 82: 215-232.

Prein, M., 2002. Integration of aquaculture into crop-animal systems in Asia. *Agricultural Systems,* 71: 127-146.

Pretty, J.N. and Shah, P., 1997. Making soil and water conservation sustainable: from coercion and control to partnerships and participation. *Land Degradation and Development,* 8: 39-58.

Pritchett, L., 2006. Who is not poor? Dreaming of a world truly free of poverty. *The World Bank Research Observer,* 21: 1-23.

Pulamte, L. and Abrol, D., 2003. Technology transfer for rural development: managing R and D at CSIR. *Economic and Political Weekly,* 38: 3315-3318.

Pullmann, H. and Allik, J., 2000. The Rosenberg Self-Esteem Scale: its dimensionality, stability and personality correlates in Estonian. *Personality and Individual Differences,* 28: 701-715.

Quijada, J.P., 1992. Reacomodos: treinta ańos despueś. *Alteridades,* 2: 61-66.

Quińones, P.H., Unland, H., Ojeda, W. and Sifuentes, E., 1999. Transfer of irrigation scheduling technology in Mexico. *Agricultural Water Management,* 40: 333-339.

Raina, R.S., 2003. Disciplines, institutions and organizations: impact assessments in context. *Agricultural Systems,* 78: 185-211.

Ramos, J.M. and Díez, A., 2003. Blending old and new technologies: Mexico's indigenous radio service messages. pp. 172-179 (Chapter 13) In: Girard, B. (Editor). *The one to watch: radio*, *new ICTs and interactivity*. FAO, Rome. 233 pp.

Ramos S., F.J., 1998. Grupo Vicente Guerrero de Espańita, Tlaxcala. Dos décadas de promoción de campesino a campesino. *Serie Estudios de Caso sobre Participación Campesina en Generación, Validación y Transferencia de Tecnología,* Red de Gestión de Recursos Naturales y Fundación Rockefeller. México.

Ravaillon, M., 1999. Are poorer states worse at targeting their poor? *Economic Letters,* 65: 373-377.

Reardon, T., 1995. Sustainability issues for agricultural research strategies in semi-arid tropics: focus on the Sahel. *Agricultural Systems,* 48: 345-359.

Rector, N.A. and Roger, D., 1996. Cognitive style and well-being: a prospective examination. *Personality and Individual Differences,* 21: 663-674.

Rehman, T., McKemey, K., Yates, C.M., Cooke, R.J., Garforth, C.J., Tranter, R.B., Park, J.R. and Dorward, P.T., 2007. Identifying and understanding factors influencing the uptake of new technologies on dairy farms in SW England using the theory of reasoned action. *Agricultural Systems,* 94: 281-293.

Reta-Mendiola, J.L., 2004. Estrategia participativa de transferencia de tecnología para la optimización de la producción de tilapia en el estado de Veracruz. Informe final de proyecto. Fundación PRODUCE-Veracruz y SIGOLFO-CONACYT, convocatoria 2000. No publicado. 97 pp.

Reta-Mendiola, J.L., Asiain Hoyos, A., Gallardo López, F. and Suárez Santacruz, C., 2004. Modelo de transferencia de tecnología para la optimización de la producción de tilapia en Veracruz, México. Avances de Investigación en el Campus Veracruz del Colegio de Postgraduados, México. 8 pp. [online] URL: http://www.colpos.mx/cveracruz/SubMenu_Publi/Avances2004/Transferencia_tilapia.html.

Reta-Mendiola, J.L., Asiain Hoyos, A., Gallardo López, F. and Suárez Santacruz, C., 2005a. Modelo de transferencia tecnológica para la optimización de la producción de tilapia en Veracruz, México. Décima octava reunión científica-tecnológica forestal y agropecuaria. Veracruz, México. 8 pp.

Reta-Mendiola, J.L., Hernández-Dworak, R., Luna, F.J., Asiain-Hoyos, A. and Coello, A., 2005b. Tilapia culture in Veracruz, Mexico: the perfect place for the perfect fish. *Panorama Acuícola Magazine,* 3: 10-19.

Reta-Mendiola, J.L., 1999. An integrated agroecosystems analysis model for tropical wetlands in Veracruz, Mexico. Ph.D. Thesis. University of Stirling, UK.

Rhoda, R., 1983. Rural development and urban migration: can we keep them down on the farm? *International Migration Review,* 17: 34-64.

Rice, E., Smale, M. and Blanco, J.L., 1998a. Farmers' use of improved seed selection practices in Mexican maize: evidence and issues from the Sierra de Santa Marta. *World Development,* 26: 1625-1640.

Rice, E., Erenstein, O. and Godínez, L., 1998b. The farming systems of the Texizapan watershed, Sierra de Santa Marta, Veracruz, Mexico. NRG Copublication 98-01. International Maize and Wheat Improvement Center (CIMMYT) and the Proyecto Sierra de Santa Marta (PSSM). México, 32 pp.

Rice, E., Smale, M. and Blanco, J.-L., 1997. Farmers' use of improved seed selection practices in Mexican maize: evidence and issues from the Sierra de Santa Marta. Economics Working Paper 97-03. International Maize and Wheat Improvement Center (CIMMYT), México. 42 pp.

Ridler, N. and Hishamunda, N., 2001. Promotion of sustainable commercial aquaculture in sub-Saharan Africa. Volume 1. Policy framework. FAO Fisheries Technical Paper. No. 408-1. Rome. 67 pp.

Rigg, J., 2005. Poverty and livelihoods after full-time farming: a South-East Asian view. *Asia Pacific Viewpoint,* 46: 173-184.

Rivera, W., 1992. Global trends in extension privatization. *Journal of Extension,* 30: [online] URL: http://www.joe.org/joe/1992fall/intl1.html

Rivera, W.M., 1990. Future of extension worldwide. *Journal of Extension,* 28: [online] URL: http://www.joe.org/joe/1990fall/fut1.html

Rivera, W.M., Qamar, K. and Van Crowder, L., 2001. *Agricultural and rural extension worldwide: options for institutional reform in the developing countries*. FAO/SDRE. Rome. 49 pp.

Rivera, W.M. and Qamar, M.K., 2003. *Agricultural extension, rural development and the food security challenge*. FAO. Rome. 83 pp.

Rivera, W. and Alex, G., 2006. Contracting for agricultural extension: review and analysis of diverse public/private contracting arragements worldwide. pp. 570-579 In: Proceedings of the 22nd Annual Conference of the Association for International Agricultural and Extension Education. May 14-19, 2006, Clearwater Beach, Florida, USA.

Rivers, T.J., 2002. Progress and technology: their interdependency. *Technology in Society,* 24: 503-522.

Rivers, T.J., 2005. An introduction to the metaphysics of technology. *Technology in Society,* 27: 551-574.

Robertson, R., 2000. Trade liberalisation and wage inequality: lessons from the Mexican experience. *The World Economy,* 23: 827-849.

Robinson, S., 2000. The experience with dams and resettlement in Mexico. Working paper of the World Commission on Dams. Prepared for thematic review I.3: Displacement , resettlement, rehabilitation, reparation and development. Cape Town, South Africa. 14 pp.

Robles G., C.A. and Almeida M., E., 1998. Experimentación campesina y tecnología sustentable en los Tuxtlas. El camino hacia una agricultura ecológica. *Serie Estudios de Caso sobre Participación Campesina en Generación, Validación y Transferencia de Tecnología,* Red de Gestión de Recursos Naturales y Fundación Rockefeller. México.

Rockström, J., 2000. Water resources management in smallholder farms in eastern and southern Africa: an overview. *Physics and Chemistry of the Earth (B),* 25: 275-283.

Rodriguez, B.M., 2006a. Disseminating genetically improved tilapia fingerlings through the GIFT licensing program. pp. 21-23 In: B.O. Acosta, R.C. Sevilleja and M.V. Gupta (eds.) Public and private partnerships in aquaculture: a case study on tilapia research and development. WorldFish Center Conf. Proc. 72, 72 pp.

Rodriguez, B.M., 2006b. Generating resources to continue tilapia genetic improvement research and development through public-private sector partnerships in Philippines. pp. 39-52 In: B.O. Acosta, R.C. Sevilleja and M.V. Gupta (eds.) Public and private partnerships in aquaculture: a case study on tilapia research and development. WorldFish Center Conf. Proc. 72, 72 pp.

Rogers, E.M., Takegami, S. and Yin, J., 2001. Lessons learned about technology transfer. *Technovation,* 21: 253-261.

Romero, R., 2005. Las Cańadas, reserva comunitaria de bosque de niebla. Centro agroecológico y de ecoturismo. Memorias 1er. Congreso Internacional de Casos Exitosos de Desarrollo Sostenible del Tropico. Universidad Veracruzana - Centro de Investigaciones Tropicales. Boca del Río, Veracruz, México. 9 pp.

Román-Ponce, H., Bueno D., H.M., Aguilar B., U., Pérez S., J.M., Rodríguez Ch., M.A. and Koppel R., E.T., 2001. *Manual del modelo GGAVATT*. Folleto Técnico No. 27. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias, México. Litográfica Alfa y Omega. 91 pp.

SAGARPA, 2001. *Programa sectorial de agricultura, ganadería, desarrollo rural, pesca y alimentación 2001-2006*. Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. México. 215 pp.

Salazar-Xirinachs, J.M. and Tavares de Araujo, J., 1999. The free trade area of the Americas: a Latin American perspective. *The World Economy,* 22: 783-797.

Salgado-Maldonado, G., Aguilar-Aguilar, R., Cabańas-Carranza, G., Soto-Galera, E. and Mendoza-Palmero, C., 2005. Helminth parasites in freshwater fish from the Papaloapan river basin, Mexico. *Parasitology Research,* 96: 69-89.

Sanchez-Gil, P., Yanez-Arancibia, A., Ramirez-Gordillo, J., Day, J.W. and Templet, P.H., 2004. Some socio-economic indicators in the Mexican states of the Gulf of Mexico. *Ocean and Coastal Management,* 47: 581-596.

Sandos, J.A. and Cross, H.E., 1983. National development and international labour migration: Mexico 1940-1965. *Journal of Contemporary History,* 18: 43-60.

Santos J., V., Carreón-Mundo, M. and Nelsom, K.C., 1998. La organización de ejidos productores forestales de la zona Maya. Un proceso de investigación participativa. *Serie Estudios de Caso sobre Participación Campesina en Generación, Validación y Transferencia de Tecnología,* Red de Gestión de Recursos Naturales y Fundación Rockefeller. México.

SARH, 1972. *Informe de labores de la Comisión del Papaloapan, 1947-1972*. Secretaría de Agricultura y Recursos Hidráulicos, México.

SARH, 1990. *Memoria de la Comisión del Río Papaloapan, Tomos I y II.* Secretaría de Agricultura y Recursos Hidráulicos, México.

Sarkar, J., 1998. Technological diffusion: alternative theories and historical evidence. *Journal of Economic Surveys,* 12: 131-176.

Scheuermeier, L.B.L., 2004. Farmer exchange networks in Paraguay. The approach of the TTR-project. *BeraterInnen News,* 2: 15-20.

Schott, J.J. and Hufbauer, G.C., 1999. Whither the free trade area of the Americas? *The World Economy,* 22: 765-782.

Scoones, I., 1998. Sustainable rural livelihoods: a framework for analysis. IDS Working Paper 72. Institute of Development Studies. Brighton, UK. 22 pp.

Scott, J.T., 1964. The measurement of technology. *Journal of Farm Economics,* 46: 657-661.

Seafood Today, 2006. El Sr. Pescado está de regreso. 6: 28-29.

Seboka, B. and Deressa, A., 2000. Validating farmers' indigenous social networks for local seed supply in central rift valley of Ethiopia. *The Journal of Agricultural Education and Extension,* 6: 245-254.

SECODAM, 2002. *México contra la corrupción*. *Para leer sobre transparencia,* 7: Secretaría de Contraloría y Desarrollo Administrativo, México. 8 pp.

SENASICA, 2006. Dirección General de Inocuidad Agroalimentaria, Acuícola y Pesquera. Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria (SENASICA). Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación. México. [online] URL: http://senasicaw.senasica.sagarpa.gob.mx.

Seneviratne, W., 2004. Local information upload strategy in building up rural community information pages on the Internet: an approach to attending the information needs of rural Sri Lanka. *The International Information and Library Review,* 36: 241-252.

SEP, 2003. *Sistema Educativo de los Estados Unidos Mexicanos, principales cifras, ciclo escolar 2002-2003*. Secretaría de Educación Pública, México. 87 pp.

Sevilleja, R.C., 2001. Adoption and economics of tilapia farming technology in the Philippines. *In*: Microbehavior and Macroresults. Proceedings of the Tenth Biennial Conference of the International Institute for Fisheries Economics and Trade, July 10-14, 2000, Corvallis, Oregon, USA. Compiled by Richard S. Johnston and Ann L. Shriver, International Institute for Fisheries Economics and Trade (IIFET).

Sevilleja, R.C., 2002. Small-scale aquaculture and adoption of genetics-based tilapia technology. Paper presented in the 14th Agricultural Policy Forum on "Socioeconomic and Policy Issues: the Aquaculture Sector". Makati City, Philippines. May 6, 2002. 13p.

Sevilleja, R.C., 2006. The effects of evolving partnerships on access to and uptake of tilapia genetic improvement technologies and their products: results of survey and policy implications. pp. 24-38 In: B.O. Acosta, R.C. Sevilleja and M.V. Gupta (eds.) Public and private partnerships in aquaculture: a case study on tilapia research and development. WorldFish Center Conf. Proc. 72, 72 pp.

Shah, K. and Gupta, V., 2000. Tourism, the poor and other stakeholders: experience in Asia. *Sustainable Livelihoods.,* Fair Trade in Tourism Paper. London: ODI

Shannon, C.E., 1948. A mathematical theory of communication. *The Bell System Technical Journal,* 27: 379-423, 623-656.

Shevlin, M., Brunsden, V. and Miles, J.N.V., 1998. Satisfaction With Life Scale: analysis of factorial invariance, mean structures and reliability. *Personality and Individual Differences,* 25: 911-916.

Shrestha, N.R., 1997. On "What causes poverty? A postmodern view" A postmodern view or denial of historical integrity? The poverty of Yapa's view of poverty. *Annals of the Association of American Geographers,* 87: 709-716.

Shrestha, R.K., Alavalapati, J.R.R. and Kalmbacher, R.S., 2004. Exploring the potential for silvopasture adoption in south-central Florida: an application of SWOT-AHP method. *Agricultural Systems,* 81: 185-199.

Sinclair, F.L., 2001. Process-based research in sustainable agricultural development: integrating social, economic and ecological perspectives. *Agricultural Systems,* 69: 1-3.

Sinclair, F.L. and Walker, D.H., 1998. Acquiring qualitative knowledge about complex agroecosystems. Part 1: Representations as natural language. *Agricultural Systems,* 56: 341-363.

Smith, A., 1776. *An inquiry into the nature and causes of the wealth of nations*. Oxford [1976], Oxford University Press.

Snyder, F.L., 1992. Aquaculture opportunities. *Journal of Extension,* 30: [online] URL: http://www.joe.org/joe/1992fall/a7.html

Solesbury, W., 2003. Sustainable livelihoods: a case study of the evolution of DFID policy. Working Paper 217. ODI, London. 36 pp.

Solimano, A., 2004. Globalization, history and international migration: a view from Latin America. Working Paper No. 37. Intenational Labour Office, Geneva, Switzerland. 33 pp.

Soloaga, I., 2006. Agricultural growth and poverty reduction: the case of Mexico. Paper presented at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006. 16 pp.

Solís, D. and Bravo-Ureta, B.E., 2005. Economic and financial sustainability of private agricultural extension in El Salvador. *Journal of Sustainable Agriculture,* 26: 81-102.

Spielman, D.J. and von Grebmer, K., 2006-. Public-private partnerships in international agricultural research: an analysis of constraints. *Journal of Technology Transfer,* 31: 291-300.

Spreij, M., 2005. National aquaculture legislation overview - Mexico. Inland Water Resources and Aquaculture Service (FIRI). FAO, Rome. [online] URL: http://www.fao.org/figis/servlet/static?dom=legalframework&xml=nalo_mexico.xml.

Stagnitti, F., 1997. A decision support tool for aquaculture. *Environmental Modelling and Software,* 12: 229-236.

Stanley, J., 2003. Financing matters: where funding arrangements meet resettlement in three Mexican dam projects. Refugee Studies Centre Working Paper No. 14. Queen Elizabeth House, International Development Centre, University of Oxford, UK. 53 pp.

Sternberg, R., 2006. Damming the river: a changing perspective on altering nature. *Renewable and Sustainable Energy Reviews,* 10: 165-197.

Stout, T.T. and Ruttan, V.W., 1958. Regional patterns of technological change in American agriculture. *Journal of Farm Economics,* 40: 196-207.

STREAM Initiative, 2005. Livelihoods and fisheries in the Lower Mekong Basin: understanding the concept of livelihoods approaches. Mekong Development Series No. 5. Mekong River Commission, Vientiane, Lao PDR. 20 pp.

Subasinghe, R.P., 2003. An outlook for aquaculture development: major issues, opportunities and challenges. Pages 31-36. *In*: FAO Fisheries Circular No. 886, Rev. 2. Review of the state of world aquaculture. FAO, Rome. 95 pp.

Sulaiman, V.R., Hall, A. and Suresh, N., 2005. Effectiveness of private sector extension in India and lessons for the new extension policy agenda. *ODI Agricultural Research and Extension Network Paper,* No. 141. Overseas Development Institute, London. 11 pp.

Sulser, T.B., Duryea, M.L., Frolich, L.M. and Guevara-Cuaspud, E., 2001. A field practical approach for assessing biophysical sustainability of alternative agricultural systems. *Agricultural Systems,* 68: 113-135.

Sutherland, A.J., Irungu, J.W., Kang'ara, J., Muthamia, J. and Ouma, J., 1999. Household food security in semi-arid Africa - the contribution of participatory adaptive research and development to rural livelihoods in Easten Kenya. *Food Policy,* 24: 363-390.

Swanson, B.E., Bentz, R.P. and Sofranko, A.J., 1997. *Improving agricultural extension. A reference manual*. FAO, Rome. 220 pp.

Tacon, A.G.J., 2001. Increasing the contribution of aquaculture for food security and poverty alleviation. pp. 63-72 In: R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery and J.R. Arthur (Eds.) *Aquaculture in the Third Millennium*. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. NACA, Bangkok and FAO, Rome. 471 pp.

Tayamen, M.M., Abella, T.A. and Sevilleja, R.C., 2006. The role of public sector in dissemination of tilapia genetics research outputs and links with private sector. pp. 16-20 In: B.O. Acosta, R.C. Sevilleja and M.V. Gupta (eds.) Public and private partnerships in aquaculture: a case study on tilapia research and development. WorldFish Center Conf. Proc. 72, 72 pp.

Teitel, S., 1981. Creation of technology within Latin America. *Annals of the American Academy of Political and Social Science,* 458: 136-150.

The Rockefeller Foundation, 1999. Gestión de Recursos Naturales. Un programa de la Fundación Rockefeller en México. [online] URL: http://www.laneta.apc.org/rock/mexico/index.html

Thorpe, A., Aguilar Ibarra, A. and Reid, C., 2000. The New Economic Model and marine fisheries development in Latin America. *World Development,* 28: 1689-1702.

Thorpe, A., Reid, C., van Anrooy, R., Brugere, C. and Becker, D., 2006. Asian development and poverty reduction strategies: integrating fisheries into the development discourse. *Food Policy,* 31: 385-400.

Tilapia Science Center and WorldFish Center, 2003. Angeles Declaration: public-private partnerships for dissemination of research outputs to end-users. Contribution No. 1698. Tilapia Science Center, Philippines and WorldFish Center. 11 pp.

Tilman, D., Cassman, K.G., Matson, P.A., Naylor, R. and Polasky, S., 2002. Agricultural sustainability and intensive production practices. *Nature,* 418: 671-677.

Tokar, D.M., Fischer, A.R. and Mezydlo Subich, L., 1998. Personality and vocational behavior: a selective review of the literature, 1993-1997. *Journal of Vocational Behavior,* 53: 115-153.

Tokar, D.M. and Subich, L.M., 1997. Relative contributions of congruence and personality dimensions to job satisfaction. *Journal of Vocational Behavior,* 50: 482-491.

Toner, A., 2002. Sustainable livelihoods approaches: can they transform development? BCID Research Paper No. 2. Bradford, UK. 36 pp.

Toner, A. and Franks, T., 2005. Putting livelihoods thinking into practice: implications for development management. BCID Research Paper No. 10. Bradford, UK. 24 pp.

Torres-Torres, F., 2002. Aspectos regionales de la seguridad alimentaria en México. *Notas,* 22: 15-26.

Tortajada, C., 2001. Institutions for integrated river basin management in Latin America. *International Journal of Water Resources Development,* 17: 289-301.

Tortajada, C., 2005. River basin management: approaches in Mexico. *VertigO,* Hors série no 1: 1-7

Tortolero, V.A., 1998. Tierra y agua en la agricultura mexicana durante el siglo XIX. *América Latina en la Historia Económica,* 10: 65-76.

Townsley, P., 1993. *A manual on rapid appraisal methods for coastal communities*. Bay of Bengal Programme. Madras, India. 118 pp.

Townsley, P., 1996. Rapid rural appraisal, participatory rural appraisal and aquaculture. FAO Fisheries Technical Paper No. 358. FAO, Rome. 109 pp.

Trewavas, A., 2002. Malthus foiled again and again. *Nature,* 418: 668-670.

Tripp, R., 2000. GMOs and NGOs: biotechnology, the policy process, and the presentation of evidence. *Natural Resource Perspectives.,* Paper No. 60. London: ODI

Tripp, R., 2005. *Self-sufficient agriculture: labour and knowledge in small-scale farming*. Earthscan, London, UK. 256 pp.

Turton, C., 2000a. Enhancing livelihoods through participatory watershed development in India. *Sustainable Livelihoods.,* Working Paper 131. London: ODI

Turton, C., 2000b. Sustainable livelihoods and project design in India. *Sustainable Livelihoods.,* Working Paper 127. London: ODI

Turton, C., 2000c. The sustainable livelihoods approach and programme development in Cambodia. *Sustainable Livelihoods.,* Working Paper 130. London: ODI

Tyrtania, L., 1992. La evolución de los lagos artificiales: el impacto ecológico de la Presa Miguel Alemán. *Alteridades,* 2: 103-108.

Umali-Deininger, D., 1997. Public and private agricultural extension: partners or rivals? *The World Bank Research Observer,* 12: 203-224.

Umali, D.L. and Schwartz, L., 1994. Public and private agricultural extension. Beyond traditional frontiers. Discussion Paper 236. The World Bank, Washington, D.C. 82 pp.

UNDP, 2001. Approaches to sustainability: decentralization, civil society and sustainable development in Mexico. Capacity 21. United Nations Development Programme. Washington, DC. 41 pp. [online] URL: http://www.undp.org/capacity21/docs/ats/ats-mexico-en.doc.

UNDP, 2003. *Human Development Report 2003. Millennium Development Goals: a compact among nations to end human poverty*. United Nations Development Programme, New York. Oxford University Press. 367 pp.

UNDP, 2004. *Human Development Report 2004. Cultural liberty in today's diverse world.* United Nations Development Programme. New York. 285 pp.

UNDP, 2006. *Human Development Report 2006. Beyond scarcity: power, poverty and the global water crisis*. United Nations Development Programme, New York. Palgrave Macmillan. 422 pp.

UNIDO, 2001. Development of clusters and networks of SMEs. United Nations Industrial Development Organization. Vienna. 36 pp.

United States Congress, 1933. Tennessee Valley Authority Act of 1933. [48 Stat. 58-59 , 16 U.S.C. sec. 831].

Valero, A., Schipper, J. and Allnutt, T., 2001. Veracruz moist forests (NT0176). World Wildlife Fund. Draft ecoregion profile. [online] URL: http://www.worldwildlife.org/wildworld/profiles

Valero, J.N., Treviño, L., Chapa, J. and Ponzio, C.A., 2006. Navegando contra corriente: pobreza, ciclos económicos y políticas gubernamentales en México, 1992-2002. Facultad de Economía, Universidad Autónoma de Nuevo León, México. 41 pp.

van den Ban, A.W., 1999. Agricultural development; opportunities and threats for farmers and implications for extension organisations. *The Journal of Agricultural Education and Extension,* 6: 145-156.

van den Ban, A.W., 2000. Different ways of financing agricultural extension. *ODI Agricultural Research and Extension Network Paper,* No. 106b. Overseas Development Institute, London.

van den Berg, P.T. and Pitariu, H., 2005. The relationships between personality and well-being during societal change. *Personality and Individual Differences,* 39: 229-234.

Vanden Berg, T.M., 1999. "We are not compensanting rocks": resettlement and traditional religious systems. *World Development,* 27: 271-283.

Viglizzo, E.F. and Roberto, Z.E., 1998. On trade-offs in low-input agroecosystems. *Agricultural Systems,* 56: 253-264.

Vollebergh, H.R.J. and Kemfert, C., 2005. The role of technological change for a sustainable development. *Ecological Economics,* 54: 133-147.

Wade, R.H., 2004. Is globalization reducing poverty and inequality? *World Development,* 32: 567-589.

Wadsworth, J., 1995. Adoption of innovations by Costa Rican livestock producers under different levels of extension intensity: predicted versus observed behaviour. *Agricultural Systems,* 49: 69-100.

Waggoner, P.E., 2004. Agricultural technology and its societal implications. *Technology in Society,* 26: 123-136.

Walker, D.H. and Sinclair, F.L., 1998. Acquiring qualitative knowledge about complex agroecosystems. Part 2: Formal representation. *Agricultural Systems,* 56: 365-386.

Warner, M., 2000. Conflict management in community-based natural resource projects: experiences from Fiji and Papua New Guinea. Working Paper 135. London: ODI

Wayne, J.H., Musisca, N. and Fleeson, W., 2004. Considering the role of personality in the work-family experience: Relationships of the big five to work-family conflict and facilitation. *Journal of Vocational Behavior,* 64: 108-130.

Webber, L.M. and Ison, R.L., 1995. Participatory Rural Appraisal design: conceptual and process issues. *Agricultural Systems,* 47: 107-131.

White, K., O'Neill, B. and Tzankova, Z., 2004. At a crossroads: will aquaculture fulfill the promise of the blue revolution? A Sea Web Aquaculture Clearinghouse report. 17 pp. [online] URL: http://www.seaweb.org/resources/sac/pdf/At_Crossroads.pdf

Winnie, W.W., 1958. The Papaloapan Project: an experiment in tropical development. *Economic Geography,* 34: 227-248.

Winters, P., Corral, L. and Gordillo, G., 2001. Rural livelihood strategies and social capital in Latin America: implications for rural development projects. Working Paper Series in Agricultural and Resource Economics No. 2001-6. University of New England. 28 pp.

Winters, P., Davis, B. and Corral, L., 2002. Assets, activities and income generation in rural Mexico: factoring in social and public capital. *Agricultural Economics,* 27: 139-156.

Wolf, S., Just, D. and Zilberman, D., 2001. Between data and decisions: the organization of agricultural economic information systems. *Research Policy,* 30: 121-141.

World Bank, 1997. Mexico - Aquaculture Development Project. Staff Appraisal Rport No. 16476-ME. 114 pp.

World Bank, 2003. Mexico southern states development strategy. 37 pp. *In*: Develpment strategy for the Mexican southern states. Volume 1: synthesis report. World Bank, Washington, DC.

World Bank, 2004. Poverty in Mexico: an assessment of conditions, trends and government strategy. Report No. 28612-ME. The World Bank, Washington, D.C. 252 pp.

World Bank, 2006a. Aquaculture: changing the face of the waters. Meeting the promise and challenge of sustainable aquaculture. Report No. 36622 - GLB. The International Bank for Reconstruction and Development / The World Bank. Washington, DC. 127 pp.

World Bank, 2006b. Doing business in Mexico. The World Bank and the International Finance Corporation. Washington, D.C. 51 pp.

World Commission on Dams, 1999. Large dams and their alternatives in Latin America: experiences and lessons learned. Summary Report. Regional consultation of the World

Commission on Dams. 11-12 August 1999, São Paulo, Brazil. 59 pp.

World Commission on Dams, 2000. *Dams and development: a new framework for decision-making*. Earthscan Publications Ltd. 404 pp.

Yiridoe, E.K. and Weersink, A., 1997. A review and evaluation of agroecosystem health analysis: the role of economics. *Agricultural Systems,* 55: 601-626.

Young, J.A. and Muir, J.F., 2002. Tilapia: both fish and fowl? *Marine Resource Economics,* 17: 163-173.

Zetina-Córdoba, P., Reta M., J.L., Becerril H., M., Asiain H., A. and Enríquez G., F., 2003a. Formación de grupos de crecimiento productivo simultáneo (GCPS) para la transferencia de tecnología en trucha arcoiris (una aproximación al modelo). pp. 75-89 En: M.A. Torneri C., J.F. López-Olguín y A. Aragón G. (Eds). 2003. *Agricultura, ambiente y desarrollo sustentable*. Publicación especial de la Benemérita Universidad Autónoma de Puebla (BUAP), México.

Zetina-Córdoba, P., 2003. Rentabilidad del cultivo de mojarra tilapia (Oreochromis spp.) en seis agroecosistemas del Estado de Veracruz. Tesis de Maestría. Programa de Agroecosistemas Tropicales, Colegio de Postgraduados, México.

Zetina-Córdoba, P., Reta Mendiola, J.L., Olguín Palacios, C. and Acosta Barradas, R., 2003b. Rentabilidad del cultivo de mojarra tilapia (*Oreochromis* spp.) en seis agroecosistemas del estado de Veracruz (México). Pages 851-859 In: Memorias del II Congreso Iberoamericano Virtual de Acuicultura CIVA 2003 (http://www.civa2003.org).

Zetina-Córdoba, P., Reta Mendiola, J.L., Olguín Palacios, C., Acosta Barradas, R. and Espinosa Sánchez, G., 2006. El cultivo de tilapia (*Oreochromis* spp) en la rentabilidad de seis agroecosistemas en el estado de Veracruz, México. *Técnica Pecuaria en México,* 44: 169-179.

Ziccardi, A., 1999. Pobreza, territorio y políticas sociales. *Revista Mexicana de Sociología,* 61: 109-126.

APPENDIXES

Appendix 1. Graphic memory.

Cage culture of tilapia is the main water-based intensive system in the area.

Many cage-based production units are managed by organized farmers, which share culture responsibilities and returns.

In some cases, high stocking densities together with limited water circulation make essential the use of aeration systems.

Low-volume high-density cage fish culture is becoming more popular in the region.

Pen culture and enclosures are the other water-based culture systems quite popular in the area.

“Trench” tanks represent a cheap entry point for new entrants.

Earth ponds are the most common land-based systems in the area.

Tilapia culture diversifies the livelihood portfolio of many vulnerable groups, particularly in remote areas.

Tanks of different size, shape and materials are gradually becoming more popular.

Hapas are commonly used in hatchery operations.

In many rural areas, the harvest is consumed and commercialized locally.

Participative methodologies are increasingly been used in community-based interventions.

Appendix 2. Juridical framework of aquaculture in Mexico (adapted from González and Garita, 1994; and Spreij, 2005).

I. Laws and regulations

- **Constitution** (Constitutión Política de los Estados Unidos Mexicanos) (1917, as amended)
- **The Fisheries Law** (Ley de Pesca) (1992)
- **Regulation to the Fisheries Law** (Reglamento de la Ley de Pesca) (1999)
- **National Water Law** (Ley de Aguas Nacionales) (1992, as amended)
- **Regulation to the National Water Law** (Reglamento de la Ley de Aguas Nacionales) (1994, as amended in 1997)
- **Decree concerning the creation of the National Commission for Aquaculture and Fisheries** (Decreto por el que se crea la Comisión Nacional de Acuacultura y Pesca) (2001)
- **By-laws of the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food** (Reglamento Interior de la Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación)
- **General Law of Ecological Balance and Environmental Protection** (1988, as amended)
- **Regulation to the General Law of Ecological Equilibrium and Environmental Protection Regarding Environmental Impact Assessment** (Reglamento de la Ley General del Equilibrio Ecológico y la Protección al Ambiente en Materia de Evaluación del Impacto Ambiental (2000).
- **Federal Animal Health Law** (Ley Federal de Sanidad Animal) (1993)
  Foreign Investment Law (Ley de Inversión Extranjera) (1993, as amended)
- **Regulations to the Foreign Investment Law and to the National Foreign Investment Registry** (Reglamento de la Ley de Inversión Extranjera y del Registro Nacional de Inversiónes Extranjeras) (1998)
- **General Health Law** (Ley General de Salud) (1984, as amended)
- **General Law of National Property** (Ley General de Bienes Nacionales) (1982)
- **Regulation for the use and exploitation of the territorial sea, navigable waters, beaches, federal maritime zones and lands gained from the sea**

(Reglamento para el uso y aprovechamiento del mar territorial, vías navegables, playas, zona federal marítimo terrestre y terrenos ganados al mar) (1991)

- **Sectoral Program for Agriculture, Livestock, Rural Development, Fisheries and Food 2001-2006** (Programa Sectorial de Agricultura, Ganadería, Desarrollo Rural Pesca y Alimentación 2001-2006).

II. Basic legislation

The setting up of an aquaculture facility in federal water bodies is managed and controlled by a system of concessions, permits and authorizations, depending on the type of aquaculture, to be issued by CONAPESCA. According to the Fisheries Law, the public interest and the availability and conservation of resources should be taken into account when granting concessions and permits. In addition, according to the General Law of Ecological Balance and Environmental Protection (hereinafter: Environmental Law), the protection of aquatic ecosystems and their ecological balance must be taken into account when granting concessions for aquaculture activities.

Concession: Commercial aquaculture (*acuacultura comercial*), carried out with the aim of obtaining economic benefits, requires a concession, which may be granted to Mexican nationals and foreigners, or to Mexican entities. The Concession may be granted for a maximum period of 50 years. The application for a concession should contain a technical and economic study, which should provide information regarding:

- Technical-biological indicators.
- Biological aspects of the species to be cultivated.
- Location, including the geographical coordinates of the production area.
- Site selection criteria.
- Requirements and programs regarding the supply of aquatic organisms.
- Description of the technologies to be applied in each phase of cultivation, except for harvesting.
- Health measures and operation techniques.
- Distribution and description of infrastructure.
- Amount and distribution of investment.
- Financial analysis of the project.
- Employment to be generated.

In addition, the application should be accompanied by an environmental impact assessment, preventive report or authorization obtained from the competent authority.

Generally, the concession should be issued within a period of 45 days. The Law and the Regulations address in detail the procedures to be followed when an extension of the concession is required. The concession may be transferred and the holder may be substituted after authorization of CONAPESCA.

The concession holder has the following obligations:

- Cultivate exclusively the authorized species or group of species in the areas established in the concession.
- Present during the first two months of the year the status of the technical and economic status of the project objective of the concession.
- Present information on harvesting and production data.
- Present information on harvesting and production within 72 hours; the report must be filled in and signed immediately after harvesting and production.
- Comply with the technical and economic conditions for the exploitation of the species, group of species or areas established in the concession.
- Assist in the preservation of the environment and the conservation and reproduction of species, including repopulation programs.
- Inform the competent authorities on findings, investigations, studies and new projects in relation to aquaculture, within the applicable legal terms, and taking into account intellectual property rights, if any; SAGARPA has a duty to treat this information as confidential.
- Comply with norms and measures of aquatic health.
- Maintain in good condition land-based establishments and permanent or temporary cultivation equipment in water bodies, and remove such establishments and equipment when requested by the competent authority.
- Allow and facilitate personnel of SAGARPA to carry out inspections.
- Admit observers designated by SAGARPA to collect scientific or technological information.
- Collaborate with SAGARPA on its aquatic programs.

- To keep a register containing the entries and exits of aquatic organisms, measures of prevention and control, as well as information on diseases.

Permit: A permit is required for exploratory aquaculture (*acuacultura de fomento*), which is carried out with the aim of study, scientific research, experimentation and exploration, and which is oriented at the development of biotechnology or any other type of innovative technology in any phase of cultivation of species of aquatic flora and fauna. A permit may be granted to Mexican and foreign scientists, technical experts and research institutes. A permit may be granted to persons or establishments that cultivate, market or process aquaculture products as long as they fulfil the requirements established for research institutes. In addition, the permit may establish limitations and conditions to the sale of the aquaculture products. The Regulation requires a minimum of 5% of the profits to be used for the development of research activities. Permits can be granted for a maximum period of four years.

Applicants are required to demonstrate and prove their scientific and technical ability. The application for a permit should be accompanied by a program or project of study or scientific research, which should provide information regarding:

- Names of the responsible person and the technical experts of the project.
- Objectives.
- Practical application of the results.
- Common and scientific name of the species of study or research.
- Location at macro-level (at local, municipal and state level).
- Location at micro-level, including geographical coordinates, as well as an indication of the necessary surface.
- Justification of the selected site.
- Description of the infrastructure.
- System and technique of cultivation, excluding harvesting.
- Origin and quantity of organisms.
- Preventive measures for sanitary control and diagnosis.
- Marketing.

The permit should be issued within a period of 45 days. The permit may be transferred and the holder may be substituted after authorization of CONAPESCA. The permit holder has the same obligations as the concession holder (see above), with the exception of presenting status reports related to the technical and economic projects. Instead, the permit holder has the obligation to present the results of the project of study or research in the form as prescribed in the permit.

Authorization: An authorization is required for aquaculture for educational purposes (*acuacultura didáctica*), the aims of which are training and instruction of those engaged in aquaculture. Authorizations may be granted only to Mexican nationals and entities. The holder of an authorization is allowed to sell the obtained aquaculture products, as long as the profits are principally used for the development of training and instruction activities. The Law and the Regulation do not specify a maximum period for which an authorization can be issued.

The application for an authorization should be accompanied by a detailed description of the educational programme, including the logistics, and should provide information regarding:

- Names of the responsible person and the technical experts of the project.
- Objectives.
- Practical application of the results.
- Common and scientific name of the cultivated species.

The authorization should be issued within a period of 21 days and is not transferable. The holder of the authorization has the same obligations as the holder of a concession, with the exception of presenting status reports related to technical and economic projects and with the exception of keeping a register.

The collection of reproductive species, larva, post larva, juveniles, eggs, seeds or fingerlings for the purpose of aquaculture or research also requires an authorization. Again, an authorization may be granted only to Mexican nationals and entities. The application for an authorization should provide information regarding:

- Common name, scientific name, state of biological development and number of species to be collected.
- Area of collection.
- Description of equipment to be used for collection, preservation and transport.
- Timetable.
- Landing site.
- Specific characteristics that determine the capacity of the aquatic establishments for acclimatization of the organisms.
- Number of ponds or surfaces to be sowed.
- Cultivation system.

In addition, the applicant should furnish documentation demonstrating his financial ability. In the case of collection for aquaculture purposes, the applicant should show a contract with the farm or hatchery to be supplied (or mention the name and location of the farm when the collection is for its own use) as well as the number and date of the concession. Also, the applicant should furnish documentation demonstrating his financial status.

The authorization should be issued within a period of 21 days and is not transferable. The holder of the authorization may have a duty to undertake repopulation activities according to the terms and conditions established by CONAPESCA. The issuance of the authorization depends on the information furnished by the National Fisheries Institute regarding the number of species, zones and periods for collection. No authorization will be issued when there is a conservation risk. In the case of collection of living aquatic organisms coming from natural populations for the purpose of aquaculture, the Regulations stipulates that the applicable rules on collection, acclimatization, preservation, transport and seed should be observed.

Generally, all concessions, permits and authorizations are registered in the National Fishery Registry, kept by CONAPESCA. Concessions, permits and authorizations end through expiry, revocation, being void or termination in the cases specified by the Law and the Regulation. The Law and the Regulation also establish detailed provisions on inspection, offences and sanctions. The latter include the imposition of fines, seizure of aquaculture products, suspension or revocation of concessions, permits and authorizations and the permanent or temporary closure of facilities that violate certain provisions. Appeals may be filed according to the Law on Administrative Procedure.

III. Land and water tenure

Land legislation in Mexico complex, voluminous and fragmented among numerous enactments. Article 27 of the Mexican Constitution establishes the government's original ownership over the nation's lands and waters and the right to transfer its title to private persons, thereby creating private property. There are two types of private land tenure in Mexico: private property and social or common property. The latter category includes *ejidos* and *comunidades*[1], which are most often in control of areas that are well suited for aquaculture. Since 1992, ownership of common ejido lands may be transferred to business associations in which the ejido or its members participate. Ejido lands may also be contracted out temporarily to third parties. As a result, over the last decade different kinds of agreements have been reached between ejidos and private aquaculture producers. Generally, the ejidos allow access to the land as their contribution to the enterprise. However, opening the possibility for private producers to start aquaculture operations has created problems over property rights. Private, ejido and federal lands (see below) all exist side by side, and in some cases, several parties claim to own the same parcels of land.

Article 27 of the Constitution also establishes inalienable government ownership over lands, waters and natural resources that make up federal public property. These include –*inter alia*– the federal maritime zone (coastal zone), rivers, currents, lakes and lagoons. The General Law of National Property establishes a general regime for granting land use rights over public lands. The management and development of the coastal zone, which extends 20 meters from the high tide line, is regulated in the Regulation for the Use and Exploitation of the Territorial Sea, Navigable Waters, Beaches, Federal Maritime Zones and Lands Gained from the Sea. All use, development and exploitation of the federal coastal zone and beaches, other than the enjoyment of the general public

[1] *Ejidos* are land use systems with their own government structure established by the Mexican state to receive and manage the land that was expropriated from large landowners and redistributed to rural peasants and farmers after the Mexican Revolution. *Comunidades* are essentially communal lands governed by a communal statute similar to that of the ejido system. The creation and operation of *ejidos* and *comunidades* is regulated in the Agrarian Law.

and the carrying out of specifically permitted temporary operations must be authorized. Concession and permit holders who have been granted rights to use federal coastlands are registered in a national registry. According to the Regulation, a permit or concession is not required for the establishment of canals and pipelines for the transport of water by cooperatives, ejidos, comunidades and private persons carrying out aquaculture activities. The establishment of such canals and pipelines, however, may not obstruct the free passage to the coastal zone.

The National Water Law establishes a comprehensive legal regime for the planning, development and management of surface and groundwater resources. The Law is administered by the CNA, which is an autonomous entity falling under the Secretariat of Environment and Natural Resources (SEMARNAT), being the responsible authority for all environmental issues under federal jurisdiction. The Law specifies fish farming as a production activity for which water resources may be used after a concession has been obtained from the CNA. Concessions can be granted for periods up to 50 years. According to the Law, water concessions are not required for farming operations using floating systems. The Law provides for a Public Registry of Water Rights, kept by the CNA, which contains an overview of all issued water concessions (and discharge permits, see below). The Law stipulates that the CNA, in cooperation with SAGARPA, should facilitate the development of farming and the issuance of the necessary water concessions. It should also support, at the request of interested parties, the use of federal water infrastructure for farming provided it is compatible with other uses, provided watercourses are not diverted and provided that water quality, navigation, other permissible uses, and the rights of third parties are not affected. The Law is implemented by the Regulation to the National Water Law.

Finally, the Environmental Law provides for the development of ecological zoning plans. There are four types of ecological zoning plans: national, regional, local and marine. The national ecological zoning plan is issued by SEMARNAT, while regional and local ecological zoning plans are issued respectively by state governments and municipal authorities. Marine ecological zoning plans are also issued by SEMARNAT and must be consistent with the national, regional and local zoning plans. The marine ecological zoning plans should determine the activities that may be carried out in the designated areas, as well as guidelines, strategies and other provisions for the preservation, protection and sustainable exploitation of natural resources.

IV. Environmental Impact Assessment

The Environmental Law requires an Environmental Impact Assessment (EIA) in the case of works and activities that may cause ecological imbalances or surpass the limits and conditions established in the applicable provisions to protect the environment and preserve and restore ecosystems. The Law spells out the works and activities that require prior authorization of SEMARNAT on environmental impact, including *–inter alia–* fishing and aquatic activities endangering the preservation of one or more species or causing damage to the ecosystems. The activities are further defined in the Regulation to the General Law of Ecological Equilibrium and Environmental Protection Regarding Environmental Impact Assessment. They include the construction and operation of farms, ponds and aquatic production parks, the production of postlarvaes and seed, the hatching of exotic species, hybrids and transgenic variations, and the construction of artificial reefs.

The EIA process starts with submission of a preventive report if there are NOMs or other provisions that regulate emissions, discharges, natural resources exploitation and, in general, the environmental impacts caused by the works or activities. A preventive report is also required if the works or activities involved are expressly provided by an urban development partial plan or an ecological zoning plan, or in case of facilities located inside authorized industrial parks. The contents of the preventive report are specified in the Regulation. Upon the preventive report being submitted and analyzed, SEMARNAT determines, within twenty days, whether an Environmental Impact Statement (EIS) is to be submitted or whether the preventive report is sufficient.

According to the Regulation, an EIS can be regional or particular. A regional EIS is to be filed *–inter alia–* in the case of industrial and aquaculture parks and aquaculture farms of more than 500 hectares. A regional EIS must provide information regarding:

- Particulars of the project, the applicant and the person responsible for the EIA.
- Description of the works or undertakings, and, where applicable, of partial development programs or plans.

- Linkage to applicable planning and zoning laws.
- Description of the regional environmental system and an indication of the region's trends in development and deterioration.
- Identification, description and assessment of the cumulative and residual environmental effects of the regional environmental system.
- Strategies to prevent and mitigate the cumulative and residual environmental effects of the regional environmental system.
- Regional environmental forecasts and an assessment of alternatives.
- Identification of methodological instruments and technical elements that support the results of the EIS.

In all cases not specifically provided for in the Regulation, a particular EIS must be submitted. A particular EIS must provide information regarding:

- Particulars of the project, the applicant and the person responsible for the EIA.
- Description of the project.
- Linkage to applicable environmental provisions, and, where applicable, to land use regulations.
- Description of the environmental system and an indication of environmental problems in the project area.
- Identification, description and assessment of environmental impacts.
- Preventive and mitigating measures.
- Environmental forecasts and the identification of alternatives.
- Identification of methodological instruments and technical elements that support the information provided.

Where highly hazardous activities are involved, the EIS must include a risk study containing preventive scenarios and measures that arise from the analysis of environmental risks involved in the project, a description of the facilities' protected zones, and an indication of the environmental safety measures.

In assessing the EIS, SEMARNAT must consider the possible effects of the work or activity on the respective ecosystems, taking into account all the elements therein and not only the resources that may be used or affected. It must also consider the use of natural resources in respect of the functional integrity and load capacities of the ecosystems forming part of the resources for undefined periods, as well as any prevention, mitigation or other measures proposed voluntarily by the applicant to avoid or minimize the negative effects on the environment. Upon assessing the EIS, SEMARNAT may authorize the work or activity, upon conditions or not, or deny the requested authorization. SEMARNAT must issue its ruling within sixty days following the receipt of the EIS. Exceptionally, this period may be extended for up to sixty additional days.

The Federal Attorney General for Environmental Protection (PROFEPA), established as an autonomous entity under SEMARNAT, is generally responsible for enforcing environmental laws, regulations and environmental NOMs. The PROFEPA performs audits and inspections and oversees compliance to the rules regarding EIA.

Finally, all Mexican states have enacted their own environmental legislation and enacted an entity charged with the administration of such laws. According to the Environmental Law, states have the responsibility *–inter alia–* to assess the environmental impact of those works and activities, in coordination with corresponding municipalities that are not expressly reserved to the federal government.

V. Wastewaters

The legal framework governing water pollution is set forth in two laws. The Environmental Law establishes general provisions pertaining to the prevention and control of water pollution that apply generally to all aquatic ecosystems (including marine waters). The National Water Law provides for a comprehensive legal regime that supports these provisions. Besides, NOMs have been issued setting out water quality and wastewater discharge standards, sampling and monitoring procedures, and other requirements. NOM-001-SEMARNAT-1996 sets out the maximum contaminant limits for wastewater discharges into national waters (including marine waters).

Individuals and legal entities, including aquaculture facilities, must obtain a discharge permit from the CNA for any continuous, intermittent or unforeseen wastewater discharges into receiving water bodies (including marine waters). In addition to the standards in the applicable NOMs, the CNA may spell out specific discharge standards.

In doing so, the CNA is required to take into account the applicable NOMs, its own water classification system, third party rights to develop or use the receiving body of water, the restrictions imposed under the National Water Plan and other public interest or general health related issues.

According to the Regulation, the permit holder has the following obligations:

- Treat all wastewater so that the conditions set forth in the NOMs and the permit are complied with.
- Pay fees for discharging wastewater into receiving bodies.
- Install and keep the monitoring equipment in good working condition.
- Inform the CNA of any process changes that entail changes in the volume or characteristics of wastewater discharges.
- Notify CNA of all pollutants present in wastewater discharges that were not originally considered in the permit application.
- Operate and keep all the equipment needed for the handling and treatment of wastewater in good working condition to ensure that the quality of wastewater, prior to its discharge, abides by the NOMs and the permit conditions.
- Cooperate with CNA inspection and enforcement actions.
- Conduct wastewater quality monitoring and sampling in accordance with the sampling standards provided for in the NOMs.
- Keep sampling records for at least three years.
- Comply with any other regulatory or permit requirements.

The Law and the Regulation include detailed provisions on inspection, offences and sanctions. The latter include the imposition of fines, suspension or revocation of discharge permits and the permanent or temporary closure of facilities that violate certain provisions.

VI. Fish movement

According to the Fisheries Law and in particular its Regulation, the introduction of living species in federal water bodies requires an authorization, to be issued by CONAPESCA. The authorization may be granted only to Mexican nationals and entities. The application should provide the following information:

- Scientific and common name of the species, specifying if the species is wild or cultivated.
- Stage of development.
- Quantity and origin, indicating the name and place of the zone or reservoir of capture or, in case of cultivation, the name and place of the establishment.
- Name and place of the zone or reservoir where the species are supposed to be introduced.

In addition, the applicant should present an aquatic health certificate and inform whether it has been verified if the genome of the species to be introduced will not alter the genome of other species. In the case of imported species, a study needs to be included containing disease records in the area of origin as well as records concerning the genetic history. In the case of species that do not exist in their natural form in the national waters, a technical study needs to be included addressing the biology and habits of the species to be introduced. Finally, in the case of exotic species, a description needs to be included of the possible effects on native flora and fauna, in particular protected species. Generally, the authorization should be issued within a period of 21 days and is not transferable.

The National Commission for the Knowledge and Use of Biodiversity (CONABIO) is an inter-secretarial commission, created in 1992, made up of representatives from *–inter alia–* SAGARPA and SEMARNAT. CONABIO generally coordinates the actions and studies related to the knowledge and preservation of biological species and promote and develop scientific research activities for the exploration, study, protection, and use of biological resources.

The Inter-secretarial Commission on Biosafety and GMOs (CIBIOGEM), created in 2002, is also made up of representatives from *–inter alia–* SAGARPA and SEMARNAT. CIBIOGEM aims to coordinate federal policies regarding biosafety and the production, import, export, movement, propagation, liberation, consumption and use of GMOs. Reportedly, CIBIOGEM has developed a list of priority issues, which includes the genetic transformation of fish.

VII. Disease control

Disease control is regulated in the Federal animal Health Law, which is applicable to aquatic animals, and the Fisheries Law, in particular its implementing Regulation, which contains detailed provisions on aquatic health. The National Service of Food Quality and Health (SENASICA), being a federal organ under SAGARPA, has the power to:

- Issue directly, or through accredited laboratories, health certificates for living aquatic organisms and aquatic establishments.
- Establish - in cooperation with the concerning authorities - the drugs, feeds, hormones and other ingredients that may be used in aquaculture.
- Promote the exchange of information with international organizations.
- Regulate quarantine issues, operation of quarantine establishments, genetic management, prevention campaigns and measures, and diagnostic and sanitary control measures in order to protect fishery resources.
- Prohibit the introduction of living aquatic species for sanitary reasons.

A health certificate is required when living aquatic organisms are farmed in farms on the national territory and the organisms are moved from one farm to another, introduced in another water body under federal jurisdiction (see above) or destined for export. Similarly, a health certificate is required if natural populations are captured for aquaculture purposes. A special health certificate is required for the import of living aquatic organisms, in which case the applicant should present –*inter alia*– a health certificate of the country of origin. The Regulation prescribes in detail the requirements and the procedures to be followed for the issuance of health certificates.

In addition, the Regulation addresses the certification and registration of quarantine establishments. It prescribes in detail the application procedure to be followed. The authorization to operate a quarantine establishment should be issued within a period of 21 days.

The following NOMs, which can be complex and may be subject to frequent revision, have been issued on aquatic health:

- NOM-010-PESC-1993 establishes health requirements for the import of living aquatic organisms for aquaculture purposes; it contains a list of organisms that may be imported for aquaculture.
- NOM-011-PESC-1993 regulates the application of quarantine in order to prevent the introduction and spread of diseases, as well as the import of living aquatic organisms for aquaculture purposes; it contains lists of diseases requiring certification and diseases requiring notification.
- NOM-030-PESC-2000 establishes requirements to determine the presence of viral diseases of living and dead crustaceans, their products and sub-products.
- NOM-EM-006-PESC-2004 establishes aquatic health requirements for the production of living and dead crustaceans, their products and sub-products; it also regulates the introduction of living and dead crustaceans into the national territory, which requires an authorization of CONAPESCA; it specifies the information that should be provided in the application and the requirements at the point of entry into the country.

VIII. Drugs

Generally, chemical substances are governed by a number of overlapping laws and regulations that fall under the jurisdiction of several different agencies. Chemical substances are grouped into three categories: pesticides, fertilizers and toxic substances. The most important piece of legislation governing chemical substances is the General Health Law, administered by the Secretariat of Health (SSA), which spells out the definition of pesticides, fertilizers and toxic substances. In addition, the Environmental Law provides general standards pertaining to chemical substances, as part of its soil pollution prevention and control provisions.

Due to the number of laws and agencies that regulate chemical substances, an Inter-Secretarial Commission for the Control of the Processing and Use of Pesticides, Fertilizers and Toxic Substances (CICOPLAFEST) was created in 1987. CICOPLAFEST, which is made up of representatives from *–inter alia–* SAGARPA, SEMARNAT and SSA, administers among other things a uniform procedure for all licensing, registration and permitting of any use, development, manufacture, distribution, storage, commercialization, export or import of chemical substances.

As to aquaculture, as mentioned above, SAGARPA has the authority to establish the drugs, feeds, hormones and other ingredients that may be used. NOM-EM-006-PESC-2004 regulates the use and application of antibiotics, including the establishment of minimum and maximum limits, for the prevention and control of diseases of crustaceans. It stipulates that new pharmaceuticals have to be approved by CONAPESCA and describes the procedure to be followed.

IX. Feed

There are few provisions on the use of feed. As mentioned above, SAGARPA has the authority to establish the feeds that may be used in aquaculture. NOM-EM-006-PESC-2004 specifies that feed producers should inform SAGARPA on a monthly basis of types and doses of pharmaceuticals that are added to feed used in shrimp culture. In addition, it stipulates that in shrimp farming the use of feed based on fresh crustaceans remains prohibited, except for Artemia (*Artemia* spp).

X. Food safety

The safety of food products sold to the public is generally regulated under the General Health Law. All fish and seafood products, whether fresh, frozen or preserved, must meet food safety regulations (NOMs), administered by the Secretariat of Health (SSA). The following NOMs, which can be complex and may be subject to frequent revision, have been issued on the safety of fishery and aquaculture products:

- NOM-027-SSA1-1993 establishes sanitary rules for fresh, cooled and frozen fish.
- NOM-028-SSA1-1993 establishes sanitary rules for preserved fish.
- NOM-029-SSA1-1993 establishes sanitary rules for fresh, cooled and frozen crustaceans.
- NOM-030-SSA1-1993 establishes sanitary rules for preserved crustaceans.
- NOM-031-SSA1-1993 establishes sanitary rules for fresh, cooled and frozen bivalve molluscs.
- NOM-032-SSA1-1993 establishes sanitary rules for preserved bivalve molluscs.
- NOM-128-SSA1-1994 regulates the establishment of the HACCP system in the fish processing industry.

- NOM-129-SSA1-1995 establishes sanitary rules for dried, salted and smoked fish products, as well as fresh, cooled and frozen cephalopod and gastropod molluscs.

XI. Aquaculture investment

The Foreign Investment Law, implemented by the Regulations to the Foreign Investment Law and to the National Foreign Investment Registry, allows up to 100% foreign ownership of aquaculture production, processing and marketing facilities. In general, foreigners are prohibited from acquiring direct dominion over lands or waters in restricted zones (which includes the coastal zone). However, the Law and the Regulation allow foreign ownership in restricted zones, provided a trust is set up for a period not to exceed 50 years. The Law and the Regulation are administered by the General Office of Foreign Investment (DGIE), falling under the Secretariat of Economy and the National Commission of Foreign Investment (CNIE). The CNIE is an inter-secretarial administrative entity with responsibility for establishing policy guidelines and criteria for the application of the legal and regulatory provisions in the area of foreign investment.

Appendix 3. An insight into the extension agent's personality

Traditionally, extension agent's performance has been associated to variables such as technical qualifications, understanding of methodological issues, institutional policies/strategies, availability of material resources, etc. However, technology transfer and extension are communication activities that involve knowledge and information exchange and, increasingly, a facilitatory role (Jones and Garforth, 1997; Fuller, 2003), in which human relations play a decisive role. Although the extension agent's communication skills have been recognized as critical elements to consider during this sort of interventions (Norrish, 2006), the study of the psychosocial aspects of the different stakeholders involved in the communication process is a relatively unexplored field (Garforth et al., 2006; Rehman et al., 2007).

Within the regional context, empirical and anecdotic evidence suggest that some extension agents are better valued and welcomed by farmers than others, despite their qualifications and technical skills. In this context, the extension agent's personality would appear to play an important –yet unknown– role in the whole communication process and, hence, in the success of tilapia farming technology uptake.

Personality has been shown to influence behaviour patterns and interpretations of objective situations in a variety of life domains (Gellatly et al., 1991; Wayne et al., 2004), and it is reasonable to expect that it might also influence personal values and attitudes (Bozionelos, 2004), which have proven to be key elements on work performance.

Although past attempts to show linkages between interests and work performance have been largely unsuccessful (Emmerich et al., 2006), a number of studies show that personality characteristics contribute in an important way to occupational career success, job satisfaction and productivity (Furnham and Zacherl, 1986; Tokar and Subich, 1997; Bradley and Hebert, 1997; Tokar et al., 1998; Lau and Shaffer, 1999; Furnham et al., 1999; Ilies and Judge, 2002; Furnham et al., 2002; van den Berg and Pitariu, 2005; Crossley and Highhouse, 2005; Gelissen and de Graaf, 2006).

During 2002, four extension agents directly involved with the surveyed tilapia farmers volunteered to answer the Raymond Cattell's Sixteen Personality Factor Questionnaire (16PF), a factor-analytically derived questionnaire designed as a research device in the study of personalities (Cattell et al., 1993). The 16 personality factors are generally acknowledged as relevant and valid dimensions of personality in various fields of research (Aluja and Blanch, 2004). The scales remain bipolar in nature, so that both high and low scores have meaning, with the normal range of sten[1] scores being 4 to 7 (mean 5.5, SD 2).

The sample included 1 female and 3 male, ages ranging from 29 to 51 years (median 38), and experience in extension from 6 to 21 years (median 13). Although all of them possessed a degree in biology or aquaculture, their socio-cultural backgrounds were different and none had any formal training on extension methodologies. Two individuals worked in NGOs and 2 were government employees. Results are summarised in Table A5.1 and Figure A5.1.

[1] A sten score is a standard score with a distribution of 1–10 (sten means "standard-ten").

Table A5.1. Cattell's Sixteen Personality Factors.

Factor	Left Meaning	Low				Average		High				Right Meaning
		1	2	3	4	5	6	7	8	9	10	
Warmth (A)	Reserved	·		··	·							Warm
Reasoning (B)	Concrete					·		··		·		Abstract
Emotional Stability (C)	Reactive			·	·	·		·				Emotionally Stable
Dominance (E)	Deferential				·	·	·	·				Dominant
Liveliness (F)	Serious				···	·						Lively
Rule-Consciousness (G)	Expedient			··	·	·						Rule-Conscious
Social Boldness (H)	Shy				·	···						Socially Bold
Sensitivity (I)	Utilitarian							·	·		··	Sensitive
Vigilance (L)	Trusting				···		·					Vigilant
Abstractedness (M)	Grounded				·		··	·				Abstracted
Privateness (N)	Forthright			·	···							Private
Apprehension (O)	Self-Assured	·		·		··						Apprehensive
Openness to Change (Q1)	Traditional		·		··	·						Open to Change
Self-Reliance (Q2)	Group-Oriented					··	·			·		Self-Reliant
Perfectionism (Q3)	Tolerates Disorder		·	·	·			·				Perfectionistic
Tension (Q4)	Relaxed		·		·	·				·		Tense

Note: Highlighted factors are those in which all individuals obtained a score above or below the average.

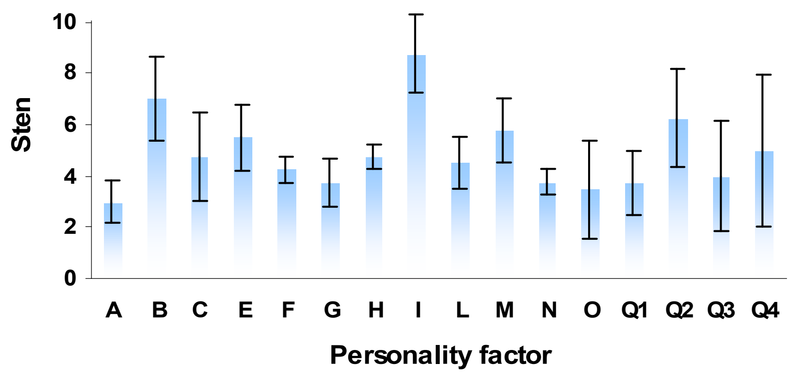


Figure A5.1. 16PF summary report indicating median values and ranges.

Even though the sample size was not big enough to achieve statistically significant results, they did suggest the presence of a similar pattern in three individual personality traits: warmth, sensitivity and privateness. Accordingly, the individuals appeared to be frank and outspoken, openly expressing their thoughts (low factor N). They were supposed to be sensitive and easily affected by surrounding situations (high factor I), but unlikely to openly show their feelings (low factor A).

Overall, the group had a tendency to view itself in a positive manner, having a strong sense of self-worth and competence. It projected a comfortable social presence. It was attentive to other people and was likely to be sensitive to their feelings. The group was socially participative and enjoyed activities involving others: its attention was generally directed towards other people. When the group chose to reveal personal matters to others, it tended to be forthright and genuine (Selene Zamudio (2002), personal communication).

Observed coincidences (particularly in personality factors A, I and N) would appear to relate to the nature of functions developed by the extension agent. Because people choose jobs hopefully congruent with their personalities, and are chosen for the potential fit between their abilities, needs, personality and job characteristics, those in jobs are not likely to have widely different personality characteristics (Furnham and Zacherl, 1986). Nonetheless, variations in personality are multivariate and substantial, at least for the teaching profession (Emmerich et al., 2006), which in many senses resemble extension.

It has been earlier noted that the low wages offered by development institutions in Veracruz have made extension an unattractive activity for many technicians. Nevertheless, all surveyed extension agents stated to be fulfilled and happy, as their time in business indirectly suggests. While findings of Furnham et al. (2002) revealed that personality does not have a strong or consistent influence either on what individuals perceive as important in their work environment or on their levels of job satisfaction, Chan and Joseph (2000) showed that well-being is generally associated with greater extraversion and lower rated importance to financial success. Moreover, intelligence appears to be a better predictor of career satisfaction (Lounsbury et al., 2004), whilst self-esteem involves both job performance (Lau and Shaffer, 1999) and global life satisfaction (Shevlin et al., 1998). Actually, Rector and Roger (1996) found that individuals with high self-esteem demonstrated better health status under stress. In the end, the study of the theoretical considerations of self-esteem and its relationship with personality are, so far, relatively unexplored fields (Eiser et al., 1995; Pullmann and Allik, 2000).

As personality appears to be a determinant feature on job performance, its understanding has an enormous value for organizations, particularly in formulating appropriate human resources strategies such as recruiting and training (Lau and Shaffer, 1999). Clearly this is an important area for future research. As such, a promising line could focus on an assessment of extension agents' personality traits and their impact on dissemination and uptake outcomes.

Appendix 4. Verifiable indicators of achievement for qualifying the use of selected management practices at farm level.

Management practice	Means of verification	Value
General broodstock management	• Good quality/performance broodstock of known origin. • Appropriate genetic management and population size. • Frequent replacement of broodstock. • Systematic record keeping.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Use of wild-caught broodstock.	1
	Do not have broodstock.	0
Rearing and conditioning of broodstock	• Stock lines in appropriate/separate holding facilities. • Conditioning of broodstock by proper feeding. • Conditioning of broodstock by proper rest. • Use of similar-sized fish or mouth-clipping of males.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Rudimentary conditioning of wild-caught broodstock.	1
	Do not have broodstock.	0
Handling of broodstock	• Handling of broodstock in cool morning/afternoon or under shade. • Holding of broodstock in good water quality conditions. • Avoidance of rough handling and overcrowd/stress situations. • Use of nets made of soft materials.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Improper care of fish.	1
	Do not have broodstock.	0
Method of breeding	• Hapa-based or controlled pond/tank method. • Collection and artificial incubation of eggs. • Hormonal sex-reversal of fry or use of GMT.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Open pond method; collection and manual sex separation of juveniles.	2
	Open pond method without sex separation.	1
	Do not have broodstock.	0

Management practice	Means of verification	Value
Nursery ponds	• Appropriate built nursery ponds. • Good water quality/quantity management. • Appropriate fertilizing strategies and aquatic weed management. • Appropriate predator control.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Improvised/inappropriate nursery facilities.	1
	Do not have nursery ponds.	0
Rearing of fry and fingerlings	• Daily monitoring of nursery facilities. • Appropriate feeding strategies. • Appropriate health management. • Frequent monitoring of growth rates.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Improper care of fry/fingerlings.	1
	Do not have nursery facilities.	0
Record keeping in hatchery operation	• Detailed/organized register of hatchery production records. • Use of data in improving productivity of breeders. • Use of data in improving efficiency of the whole operation.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Only partial data are recorded.	2
	Unsystematic/deficient record keeping.	1
	Do not keep records.	0
Packing and transportation of fingerlings	• Use of oxygenated bags or aerated containers. • Appropriate water quality monitoring. • Appropriate acclimatization of fingerlings. • Use of appropriate densities.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Rudimentary transportation of fingerlings.	1
	Do not pack and transport fingerlings.	0
Pond (or cage) preparation	• Appropriate characteristics of site. • Appropriate access and security. • Appropriate design/construction of facilities. • Weeds/pests elimination.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Inappropriate pond/cage preparation.	1
	Do not prepare the facilities.	0

Management practice	Means of verification	Value
Fertilizing and filling the pond	• Analysis of soil/water (e.g. pH monitoring). • Appropriate use of lime. • Appropriate use of organic/inorganic fertilizers. • Daily monitoring of water productivity (e.g. use of Secchi disc).	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Inappropriate management of water productivity.	1
	Do not manage water productivity.	0
Stocking of fingerlings	• Ensure good water quality conditions before stocking. • Use of good quality fingerlings (e.g. similar size/age, known origin, proved performance). • Use of appropriate stocking densities. • Use of monosex fingerlings. • Appropriate acclimatization of fingerlings.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Four activities are missing.	1
	Inappropriate stocking strategy.	0
Daily management	• Daily inspection and care of facilities. • Daily monitoring of fish behaviour. • Daily monitoring of plankton productivity. • Daily monitoring of any unusual conditions (e.g. fish gasping for air at the water surface in early morning or any dead fish floating). • Detailed/organized record keeping of daily activities.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Four activities are missing.	1
	Inappropriate daily management.	0
Feed and feeding	• Use of good quality feeds (e.g. agricultural by-products or commercial formulated diets). • Daily feeding according to the weight of the fish and total biomass. • Frequent sampling of the fish and adjustment of feeding rates. • Detailed/organized record keeping of feeding strategy.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Inappropriate feeding strategy.	1
	Do not feed fish (i.e. growth totally depends on water productivity).	0

Management practice	Means of verification	Value
Water quality management	• Monitoring strategy of water parameters according to the size/intensity of the operation. • Partial water replacements according to size/intensity of the operation. • Constant monitoring and control of phytoplankton "blooms". • Detailed/organized record keeping of water quality parameters and management strategy.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	At least occasional checks of parameters; rudimentary management practices.	1
	Inappropriate water quality management.	0
Oxygen monitoring and aeration	• Dissolved oxygen monitoring strategy according to the size/intensity of the operation. • Aeration strategy according to the size/intensity of the operation. • Farm has at least some kind of emergency aeration. • Detailed/organized record keeping of dissolved oxygen data.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Use of improvised measures (e.g. emergency water replacements).	1
	Do not check/manage dissolved oxygen.	0
Sampling	• Frequent measures of weight/length. • Avoidance of rough handling and stress situations during sampling. • Detailed/organized record keeping of growth dissolved oxygen data	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Sampling only during partial harvests.	2
	Occasional sampling.	1
	Do not sample.	0
Purging	• Use of any method to test fish quality before harvesting. • Farm has facilities to purge fish. • Regular use of any method to purge fish.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Only purge fish if demanded by consumer.	2
	Do not purge but clean fish after harvest.	1
	Do not purge/clean fish before marketing.	0

Management practice	Means of verification	Value
Post harvest handling	• Proper handling of fish during/after harvesting (e.g. during cool morning/afternoon or under shade). • Farm has appropriate equipment/facilities for harvest operations. • Farm has appropriate equipment/facilities for post harvest operations. • Appropriate hygiene measures taken into account. • Use of ice to maintain fish fresh after harvest.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Four activities are missing.	1
	Poor harvest/post harvest management.	0
Marketing strategies	• Use of any promotion strategy. • Appropriate sale strategies (e.g. planned harvests during special holidays). • Appropriate equipment/facilities for sale operations. • Use of any strategy to add value (e.g. fish is sold gutted, processed, fried, live, etc.).	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Occasional sales of whole fish at farm level.	1
	Do not sell fish (i.e. fish only for family consumption).	0
Record keeping in grow-out and post harvest operations	• Detailed/organized register of grow-out/post harvest/marketing activities. • Use of data in improving grow-out decisions. • Use of data in improving post harvest/marketing procedures. • Use of data in financial analysis.	5
	One of the above activities is missing.	4
	Two activities are missing.	3
	Three activities are missing.	2
	Unsystematic/deficient record keeping.	1
	Do not keep records.	0

Appendix 5. Technology Level Indices (*TLI*s) and Technological Change values calculated for each farm during the periods 2001-2002 (initial) and 2003-2004 (final). *TLI*s range from zero to 100; Technological Change calculated from Total *TLI*s.

Farmer ID	Group No.	Initial *TLI* (2001-2002)				Final *TLI* (2003-2004)				Technological Change
		Hatchery	Grow-out	Post-harvest	Total	Hatchery	Grow-out	Post-harvest	Total	(Percentage)
1	1	40.0	40.0	40.0	40.0	52.5	52.5	55.0	53.0	32.50
2	1	0.0	32.5	0.0	13.0	0.0	47.5	35.0	26.0	100.00
3	1	0.0	47.5	40.0	27.0	0.0	60.0	55.0	35.0	29.63
4	1	70.0	57.5	60.0	63.0	77.5	70.0	70.0	73.0	15.87
5	2	0.0	50.0	40.0	28.0	47.5	67.5	65.0	59.0	110.71
6	2	0.0	50.0	40.0	28.0	47.5	67.5	65.0	59.0	110.71
7	2	0.0	50.0	40.0	28.0	47.5	67.5	65.0	59.0	110.71
8	2	0.0	50.0	40.0	28.0	47.5	67.5	65.0	59.0	110.71
9	2	0.0	37.5	20.0	19.0	25.0	47.5	50.0	39.0	105.26
10	2	0.0	50.0	40.0	28.0	47.5	67.5	65.0	59.0	110.71
11	2	35.0	40.0	20.0	34.0	55.0	45.0	45.0	49.0	44.12
12	2	0.0	37.5	20.0	19.0	25.0	47.5	50.0	39.0	105.26
13	2	0.0	37.5	20.0	19.0	25.0	47.5	50.0	39.0	105.26
14	2	0.0	37.5	20.0	19.0	25.0	47.5	50.0	39.0	105.26
15	2	0.0	45.0	40.0	26.0	32.5	55.0	55.0	46.0	76.92
16	2	0.0	35.0	30.0	20.0	30.0	47.5	45.0	40.0	100.00
17	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
18	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
19	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
20	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
21	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
22	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
23	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
24	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
25	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
26	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
27	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
28	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
29	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
30	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
31	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
32	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
33	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
34	4	0.0	42.5	0.0	17.0	0.0	55.0	45.0	31.0	82.35
35	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
36	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
37	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
38	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
39	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
40	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
41	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
42	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
43	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
44	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
45	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95

Farmer ID	Group No.	Initial *TLI* (2001-2002)				Final *TLI* (2003-2004)				Technological Change
		Hatchery	Grow-out	Post-harvest	Total	Hatchery	Grow-out	Post-harvest	Total	(Percentage)
46	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
47	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
48	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
49	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
50	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
51	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
52	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
53	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
54	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
55	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
56	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
57	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
58	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
59	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
60	4	0.0	47.5	0.0	19.0	0.0	62.5	45.0	34.0	78.95
61	4	40.0	60.0	40.0	48.0	57.5	70.0	55.0	62.0	29.17
62	4	0.0	30.0	0.0	12.0	0.0	47.5	25.0	24.0	100.00
63	4	0.0	30.0	0.0	12.0	0.0	47.5	25.0	24.0	100.00
64	4	0.0	30.0	0.0	12.0	0.0	47.5	25.0	24.0	100.00
65	4	37.5	47.5	25.0	39.0	55.0	57.5	45.0	54.0	38.46
66	4	37.5	47.5	25.0	39.0	55.0	57.5	45.0	54.0	38.46
67	4	37.5	47.5	25.0	39.0	55.0	57.5	45.0	54.0	38.46
68	4	0.0	50.0	30.0	26.0	55.0	62.5	60.0	59.0	126.92
69	4	0.0	50.0	30.0	26.0	55.0	62.5	60.0	59.0	126.92
70	4	0.0	50.0	30.0	26.0	55.0	62.5	60.0	59.0	126.92
71	4	0.0	50.0	30.0	26.0	55.0	62.5	60.0	59.0	126.92
72	4	0.0	50.0	30.0	26.0	55.0	62.5	60.0	59.0	126.92
73	1	0.0	40.0	0.0	16.0	37.5	50.0	40.0	43.0	168.75
74	1	0.0	40.0	0.0	16.0	37.5	50.0	40.0	43.0	168.75
75	1	0.0	40.0	0.0	16.0	37.5	50.0	40.0	43.0	168.75
76	1	0.0	40.0	0.0	16.0	37.5	50.0	40.0	43.0	168.75
77	1	0.0	40.0	0.0	16.0	37.5	50.0	40.0	43.0	168.75
78	1	0.0	40.0	0.0	16.0	37.5	50.0	40.0	43.0	168.75
79	1	0.0	40.0	0.0	16.0	37.5	50.0	40.0	43.0	168.75
80	1	0.0	45.0	35.0	25.0	50.0	50.0	50.0	50.0	100.00
81	6	0.0	25.0	25.0	15.0	27.5	32.5	40.0	32.0	113.33
82	6	0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33
83	6	0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33
84	6	0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33
85	6	0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33
86	6	0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33
87	6	0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33
88	6	0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33
89	6	0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33
90	6	0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33
91	6	0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33
92	6	0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33
93	6	0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33
94	6	0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33
95	6	0.0	30.0	0.0	12.0	30.0	40.0	30.0	34.0	183.33

Farmer ID	Group No.	Initial *TLI* (2001-2002)				Final *TLI* (2003-2004)				Technological Change
		Hatchery	Grow-out	Post-harvest	Total	Hatchery	Grow-out	Post-harvest	Total	(Percentage)
96	6	0.0	30.0	30.0	18.0	27.5	37.5	35.0	33.0	83.33
97	6	0.0	30.0	30.0	18.0	27.5	37.5	35.0	33.0	83.33
98	6	0.0	30.0	30.0	18.0	27.5	37.5	35.0	33.0	83.33
99	6	0.0	30.0	30.0	18.0	27.5	37.5	35.0	33.0	83.33
100	4	0.0	42.5	0.0	17.0	0.0	47.5	45.0	28.0	64.71
101	4	0.0	42.5	0.0	17.0	0.0	47.5	45.0	28.0	64.71
102	4	0.0	42.5	0.0	17.0	0.0	47.5	45.0	28.0	64.71
103	4	0.0	42.5	0.0	17.0	0.0	47.5	45.0	28.0	64.71
104	4	0.0	42.5	0.0	17.0	0.0	47.5	45.0	28.0	64.71
105	4	0.0	42.5	0.0	17.0	0.0	47.5	45.0	28.0	64.71
106	4	0.0	42.5	0.0	17.0	0.0	47.5	45.0	28.0	64.71
107	2	80.0	77.5	60.0	75.0	90.0	90.0	90.0	90.0	20.00
108	6	0.0	37.5	20.0	19.0	17.5	40.0	25.0	28.0	47.37
109	6	0.0	37.5	20.0	19.0	17.5	40.0	25.0	28.0	47.37
110	6	0.0	37.5	20.0	19.0	17.5	40.0	25.0	28.0	47.37
111	6	0.0	37.5	20.0	19.0	17.5	40.0	25.0	28.0	47.37
112	2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.00
113	3	0.0	37.5	20.0	19.0	47.5	47.5	45.0	47.0	147.37
114	3	0.0	37.5	20.0	19.0	47.5	47.5	45.0	47.0	147.37
115	3	0.0	37.5	20.0	19.0	47.5	47.5	45.0	47.0	147.37
116	3	0.0	37.5	20.0	19.0	47.5	47.5	45.0	47.0	147.37
117	3	0.0	37.5	20.0	19.0	47.5	47.5	45.0	47.0	147.37
118	3	0.0	37.5	20.0	19.0	47.5	47.5	45.0	47.0	147.37
119	3	0.0	37.5	20.0	19.0	47.5	47.5	45.0	47.0	147.37
120	3	0.0	37.5	20.0	19.0	47.5	47.5	45.0	47.0	147.37
121	3	0.0	37.5	20.0	19.0	47.5	47.5	45.0	47.0	147.37
122	3	0.0	37.5	20.0	19.0	47.5	47.5	45.0	47.0	147.37
123	1	0.0	30.0	0.0	12.0	47.5	45.0	45.0	46.0	283.33
124	1	0.0	32.5	0.0	13.0	47.5	45.0	45.0	46.0	253.85
125	1	0.0	32.5	0.0	13.0	47.5	45.0	45.0	46.0	253.85
126	1	55.0	57.5	0.0	45.0	65.0	62.5	50.0	61.0	35.56
127	5	0.0	40.0	0.0	15.0	0.0	40.0	25.0	21.0	40.00
128	5	0.0	40.0	0.0	15.0	0.0	40.0	25.0	21.0	40.00
129	5	0.0	40.0	0.0	15.0	0.0	40.0	25.0	21.0	40.00
130	5	0.0	40.0	0.0	15.0	0.0	40.0	25.0	21.0	40.00
131	5	0.0	40.0	0.0	15.0	0.0	40.0	25.0	21.0	40.00
132	5	0.0	40.0	0.0	16.0	40.0	45.0	30.0	40.0	150.00
133	5	0.0	40.0	0.0	16.0	40.0	45.0	30.0	40.0	150.00
134	5	0.0	40.0	0.0	16.0	40.0	45.0	30.0	40.0	150.00
135	5	0.0	40.0	0.0	16.0	40.0	45.0	30.0	40.0	150.00
136	5	0.0	40.0	0.0	16.0	40.0	45.0	30.0	40.0	150.00
137	5	0.0	40.0	0.0	16.0	40.0	45.0	30.0	40.0	150.00
138	5	0.0	40.0	0.0	16.0	40.0	45.0	30.0	40.0	150.00
139	5	0.0	40.0	0.0	17.0	52.5	50.0	45.0	50.0	194.12
140	2	65.0	75.0	90.0	74.0	85.0	87.5	95.0	88.0	18.92
141	3	72.5	60.0	60.0	65.0	85.0	95.0	60.0	84.0	29.23
142	3	70.0	82.5	70.0	75.0	80.0	87.5	75.0	82.0	9.33