UNDERSTANDING SMALL AND MEDIUM SCALE

TILAPIA CULTURE IN NICARAGUA

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UNDERSTANDING SMALL AND MEDIUM SCALE TILAPIA CULTURE IN NICARAGUA

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UNDERSTANDING SMALL AND MEDIUM SCALE

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VITA

Pablo Rolando Martínez Mejía, son of Pablo Martínez Gómez and Odalina Mejía Escobar, was born June 27, 1970, in Tegucigalpa, Honduras. He attended the Panamerican Agriculture School in Honduras, for three years, then entered Iowa State University in January1994, and graduated with a Double Bachelor of Science degree in Agricultural Business and Animal Science. After working as an instructor and economics laboratory assistant in the Panamerican Agriculture School's Department of Economics for five years, he entered Graduate School, Auburn University, in August 2001. He obtained his Master's degree in December 2003. During the same period worked in the Aquaculture Collaborative Research Support Program (ACRSP) in Auburn and took part in several workshop in the Central American countries of El Salvador, Honduras, and Nicaragua. He married Elizabeth Trejos Castillo, in July 1996. He is the father of Pablo Enrique Martínez Trejos, born on November 19, 1997 and Isaac Rolando Martínez Trejos born on February 23, 1999.

DISSERTATION ABSTRACT

UNDERSTANDING SMALL AND MEDIUM SCALE

TILAPIA CULTURE IN NICARAGUA

Pablo Rolando Martínez-Mejía

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Nicaragua has abundance of natural resources to make aquaculture an important economic activity. But despite the efforts of multiple stakeholders, tilapia culture has not developed as expected. Small and medium scale tilapia culture has been promoted for over two decades as a means to ensure food security and income generation. So far, the results have been uncertain. Although many ponds have been abandoned, a number of producers have managed to stay in business. The understanding of how those producers have manage to avoid the factors limiting tilapia culture would offer significant information for further development interventions. Three related studies herein provide information on the economic and financial analysis of several tilapia operations; export opportunities for Nicaragua in U.S. market for tilapia fillets, and the Nicaraguan Aquaculture Knowledge and Information System (AKIS). The economic and financial analysis was conducted using the enterprise budget analysis, estimation of break-even prices, sensitivity analysis, and estimation of internal rates of return. The analysis of export opportunity analysis was based on the estimation of market growth rate using a double log OLS model and changes in market shares estimated using a linear version of the Almost Ideal Demand System Model (LA/AIDS). The analysis of the AKIS followed the methodology suggested by FAO & the World Bank. The results indicated that small and medium scale tilapia culture in Nicaragua is a highly subsidized minor economic activity. Only producers operating with an 80% subsidy on the main inputs enjoyed significant rates of return. Export opportunities were promising; the market in the U.S. is growing and Nicaragua's market share, despite being very small, is also growing. Finally, the results of the analysis of the AKIS indicated that the different stakeholders of tilapia culture in Nicaragua worked in isolation and had particular plans. Producers had a basic level of technical knowledge on tilapia culture. In summary, the overall analysis elucidated a complex situation, one that requires particular attention in areas of knowledge, economic use of resources, management, and marketing.

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Style manual or journal used Aquaculture Economics

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INTRODUCTION

Nicaragua is the less developed country in Central America and the second poorest country in the Western Hemisphere. Nicaragua's economy has not progressed as expected despite its plentiful natural resources and significant financial support by international donors. According to the United States Agency for International Development –USAID- (2003), the socioeconomic conditions indicate an urgent need to promote sustainable economic growth.

In 2003, reported economic indicators showed a severe situation in Nicaragua; real per capita Gross Domestic Product (GDP) and income levels were lower than those of the 1960s. Real economic growth dropped from 7% in 1999 to 1% in 2002; 25% of the population lived on less than two dollars a day. There was a 50% rate of unemployment and underemployment, and income distribution was one of the most unequal in the world (USAID 2003). Furthermore, Nicaragua's access to capital was very limited. As USAID (2003:2) stated, "access to capital, a key factor in economic development, decreased sharply with the collapse of the national banking sector, and foreign direct investment is declining."

The problem is complex and difficult to resolve. Potential solutions require a combination of different strategies aiming to generate economic growth. For example, USAID promotes economic growth and rural diversification joined with programs that ensure the sustainable use of Nicaragua's natural resources. Rural diversification projects designed to support the efforts of entrepreneurs looking for new markets for agricultural products. Accordingly, the economic growth strategy should be based on promoting more competitive local businesses, higher national productivity, international trade growth, and attracting private investment (USAID 2003).

Rural diversification in Nicaragua is crucial to improve the competitiveness of the important agricultural sector. A sector that produces 29% of the GDP, employs 42% of the national labor force, and has been hurt by the drop in price of traditional export commodities such as coffee. Falling export commodity prices are affecting the economy and have motivated the government, producers, and cooperation programs to look for alternative export commodities such as shrimp and tilapia.

For example, in the community Las Chinas, USAID initiated a tilapia culture demonstration project in response to the crisis in world coffee prices. Overall, 106 families participated in this pilot project, initiated by USAID in alliance with the Inter-American Institute for Agricultural Cooperation (IICA), and the Nicaraguan government Rural Development Institute (IDR). The farmers received financing and technical assistance in establishing ponds and raising tilapia. Participating families produce tilapia for their own consumption and for local market sales. The results indicated that aquaculture in Nicaragua has been growing due to its potential for solving problems related to unemployment, income, food security, and supply foreign currency (FAO 2002).

The Nicaraguan government has supported aquaculture, specially shrimp production, for export markets for more than two decades granting tax breaks on imports of inputs, other tax incentives to aquaculture producers, and land concessions. Land concessions have been granted in the large mangrove systems of the Gulf of Fonseca, in the Pacific Ocean. New policies may encourage foreign investment in aquaculture by opening new land concessions for shrimp farming (FAO 2002).

Nicaragua has favorable natural conditions for the development of aquaculture. Of Nicaragua's 1,200,000 hectares in total surface water area, 1,033,800 hectares are reservoirs, with 53,500 hectares of that area suitable for aquaculture production (FAO 1992, Neira & Engle 2003). Commercial shrimp farming could be practiced in an estimated of approximately 30,000 hectares; the largest potential area for shrimp farming in Central America (USDA-FAS 1995). Tilapia culture could be an important industry through culture in ponds and cage culture in lakes and reservoirs (Neira and Engle 2003). In 2000, there were 269 aquaculture enterprises in Nicaragua; 144 were dedicated to shrimp production, and the remaining, 125, to tilapia culture. According to FAO (2002), during 2001 there were 8,999 hectares in shrimp production and 24 hectares in fish[1] production.

Nevertheless, despite the great potential for aquaculture, several factors have delayed the development of aquaculture, particularly tilapia culture, in Nicaragua. The reported factors include lack of trained aquaculturists (FAO 1984, USDA-FAS 1995), indistinguishable marketing of low quality, wild-caught and farmed tilapia (Engle & Neira 2003a), environmentalists' opposition to large-scale culture due to the

[1] The source of information does not specify the fish specie (s) under production.

implementation of environmentally dubious technologies (Montenegro 2001), and lack of institutional support (FAO 1984).

Yet, despite difficulties, some producers have managed to stay profitable. The recording and understanding of the approaches taken by successful tilapia producers could elucidate suitable management strategies than can be conveyed to local and international researchers and other producers. The understanding of how producers overcome difficulties should be based on an assessment of producers' current knowledge, business environment, economic factors affecting their daily management practices, and market opportunities (The World Bank 1998).

Problem Statement

The Aquaculture Collaborative Research and Support Program (ACRSP) supports research on tilapia culture in Nicaragua. Previous studies supported by the ACRSP focused on better understanding markets and marketing approaches for tilapia products. Those market studies determined preferred sizes for tilapia in restaurants, supermarkets, and outdoor markets. Thus, producers can apply production practices to obtain specific product size for sale at specific venues. This dissertation will complement previous market studies by providing information on economic and financial performance, export opportunities for tilapia products, and existing local knowledge.

The general objectives of this dissertation are to assess the economic and financial feasibility of tilapia culture, to conduct an analysis of export opportunities for fresh and frozen fillets from Nicaragua into the U.S. market, and to conduct a comprehensive analysis of the Aquaculture Knowledge and Information System (AKIS) for tilapia culture in Nicaragua.

Specifically, this dissertation consists of three papers, 1) Small and Medium Scale Tilapia Culture in Nicaragua: Financial and Economic Analysis, 2) Tilapia Fillets Market in the U.S.: An Analysis of Nicaragua's Export Opportunities, and 3) Understanding the Aquaculture Knowledge and Information System in Nicaragua.

The financial and economic analysis will be presented in the first paper, which provides a general overview of the economic sustainability of tilapia culture in Nicaragua. The second paper will address the analysis of export opportunities using the approach proposed by Cuyvers et al. (1995); this approach uses the interaction between the rate of growth of the market and market share of exporting countries to evaluate export opportunities. Finally, the third paper presents the analysis of the Aquaculture Knowledge and Information System for rural development; the analysis includes an assessment of indigenous knowledge, stakeholder analysis, as well as an analysis of strengths, weaknesses, opportunities, and threats.

The resulting analyses will provide a comprehensive description of the aquaculture sector and reveal important information that can be useful in the design of future aquaculture development interventions in Nicaragua.

SMALL AND MEDIUM SCALE TILAPIA CULTURE IN NICARAGUA: ECONOMIC AND FINANCIAL ANALYSIS

Abstract

Small and medium scale tilapia culture in Nicaragua has been practiced for over 20 years. During that period, it went from production systems including mixed-sex culture and the use of animal manures, and/or inorganic fertilizers to implementing more intensive pond and cage production systems. In addition, it went from being a national economic development activity supported heavily by the government, to a localized enterprise, still supported by the government, but at a substantial lower level. This paper provides an economic and financial analysis of several tilapia culture enterprises identified in 2005. The study includes an enterprise budget analysis, a break-even price analysis, the estimation of the internal rate of return of the enterprises, and a sensitivity analysis. The results indicate that fingerlings production, as the Nicaraguan government promoted it was not profitable. The three-phase grow-out production systems also promoted by the government yielded low levels of profitability. The members of a cooperative that operate with an 80% subsidy presented the most profitable enterprise. The results also indicate that without the subsidy the members of the cooperative would not be able to stay in businesses. Finally, cage culture seems like a profitable alternative if the proper production parameters are implemented.

1. Introduction

The decision process faced by aquaculture producers involves a series of economic choices, related to the demand and supply of fish under production that determine the overall profitability of fish culture. As Jolly & Clonts (1993:35) stated, "the decision of what to produce is determined by the questions on whether the product is saleable as well as the individual farmer's preferences." If the product is marketable, consumers are willing to pay a given price, and if consumers are willing to pay a certain price, then, producers are willing to grow the fish at a certain cost.

Profitability is one of the crucial elements for sustainability, and the ultimate measure of economic success (Molnar et al. 1991). The profitability of tilapia culture determines the degree in which the producers become involved in marketing. Thus, if the profitability of the enterprise is high enough, fish producers will engage in production and marketing of the product.

The profitability of any enterprise is determined by the difference between production costs and selling price. More specifically, "The producers' profit or net income per unit of land or water area (Y) is mainly affected by production (Q), the cost of production and marketing (C), and the price received (P)." Net income (Y) is equal to the difference between revenue (QP) minus cost (C) (Shang 1981:17).

Given that the relationship between production cost and price determines the level of profits, if profits are to be higher, one or a combination of the following events may happen: production increases, cost decreases, and/or price rises. Producers can manipulate the first two events, while, under perfect competition, the last one, price, depends on the forces of supply and demand existing in the market (Shang 1981).

Aquaculture producers, like any other entrepreneurs seek to enhance the profitability of the enterprises, although they are not always successful. The inclusion of economic analysis in aquaculture helps to eliminate non-profitable enterprises (Engle et al. 1997). With that consideration, the general objective of the paper is to conduct an economic and financial analysis of several tilapia culture businesses in Nicaragua. The specific objectives are:

1. To estimate the net returns, break-even prices, internal rates of return, and conduct a sensitivity analysis of fingerling production,
2. To estimate the net returns, break-even prices, internal rates of return, and conduct a sensitivity analysis of pond production.
3. To estimate the net returns, break-even prices, internal rates of return, and conduct a sensitivity analysis of cage tilapia production.

The next section provides the conceptual framework of the analysis, which includes a comprehensive review of previous studies and concepts related to economic analysis of aquaculture enterprises. The following section describes the research method, which includes the data collection process, sources of data, and data analysis. Following are the results and discussion, and finally the conclusions.

2. Conceptual Framework

When first introduced in Nicaragua, tilapia production systems included mixed-sex culture and the use of animal manures, and/or inorganic fertilizers. At the time of this study, producers were implementing more intensive pond and cage production systems to meet the demand of the market (Engle 1997). More intensive aquaculture production systems require higher investments and better management practices.

Aquaculture production is the process in which resources and management are combined to produce fish (Jolly & Clonts 1993). Some of those resources are inputs purchased from suppliers at different prices. Those prices have an effect on production costs, and therefore, determine the amount of inputs purchased and the amount of fish produced by farmers (Shang 1990). In general, fingerlings, feed, chemicals, ponds, equipment, and technical, institutional, and government assistance are the most common inputs in aquaculture (Jolly & Clonts 1993). Keeping control of inputs costs is very important for the profitability of any fish culture enterprise. One important tool to document and keep up to date with input costs and other operating expense is the farm plan.

A farm plan is a useful management tool that allows producers to compare different production alternatives that require different amounts and combinations of inputs. Jolly & Clonts (1993:141) define a farm plan as "an outline or scheme for the organization and utilization of the resources available on a given farm." Therefore, the farm plan should be considered before engaging in production activities.

For most small producers the farm plan exists only in their heads (Jolly & Clonts 1993). That practice, although widespread, is not a good one. When producers keep their farm plan in their heads, they do not have reliable means for comparing their real performance against the planned use of resources. Within the farm plan, the planned use of resources is presented in the farm budget.

A budget is a plan to coordinate the flow of resources in and out of the farm to achieve a specified set of objectives established in the farm plan (Jolly & Clonts 1993:151). The proper analysis of a budget requires not only some level of knowledge about the production process, but also knowledge of the socioeconomic characteristics of the producers. In aquaculture, an enterprise budget analysis is a procedure of estimating costs and returns for a particular fish culture activity (Jolly & Clonts 1993). Generally, an enterprise budget analysis includes six steps: first, to calculate the total production and the expected output price; second, to estimate variables costs; third, to calculate income above variables costs; fourth, to estimating fixed costs; fifth, to calculate total costs, and sixth, to estimate the returns to land, capital, and management (Jolly & Clonts 1993).

In addition to the previous six steps, this study includes a break-even price analysis, the estimation of the internal rate of return for a period of five years, and a sensitivity analysis for a 20% increase and 20% decrease in feed price. The break-even price analysis generates the product's selling prices to cover variable and total costs. The estimated internal rate of return corresponds to the interest rate that equates the present value of the expected future cash flow, or receipts, to the initial investment or cost expenses (Jolly & Clonts 1993). The higher the internal rate of return, the better, as higher interest rates are synonymous to higher profitability. The sensitivity analysis is useful to test what happens to the economic feasibility, measured as net return or IRR, of the different enterprises if events differ (Shang 1990).

Fingerling Economics

Fingerlings are an essential input to aquaculture; however, they present several economic and technical challenges to the tilapia industry (Fitzsimmons 1997). Tilapia fingerlings production presents some unique characteristics; tilapia can easily produce offspring in ponds without farmer assistance (Molnar et al. 1996). Given favorable conditions, tilapia reach sexual maturity in 6-8 months of hatching, at a size of less than 100 g in some cases. When reproduction in the pond occurs, the offspring of the original stock competes for food, resulting in stunted growth and unmarketable fish (Phelps & Popma 2000).

Fingerlings production is one of the most profitable enterprises in aquaculture, but also the most risky and complex (Molnar et al. 1996). Therefore, the economic analysis of fingerlings production is central to the success of tilapia production (Molnar et al. 1996). However, despite its importance, only a few studies have examined tilapia fingerling production costs (Engle 1997).

In neighboring Honduras, Triminio & Meyer (2005:257) reported "farmers who have some idea of their costs report that the expense of producing a fingerling is between U.S.$ 0.005 to 0.020." The authors also reported selling prices ranging from U.S.$ 0.02 to 0.03 for fingerling sizes ranging from 0.05 to 3.00 g. In another study, Lutz (2000) states a purchasing cost of U.S.$ 0.18 per 50 g fingerlings in a budget for pond production in the tropics.

Despite its high profitability, the complexity of operation and level of investment necessary to establish a hatchery has proven difficult for most tilapia producers. The reproductive characteristics of tilapia have forced producers to turn to public and private hatcheries for seed of uniform size and gender (faster growing male fingerlings) (Molnar et al. 1996). Furthermore, according to FAO (1996:51) "the cost of constructing and maintaining the required facilities (hatcheries, transport) is considered prohibitive for many producers." For the previous reasons, public hatcheries play a significant role in supplying tilapia fingerlings at early stages of aquaculture development in a given region. However, at the same time, public hatcheries sometimes create dependency problems for producers, who often believe they should be supplied with subsidized fingerlings. According to FAO (1996) & Molnar et al. (1996) producer expectations for free or low cost fingerlings impede the development of a private market that is crucial for the further expansion of aquaculture.

Pond Economics

Tilapia is produced using a wide variety of production systems determined by the socioeconomic characteristics of the producer. As Molnar et al. (1996:9) stated, "The kind of technology used is closely linked to the socioeconomic circumstances of the farmer, as the intensity of production often corresponds to the amount of capital investment (Molnar et al. 1996:9)." Consequently, the proper understanding of tilapia culture compels the analysis of the socioeconomic factors using multiple sources of data. However, the task is not easy, since in aquaculture, quantitative and qualitative data usually are unavailable because aquaculture is in its early stages of development (Engle et al. 1997).

Despite the limited amount of data, some researchers have documented various basic facts about the economics of tilapia culture. Teichert-Coddington & Green (1997) estimated the average yield (kg/hectare), income above variable costs (U.S.$) and net returns to land and management (U.S.$) of 20 different production systems in Honduras. The authors reported that several production systems with a stocking density of two fingerlings/m^2 generated the most profits. The same authors also concluded that feeding was less profitable than fertilization at low stocking rates. In another study, Lutz (2000), in a budget for tilapia culture under assumptions of production in tropical conditions, estimated a production cost of U.S.$ 1.47 per kg of tilapia with an average weight of 800 g. Engle (1987 cited in Engle 1997) reported net returns above total costs of U.S.$ 645 per hectare in monoculture of tilapia in Panama; equivalent to a rate of return of 13%. Head & Zerbi (1995 cited in Engle 1997) reported a breakeven price of U.S.$ 3.86 per kg in an intensive commercial saline pond culture system in Puerto Rico, and an internal rate of return of 18%.

Cage Economics

Cage production is an intensive management system that facilitates the use of water bodies unsuitable for conventional production systems that require draining or seining for the period of harvest (Lazur 2000). Thus, cage culture makes possible the exploitation of public or communal water reservoirs, lakes, irrigation systems, village ponds, rivers, cooling water discharge canals, and estuaries (McGinty & Rakocy 1989, Watanabe et al. 2002). Other economic advantages of cage production over pond production are that the level of initial capital investment is low compared with open ponds (Watanabe et al. 2002), and that by concentrating fish, the farmer has better control over feeding and harvesting. However, the disadvantages include higher risk of poaching and water quality problems, and reliance on commercial feeds s (Lazur 2000, Watanabe et al. 2002).

In cage culture, producers rear fish in cages as small as four m^3, stocked at 200 to 300 fish/m^3, as in cages as large as 100 m^3 stocked at 25 to 50 fish/m^3. Yields range from

150 kg/m^3/crop in four m^3 cages to 50 kg/m^3/crop in 100 m^3 cages (Watanabe et al. 2002).

The financial and economic analysis of the different documented enterprises is crucial for the future development of tilapia culture in Nicaragua. The study will help to maintain the profitable enterprises that in the end will determine the future development of tilapia culture in Nicaragua. As Watanabe et al. (2002:484) suggested "in both tropical and temperate zones future development of tilapia aquaculture in the Americas depend on the ability of production systems to produce more fish with less water, less food, and less time to lower costs."

This study will provide specific information about the economic performance of the identified fingerlings and grow-out of tilapia in pond and cage based systems in Nicaragua. The results will present some guidelines that private firms, nongovernmental organizations, and development institutions could utilize to further the practice of tilapia culture in Nicaragua.

3. Methodology

The Aquaculture Collaborative Research Support Program (ACRSP), the program providing the funds for this study, makes information on diverse aquaculture topics available to farmers, educators, other researchers, public policy makers, loan officers, and investors (Veverica & Molnar 1997). The information provided is the result of a series of research activities funded by the ACRSP, and oriented to develop tilapia culture in Nicaragua as part of a larger focus on Central America. This study will provide new information that can be used by the ACRSP and other individuals and institutions to orient future training and research activities in regard to further develop tilapia culture in Nicaragua.

The sampling for this study started when several tilapia producers were approached during a short seminar on tilapia culture and pond construction held by an ACRSP team in Estelí, Nicaragua from November 9 to 12, 2005. During that seminar, the author gave a lecture on budget making and a short presentation about the objectives of the study and how it might benefit tilapia culture in Nicaragua. Subsequently, the researcher requested to the seminar attendees their participation and collaboration. Those who assisted in the short seminar, and agreed to participate in this study led to other stakeholders in their areas.

The sampling technique used to identify potential respondents is called network snowball sampling. Snowball sampling is used when there is an interest in sampling an interconnected network of people and organizations where each is connected with another through direct or indirect relationships (Neuman 1997). The connections do not always take the forms of a direct interaction or influence but merely direct or indirect links (Neuman 1997). For example, one stakeholder might know about the existence of a second stakeholder only because they buy inputs from the same supplier. The second stakeholder might know another, and so on. The sampling process finishes when the links return to the initial stakeholders. Snowball sampling provides a suitable approach to identify the stakeholders in tilapia culture in Nicaragua and accomplish the objectives of the study.

Two types of interviews were used. A total of 13 open-ended interviews were conducted with producers, whereas seven semi-structured interviews were used with other stakeholders (Appendix 1). Interviews are one of the most important sources of information in case studies (Yin 1994). When open-ended interviews are used, the objective is to obtain information about relevant subjects and the respondents' opinion about those aspects of the situation where the individual is knowledgeable (Yin 1994). The use of open-ended interviews allows stakeholders to become informants rather than respondents. According to Yin (1994:84), informants "not only provide the case study investigator with insights into a matter but also can suggest sources of corroboratory evidence – and initiate the access to such sources."

Several questions in the open-ended interviews (Appendixes 1 and 2) used with the producers were designed to gather data on farm income and production costs. The data provided by different producers were used to estimate averages and ranges of values. Nevertheless, in one case, an independent producer provided enough information to develop a budget. The results of the analysis of that budget is presented and discussed as well in the results section.

In other cases, in addition to the information provided during the interviews, several stakeholders working in research and/or extension institutions provided a number of documents reporting budgets on fingerling production, three-phase grow-out, and cage production. Those budgets were further analyzed to estimate their economic feasibility. The results of those analyses are very important since they provide an idea about the expected returns of the production systems proposed by the government and other research and extension institutions.

Overall, the multiple sources of data for this study included documents, archival records, and interviews. Many of the documents and archival records were obtained during the literature review process, while the remaining ones were collected during visits to research, educational, and extension agencies in Nicaragua.

The main tilapia production system promoted in Nicaragua is described in a document presented by the government agency Administración de Pesca y Acuicultura[2] (ADPESCA) to the Programa Regional de Apoyo a la Pesca en el Istmo Centro Americano[3] (PRADEPESCA) in 1999. The document titled "Piscicultura, Proyecto Transferencia de Tecnología, Producción de Semilla de Tilapia (*O. niloticus*) y Engorde en Tres Etapas[4]" outlines the production process and an enterprise budget. The approach features fingerlings production and grow-out of tilapia in three phases (ADPESCA 1999). The document also indicates that the production system was validated at the aquaculture station "Los Chilamates" before being transferred to producers. The station is located in the Escuela Católica de Agriculture y Ganaderia de Estelí (ECAGE) today named Universidad Catolica del Tropico Seco (UCATSE).

The project proposed by ADPESCA had five objectives; 1) to produce tilapia fingerlings, both mono-sex and mixed-sex to be stocked in different projects in the area, 2) to clarify the production process of grow-out in 3 phases, 3) to support the academic training of professionals in the area of aquaculture, 4) to transfer fingerlings production and grow-out technologies that were suitable to the conditions of producers in northern Nicaragua, and 5) to contribute to the development and extension of fish culture in communities deficient in animal protein sources by supplying fingerlings at production cost and implementing productive projects (ADPESCA 1999).

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[2] Fisheries and Aquaculture Administration.
[3] Central American Regional Fisheries Development Support Program.
[4] Aquaculture, Technology Transfer, Tilapia Fingerlings Production, and Three Phases Grow-out Project.

ADPESCA proposed fingerlings production following six steps: broodstock selection, reproduction, fry harvest and grading, sex reversal, fingerlings harvest, and evaluation of treatment efficiency. Broodstook was selected from the fish held at the Universidad Nacional Agraria (UNA)- ADPESCA farm.

Assumptions of ADPESCA's fingerlings production budget. Initially, 180 female and 60 male fish (3:1 proportion) were put together in a 160 m^2 pond. They were fed 3% of biomass during the first 15 days and 1% the following 15 days. After that the males and females were separated and put in different ponds. Fry were harvested using a 1 mm net on the 15, 20, 25, and 30th days. Fry were classified by size using a 4 mm mesh net, those 12 mm and larger could not pass the mesh, and were separated for mixed sex production. Those less than 12 mm were counted and put in ponds for sex reversal. Sex reversal took place in eight 12 m^2 ponds that were cleaned and disinfected with lime. The ponds were stocked with 48,000 fry for a population density of 500 fry/m^2 (ADPESCA 1999).

The sex reversal process was achieved by feeding fry a finely ground 35% protein commercial feed. The feed was prepared once per week containing 60 mg of 17 α methyl testosterone per kg of feed. The appropriate amount of hormone was dissolved in 250 to 500 ml of 95% ethyl alcohol. The solution was then used to wet the feed. The feed was let to dry for 24 hours, and then was stored in covered buckets. Hormone-treated feed was fed in seven portions, starting at 7:00 am and finishing at 4:00 pm, for 28 days. Feed rate was adjusted weekly; the first week fish were feed 30% of biomass, the second week 25%, the third week 20%, and 15% the last week. Expected weights per week were 0.10, 0.25, 0.50, and 0.75, g respectively. According to the document a mortality rate of 45% can be expected (ADPESCA 1999).

Assumptions for ADPESCA's grow-out production budget. In phase one, the suggestions included a stocking density of 10, 1 g fingerlings/m^2, a total pond area of 747 m^2, an ending average weight in the range of 70 to 100 g, and a 90 day culture period with an expected mortality of 25%. In the second phase, the recommendations included a stocking density of six fingerlings/m^2, a total area of 907 m^2, an ending average weight between 200-250 g, and a production period of 90 days with an expected mortality of 15%. For the third phase, ADPESCA recommended a stocking rate of four fish/m^2, an area of 907 m^2, an ending weight between 450-500 g, and a time period of 90 days with an expected mortality of 15%. The feeding system included the use of 256 kg of organic fertilizer and 3,825 kg of commercial feed. The document did not provide any specifics on water exchange or other production parameters.

In 2002, the Projecto de Desarrollo de Area[5] (PDA) "Aguas Azules" in collaboration with the Universidad Centroamericana (UCA) and ADPESCA conducted the first phase of a project on cage culture of tilapia in Lake Nicaragua. The PDA funded training on cage tilapia culture for the members of the fishermen cooperative Unión Maravillosa with funds from the New Zealand government obtained through the agency World Vision Nicaragua.

The project consisted of 16 cages using a low-volume, high-density production system. One cage was 2.1 x 1.9 x 1.9 m (7.58 m^3) while the other 15 were 1.5 x 1.2 x 1.2 m (2.16 m^3), for a total cage volume of 39.98 m^3. The cages were placed in an open lake

[5] Area Development Project.

area of 39 m^2, leaving a distance of 0.5 meter between cages. Since the cages were positioned in a place of the lake where water had a profundity of only one meter, the real useful volume of one cage was 3.99 m^3 and 1.80 m^3 for the other 15; the total cage-water volume was then estimated in 31 m^3 (Saavedra 2003).

In total, 5,000 fingerlings of 10 g each were stocked. The largest cage was stocked with 500 fingerlings for a density of 125 fingerlings/m^3. The others were stocked with 300 fingerlings for a density of 167 fingerlings/m^3 (Table 1.6). The production parameters were a feed conversion of 1.76, an average harvest weight of 550 g, and production cycle of 183 days with a mortality rate of 16% (Saavedra 2003).

Data analysis.

The data were analyzed using a triangulation research strategy as described by Yin (1994). Triangulation refers to the use of multiple sources of evidence that supply both quantitative and qualitative data to validate the conclusions of the analysis. According to Yin (1994:91), "case studies need not be limited to a single source of evidence. In fact, most of the better case studies rely on a variety of sources." Once gathered, all sources of evidence are reviewed and analyzed together.

The study has several limitations given the nature of the data source. In general, producers do not keep written records of production costs, sales, and in most cases do not verbalize perceptions regarding the opportunity cost of land and other assets. FAO (1996:35) noted, "Because the products of small-scale rural aquaculture are only partially marketed, and objectives relating to the production of fish are only part of the story, quantification is inherently problematic." Small producers, in fact, only market a fraction of their production and do not keep records of their transactions. Commercial producers, for the most part, do not keep good records either. Instead, patterns of informal cash management, tax avoidance, and rough calculations of profits and losses tend to characterize most types of farm business management including aquaculture (FAO 1996).

4. Results and Discussion

This chapter provides the results of the economic and financial analysis of the data provided by ADPESCA on its 1999 project, an individual producer, the producers working with the Instituto de Desarrollo Rural[6] (IDR), and PDA on its 2002 project. The economic and financial analysis of the different data sets included first, the estimation of net returns above variable costs and break-even price to cover variable costs, and next the estimation of three Internal Rates of Return (IRR). One for the original data, one for the possible net returns generated by a 20% increase, and one for the possible net returns generated by a 20% decrease in the price of commercial feed (sensitivity analysis). All IRR were estimated for a period of five years.

For comparison purposes, the data collected from the different enterprises were used to generate budgets for an area of 1,000 m^2. In addition, the IRR from the different enterprises were estimated adjusting the original net returns for inflation to the year 2005.

Fingerlings Production: ADPESCA Recommendations

The fingerlings production budget for 26,400, 5-10 g fingerlings (Table 1.1) presented by ADPESCA generated gross receipts of U.S.$ 1,056 and total variable cost of U.S.$ 948, and net returns above variable costs of U.S.$ 107.83. The estimates were calculated using a selling price of U.S.$ 0.04 for 5-10 g fingerlings. The analysis

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[6] Rural Development Institute.

indicated a break-even price to cover variable costs of U.S.$ 0.036, which is 90% of the actual market-selling price. Since the budget presented by ADPESCA ignored fixed costs, the total cost and the break-even price to cover total costs were expected to be higher.

The IRR were estimated using an initial investment of U.S.$ 4,000 (Table 1.7). The investment represented the cost of building the tanks and pond necessary to carry out fingerlings production as recommended by ADPESCA; it was assumed that the farmers owned the land and a cost[7] of U.S.$ 14/m^2 of tank and U.S$ 1.21 for pond construction (EAGE & AECI 1998, Interview 2005). The estimated net returns of U.S.$ 213, 123, and 29 corresponded to a 20% decrease in feed price, original feed price, and a 20% increase in feed price. Those net returns minus the initial investment were equivalent to IRR of -7% and –21%, and less than –21%, respectively. Overall, the estimated IRR suggested that fingerlings production was not profitable.

Nevertheless, the enterprise could be profitable if the production process presented by ADPESCA were improved in several ways. First, brooders were fed 3% of total biomass; that value is higher that the recommended 1-2% (Phelps & Popma 2000). Second, ADPESCA recommended that only fry equal or less than 12 mm should be sex reversed. According to Phelps and Popma (2000:44) “Grader selectivity should be verified to confirm that 85-90% of the 13 mm fish are able to swim through the grader and no more than 5% of the 15 mm fish are able to swim through.” Third, the stocking density of 500 fry/m^2 during sex reversal is significantly lower than the recommended

[7] Cost of pond was adjusted for inflation through 2005. Tank cost obtained from one producer in 2005.

1000-2000 fry/m^2 (Phelps & Popma 2000). All the adjustments would result in either cost reductions or income increases, which would increase net income and profitability.

Pond Production: Three-Phases Grow-out- ADPESCA's Recommendations

The grow-out budget offered by ADPESCA generated gross receipts of U.S.$ 3,234, total variable costs of U.S.$ 2,660 for a net return above variable costs of U.S.$ 574. The estimates were calculated using a selling price of U.S.$ 1.54 per kg of fish (Table 1.2). The analysis suggested a break-even price to cover variable costs of U.S.$ 1.27 that represents 82% of the actual market price. Again, since the budget presented by ADPESCA ignored fixed costs, the total cost was expected to be higher. Feed cost represented approximately 66% of total variable cost. As with fingerling production, the information provided for ADPESCA did not indicate the source of commercial feed, but most likely is a national supplier.

For this production system the IRR were estimated using an initial investment of U.S.$ 1,200 (Table 1.7). The amount represented the cost of building the ponds, with a useful life of five years, necessary to carry out production as recommended by ADPESCA. It was assumed that the farmers own the land. The results indicated net returns of U.S.$ 1076 for a 20% decrease in the price feed, U.S.$ 655 for the original prices, and U.S.$ 233 for a 20% increase in feed price. The analysis generated IRR of 114%, 65%, and 8% respectively.

Even thought, the results indicated that three phases grow-out production was profitable; the recommendations suggested by ADPESCA could be adjusted to obtain even better results. For example, feed conversion during phases II and III were estimated in 3.17 and 3.20 respectively. Those values indicate an unnecessary use of commercial feed. In similar production systems, using organic fertilizer and commercial feed, producers in Honduras reported a significantly lower feed conversion of 0.6 (Martinez et al. 2004). Feed expenses in the production system recommended by ADPESCA account for 66% of total variable costs; any significant reduction in this item could result in higher net returns and IRR.

Pond Production: Individual Producer

This budget was generated in collaboration with a producer who kept partial records of his production costs. The data provided by the producers was used to generate a budget for a 1,000 m^2 brick and concrete pond stocked with 15,000, 20 g fingerlings. The production parameters for this production systems included a stocking rate of 15 fingerlings/m^2, an ending average weight of 227 g, a 180 day production cycle with a mortality rate of 7%, purchase of 11,486 kg of commercial feed, and utilization of water exchange (Table 1.3).

The results (Table 1.3) indicated gross receipts of U.S.$ 7,040, total variable cost of U.S.$ 6,394 that represented approximately 94% of total costs, and fixed cost of U.S.$ 416, for a net return above variable and fixed costs of U.S.$ 646 and 230 respectively. The estimates were calculated using a selling price of U.S.$ 2.20 per kg of fish. The analysis suggested a break-even price to cover variable and fixed costs of U.S.$ 2.00 and 2.13 respectively. The break-even price to cover variable costs and fixed costs were equivalent to 90% and 97% of the actual market price. The results also indicated that feed and fingerlings purchases, each, represented 35% of total costs.

The initial investment of the individual producers was estimated in U.S.$ 14,000 (Table 1.7). The amount represented the cost of building and equipping the brick and concrete pond with a useful life of 20 years. The results indicated net returns of U.S.$ 706, 230, and -246 corresponding to a 20% decrease on feed price, original price, and a 20% increase in feed price. Those net returns minus the initial investment per production cycle generated an IRR of –19% for the price reduction. The other two IRR could not be estimated, but would be less than -19%. The economic analysis suggested that tilapia culture for the individual producer was not profitable.

Despite the negative results, the profitability of this sort of enterprises could be improved if, the initial investment were lower. The pond built by this producer is very expensive; building a cheaper pond would increase the profitability of the enterprise. The estimated feed conversion with a value of 4 was significantly high. Improvements in feed conversion would increase net returns and profitability.

Pond Production: Cooperative COOSEMPROTIR, R.L. excluding the subsidy from IDR.

The data for this budget was provided by the members of the cooperative COOSEMPROTIR R.L. located in the Nicaraguan Northern communities of Pueblo Nuevo and Los Horcones, Department of Estelí. These producers received technical assistance and an 80% subsidy on the cost of fingerlings, feed, plastic, and hose from the IDR. However, for this specific budget, the subsidy was ignored to estimate the real production costs.

The data provided by the producers was used to average values that then were used to generate the budget for an area of 1,000 m^2. The budget was estimated considering the following parameters: fingerlings initial weight of 1 g, an stocking density of 4 fingerlings/m^2 for a total of 4,000 fingerlings stocked, a final weight of 340 g, and a production cycle of 195 days with an expected mortality rate of 12.5%. The production system also included the use of animal manure to fertilize the pond and 1,920 kg of commercial feed, and the practice of water exchange as needed. Producers in the cooperative followed the instructions provided by the IDR extension agent who recommends water exchange depending on the color of the water (Table 1.4).

The results indicated gross receipts of U.S.$ 2,618, total variable cost of U.S.$ 2,445 for a net return above variable costs of U.S.$ 173; the estimates were calculated using a selling price of U.S.$ 2.20 per kg of tilapia. Fixed costs were estimated at U.S.$ 427, for a total production cost of U.S.$ 2,872. The analysis indicated a break-even price to cover variable and total costs of U.S.$ 2.05 and 2.41 respectively. Those break-even prices represented 91% and 109% of the original market price, correspondingly. The main cost was feed, which represented 41% of total cost.

Since the subsidy did not include pond digging, the members of the cooperative had to finance on their own the cost of building the pond (s). The initial investment for a 1,000 m^2 pond, the average pond dimensions, was estimated at U.S.$ 950 (Table 1.7). The results indicated net returns of U.S.$ 5 for a 20% decrease in feed price, -254 for the original feed price, and –512.0 for the 20% increase in feed prices. Given that the values were all negative, the corresponding IRR could not be estimated. Nevertheless, the results suggested that without the subsidy tilapia culture was unprofitable.

The financial and economic analysis of this budget suggested than tilapia production following the recommendations of the IDR was unsuccessful. However, changes in pond management could reduce feed cost and increase net returns. In Honduras producers running similar production systems obtained 454 g fish with a feed conversion of 0.6 (Martinez et al. 2004). The value of 0.6 is significantly lower than the

1.6 reported by the producers in Nicaragua. It is important to mention that these producers reported labor cost that represented 34% of variable costs, and, since in most cases, producers themselves carried out the labor activities, the reported labor costs represented a source of income as well.

Pond Production: Cooperative COOSEMPROTIR, R.L. including the subsidy from IDR.

Here, the analysis included the same data and parameter as in the previous budget, except that instead of using the total cost of the inputs, only the 20% of fingerlings, feed, plastic, and hose cost was considered (Table 1.5).

The results showed gross receipts of U.S.$ 2,618, total variable cost of U.S.$ 1,371 for a net return above variable costs of U.S.$ 1,277 and total cost of U.S.$ 1,535 giving a net return above total costs of U.S.$ 1,083. The analysis indicated a break-even price to cover variable of U.S.$ 1.13, equivalent to 51% of the actual market price, and a break-even price to cover total costs of U.S.$ 1.29, equivalent to 59% of the market price. With the subsidy feed only represented 15% of total cost (Table 1.5)

Other results indicated net returns of U.S.$ 1,135, 1,083, and 1,031 corresponding to a 20% decrease on feed price, original price, and a 20% increase. Those net returns minus the initial investment generated IRR of 214, 204, and 195% for a 20% decrease, original price, and 20% increase (Table 1.7). In all cases, with subsidy, tilapia culture was highly profitable to the members of the cooperative COOSEMPROTIR, R.L. In addition, since producers themselves carried out most labor tasks, a significant portion of labor' costs, that represented 63% of total costs, was kept by the producers.

Cage Production: PDA Budget

The next section shows the analysis of a cage culture project carried out by the PDA in Lake Nicaragua (Saavedra 2003). The results showed gross receipts of U.S.$ 3,492 Total variable cost of U.S.$ 2,860 for a net return above variable costs of U.S.$ 632, and total cost of U.S.$ 3,160 producing net returns above all costs of U.S.$ 332. The figures were calculated using a selling price of U.S.$ 1.50 per kg of fish. The analysis suggested a break-even price to cover variable of U.S.$ 1.23, equivalent to 82% of actual prices, and a break-even price to cover total costs of U.S.$ 1.36, equivalent to 91% of the actual price. Feed cost represented approximately 33% of total cost (Table 1.6).

The investment for the assembly of 16 cages was estimated in U.S.$ 3,600 (Saavedra 2003). The results indicated net returns of U.S.$ 541 if the price of feed decreases by 20%, U.S.$ 349 for the original price, and U.S.$ 129 if feed costs increase by 20%; the net returns minus initial investment generated IRR of 17%, -1%, and <–1%, in that order (Table 1.7). Therefore, only if feed prices decrease by 20%, then tilapia cage culture becomes profitable.

Cage culture following PDA's recommendations could be profitable if some adjustments were made. The stocking densities used during this training were significantly lower than the standard 500 fingerlings/m^3. If the stocking rates were increased the profitability of cage culture following similar production parameters would be higher (Saavedra 2003). Additionally, with an estimated cost of U.S.$ 1.36, producers could transport their product to the farmers markets in Managua where consumers are willing to pay up to U.S.$ 2.07per kg. This could be possible given the proximity, 45 minutes, between the area of production and the city of Managua.

Table 1. 8 provides a comparison between the average price received by the producers represented in this study and prices[8] reported by Engle & Neira (2003a,b) and Neira & Engle (2003) on whole sale prices paid by supermarkets, open-air market vendors, and restaurants. The comparison showed that the average price received by the producers in this study was 20% higher than the one pay by supermarkets, 84% higher than the one paid by open-air vendors, and 19% higher that the one paid by restaurants. Thus, the producers represented in this study, obtained higher prices for their product, up to some point, because they sold directly to the final consumers through pond bank sales, to neighbors or in farmer markets in their regions. If they were to sell their product to intermediaries, supermarkets, open-air vendors, and restaurants, their profits would be drastically reduced. The profitability of the enterprises analyzed could improve if prices were to increase; however, in perfectly competitive markets, that depends on the forces of supply and demand.

5. Conclusions

The information provided by the results of the economic and financial analysis helps to eliminate production systems that are not profitable (Engle et al. 1997), and avoid the waste of resources, since no profits means that production costs exceed selling prices. In some cases, unprofitable enterprises can be turned around and become profitable. That can be achieved if either prices increase or costs decrease. But according to Watanabe et al. (2002) "in both tropical and temperate zones future development of tilapia aquaculture in the Americas depend on the ability of production systems to

[8] Prices were adjusted for inflation through 2005.

produce more fish with less water, less food, and less time to lower costs." Thus, the future of tilapia culture in Nicaragua depends on producers' ability to lower costs.

The results indicated that fingerlings production as promoted by the government agency ADPESCA was not profitable. The production process and budget proposed by ADPESCA are flawed. Even though the analysis was conducted considering only the variable costs, all estimated IRR were negative; if fixed costs were included the result would be even poorer. Furthermore, several technical recommendations do not correspond to standard ones published in scientific journals. The promotion of tilapia culture suggesting inappropriate production processes and ignoring real production costs prove the incongruity of the government approach.

Grow-out in three phases generated better results. However, if fixed cost were included in the budget analysis, profits would be lower. The estimated IRR indicate that if feed prices increase by 20%, the activity generates low profitability, however, under the two other scenarios the activity was significantly profitable. Again, ADPESCA recommendations are questionable, specifically, regarding feed use. ADPESCA recommendations result in higher that average feed conversion that inflate production costs and reduce profitability. If adjustments in feed use were done, profits would increase.

The analysis of the individual producer showed discouraging results. The break-even price to cover total cost was almost equal to the actual market price. Any drop in price or increase in cost would generate negative net returns. Furthermore, all three estimated IRR were negative. High initial investment on the construction of the brick pond and the cost of feed were the main factors why tilapia was unprofitable for this producer. Constructing lower cost ponds and having access to lower price commercial feeds could enhance the economic feasibility of this sort of enterprises.

The analysis of the enterprises operated by the members of the cooperative COOSEMPROTIR, R.L. indicated that without the subsidy, tilapia culture was not profitable. If they stayed in business it was because of the generous profits produced by the subsidy. This confirmed why the members of the cooperative were involved in tilapia culture; even if they had to invest in building the ponds the rate of return generated by the subsidy from IDR, was very attractive.

At this point it is important to discuss the effects of the subsidy on the market for tilapia in Nicaragua. Lets start with the fact that the individual producers and the members of the cooperative sold their product in the same markets, and, therefore received the same price for their products. While the individual producer was losing money, the members of the cooperative were enjoying significant profits. This situation is an example of government market manipulation that illustrates the direct consequence of government intervention in the market.

Like in many other countries, in Nicaragua, government interventions in the form of input subsidies have long influenced aquaculture. This sort of intervention is beneficial to producers in the short run, but tend to cause surplus in the market because the real cost of production may be shifted to taxpayers who eventually pay for the subsidy (Jolly & Clonts 1993). This increases the level of income of the producers benefiting from the subsidy and decreases the level of income of those, like the individual producers, who bear the full cost of production. The subsidy provided by the IDR is a short term solution for tilapia culture, but as Jolly & Clonts (1993:290) stated about government interventions in the market " there should be longer-term solutions planned and short-term policies enacted to guide production and consumption along the lines needed for ultimate social and economic good of the economy." Without long-term solutions, the future of tilapia culture in Nicaragua is uncertain.

In all grow-out production enterprises, producers could attain higher net returns, and levels of profitability by selling tilapia in a different form. In Honduras the members of a cluster involving twelve tilapia farms and four fried tilapia restaurants complement their activity. The owners of the tilapia farms ensured the restaurant a constant supply of fresh tilapia, while the owners of the restaurants were willing to pay a good price (U.S.$ 2.4 / kg in 2002) for pond bank sales, and to share market information with the farmers. Because of the dynamics of the cluster, fresh tilapia producers avoided other marketing strategies with greater uncertainty and inconvenience (Martinez et al. 2004).

Small and medium-scale tilapia culture in Nicaragua was adopted and practiced because of the subsidy provided by the government. First, fingerlings supplied to producers were either produced in the fish farm of the UNA-ADPESCA, a public university, or imported by the IDR. In either case, fingerlings were provided to producers at subsidized prices. This was especially important for the members of the cooperative, who are perceived as success story of government support toward tilapia culture.

In either case, further development of tilapia culture requires efforts in areas of production and marketing. Producers have a need for more intensive production systems that generate higher profits, and do not require government subsidies. Producers in Nicaragua also need guidance and assistance to explore already existing markets where consumers are willing to pay higher prices for tilapia products.

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Table 1.1 Commercial tilapia fingerlings budget; estimated costs and returns for fingerlings production, Nicaragua 2005 (ADPESCA 1999).

500	Fry stocked/m^2 during sex reversal	100	g/1000 Beginning weight
50	Firgelings/m^2 during pre-development	45	% Death Loss
5-10	g ending weight	250-500	kg/1000 m^2/year
2.62	kg of feed / kg of gain	96	Area sex reversal (m^2)
120	Day of production cycle	427	Area pre-development (m^2)

	Item	Unit	Qt.	U.S.$* Price or cost/unit	Value or cost	% of total
1	Gross receipts					
	Fingerlings	Unit	26,400.00	0.04	1,056.00	100.0%
2	Variable costs					
	Lime	kg	60.00	0.06	3.60	0.4%
	Organic fertilizer	kg	171.00	0.02	3.42	0.4%
	Feed for broostock	kg	34.00	0.63	21.42	2.3%
	Feed during reproduction	kg	47.00	0.63	29.61	3.1%
	Feed for sex reversal	kg	103.00	0.63	64.89	6.8%
	Feed for pre-development	kg	416.00	0.63	262.08	27.6%
	Hormone	g	7.00	20.00	140.00	14.8%
	Ethilic alcohol	Liter	52.00	1.50	78.00	8.2%
	Equipment	Several			300.00	31.6%
	Overhead 5%				45.15	4.8%
	Total variable costs	U.S.$			948.17	100.0%
		U.S.$				
3	Income above variable cost:	U.S.$			107.83	
		U.S.$				
4	Net return above v. costs	U.S.$			107.83	
		U.S.$				
Break even price U.S.$/kg to cover variable costs		U.S.$			0.036	

*All values in U.S. dollars. April 1999 exchange rate: U.S.$1.00 = Córdova 11.56

Table 1.2 Commercial tilapia budget; estimated costs and returns for three-phases grow production, Nicaragua 2005 (ADPESCA 1999).

10,6,4	Firgerlings stocked /m^2	1,000	g/1000 Beginning weight
2.40	kg of feed / kg of gain	50	% Death Loss
500	g ending weight	2,800	kg/1000 m^2/year
1,000	Budget area (m^2)	270	Day of production cycle

	Item	Unit	Qt.	U.S.$* Price or cost/unit	Value or cost	% of total
1	Gross receipts					
	Tilapia	kg	2,100.00	1.54	3,234.00	100.0%
2	Variable costs					
	Lime	kg	56.00	0.06	3.36	0.1%
	Organic fertilizer	kg	282.00	0.02	5.64	0.2%
	Bags	Unit	83.00	0.50	41.50	1.6%
	Fingerlings	Unit	8,300.00	0.04	332.00	12.5%
	Phase I feed	kg	203.00	0.35	71.05	2.7%
	Phase II feed	kg	2,038.00	0.35	713.30	26.8%
	Phase III feed	kg	2,791.00	0.35	976.85	36.7%
	Materials	Several			390.00	14.7%
	Overhead 5%				126.69	4.8%
	Total variable costs	U.S.$			2,660.39	100.0%
3	Income above v. costs	U.S.$			573.62	
4	Net return above v. costs	U.S.$			573.62	
Break even price U.S.$/kg to cover variable costs		U.S.$			1.27	

* All values in U.S.$. April 1999 exchange rate: US$1.00 = Córdovas 11.56

Table 1.3 Commercial tilapia budget; estimated costs and returns for production by an individual producer, Nicaragua 2005.

15	Firgerlings stocked / m^2	20,000	g/1000 Beginning weight
4	kg of feed / kg of gain	7	% Death Loss
227	g ending weight	6,400	kg/1000 m^2/year
1,000	Budget area (m^2)	180	Day of production cycle

	Item	Unit	Qt.	U.S.$* Price or cost/unit	Value or cost	% of total
1	Gross receipts:					
	Tilapia	kg	3,200.00	2.20	7,040.00	100.0%
2	Variable costs					
	Fingerlings	Unit	15,000.00	0.16	2,400.00	35.2%
	Feed 27%-100 lb.	Sack	253.00	9.40	2,378.20	34.9%
	Labor				441.15	6.5%
	Overhead				1,175.00	17.3%
	Total variable costs	U.S.$			6,394.35	93.9%
3	Income above variable costs	U.S.$			645.65	
4	Fixed costs	U.S.$				
	Pond depreciation	U.S.$			350.00	5.1%
	Hose	Unit	5.00	9.37	46.85	0.7%
	Cast net	Unit	1.00	18.75	18.75	0.3%
	Total fixed costs	U.S.$			415.60	6.1%
5	Total costs	U.S.$			6,809.95	100.0%
6	Net return above total costs	U.S.$			230.05	
Break even price to cover variable costs U.S.$/kg		U.S.$			2.00	
Break even price to cover all costs U.S.$/kg		U.S.$			2.13	

* All values in U.S.$. November 2005 exchange rate: U.S.$1.00 = Córdovas 17.00

Table 1.4 Commercial tilapia budget; estimated costs and returns for members of the cooperative COOSEMPROTIR, R.L., excluding the subsidy from IDR, Nicaragua 2005.

4	Firgerlings stocked / m^2	1,000	g/1000 Beginning weight
1.60	kg of feed / kg of gain	12.5	% Death Loss
340	g ending weight	2,200	kg/1000 m^2/year
1,000	Budget area (m^2)	195	Day of production cycle

	Item	Unit	Qt.	U.S.$ Price or cost/unit	Value or cost	% of total
1	Gross receipts:					
	Tilapia	kg	1,190.00	2.20	2,618.00	100.0%
2	Variable costs					
	Fingerlings	Unit	4,000.00	0.02	80.00	2.8%
	Feed (30%) - 66 lb.	Sack	64.00	18.35	1,174.40	40.9%
	Labor	Unit	550.00	1.76	968.00	33.7%
	Overhead				222.24	7.7%
	Total variable costs	U.S.$			2,444.64	85.1%
3	Income above variable cost	U.S.$			173.36	
4	Fixed costs					
	Pond depreciation	U.S.$			105.00	3.7%
	Plastic	Roll	6.00	70.58	211.74	7.4%
	Hose	Roll	3.00	53.00	79.50	2.8%
	Seine	Unit	1.00	35.00	7.00	
	Cast net	Unit	1.00	24.00	24.00	0.8%
	Total fixed cost	U.S.$			427.24	14.9%
5	Total costs	U.S.$			2,871.88	100.0%
6	Net return above total costs	U.S.$			(253.88)	
Break even price U.S.$/kg to cover variable costs		U.S.$			2.05	
Break even price U.S.$/kg to cover all costs		U.S.$			2.41	

* All values in U.S.$. November 2005 exchange rate: U.S.$1.00 = Córdovas 17.00

Table 1.5 Commercial tilapia budget; estimated costs and returns for members of the cooperative COOSEMPROTIR, R.L., including the subsidy from IDR, Nicaragua 2005.

4	Firgerlings stocked / m^2	1,000	g/1000 Beginning weight
1.60	kg of feed / kg of gain	12.5	% Death Loss
340	g ending weight	2,200	kg/1000 m^2/year
1,000	Budget area (m^2)	195	Day of production cycle

	Item	Weight each	Unit	Qt.	U.S.$ Price or cost/unit	Value or cost	% of total
1	Gross receipts:						
	Tilapia		kg	1190.00	2.20	2618.00	100.0%
2	Variable costs						
	Fingerlings		Unit	4000	0.02	16.00	1.0%
	Feed (30%) - 66 lb.		Sack	64.00	18.35	234.88	15.3%
	Labor		Unit	550.00	1.76	968.00	63.1%
	Overhead					121.89	7.9%
	Total variable costs		U.S.$			1340.77	87.3%
3	Income above variable costs		U.S.$			1,277.23	
4	Fixed costs						
	Pond depreciation		U.S.$			105.00	6.8%
	Plastic		Roll	6.00	70.58	42.35	2.8%
	Hose		Roll	3.00	53.00	15.90	1.0%
	Seine		Unit	1.00	35.00	7.00	0.5%
	Cast net		Unit	1.00	24.00	24.00	1.6%
	Total fixed cost		U.S.$			194.25	12.7%
5	Total costs		U.S.$			1,535.02	100.0%
6	Net return above total costs		U.S.$			1,082.98	
Break even price U.S.$/kg to cover variable costs			U.S.$			1.13	
Break even price U.S.$/kg to cover all costs			U.S.$			1.29	

* All values in U.S.$. November 2005 exchange rate: U.S.$1.00 = Córdovas 17.00

Table 1.6 Commercial tilapia budget; estimated costs and returns for cage production by members of the cooperative Unión Maravillosa, Nicaragua 2005.

161	Firgerlings stocked / m^2	10,000	g/1000 Beginning weight
1.76	kg of feed / kg of gain	16	% Death Loss
550	g ending weight	4,850	kg/1000 m^3/year
31	Budget area (m^3)	183	Day of production cycle

	Item	Weight each	Unit	Qt.	U.S.$ Price or cost/unit	Value or cost	% of total
1	Gross receipts:						
	Tilapia		kg	2,328.00	1.50	3,492.00	100.0%
2	Variable costs						
	Fingerlings		Unit	5000	0.09	435.00	13.8%
	Feed (27%)		kg	4020	0.26	1,045.20	33.1%
	Labor					1,090.00	34.5%
	Equipment					15.00	0.5%
	Maintanance					50.00	1.6%
	Marketing					100.00	3.2%
	Overhead					125.00	4.0%
	Total variable costs		U.S.$			2,860.20	90.5%
3	Incove above variable costs		U.S.$			631.80	
4	Fixed costs						
	Cages' depreciation		U.S.$			300.00	9.5%
	Total fixed costs		U.S.$			300.00	9.5%
5	Total costs		U.S.$			3,160.20	100.0%
6	Net return above total costs		U.S.$			331.80	
Break even price U.S.$/kg to cover variable costs			U.S.$			1.23	
Break even price U.S.$/kg to cover all costs			U.S.$			1.36	

* All values in U.S.$. October 2003 exchange rate: U.S.$1.00 = Córdovas 15.36

Table 1.7 Financial analysis summary table: break-even prices, net returns, initial investment, and estimated internal rates of return at different input prices (sensitivity analysis) for six different commercial tilapia culture enterprises, Nicaragua 2005.

	Break-even price*		Net return*			Investment*	IRR**		
Enterprise	Variable cost	Total Cost	-20%	Original Price	+20%	(U.S.$)	-20%	Original Price	+20%
Fingerlings	0.05	na	214.00	123.00	32.00	4,000.00	-7.00	-21.00	< -21.00
Three-phase growth	1.45	na	1,076.00	654.00	233.00	1,200.00	114.00	65.00	8.00
Individual producer	2.00	2.13	706.00	230.00	-246.00	14,000.00	-19.00	> -19.00	> -19.00
IDR-Full cost	2.05	2.41	4.50	-254.00	-512.00	950.00	na	na	na
IDR-Subsidized	1.13	1.29	1,135.00	1,083.00	1,031.00	950.00	214.00	204.00	195.00
Cage production	1.29	1.43	568.00	349.00	129.00	3,600.00	17.00	-1.00	<-1.00

* Break even prices, net returns, and investments were adjusted for inflation through 2005.

** Estimated with 2005 values.

Table 1.8 Price comparisons for tilapia sold as whole, live fish equivalent, Nicaragua 2003 – 2005

	Engle & Neira (2003a)	Engle & Neira (2003b)	Neira & Engle (2003)	Present study (2005)
Price* (U.S.$/kg)	1.53	1	1.55	1.84
Price range (U.S.$/kg)	1.14 - 1.95	0.37 - 3.18	1.14 - 1.95	1.5 - 2.20
Percent of 2003 price	120%	184%	119%	100%
Type of sale	Supermarkets	Open-air markets	Restaurants	Consumers

* Prices were adjusted for inflation through 2005.

TILAPIA FILLET MARKET IN THE U.S.: AN ANALISIS OF NICARAGUA'S EXPORT OPPORTUNITIES

Abstract

In an assessment of Nicaragua's growing aquaculture sector, tilapia culture was identified as one of a series of opportunities to strength exports and business (USDA-FAS 1995). Nicaragua has the potential to follow the steps of Costa Rica and Honduras that currently figure as two of the top suppliers of fresh and frozen fillets into the U.S. market. This study assesses the export opportunities of Nicaragua in the market of tilapia fillets in the U.S. The study applies the approach suggested by Cuyvers et al. (1995) based on a combination of market growth rate and market shares. The variables for the study were imports of tilapia fillets into the U.S. from ANDEAN nations, nations covered under the Caribbean Basic Economic Recovery Act (CBERA), and Asian nations. Because Nicaragua's share in the U.S. market of tilapia fillets was very small, Nicaragua's opportunities were deduced from those CBERA nations. The monthly growth rate, calculated using an OLS model, was estimated in 91,574 kg or 3%. The monthly market shares were 33, 29, and 37% for ANDEAN, CBERA, and Asian nations, respectively. Changes in market shares were estimated using a modification of the Almost Ideal Demand System (LA/AIDS). The results indicated that the market share of ANDEAN and Asian nations are decreasing at monthly rates of 1 and 3%, respectively, whereas the CBERA nations' share is increasing at a rate of 4%.

1. Introduction

Initially, the government and other organizations promoted tilapia culture in Nicaragua as a social activity intended to ensure food security in rural regions. The original production systems were based on the use of locally available resources to minimize production costs (FAO 1984). Thus, the government focused on supporting only small and medium scale tilapia culture. However, since small and medium scale tilapia culture did not show the expected development after 10 years, the government shifted to support large-scale, export oriented enterprises.

Furthermore, in an assessment of Nicaragua's growing aquaculture sector, tilapia culture was identified as one of a series of opportunities to strengthen exports and business investment (USDA-FAS 1995). Tilapia culture, a non-traditional activity, could also benefit from the Central American Free Trade Agreement (CAFTA) that favors non-traditional exports (USAID 2003). As a result of these favorable conditions, a large export oriented company has entered the industry successfully, and become a recognized exporter of fresh and frozen tilapia fillets to the U.S. market.

At the time of this study, the major suppliers of both, fresh and frozen fillets, to the U.S. were Ecuador, Honduras, Costa Rica, Panama, China, and Indonesia. Nicaragua has the potential to follow the steps of neighboring countries like Honduras and Costa Rica in tilapia culture. As Fitzsimmons (2003:1) stated, "Like its neighbors, Nicaragua has the tropical conditions that are optimal for fish growth. There are abundant supplies of high quality water, land costs are relatively low and a rapidly growing workforce is looking for additional employment."

Furthermore, tilapia culture in Nicaragua could benefit from the growing demand for tilapia products in the U.S., especially fresh and frozen fillets. According to Aquaculture Outlook (2005:10), “U.S. tilapia imports surged to 249 million pounds in 2004, up 25% from 2003, and 68% higher than in 2002. The value of tilapia imports rose almost as fast, climbing to U.S.$ 297 million in 2004, 23% higher than the previous year and 71% higher in 2002.” Despite the growing per capita consumption of seafood in general, there are a limited number of studies analyzing the demand structures for fish and shellfish (Wellman 1992).

Most studies on finfish consumption have used data at wholesale level but are limited in scope (Nash & Bell, Doll, Tsoa, Schrank & Roy cited in Cheng & Capps 1988). Besides, in some time series studies the demand for fish was estimated as an aggregate commodity; thus, neglecting potential market interactions between fish species and other products (Cheng & Capps 1988, Wellman 1992).

As fish consumption in the U.S. grows, stakeholders, including producers located in exporting countries like Nicaragua, need more information about consumption. As Wellman (1992:445) stated “As the popularity of seafood in the U.S. continues to increase, rational decision making by fishery managers and industry representatives will require reliable measures of household demand for fishery products.” Household demand responds to changes in the price of fish and fish substitutes; therefore, its examination is a required first step in the socioeconomic analysis of any aquaculture and fisheries management design (Wellman 1992).

The Aquaculture Collaborative Research and Support Program (ACRSP) has supported tilapia culture research in Nicaragua by funding studies to better understand markets and marketing approaches. Those studies determined preferred sizes for tilapia in restaurants, supermarkets, and outdoor markets (Engle & Neira 2003ab). This study will complement previous ones by providing an analysis of the export opportunities for Nicaragua in the market for fresh and frozen fillets in the U.S. as well as a description of the supply side of the market and income elasticities of demand. Therefore, the objectives of this study are:

1. To estimate the growth rate of the fresh and frozen tilapia fillet market in the U.S.
2. To estimate changes in Nicaragua's market share in the fresh and frozen tilapia fillets market in the U.S.
3. To discuss export expansion opportunities for Nicaragua in the fresh and frozen tilapia fillet market, given the market's growth rate, market share, and estimated elasticities.

2. Conceptual Framework

The growth rate of a market measures the charge in demand; it elucidates if demand is increasing, decreasing or if it remains constant. For the purpose of this paper, the growth rate of the market will be estimated using the variable 'total imports of fresh and frozen tilapia fillets into the U.S.' as a proxy of the entire market. This is possible because imports can be used as an alternative to estimate market size (Cuyvers et al. 1995).

Market shares determine the degree of concentration in the market. If a few countries supply a market, the degree of concentration is high. On the contrary, if many countries supply the market, the degree of concentration is low. According to Cuyvers et al. (1995:180) "concentration is a bigger problem in a non-growing market in which a market share will have to be capture from competitors (very often firmly established). As a result, a larger degree of concentration is tolerated for small but growing markets, and even more for large and growing markets." Therefore, if the market for fresh and frozen tilapia is increasing and the level of concentration is low, it would be easier for Nicaragua to expand its exports. On the contrary, if the market remains constant or decreasing and the level of concentration is high, it would be more difficult for Nicaragua to compete.

Market shares and elasticities will be estimated using a modified version of the "Almost Ideal Demand System (AIDS)." The AIDS model has certain characteristics that make it convenient for demand analysis of fish products. The AIDS model provides an arbitrary first-order approximation to any demand system; it starts from a specific class of preferences that permit exact aggregation over consumers without invoking parallel, linear Engle curves. Furthermore, it has a functional form that is consistent with known household budget data and it is simple to estimate. In addition, it can be used to test the restrictions of homogeneity and symmetry through linear restrictions on fixed parameters (Deaton & Muellbauer 1980, Wellman 1992).

The AIDS model has been used to determine the demand of fish products in previous studies. Wessells & Willen (cited in Eales et al. 1997) used an AIDS model to estimate household demand for meat in Japan, using data at the import level and fish as an aggregated substitute. Wellman (1992) developed a variation of the AIDS model for disaggregated fish products to address the limitations of past U.S. fish demand research at the retail level. Seale et al. (2003) used a differences version of the AIDS model to estimate the demand for red wine in the U.S.; they estimated the conditional expenditure on imported red wines.

3. Methodology

OLS Model

The growth rate of the variable total imports was estimated using two OLS models, one with the variable in levels, and another with the logarithm of the variable. The first model gave the results in kg per month; meanwhile the second provided the results as monthly percentage change. The models are represented by the equations,

$$y_t = \alpha_0 + time + \varepsilon_t$$

and,

$$\ln y_t = a_o + time + \varepsilon_t$$

where y_t is the total imports of fresh and frozen fillets into the U.S. Out of the two models, the log model is more significant than the linear because it takes care of the time trend (non-stationary) of the variables.

LA/AIDS Model

The proposed model is based on the original AIDS model proposed by Deaton & Muellbauer (1980), which starts with expenditure equation determined by the first stage budgeting process:

(1) $$M_t = p_{1t}q_{it} + p_{2t}q_{2t} + p_{3t}q_{3t}$$

where M_t is the value of fresh and frozen fillets imports into the U.S. from three commercial regions: ANDEAN[9] nations, nations covered under the Caribbean Basic Economy Recovery Act (CBERA[10]), and Asian nations (China and Indonesia). The term $p_{1t}q_{1t}$ represents the value of the imports from the Andean nations, $p_{2t}q_{2t}$ represents the value of imports from CBERA nations, and $p_{3t}q_{3t}$ represents the value of imports from Asian nations.

The value of fresh and frozen tilapia fillets imported from Nicaragua to the U.S. market during the period January 2000 to February 2006 represented only 0.08% of the total market. For the same period, the value of imports from Nicaragua represented only 0.4% of the total imports from CBERA nations. Because the value of imports from Nicaragua is too small to justify an individual equation, and since Nicaragua is already included in the variable import from CBERA, Nicaragua's opportunities were deduced from those CBERA nations.

In the AIDS model the respective expenditure or market shares are given by (Deaton & Muellbauer 1980) as:

(2) $$w_{it} = \alpha_i + \Sigma_{j=1}^{3}\gamma_{ij} \ln p_{jt} + \beta_i \ln(M_t / P_t)$$

where i = 1,2,3, (Andean, CBERA, and Asian imports of fresh and frozen fillets); and $w_{it} = p_{it}q_{it} / M_t$ is the i^{th} imports' share in the month t on a value basis; and P_t is a price

[9] Andean nations are: Bolivia, Colombia, Ecuador, Perú, and Venezuela.

[10]CBERA, includes 24 Central American and Caribbean nations. Among those, Costa Rica, Honduras, Jamaica, Panama, all are major fresh and frozen fillet suppliers, while Nicaragua is a minor supplier.

index derived from the AIDS cost function in the so called "true" AIDS model. The aggregation of the individual budget shares generates the shares of aggregate expenditure on good *i* in the aggregate budget of all households.

In the linear approximate AIDS (LA/AIDS) model, the price index, P_t, is substituted by the Stone price index (Alston et al. 1994) and:

(3) $$\ln P_t^s = \Sigma_{i=1}^{3} w_{it} \ln p_{it}$$

and substituting (3) into (2) yields the LA/AIDS model (Alston et al. 1994):

(4) $$w_{it} = \alpha_i + \sum_{j=1}^{3} \gamma_{ij} \ln p_{ij} + \beta_i \ln(M_t / P_t^S) + \varepsilon_{it}$$

In (4), ε_{it} is the error term. In the LA/AIDS model all the estimated parameters were expected to have positive signs because they represent market shares that cannot be negative. Thus, the analysis consists of comparing the magnitude of those market shares represented by:

$$w_{it} = p_{it} q_{it} / M_t$$

Since this study investigates time series data, the first difference and not the levels of the variables are recommended to estimate the model (Seale et al. 2003). Hence, the LA/AIDS model in differences requires an adjustment, and is denoted by the equation:

(5) $$dw_{it} = \alpha_i + \sum_{j=1}^{3} \gamma_{ij} d \ln p_{jt} + \beta_i d \ln(M_t / P_t^D) + \varepsilon_{it}$$

Since the data contains monthly values, in (5) "*d*" represents the first difference of the variables. In the first difference LA/AIDS model, the estimated parameters have the same interpretation with exception of α_i. The intercept now indicates the trend effect of the model. The intercept is interpreted as the monthly change in the market share of the fillets market. In the difference LA/AIDS model, the Stone price index (3) is substituted by the Divisia price index (Deaton & Muelbauer 1980). According to Seale et al. (2003:192) "Unlike the Stone index, the Divisia price index does not vary with constant prices even if income changes, and preferences are nonhomothetic. Further, parameter estimates based on the first difference version of the AIDS model utilizing the Divisia price index are invariant to units of measure, and there is no simultaneity problem as in the levels version."

The Divisia price index is defined as:

(6) $$d \ln P_t^D = \sum_{i=1}^{3} w_{it}^* d \ln p_{it}$$

where $w_{it}^* = \left(\frac{w_{it} + w_{it-1}}{2} \right)$ is the average market share between time t and time t_{-1}.

However, because the data in this analysis represented monthly and not yearly observations it was necessary to deseasonalize the data. Kmenta (1986 in Seale et al. 2003) suggested the use of the twelfth difference of the data to take care of seasonality issues. As a result of the adjustment, the final differences LA/AIDS model is:

$$dw_{it} = \alpha_i + \sum_{j=1}^{3} \gamma_{ij} d \ln p_{jt} + \beta (d \ln M_t - \sum_{j=1}^{3} w_{it}^* d \ln p_{it}) + \varepsilon_{it}$$

and now "*d*" represents the twelfth, rather than the first difference of the variables.

The LA/AIDS model can be restricted to comply with the microeconomic theory that explains consumers' behavior. According to Deaton & Muellbauer 1980 those restrictions are:

Adding-up: the sum of the changes in the estimated parameters should be equal to zero.

$$\sum_{i=1}^{3} a_i = \sum_{i=1}^{3} \gamma_{ij} = \sum_{i=1}^{3} \beta_i = 0$$

Homogeneity: the changes in the demand function are homogenous of degree 0. That is, the changes in prices and income are equal.

$$\sum_{j=1}^{3} \gamma_{ij} = 0 \qquad j = 1, \ldots 3$$

Symmetry: the effect of the variable x on variable y is equal to the effect of variable y on variable x (Slustsky condition).

$$\gamma_{ij} = \gamma_{ji}$$

The general restrictions implied in the estimated elasticities are the main content of utility theory from the standpoint of estimation. This is possible because the restrictions hold regardless of the form of the utility function (Kinnucan 2005). According to Deaton & Muellbauer (1980:315) "If the restriction holds, then the equations in the LA/AIDS model represent a system of demand functions which add up to total expenditure ($\Sigma w_i = 1$), are homogeneous of degree zero in prices and total expenditure taken together, and which satisfy Slutsky symmetry."

The parameters estimated in the LA/AIDS model do not represent true elasticities. The conditional price and expenditure elasticities for the LA/AIDS model can be computed using the following formulas (Seale et al. 2003):

Own-price elasticities:

(7) $$E_{ii} = \frac{\partial \ln q_i}{\partial \ln p_i} = -1 + \frac{\gamma_{ii}}{w_i} + w_i \quad \text{or} \quad E_{ii} = \frac{\partial \ln q_i}{\partial \ln p_i} = -1 + \frac{\gamma_{ii}}{w_i^*} + w_i^*$$

Cross-price elaticities:

(8) $$E_{ij} = \frac{\partial \ln q_i}{\partial \ln p_j} = \frac{\gamma_{ij}}{w_i} + w_j \quad \text{or} \quad E_{ij} = \frac{\partial \ln q_i}{\partial \ln p_j} = \frac{\gamma_{ij}}{w_i^*} + w_j^*$$

Expenditure elasticities:

(9) $$E_i = \frac{\partial \ln q_i}{\partial \ln M} = 1 + \frac{\beta_i}{w_i} \quad \text{or} \quad E_i = \frac{\partial \ln q_i}{\partial \ln M} = 1 + \frac{\beta_i}{w_i^*}$$

In (7), if the market share increases with own-price such that $\gamma_{ii} > 0$, then, the demand will be price inelastic. If market share decreases with own-price such that $\gamma_{ii} < 0$, then, the demand will be price elastic. In (8), if the estimated elasticity is negative, the commodities are substitutes; if it is positive, the commodities are complements. And in (9), if the market share increases with import expenditure ($\beta_i > 0$), then, the product is a superior good in international trade ($E_i > 1$); on the contrary, if the market share decreases with import expenditure ($\beta_i < 0$), then the product is a normal good in international trade. In other words, for normal goods, imports, from a given country, decrease as import expenditures increase.

Data

The data for this study was downloaded from the database of the National Marine Fisheries Service, Fisheries Statistics and Economics Division (NMFS), and subdivision of the National Oceanic and Atmospheric Administration (NOAA) for the period between January 2000 and February 2006. The original data contained monthly quantities (kg) and values (U.S.$) of fresh and frozen fillets, and whole frozen tilapia coming from Andean nations, CBERA nations, China, and Indonesia.

The three variables, ANDEAN, CBERA, and Asian nations were chosen because they contained the nations that supply most of the fresh and frozen fillets to the U.S. Asian countries like Thailand, Indonesia, China, and Taiwan dominate the frozen fillets market. However, China alone accounted for 77% of the frozen imports in 2004 (Aquaculture Outlook 2005). In contrast, Latin American countries dominate the market for fresh fillets; for example in 2004, Ecuador accounted for 48% of the imports, while imports from Honduras and Costa Rica accounted for 38% of fresh fillets imports (Aquaculture Outlook 2005).

The data on frozen whole tilapia were eliminated because the market for frozen whole tilapia was already dominated by China (Aquaculture Outlook 2005) and did not represent an opportunity for Nicaragua. The data from China and Indonesia were added together to form the variable imports from Asia nations. The data were transformed by adding fresh and frozen fillet import together in each month. This was necessary for two reasons, first, because the volume of imports from Nicaragua was equal to zero for many months, and second, because imports of tilapia fillets from Nicaragua consisted of approximately 30% frozen fillets and 70% fresh fillets during the period under study. Prices for the remaining two commodities were estimated by dividing revenue over quantities. The final set of data consisted of 74 observations in level format and 60 observations in difference format. The difference transformation was necessary to realize the objectives of this study and to fit the first difference LA/AIDS model.

The next section shows the results of the graphical analysis of the original data. The chart imports of fresh and frozen fillets into the U.S. from ANDEAN, CBERA, and Asian nation (Figure 2.1) shows that imports from ANDEAN and CBERA nations move all along at approximately one million of kg per month, whereas imports from Asian nations have increased in the last four years from 50 thousands to four millions kg per month. The chart price of imports from ANDEAN, CBERA, and Asian nations in the U.S (Figure 2.2) indicates that prices from ANDEAN and CBERA nations are constant at value of approximately U.S.$ 6/kg, while prices from Asian fillets have decreased from U.S.$ 4-3/kg approximately. The chart of the value of those imports (Figure 2.3) shows a similar behavior, ANDEAN nations and CBERA nations moved all along at approximately U.S.$ 6 million per month, whereas the value of imports from Asia increased roughly from a quarter to U.S.$ 12 millions per month in a period of six years.

4. Results and Discussion

The following section shows the results of the graphical analysis of the variables used in the LA/AIDS model. The graphical inspection of the variable total imports with respect to time showed an upward trend. Both, the chart of the variable, in levels (Figure

2.4) and in natural logarithm (Figure 2.5), indicated an upward trend with respect to time. The growth rate of the variable in levels form was estimated to be 91,574 kg/month. The regression had a t value of 27, and an adjusted R^2 equal to 0.91. The monthly change of the variable, given by the log, was estimated at 3%. This regression had a t value equal to 51, and an adjusted R^2 equal to 0.97. The results confirmed the pattern seen in the plot of the data, and indicated that imports of fresh and frozen fillets are increasing by 91,574 kg/month or 3% per month.

Estimated Parameters, Market Shares and Elasticities

This section presents the results[11] of the different estimated models: model 1 is a LA/AIDS model with restrictions using the variables in levels; model 2 is a LA/AIDS model with restriction using the first difference of the variables; Model 3 is a LA/AIDS model with restrictions using the variables in levels and corrected for autocorrelation; finally, model 4 is a LA/AIDS model with restriction using the first difference of the variables and corrected for autocorrelation.

This section shows the outcome of the first two models. The results of the model 1 (Table 2.1), indicated that in the equation ANDEAN nations (first equation), only two estimated parameters were significant, the intercept and expenditure both at the 95% level. This first equation had a good explanatory power with an adjusted R^2 value of 0.67. However, the measure of autocorrelation for this equation, the Durbin-Watson[12] (D-W)

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[11] The models were estimated using the software package LIMDEP.

[12] After examining both the levels and differences models, the next step was to test the models for autocorrelation using the Durbin-Watson test. The test is based on the null hypothesis that the parameter ρ (autocorrelation coefficient) is equal to zero. The D-W values for the model in levels indicate that if the equations have autocorrelations at the 95% level are: dl = 1.46 and du = 1.77. For the model in differences dl=1.41 and du=1.77, at the 95% level. The results of the test indicate that all the equations in the models,

coefficient, which measures the level of autocorrelation in the data, had a value of 0.92, suggesting the incidence of autocorrelation in the data. In the CBERA nations equation (second equation) three parameters were significant: the intercept and own-price at the 95% level, and expenditure at the 90% level. The second equation had a very good explanatory power with an adjusted R^2 of 0.86, and a D-W value of 1, indicating the presence of positive autocorrelation in the data.

In the Asian nations equation (third equation), three parameters were significant: the intercept, the cross price parameter Asian nations-ANDEAN nations, and the parameter expenditure. The intercept and the expenditure parameter were both significant at the 95% level, while the cross price parameter was significant at the 90% level. The overall explanatory power of the equation was very good, since the adjusted R^2 had a value of 0.87, however, the D-W in this equation had a value of 1.2, indicating again positive autocorrelation.

Now, this section shows the results of the model 2 (Table 2.1). In this model, the intercept has a special interpretation since it reveals the trend of the data. Therefore, the values –0.001 and -0.03 for the first and third equation indicated a monthly reduction of 1 and 3% in the market shares of the ANDEAN and Asian nations; for a total market share lost of 4%. In the second equation the value of the intercept was 0.04, this indicated a monthly increase of 4% in the market share of CBERA nations. Notice that the market share lost of ANDEAN and Asian nations was equal to the increase in the market share of the CBERA nations.

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levels and differences, have positive autocorrelations. For that reason, it was necessary to estimate all the equations using the option in the software package –Limdep – that corrects for autocorrelation using ρ.

Other results in this model showed that in the first equation only two parameters were significant: the cross price parameter ANDEAN-CBERA nations at the 95% level and the expenditure at the 90% level. The explanatory power of the equation was very poor with an adjusted R^2 value of 0.03; the D-W value for this equation equal 0.99, suggesting positive autocorrelation.

In the equation CBERA nations four parameters were significant, the intercept, the cross price CBERA–ANDEAN nations, the own-price, and the expenditure all at the 95% level. The explanatory power of second equation was good with an adjusted R^2 of 0.56 and a D-W parameter of 1.6 that was inconclusive. In the Asian nations equation two parameters were significant, the intercept at the 90% level, and the expenditure at the 95% level. The explanatory power of the equation was good with an adjusted R^2 of 0.38, and the D-W parameter had a value of 1.55, which was inconclusive.

The following section shows the outcomes of models 3 and 4. The results of model 3 (Table 2.1) indicated that in the first equation only two parameters were significant, the intercept and the expenditure, both at the 95% level. The explanatory power of the equation improved since the new adjusted R^2 had a value of 0.75 (previous value of 0.67). The second equation also had two significant parameters, the intercept and the expenditure, both at the 95% level. The explanatory power improved slightly since the new adjusted R^2 had a value of 0.89 (previous value of 0.86). Finally, the last equation presented similar results, the intercept and the expenditure were significant, both at the 95% level. The explanatory power improved slightly from an adjusted R^2 of 0.87 to a new one of 0.88.

The results of model 4 (Table 2.1) indicated that in the first equation three parameters were significant, the own-price and the expenditure at the 90% level, and the cross price ANDEAN-CBERA nations at the 95% level. The explanatory power of the model, even though still low, improved significantly from a previous adjusted R^2 of 0.03 to a new one of 0.24. In the equation CBERA nations four parameters were significant, the intercept, the cross price CBERA–ANDEAN nations, the own price, and the expenditure, all at the 95% level. The explanatory power of the model improved slightly with an adjusted R^2 of 0.58 (previous value of 0.56). In the last equation only two parameters were significant, the intercept at the 90% level, and the expenditure at the 95% level. The explanatory power improved slightly from an adjusted R^2 of 0.38 to 0.40.

Market Shares

The market shares indicate the percentage of the market (value in U.S$) supplied by each region in the last six years. The market shares were estimated to be 33% for ANDEAN nations, 28% for CBERA nations, and 37% for Asian nations. Since Nicaragua's export opportunities are deduced from those of CBERA nations, the result indicates than Nicaragua share with the other 24 nations included in the variables imports from CBERA nations, 28% of the market.

Elasticities

The parameters estimated in the differences models are difficult to interpret; therefore it was necessary to transform those parameters to elasticities. The elasticities were determined using only the parameters statistically significant in models three and four (models corrected for autocorrelation). The results of model 3 (Table 2.2) indicated that the expenditure elasticity for the ANDEAN nations had a value of 0.75. This implied that tilapia fillets imported from ANDEAN nations were a normal good in international trade. In the equation for CBERA nations, the expenditure elasticity had a value of 0.65 that categorized tilapia fillets from those nations as normal goods as well. In the last equation, the expenditure elasticity had a value of 1.49, suggesting that imports from Asian nations were a superior good.

Model 4 showed that in the first equation the own price elasticity had a value of –0.22. That elasticity had the expected negative sign, and indicated that a 10% increase in own price would reduce demand by 2.2% (Table 2.2). The cross price elasticity ANDEAN–CBERA nations had a value of 0.15. The positive sign suggested that imports from those two regions were substitutes. The expenditure elasticity for ANDEAN nations was estimated to be 0.74, suggesting that ANDEAN nations imports were a normal good.

In the equation CBERA nations, the cross price elasticity CBERA–ANDEAN nations was estimated to be –0.18. This result contradicted equation one, and suggested, that imports from those regions were complements. The own-price elasticity with a value of –0.11 had the expected negative sign, and indicated that a 10% increase in own-price reduces market share in 1.1%. Finally, the expenditure elasticity for CBERA nations had a value of 0.31, indicating that imports were a normal good. In the last equation, the expenditure elasticity had a value of 1.83, revealing that imports from Asian nations were a superior good.

5. Conclusions

This analysis of export opportunities for Nicaragua in the market of fresh and frozen fillets in the U.S. was based on the proposition that it would be easier for Nicaragua to increase its market share if the market has a positive growth rate and if it is supplied for several nations, which control small shares of the market. That is, countries that already control a large share of the market have more opportunities to increase their exports if the market is growing. On the contrary, countries that have a small market share have a hard time increasing their export even if the market is growing. When the market is not growing, both, countries with large or small market shares have difficulties increasing their exports.

CBERA nations supplied approximately 28% of the market of fresh and frozen fillets in the U.S. Even though the market share was large, the 24 countries of CBERA nations suggest that there is a low degree of market concentration, at least in 28% of the market.

Other results indicated that the market for fresh and frozen tilapia fillets in the U.S. was indeed increasing, and providing opportunities for larger imports (exports from Nicaragua). Furthermore, the intercept term in model two revealed that the market shares of both ANDEAN and Asian nations were decreasing, while imports from CBERA nations were increasing. Since the results for Nicaragua were deduced from those for CBERA nations, the increase in the market share of CBERA nations means more opportunities for Nicaragua. Hence, the situation for Nicaragua looks promising because the market was growing and the market share of CBERA nations was increasing.

The expenditure elasticity for CBERA nations suggested that fresh and frozen fillets were international normal goods. This means that as income increases in the U.S., consumers demand more products from the CBERA region. However, the expenditure elasticities estimated with the parameters generated by models 1 and 3 provided an interesting result: both, imports from ANDEAN and CBERA nations were normal goods in the international trade, while imports from Asian nations were categorized as superior goods. Meaning that as income increases, consumers spend more on imports from Asian nations than from ANDEAN and CBERA nations.

These finding suggested that Nicaraguan exporters of tilapia should keep track of changes in income in the U.S. As income in U.S. increases, consumers buy more fresh and frozen fillets. Further studies of Nicaragua' export opportunities should focus on alternative export markets and perhaps different products presentation. The U.S. market for tilapia is already occupied by large exporting nations such as China, Ecuador, Costa Rica, and Nicaragua small market share makes competition with those nations difficult, but not impossible.

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Table 2.1. Estimated parameters for the LA/AIDS models; fresh and frozen tilapia fillets market, U.S., 2006.

	α_i		γ_{ii} or γ_{ij}		βi		
Region	Intercept	ANDEAN	CBERA	Asian	Expenditure	Adj. R^2	D-W
Model 1: Variables in levels and restrictions applied.							
ANDEAN	1.411	-0.046	-0.062	0.108	-0.069	0.67	0.92
	(9.23)**	(1.117)	(-0.882)	(-0.769)	(2.662)**		
CBERA	1.831	-0.062	0.105	-0.042	-0.106	0.86	1
	(16.44)**	(-1.5)	(-2.45)**	(1.09)	(-12.43)**		
Asia	-2.242	0.108	-0.042	-0.065	0.175	0.87	1.2
	(-11.66)**	(1.72)*	(-1.09)	(-0.84)	(11.54)**		
Model 2: Variables in differences and restrictions applied.							
ANDEAN	-0.01	0.134	-0.133	-0.0003	-0.064	0.03	0.99
	(-0.74)	(2.38)	(-3.43)**	(-0.007)	(-1.95)*		
CBERA	0.04	-0.133	0.173	-0.039	-0.22	0.56	1.6
	(3.85)**	(-3.43)**	(4.12)**	(-1.08)	(-8.65)**		
Asia	-0.03	-0.00034	-0.039	-0.039	0.284	0.38	1.55
	(-1.86)*	(-0.007)	(-1.08)	(0.646)	(7.032)**		
Model 3: variables in levels, restrictions applied and corrected for autocorrelation.							
ANDEAN	1.562	0.019	-0.061	0.041	-0.082	0.75	1.67
	(8.47)**	(0.26)	(-1.27)	(0.64)	(-5.93)**		
CBERA	1.782	-0.061	0.078	-0.016	-0.101	0.89	1.84
	(14.42)**	(-1.27)	(1.74)	(-0.44)	(-11.10)**		
Asia	-2.335	0.034	-0.014	-0.02	0.184	0.88	1.92
	(-10.28)**	(0.55)	(-0.37)	(-0.26)	(10.61)**		
Model 4: variables in differences, restrictions applied and corrected for autocorrelation.							
ANDEAN	-0.0002	0.148	-0.15	0.00196	-0.088	0.24	1.44
	(-0.014)	(2.25)*	(-3.41)**	(0.038)	(-2.57)*		
CBERA	-0.033	-0.15	0.172	-0.021	-0.199	0.58	1.9
	(3.09)**	(-3.41)**	(3.87)**	(-0.56)	(-7.53)**		
Asia	-0.04	-0.029	-0.025	0.054	0.311	0.4	1.77
	(-2.38)*	(-0.57)	(-0.67)	(0.88)	(7.55)**		

* Parameter significant at 10% statistical level.

** Parameter significant at 5% statistical level.

Table 2.2 Estimated elasticities; fresh and frozen tilapia fillets market, U.S., 2006.

	Elasticities				
Model 3*:	ANDEAN	CBERA	Asian	Expenditure	w*
ANDEAN	-0.61	0.11	0.50	0.76	0.34
CBERA	0.13	-0.44	0.32	0.65	0.29
Asian	0.43	0.25	-0.68	1.49	0.37
Model 4*:					
ANDEAN	-0.22	-0.16	0.38	0.74	0.34
CBERA	-0.18	-0.12	0.30	0.31	0.29
Asian	0.26	0.22	-0.48	1.83	0.37

* Variables in levels, restrictions applied and corrected for autocorrelation.
* Variables in differences, restrictions applied and corrected for autocorrelation.

Figure 2.1 Imports of fresh and frozen fillets into the U.S. from ANDEAN, CBERA, and Asian nations, 2000:1-2006:2

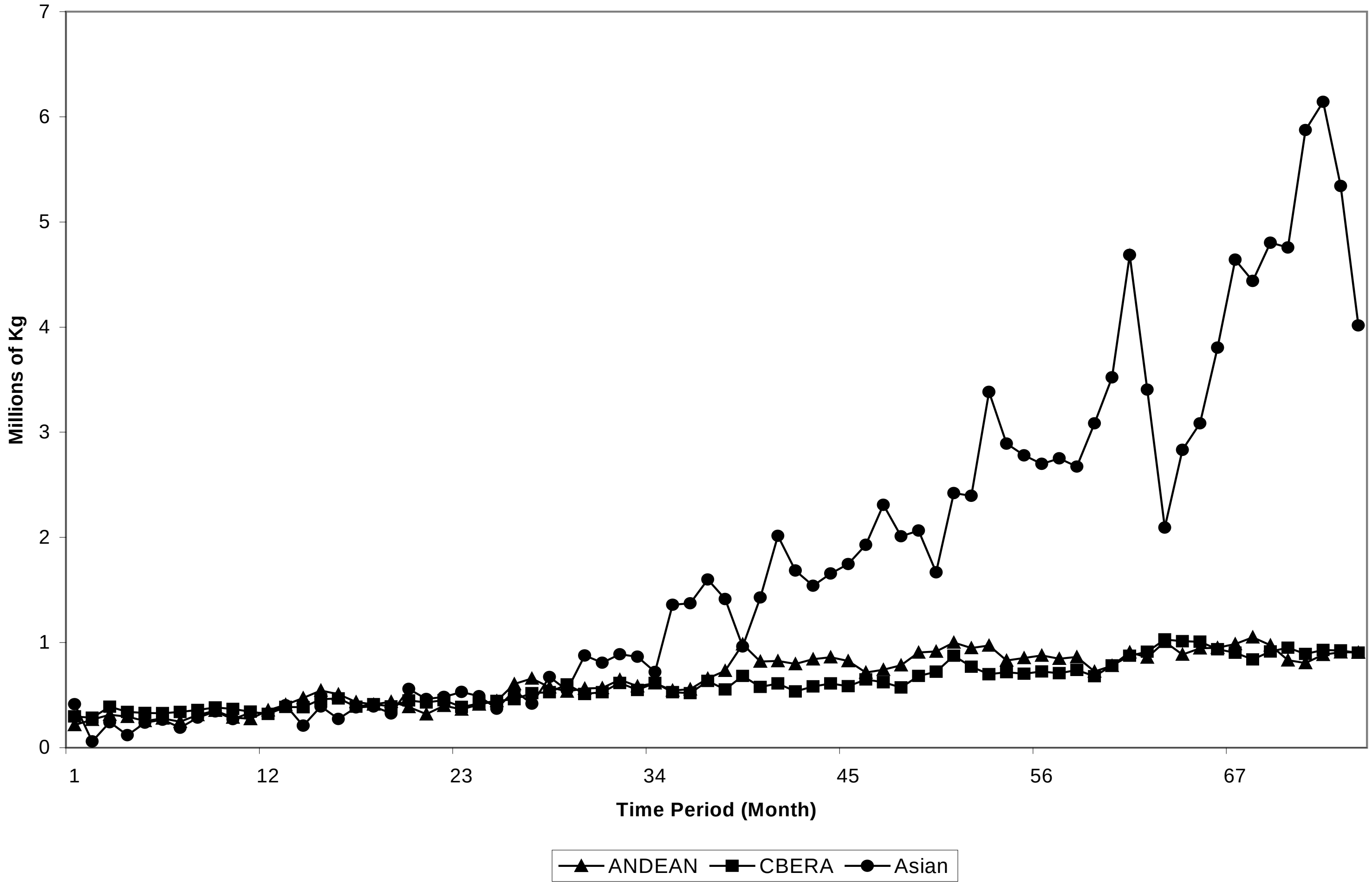


Figure 2.2 Price of imports of fresh and frozen fillets into the U.S. from ANDEAN, CBERA, and Asian nations in the U.S. 200:1-2006:2.

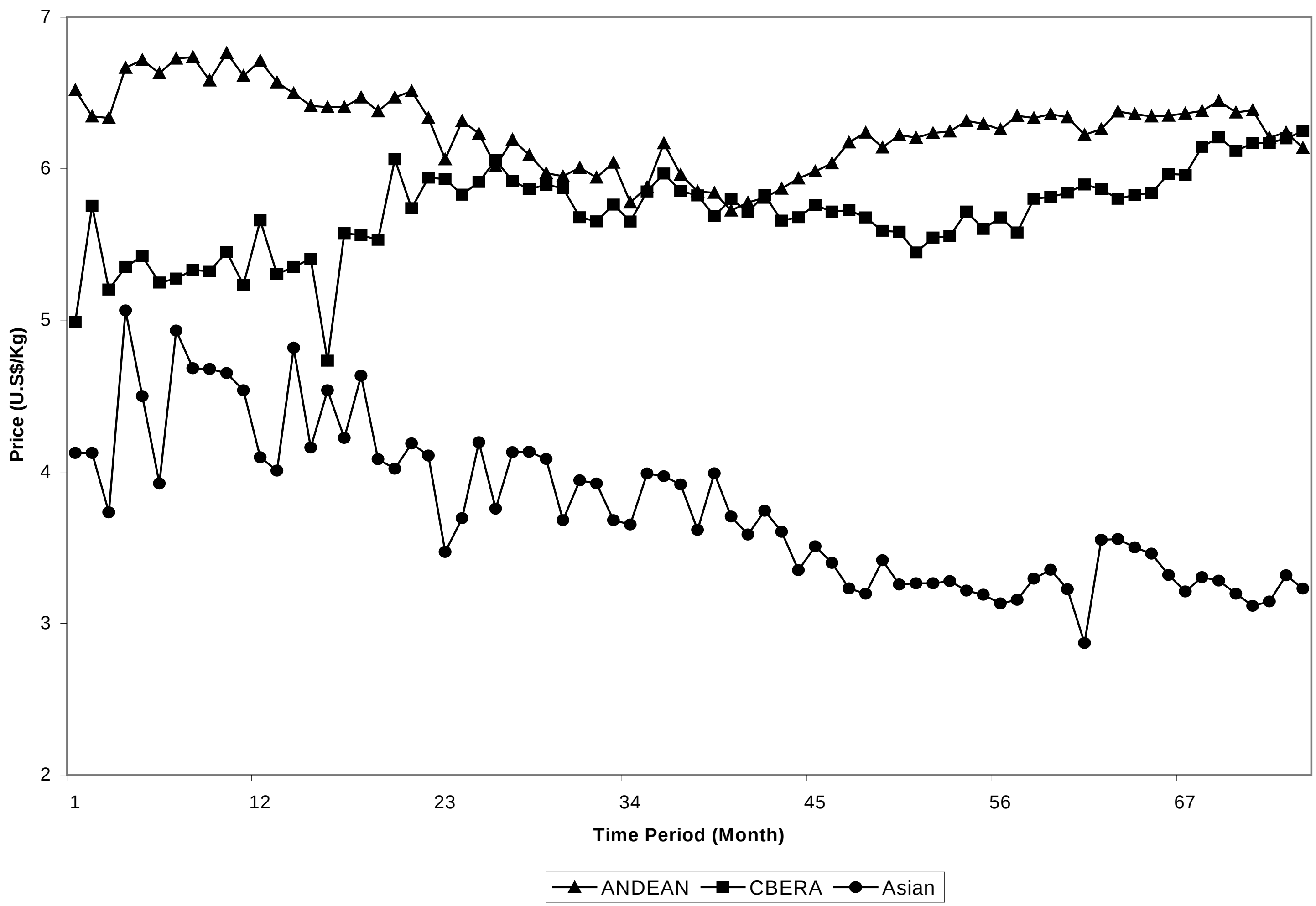


Figure 2.3 Value of imports of fresh and frozen fillets into the U.S. from ANDEAN, CBERA, and Asian nations, 200:1-2006:2.

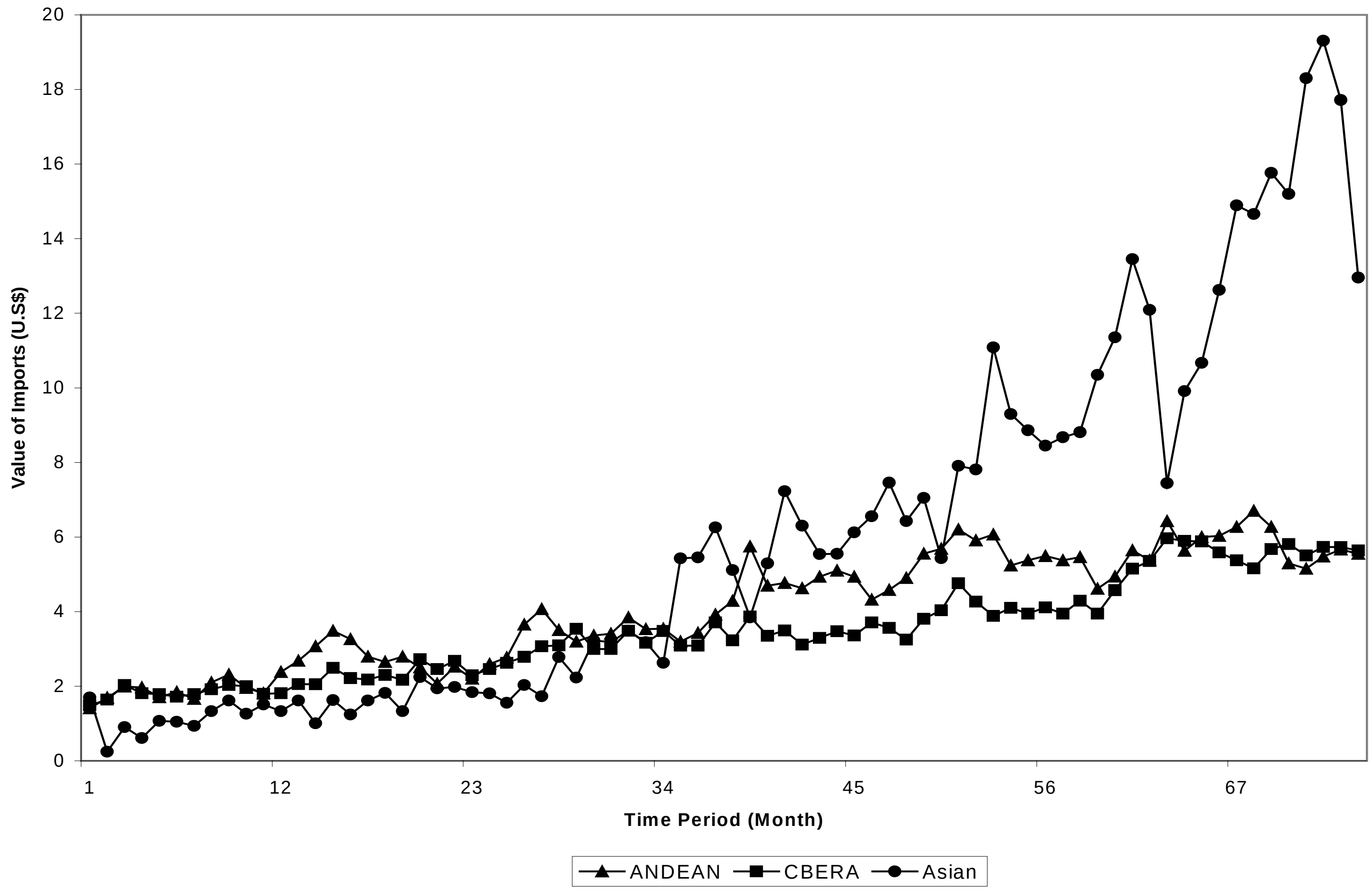


Figure 2.4. Total imports of fresh and frozen fillets into the U.S., 2000:1-2006:2

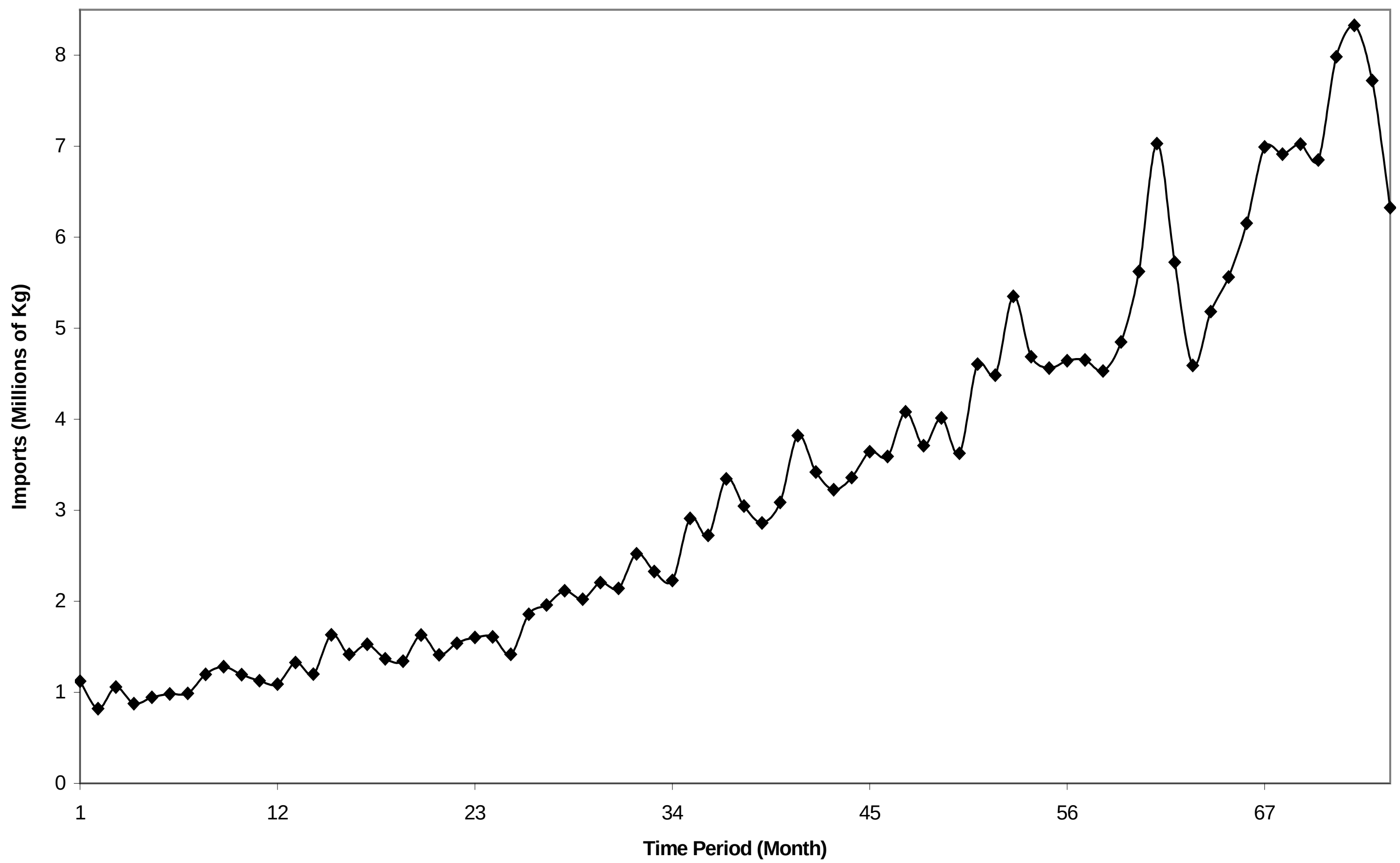
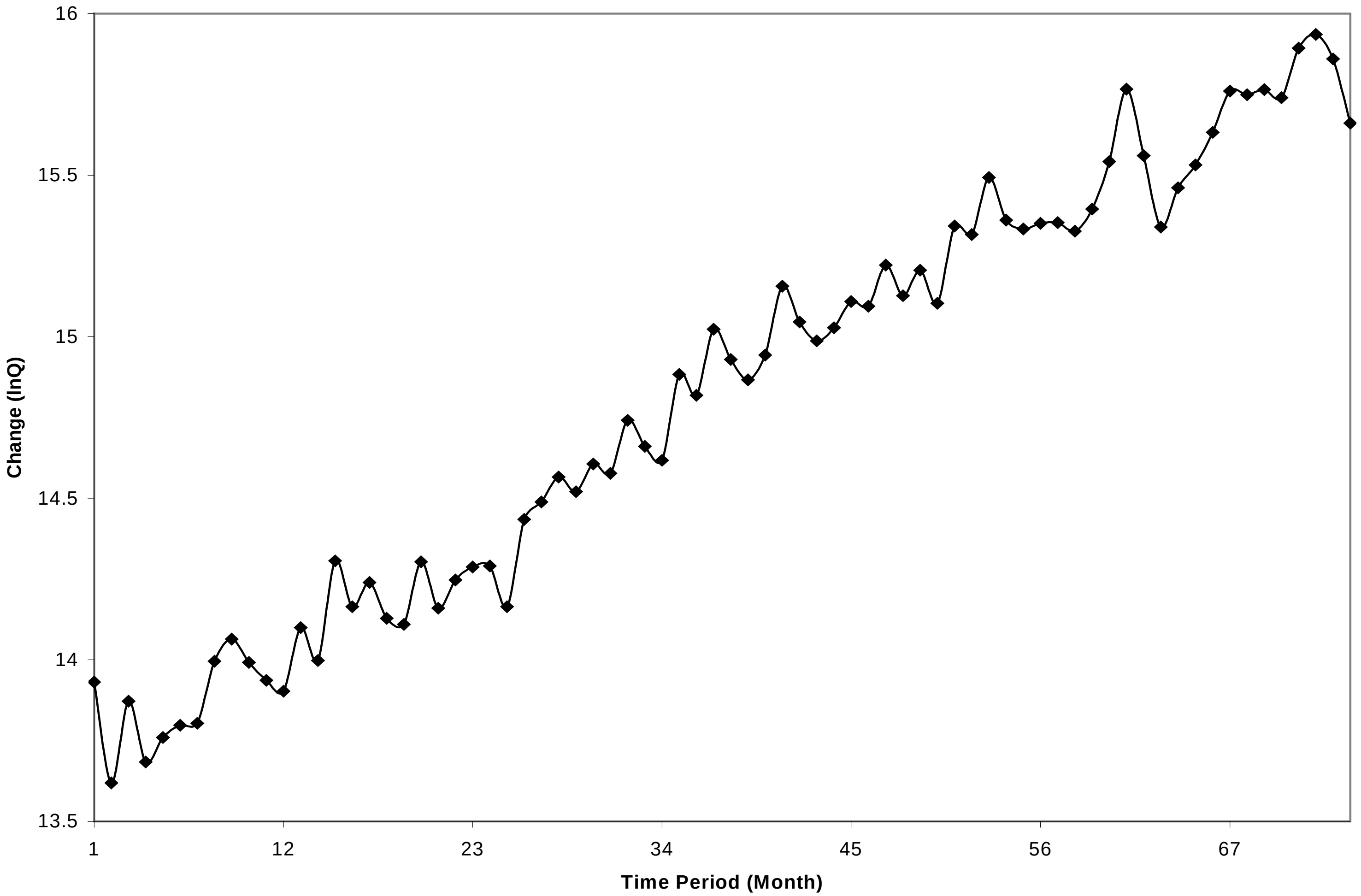


Figure 2.5 Change in total imports of fresh and frozen fillets into the U.S., 2000:1-2006:2



UNDERSTANDING THE AQUACULTURE KNOWLEDGE AND INFORMATION SYSTEM IN NICARAGUA

Abstract

The flow of information between researchers, extension agents, educational institutions, and producers involved in tilapia culture should produce technologies that better suit the needs of producers. Understanding the aquaculture knowledge system requires the identification of stakeholders, their interactions, and the documentation of producers' knowledge. In Nicaragua, the analysis of the Aquaculture Knowledge and Information System (AKIS) for tilapia culture revealed that the system was not well developed. At the time of this study, tilapia culture was a highly subsidized activity undertaken by only a small number of producers mainly located in Northern Nicaragua. The level of producer knowledge was low and ignored by other stakeholders in tilapia culture. Researchers, extension agents, and educational institutions often did not share nor discuss their experiences in tilapia culture with each other; thus, each institution worked largely in isolation. The analysis of the AKIS also showed that small and medium-scale tilapia culture had not developed due to a pattern of government support that has favored shrimp production over fish culture, lack of a domestic supply of good quality commercial feed and fingerlings, and the environmental controversy over large-scale tilapia culture in Lake Nicaragua. The future of small and medium-scale tilapia culture depends on the

successful expansion of export oriented tilapia culture that could attract other businesses, such as input suppliers.

1. Introduction

The decision-making processes of aquaculture producers are dynamic and unique to each situation (Warren 1991, Warren & Rajasekaran 1993). That is, they are affected by the availability of resources, management styles, market conditions, interactions with other socio-economic sectors, and private and public support or opposition (Warren & Rajasekaran 1993, The World Bank 1998). Documenting that decision process is crucial to further aquaculture development because it answers the following question: how do producers try to solve their problems using their own knowledge?" (Röling 1988, Rajasekaran 1993).

The Food and Agriculture Organization (FAO) and the World Bank being aware of the importance of farmers' knowledge issued a document proposing the integration of farmers, educational, research, and extension institutions into an Agricultural Knowledge and Information System for rural development (AKIS) (FAO & World Bank 2000). This perspective was intended to respond to the knowledge and information needs of large numbers of rural communities by helping them reach informed decisions on the better management of their farms, households, and communities (FAO & World Bank 2000).

This approach also was intended to facilitate the exchange of ideas between decision-makers in governments and development organizations. This exchange of ideas aimed to ensure the formulation and due consideration of well-founded proposals for investment in AKIS. The AKIS approach would also ensure a more effective and efficient system capable of achieving better results from complementary investments in education, research, and extension (FAO & World Bank 2000).

Ideally, an AKIS is characterized by a systematic flow of information between farmers, researchers, extension agents, and educational institutions (Röling 1988). With farmers as the center of the system (Figure 3.1), all stakeholders put their expertise together to generate agriculture technologies that suit producers' needs and enhance the system as a whole (FAO & The World Bank 2000).

For the purpose of this study, FAO and World Bank's AKIS framework was adapted to aquaculture as the Aquaculture Knowledge and Information System. The application of the AKIS approach to aquaculture was necessary to perform an analysis of the level of collaboration among producers, researchers, extension agents, and educational institutions involved in tilapia culture in Nicaragua.

The adjustment of FAO and World Banks' AKIS to aquaculture in Nicaragua seemed quite logical and proper. According to Veverica and Molnar (1997:399) "In general, extension approaches and notions developed for land-based agriculture are applicable to aquaculture." But certain details should be considered when using the AKIS approach to aquaculture. There are two main differences between aquaculture and agriculture; aquaculture is relatively a new activity in many regions, and it utilize extension agencies units that often are weakly linked to agriculture extension. As Veverica and Molnar (1997) argued, aquaculture can be considered in the framework of a nontraditional crop.

Aquaculture in Nicaragua: An Overview

The first important effort to promote and develop aquaculture in Nicaragua was an initiative by the Sandinista government in 1982. The program started with the creation of the Instituto Nicaragüense de la Pesca[13] (INPESCA) and the construction of the first aquaculture farm in Nicaragua (FAO 1992). The mission of INPESCA was to promote tilapia (*Oreochromus sp*.) and carp (*Cyprinus sp.*) culture as a means for improving the diets of Nicaraguans, as well as marine shrimp as an export oriented crop. In its initial operations, INPESCA designated 8,000 m^2 of ponds to evaluate production of *O. auraes*, 1,000 m^2 for *O. niloticus*, 1,100 m^2 for carp, 100 m^2 for guapote (*Cichlasoma managuense*), 5,000 m^2 for *Penaeus vannamei*, and some areas for *Penaeus stylirostris* (FAO 1984).

In 1982, the Universidad Centroamericana (UCA) also began to promote aquaculture in Nicaragua and built its own aquaculture station. The station was built for two purposes, first as a training center for university students, and, second, as a means for promoting aquaculture among rural cooperatives and private producers in the country (FAO 1984).

It is not clear the extent to which the UCA and the government coordinated their initiatives; however, the government and UCA approached extensive aquaculture as a social activity rather than an economic activity. It was a social activity because it was intended to ensure food security in rural regions. To minimize production costs, the production was based on the use of locally available feedstuff, dams and small lakes, and fingerlings that were distributed at no cost by the government (FAO 1984).

[13] National Fisheries Institute.

The project executed by INPESCA did not achieve the expected results (FAO 1984). By 1984, the project was already failing due to lack of properly trained personnel at different levels, inappropriate infrastructure, low quality broodstock, inappropriate technical equipment, limited technical assistance, poor organization, and lack of funds (FAO 1989). Today, it is clear that the apparent successful promotion and adoption of tilapia culture during the period 1982-1984 was an illusion. If people were building small ponds and producing tilapia, it was because INPESCA was providing fingerlings at no cost. Potential adopters, with little technical knowledge, were willing to "try" the new technology as a subsidized novelty. Once the subsidy was reduced or eliminated, producers abandoned the activity.

Evidence of similar behavior has been recorded in other parts of the world. According to FAO (1996), numerous small-scale rural aquaculture projects remain active until the promoting organization ceases to provide fish seed. At that point, the beneficiaries experience serious difficulties obtaining fingerlings for restocking. Since, the fingerlings were not available; the producers lack resources for purchasing what was available, or they experience transportation problems that delay the start of a new fish crop. In many projects, fingerlings were provided free of charge, and without making provision for training the participants in seed production.

In 1989, what seemed to be a significant adoption of fish culture was already at a halt; tilapia production in rural areas was not growing at all (FAO 1989). The remaining producers were members of cooperatives that obtained most of their inputs through government agencies. In four years, tilapia and carp production decreased from 68 metric tons in 1989 to three metric tons in 1992; an average decreasing rate of 54% per year, (FAO 1994). By 1992 the government had stopped all activities in fish culture.

In contrast, marine shrimp production was growing and getting more governmental support. In 1989, the government shifted its focus from fish culture to shrimp culture. That year, there were already 100 hectares under operation for a total production of 45 metric tons of shrimp that generated US$250,000 (FAO 1989). The government decided to emphasize shrimp production for two reasons, first, the ability of industry to generate foreign currency and, second, the willingness of private investors to develop it (FAO 1994).

After INPESCA was reorganized, subsequent government agencies tended to disregard fish culture and support shrimp production. At the same time, the interest moved from supporting cooperatives to fostering private, export-oriented companies. For example, during the government of Violeta de Chamorro, INPESCA became the Agency for Promotion and Development of Fisheries (MEDEPESCA). MEDEPESCA favored the development of shrimp production by private producers mainly through land concessions (Rocha 2003). Then, MEDESCA became the Administration of Fisheries (ADPESCA) that at the moment of this study was promoting and monitoring the development of shrimp production and some minor aspects of fisheries, including aquaculture.

Nonetheless, after the large scale government's program on aquaculture ended, other national and international organizations, as well as several producers continued supporting tilapia culture. That support focused mainly on the Northern departments of

Estelí, Matagalpa, Madriz, and Ocotal; yet, individual producers carried out other isolated activities in Granada, Jinotega, and Managua (ADPESCA & AECI 2002).

In 1992, the Escuela Católica de Agricultura y Ganadería de Estelí (ECAGE) began the construction of the Agro-aquaculture station "Los Chilamates." The construction of this farm started with ECAGE funds. Since 1993, however, the station expanded with funds provided by the Spanish Agency for International Cooperation (AECI). The purpose of the farm was to supply tilapia to the cafeteria of the ECAGE, and to provide an aquaculture laboratory for students. That was important because the farm output was destined to supply the cafeteria of ECAGE with good quality fish protein at a low price. That guaranteed a secure market and ensured the existence of fish culture in the ECAGE. At the same time, the installation provided an ideal site for practical education in fish culture (ADPESCA 1999).

The purpose of "Los Chimalates" changed in 1997 when ECAGE started to receive technical assistance from ADPESCA. The collaboration between the two institutions allowed ECAGE to play a broader role in the promotion of tilapia in Northern Nicaragua. By 1998, ECAGE and ADPESCA began to commercialize tilapia in the Department of Estelí; however, later that year Hurricane Mitch damaged the farm and disrupted the project. In 1999, ECAGE started a collaboration program with the Programa Regional de Apoyo al Desarrollo de la Pesca en el Istmo Centroamericano[14] (PRADEPESCA) to advance tilapia culture in the region (ADPESCA 1999).

Despite its partnership with ADPESCA and PRADEPESCA, ECAGE did not have a large impact on the development of tilapia culture in Northern Nicaragua in part

[14] Regional Program to Support the Development of Fisheries in Central America.

because in 2002, ECAGE was reorganized as the Universidad Católica del Trópico Seco (UCATSE). Under the new organization system, tilapia culture was carried out under its original objectives: to supply tilapia to the cafeteria of the ECAGE and to provide an aquaculture laboratory for students.

Recent Efforts to Develop Pond Culture

In 2000, a new project started in the poor Northern region. The main objective of the project was to provide a source of animal protein to the dwellers of several rural communities. The first phase of the project was a coordinated effort by the international organization CARE and the government agency Instituto de Desarrollo Rural[15] (IDR). The IDR functioned as the administrator of the funds provided by the Banco Interamericano de Desarrolo (BID), while CARE executed the project as part of the their broad project RENACER (Recursos Naturales, Capacitación y Economía Rural[16]) (Saavedra et al. 2003).

The project included a total of 56 ponds from which, 37 were located in the municipality of Pueblo Nuevo and 19 in the municipality of Totogalpa. The project's approach included the adoption of a production system based on the use of livestock manure to fertilize ponds, locally available feedstuffs, pond-fertilized water to irrigate adjacent crops, and household consumption of 20% of the production to ensure food security, while the rest of the production would be sold to generate income (Saavedra et al. 2003).

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[15] Institute for Rural Development.
[16] Natural Resources, Training, and Rural Economics.

Although the project used the same approach in both communities, the results were quite different due to disparities in the sources of water. In Totogalpa, wells were the main source of water of 79% of the ponds, while the remaining 21% obtained water from rivers, creeks, and springs. Additionally, water pumps were necessary in 95% of the ponds; only 5% of the farms had gravity-supplied water (Saavedra et al. 2003).

In contrast, rivers, creeks, or springs were the sources of water in 76% of the ponds in Pueblo Nuevo; the remaining 24% obtained their water from a well. Water pumps were necessary in only 29% of the ponds while in the remaining 71% of the ponds water was supplied by gravity (Saavedra et al. 2003). The disparity in water sources and supply between the two communities had economic implications that proved crucial for the success of the project in each place.

When water is difficult and costly to supply, producers operate with limited options in pond water quality management, especially in those ponds where water has to be pumped. According to Saavedra et al. (2003) producers reported that they did not make water exchanges as often as needed because of the high cost involved. As a result, water quality declined and many fish died. To make things worse, water losses due to seepage were already a concern. Consequently, fish not only suffered from lack of water exchange, but they also suffered from the lower than optimal volume of water in the ponds. In any case, each condition increased the risk of oxygen depletion and fish mortality (Saavedra et al. 2003).

In addition to water problems, producers were facing other limiting factors. In particular, the project lacked funds and technical personnel to teach producers how to manage their ponds and how to solve marketing problems. For example, without a vehicle, the project could not support producers who needed assistance transporting their surplus production to larger markets (Saavedra 2003). Despite common issues in the two communities, the project ceased its support for tilapia production in Totogalpa, while it extended its efforts in Pueblo Nuevo where water supply was less of a problem.

Meanwhile, some individuals and small institutions were carrying isolated tilapia culture projects in several communities. In 2002, a total area of 2.3 hectares, including floating cages (2% of total area), was in tilapia production in the Departments of Managua, Masaya, Granada, Matagalpa, Jinotega, Estelí, and Madriz. The producers consumed most of the production of those projects, even though sales of tilapia to neighbors were occurring. The main issue for the small producers in those projects was the need to improve and increase the size of the ponds, because low production capacity and poor pond construction were considered as main barriers to profitability (Saavedra et al. 2003).

Recent Efforts to Develop Cage Culture

Another recent effort to develop tilapia culture was led by the Proyecto de Desarrollo de Area (PDA) "Aguas Azules," financed by a New Zealand's NGO[17] "Vision Mundial Nicaragua." From July 2002 to January 2003, the PDA contracted technical assistance from UCA and started a collaboration program with ADPESCA to help the members of the cooperative Unión Maravillosa to produce tilapia in 16 low-volume, high-density floating cages in Lake Nicaragua. ADPESCA assisted the program on processing and marketing issues. ADPESCA coordinated the transportation and

[17] Non-Government Organization.

processing using the facilities of the export oriented company EXPOMAR, and negotiated the sale of the product with Supermarket La Colonia de Plaza España in Managua (Saavedra 2003).

The cage project with Unión Maravillosa yielded promising results: 99% of the sex-reversed fingerlings were male, average weight gain was 2.94 g per day, no diseases affected the fish, average final weight was 630 g, the production cycle took 10 months, average yield was 287 kg/m^3 for a total production of 2,418 kg (Saavedra 2003). Despite these promising results, the project nevertheless ended. The project was profitable only if the tilapia produced was filleted and sold to supermarkets. However, when the producers took control of the enterprise, they preferred to sell their fish on the lakeshore at a lower price rather than process the fish and add value to it, making cage production unprofitable.

While small and medium-scale tilapia culture in Nicaragua have not shown significant progress in approximately 24 years, a large export oriented company has entered the industry. Nicanor S.A. is a partly Norwegian owned company operating its own hatchery farm near Managua and cage-production in Lake Nicaragua (NORAD 2003). The activities of Nicanor S.A. in Nicaragua have generated controversy due to potential environment issues.

Tilapia Culture and the Environment

Environmentalists have opposed the operation of industrialized cage production systems in Lake Nicaragua.[18][19] Nicanor SA, (Patrick Bolaños, nephew of Nicaragua's

[18] The aboriginal name for this lake, Cocibolca (Nicaragua) means "sweet sea". It is the largest lake in Central America and one of the very few, or perhaps the only, freshwater lake to have sharks, although

president, Enrique Bolaños, was the first general manager), opened a tilapia farm and processing plant on the shores of San Ramón, Ometepe. The environmentalists argued that the mere presence of Nicanor S.A. in Lake Nicaragua violated Nicaraguan environmental laws and a series of international environmental agreements (Montenegro[20] 2001).

Critics claimed that Nicanor S.A. was polluting Lake Nicaragua by releasing organic waste into the lake (Montenegro 2001). Effluents from intense concentrations of fish organic waste, food residue, and toxic cleaning substances would enter the waters of Lake Cocibolca and other proposed sites. Montenegro (2001) asserted that there would be a septic tank for the sewage of the few workers on land, but that there was no provision for the purification of the waste of 5,000 tons of tilapia. He compared the tilapia water discharge to the release of untreated water wastes from a city of 83,333 people directly into a vulnerable body of water. The idea of tilapia being produced in polluted waters also has affected the marketing of tilapia products, since consumers fear ingesting contaminated food (Engle & Neira 2003a,b).

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their numbers have dropped precipitously. Cocibolca is one of the 40 largest lakes in the world by both surface area and volume. Its origins are both tectonic and volcanic.

[19] " Lake Nicaragua is 3,089 sq mi (8,001 sq km), c.100 mi (160 km) long and up to 45 mi (72 km) wide. Located in SW Nicaragua; the largest lake of Central America. It is drained into the Caribbean Sea by the San Juan River. Lake Nicaragua, along with Lake Managua (which drains into it from the northwest), occupies part of the Nicaragua Depression. This extensive lowland region stretches across the isthmus. Once part of the sea, the lake was formed when the land rose. There are several islands in the lake (the largest is Isla de Ometepe); and small volcanoes rise above its surface. The freshwater of Lake Nicaragua contains fish usually associated with saltwater, including tuna and sharks, which have adapted to the environmental change. The lake is a transportation route; Granada is its chief port. Located only 110 ft (34 m) above sea level, the lake reaches a depth of 84 ft (26 m). It was to be an important link in the proposed Nicaragua Canal (Columbia Encyclopedia 2005)."

[20] Dr. Montenegro is the founder the "Centro para la Investigación de Recursos Acuáticos de Nicaragua (CIRA)." CIRA keeps control of the water quality in Nicaraguan Lakes.

In addition to water pollution, tilapia has been blamed for the rapid loss of native fish species in Nicaragua.[21] Researchers expressed their concern about the potential for ecological disaster in Lake Nicaragua (McKaye & Ryan 1995). Such disasters might destroy native fish populations and undermine genetic diversity. Some who have studied lake ecology in Nicaragua maintained that tilapia displaces other species by depleting their food sources (Hernández 2002). Environmentalists argue that tilapias are highly efficient omnivores able to find food in nutrient poor lakes. Thus, opposition to tilapia culture by environmentalists, individuals, and institutions has been both vocal and persistent.

Despite the opposition by environmentalists and the concern that tilapia products may be polluted, several market surveys conducted in 2001 found that tilapia were sold in restaurants, supermarkets, and open-air fish markets. Those studies reported that 21% of the restaurants, 26% of the supermarkets, and 65% of the open-air fish markets sold tilapia (Engle & Neira, 2003ab; Neira & Engle 2003). The respondents also indicated that tilapia sales had increased over the previous year. Additionally, 50% of the respondents who were not selling tilapia indicated that they were likely to begin selling tilapia the following year (Engle & Neira 2003a).

The aquaculture sector in Nicaragua began in 1982. Ever since, many producers, extension agents, donors, researchers, and educational institutions have interacted to develop tilapia culture; however, their degree of success has been modest. A description

[21] Fishermen have reported that catches of the main native species such as *Cichlasoma nicaraguense, Cichlasoma longimanus, Cichlasoma rostratum* and *Cichlasoma citrinellum/labiatum* are inversely related to the catches of the introduced tilapia species *Oreochromis aureus, Oreochromis mossambicus, and Oreochromis niloticus* (McKaye & Ryan 1995; Hernández 2002).

of the Nicaraguan AKIS should provide information about the different capacities, advantages, interactions, and roles of current stakeholders.

Problem Statement

The main objective of this paper is to understand the AKIS for tilapia culture in Nicaragua. Such understanding includes identifying local institutions and processes upon which to build the industry, and endeavors the foundation and strategy for fostering broader participation and cooperation. To achieve that broader goal, it is necessary to accomplish three specific objectives:

1. To conduct a stakeholder analysis (SA).
2. To assess producers technical knowledge, and
3. To conduct an analysis of strengths, weaknesses, opportunities, and threats (SWOT) as perceived by producers.

The resulting study could provide relevant information of the AKIS in Nicaragua, which could be used by national and international organizations interested in the further development of aquaculture in Nicaragua. According to Rivera et al. (2006:21), "An [AKIS] assessment will reflect the needs of the specific country and the specific context and stage of development in which it operates, address the institutional constraints and opportunities inherent in the country as a whole, clarify the extent to which it is institutionally pluralistic, and identify where are the strengths and weaknesses of its knowledge system."

2. Conceptual Framework

Aquaculture Knowledge and Information Systems

Three of the concepts contained in the acronym AKIS: knowledge, information, and system require some degree of discussion. The first two terms, knowledge and information, are commonly confused. While knowledge refers to individuals' concepts, models, ideas, theories, constructs, and hypotheses, information, on the other hand, refers to patterned or formatted data that reduce individuals' uncertainty beyond his/her existing knowledge. Thus, information provides the bases for human development and productive action (Röling 1988).

According to Hurtubise (1984 in Röling 1988), the notion of system is used for three different modeling ends: first, for analytical purposes, second, for design purposes, and third, for simulation purposes. The first refers to the simplification of a difficult phenomenon by applying system analytic concepts. Examples are the local farming system and the agricultural information system. The second purpose, design, refers to the creation of a system to perform some functions, for example, the heating system and the agricultural and information system. Finally, the third purpose, simulation, refers to the creation of a system to resemble a rather complex phenomenon. For example, farm economic models predict the likely outcome of major investment decisions under different scenarios and assumptions (Röling 1988).

All three definitions suggest that an AKIS could serve all three purposes: analysis, design, and simulation. However, as Röling (1998:187) stated about the agricultural information system "it is a highly complex phenomenon, which we hope to be better able to analyze by calling it a system and analyzing it by the use of system analytic concept…the agricultural information system is also a deliberately created system. Using design criteria developed by extension science, by specialists in the administration of agricultural research and others…it seems feasible to quantify information flows and knowledge gains, to design formulas governing flows and transformations, and to stimulate either natural or designed systems with a view to experiment with their improvements." In either case, a system can be defined as an arrangement of elements that work together to accomplish a general purpose (Fresco 1986, Hurtubise 1984 in Röling 1988).

The system approach implemented in the AKIS has the potential to improve some deficiencies in research and extension models of previous government programs. The linkages existing in the system allow institutions to develop a larger base of technology innovation services available to rural producers (Rivera et al. 2006).

Stakeholders' Analysis (SA)

According to ODA (1995), SA helps to identify the different stakeholders; it can draw out the interests of participants in relation to the problems faced by tilapia culture. It can also identify conflicts of interest among stakeholders, which will influence the further development of tilapia culture. It also helps to identify relations between stakeholders, which can be built upon, and may be enabled by "coalitions" of project sponsorship, ownership, and cooperation. Finally, it can help to assess the appropriate type of participation by different stakeholders, at successive stages of the project cycle.

The first step of the SA is to identify and classify the different stakeholders as either primary or secondary. Primary stakeholders are those people and groups in the end affected by the project, in this case the producers. Secondary stakeholders are intermediaries in the process of delivering aid to primary stakeholders; they are the educational, research, and extension agencies involved in tilapia culture (ODA 1995). Once stakeholders are identified, it is necessary to assess their influence and importance within the AKIS. Stakeholders' importance refers to the understanding of how some producers may be directly affected by the future of tilapia culture, while influence refers to the ability of some stakeholders to manipulate the future of tilapia culture (ODA 1995).

Recording Producers Knowledge

The recording of producers' knowledge allows researchers to know the level of knowledge of the producers, and, their needs for scientific knowledge. The World Bank (1998:2) argue that a better understanding of the local circumstances, including indigenous knowledge systems and practices, could help to better incorporate worldwide technologies to solve problems facing local communities in the developing countries. As Rajasekaran (1993:9) stated, analyzing decision processes that further aquaculture development are crucial since it answers the question, "How do producers try to overcome or adapt the problems using their own knowledge?

The SWOT Analysis

SWOT is an acronym that stands for Strengths, Weaknesses, Opportunities, and Threats (Panasia 2002). The SWOT analysis is frequently used as a management tool for reflection, decision-making, and appraising options. The purpose of the SWOT analysis is "to gather, analyze, and evaluate information and identify strategic options facing community, organization, or individual at a given time (Panasia 2002:1)." Therefore, SWOT analysis provides information about stakeholders' perceptions of their internal and external operational environments.

According to Promise (2002), strengths and weaknesses are essentially internal to the business and related matters concerning resources, strategies, and organization in key areas such as marketing, management systems, knowledge, and others. Threats and opportunities are external factors challenging a business, and can exist or develop in the following areas: the company's own industry where structural changes may be occurring, the market place which may be changing due to economic or social factors, the competition which may be creating new threats or opportunities, and new technologies which may be causing fundamental changes in products and processes. The application of the SWOT analysis to the AKIS in Nicaragua is appropriate to assess how producers perceive their own business and the structural changes in the tilapia culture industry.

3. Methodology

Data were collected through unstructured personal interviews and documents provided by several stakeholders. The subjects of the interviews were identified through a network sampling technique. The first subjects were approached in Estelí, Nicaragua during a seminar carried out by ACRSP personnel in November 9-12, 2005. The initial contacts and subsequent referrals yielded a sample of 13 primary stakeholders and 8 secondary stakeholders. A more detailed discussion of the methodology is presented in the first paper of this dissertation.

4. Results and Discussion

Stakeholder Analysis

The identified stakeholders in tilapia culture in Nicaragua were the members of the cooperative COOSEMPROTIR, R.L., three small commercial producers, (one in Ocotal, Department of Madriz, another one in Granada, and one in Rivas [Figure 3.2]), the IDR, the Universidad Nacional Agraria (UNA), UCA, ADPESCA, the UCATSE, the Panamerican Agriculture School "Zamorano", the Catholic Relief, Development and Social Service organization CARITAS[22], and the Centro para la Investigación de Recursos Acuáticos de Nicaragua[23] (CIRA). The identified stakeholders were then classified as either primary or secondary.

Primary Stakeholders. The primary stakeholders were the producers. At the time of the study 90% of the primary stakeholders were members of the cooperative COOSEMPROTIR, R.L. Their farms were located at the communities of Pueblo Nuevo, Los Horcones, and San Juan de Limay. A total of 11 members of the cooperative COOSEMPROTIR, R.L. were interviewed; six of 10 in Pueblo Nuevo and five of 13 producers in Los Hormones. None of the five producers in San Juan de Limay were interviewed. However, facts gathered from other stakeholders suggested that the situation of producers in San Juan de Limay was uncertain since only five of original 15 producers

[22] CARITAS is a Latin word meaning love, charity, and compassion and is the acronym for the Catholic Church Agency for Development (Caritas Australia 2006).
[23] Center for Research of Water Resources in Nicaragua.

remained in the project. Water supply problems were the main reasons why producers abandoned tilapia culture there.

The socio-economic characteristics of the member of cooperative showed that the average age of the producers interviewed was 49 years. One of 11 had a college degree; the rest had only elementary school level education, in addition, only three of the 11 producers were women (Tables 3.1).

The members of the cooperative had a total of 20 ponds with a total area of 5,375 m^2. Five producers had only one pond, four had two ponds, one had three ponds, and one had four ponds. The average pond size was 343 m^2 with an average depth of 1.5 meters (Table 3.2). Four producers built small ponds to nurture the fingerlings before putting them in the larger pond; the nursery ponds averaged 53 m^2. The main purposes of the small ponds were saving water and increasing weight gain in the initial production phase. Only two of the 16 large ponds were not lined with plastic. Plastic was used as lining to reduce water losses. Instead of plastic, one producer used manure to seal the soil and reduce water loss, while another producer carved the hillside pond from rock.

One of the three identified producers that work alone was not interviewed because his farm was located far from the others. The two interviewed producers were working in relative isolation from the other producers. One was operating six kilometers out of the city of Ocotal. He stocked 3,000 20-g fingerlings in 200 m^2 ponds built with brick and covered with cement. His source of water was a creek, and he bought fingerlings from the UNA and commercial feed from a national supplier.

The other producer was located in Granada. He owned one pond of 165 m^2, three of 22 m^2, two of six m^2, and one of 12 m^2. The ponds were constructed to use the walls of a large water tank. For that reason, several of the ponds were constructed inappropriately; they only received sunlight half of the day since the taller tank obstructs the rays. This producer bought 3,000 fingerlings from UNA to stock the ponds and commercial feed from a national supplier. He had not yet harvested a crop.

Secondary Stakeholders: IDR. At the time of the study the IDR represented the main secondary stakeholders in tilapia culture in Nicaragua. Its activities in Estelí were known by most stakeholders in tilapia culture, and were perceived as a success story. The activities of IDR were the second phase of a project initiated by CARE-RENACER in 2000. IDR worked with 11 producers in Pueblo Nuevo, 12 in Los Horcones, and three in San Juan de Limay; all located in the municipality of Pueblo Nuevo, Estelí. No activities were conducted in the municipality of Totogalpa. The project had a total cost of U.S.$ 135,469, with U.S.$ 105,999 financed by the Inter-American Development Bank through the IDR. The producers in the project financed U.S.$ 29,469 through bank loans, and sales of cattle and fish.

IDR supports organized groups by evaluating their proposals and by providing funds. For that reason, the IDR helped the tilapia producers to organize the cooperative COOSEMPROTIR, R.L. in Estelí. Once the producers were organized, the IDR provided the requested assistance. The objectives of this tilapia project was to reach a stable production of 2,270 kg per month for the national market with 35 producers, and to build at the end of the project a U.S.$ 20,000 fingerlings production farm in the area.

It is important to mention that there is a significant difference in access between the town of Pueblo Nuevo and the community of Los Horcones. Pueblo Nuevo can be reached from the Panamerican highway on 15 kilometers of cobble-paved road in around 15 minutes. To access Los Horcones, one passes through Pueblo Nuevo and then travels 11 more kilometers. The trip between Pueblo Nuevo to Los Horcones takes approximately 30 minutes driving on a steep, rough road that crosses seven creeks. San Juan de Limay is located further in the direction of Los Horcones. The community of San Juan de Limay was not visited because there were only three producers and the access was time consuming and difficult. In addition, during the rainy season the creeks are sometimes impossible to cross.

At the time of the study, the IDR office for the project was located in the community of Los Horcones, where the fingerling farm will be built. The location of the project's office has been a source of conflict between cooperative members and with IDR personnel. Several members of the cooperative prevailed despite the opposition of others. IDR personnel expressed their discontent only after the decision was taken. The main justification for the office and fingerling farm location at Los Horcones was the easy access to good quality water.

In addition to providing technical assistance, IDR personnel bought all the inputs needed by the project. The inputs were stored in the IDR office in Los Horcones. Commercial feed was purchased in Costa Rica and fingerlings were obtained from the Panamerican Agriculture School Zamorano in Honduras. At the beginning, producers used a national brand feed, but they discontinued it because the feed did not float.

Sinking feed often creates water quality problems. Furthermore, laboratory analysis indicated that the feed in question did not have the expected percent protein. Costa Rican feed was more expensive[24] but producers felt that it yielded better results.

Fingerlings first were bought in the UNA located in Managua, but were then imported from the Panamerican Agriculture School in Honduras. It takes approximately five hours to make the trip from the Panamerican Agriculture School to the storehouse of the project, since the fingerlings have to go through customs in the border. Producers had little to do with the purchase, transportation, and import process of fingerlings; everything was done by the IDR.

Ponds were stocked on the decision of the cooperative members. For most members, it was not clear what factors were considered when deciding to import fingerlings, but some mentioned fingerling availability, mortality, and failure in the production cycle as the main factors. IDR personnel also helped market the product by providing coolers to transport fish and accompanying fish producers to fairs in several cities in the area. According to several producers, the IDR should help with the marketing of the product because they promised that all the production in the project would be sold to an exporting company at a high price. Unfortunately, that never happened and producers considered marketing their product as a burden. In fact, some producers preferred to sell their product through pond banks sales at a lower price rather than

[24] National feed had a price of C$260 per 100 pounds or C$2.6 per pound. The final price of the Costa Rican feed is C$400 per 66 pounds or C$6.06 per pound. With the subsidy, producers only paid 10% of the actual feed cost.

traveling to the neighboring cities of Somoto, Ocotal, and Estelí. Fish sales in Somoto and Ocotal take place every other week, while sales in Estelí take place every Friday.

UNA. It works as an education and extension agent. It is involved in tilapia culture through the "Granja Demostrativa de Cultivo de Peces." This demonstration farm was built in 1982 but its operation was interrupted in 1984. Since 1999, it has operated under the combined effort of the UNA and ADPESCA. The main objectives of the farm are fingerlings production, technical training for potential producers, and laboratory for students. It promotes tilapia culture by distributing free fingerlings. The farm has the capacity to produce 150,000 fingerlings per month, with sizes between five and 20 g. The farm has supplied fingerlings to development projects, individual producers, and export oriented companies.

UCA. It operates as a research, extension, and educational center. It has been involved in tilapia culture since the construction of its tilapia farm in 1982. The farm has the capacity to produce 16,000 fingerlings per time cycle. Currently, UCA provides technical training and technical assistance to those interested in tilapia culture. The main objective of the tilapia farm is fingerlings production for its own grow-out farm. The grow-out is done under integrated aquaculture, where the fertilized water from the ponds is also used to irrigate crops. UCA has been negotiating with a private company to supply fingerlings and technical assistance to an export-oriented project using cage production.

The role of UCA in tilapia culture has been very active in the past. UCA personnel and students have conducted technical and economic studies of cage production, evaluation of the project IDR/CARE, marketing studies for private producers, and education of aquaculture professionals. In 2006, however, UCA will graduate its last class of Engineers in Aquaculture Production. The major will not be offered any more due a low demand.

ADPESCA**.** Another secondary stakeholder was the extension and research government institution ADPESCA. ADPESCA is adjunct to the Ministerio de Fomento, Industria y Comercio[25] (MIFIC). The mission of ADPESCA is to apply the policy of rational and sustainable use and exploitation of fisheries and aquaculture (MIFIC 2005). The function of ADPESCA includes analyzing aquaculture projects, keeping record of the number of farms in operation, issuing technical guarantees, and evaluating the environmental impact of tilapia projects in coordination with the Ministerio del Ambiente y los Recursos Naturales Nicaragua (MARENA).

ADPESCA publishes the Anuario Pesquero y Acuícola de Nicaragua. This yearly publication contains data on marine fisheries and wild–caught and aquaculture shrimp. The information for tilapia is minimal, since no national plan for the development of the activity exists. The Nicaraguan government has a national plan for shrimp culture and its capture fisheries, a foreign currency generating activity. In summary, the role of ADPESCA in tilapia culture is limited to assist other stakeholders rather than to promote and develop tilapia culture per se.

UCATSE. This institution is mainly involved in research and education. The UCATSE has its own Agro-aquaculture station "Los Chilamates." Since 2002, however, the station has been underutilized due to lack of funds. The station was in need of new broodstock and laboratory equipment to carry out basic analyses. The research conducted

[25] Promotion, Industry, and Trade Ministry.

by students in UCATSE was oriented to testing the viability of fingerling production in different parts of the year and to use cheaper substitutes for traditional inputs in fingerlings production. For example, three university theses, "Validación de producción de semilla revertida (solo machos) de tilapia (*Oreochromis niloticus*) en la estación agroacuícola "Los Chilamates" (Canales et al. 2003), "Validación de la producción de semilla revertida de tilapia (*Oreochromis nilotica*) en los meses más frios en la estación agroacuícola "Los Chilamates" (Gonzáles 2003)," and "Efectos de dos niveles de inclusión de hormona Testogan en la reversión de sexo de tilapia (*Oreochromis niloticus*) (Rodríguez et al. 2003)" tested the viability of producing fingerlings at differents seasons of the year. They also examined the feasibility of using the hormone Testogan as a substitute for the hormone regularly used during sex reversal of fingerlings. However, since 2003 no additional studies have been conducted because the farm is used mainly for production purposes.

Panamerican Agriculture School "Zamorano." This institution is an extension, research, and educational center located in Honduras, approximately 70 kilometers from the border between Honduras and Nicaragua. The person in charge of the aquaculture section and head of aquaculture in "Zamorano", Dr. Daniel Mayer is considered an authority in tilapia culture in the region. He has trained several Nicaraguan producers and technical personnel. In fact, a manual elaborated by Dr. Meyer, has been used as a guideline for tilapia culture by researchers and educators in Nicaragua. Lately, "Zamorano" has become the new supplier of fingerlings for the IDR project.

CARITAS. The Catholic non-government organization has just recently been promoting tilapia culture as a minor component of their activities. Its extension agents tend to have very basic knowledge of tilapia production. CARITAS could play an important role promoting small-scale tilapia culture among the more than 3,000 producers participating in its project. The main objective of the CARITAS is to improve the economic situation of its more than 3,000 beneficiaries through the transfer of new technologies. Those technologies have focused on vegetables production, the use of byproducts, and use of water.

CIRA. Finally, the last secondary stakeholder was the CIRA, an entity of the Universidad Nacional Autónoma de Nicaragua (UNAN). The center is a research institution that has legal authority over the quality of water in Nicaragua. Despite several calls and visits, it was impossible to interview personnel from CIRA. The description of this stakeholder is based on public documentation and perspectives provided by other stakeholders.

The CIRA has played a very important role in the negative campaign against tilapia culture in Nicaragua. Its studies have been used by environmentalist to justify a campaign against the operation of large-scale farms in the Managua and Nicaragua Lakes. For example, the organization La Suerte,[26] which favors eco-tourism in Nicaragua, has a web page article "Tilapia Farming Benefit or Menace?" authored by the

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La Suerte Biological Field Station is being developed exclusively for research, education, and conservation. The Field School offers broad undergraduate and graduate training in Neotropical field ecology. Since it was established in 1993, La Suerte has attracted over 350 students from across the United States, Canada, Latin America, India and Japan to study tropical rainforest ecology and conservation (La Suerte 2005).

director and founder of CIRA. According to one of the secondary stakeholders, the "war against tilapia" conducted by the environmentalists has had the support of CIRA, and it has been based on misinformation about the true biology of the fish.

In an effort to inform people about the real nature of tilapia, several institutions conducted a seminar to inform the mayors of several towns in the island of Ometepe (where Nicanor S.A. operates) and personnel of several government agencies about the true biology of tilapia. According to one tilapia stakeholder who attended the seminar in the island of Ometepe, the questions raised by the attendees indicated a lack of knowledge about the biology and behavior of tilapia. People believed that tilapia eat other fish eggs (tilapias carry their own offspring in their mouth). People also believed that tilapia were exterminating other species in the lake, because one study conducted by the CIRA used an incomplete database, according to a stakeholder. The people lecturing at the seminar also learned that fishermen do not oppose to having wild tilapia in the lake as some environmentalists have argued (Interview 2005).

It is not clear if either the war against tilapia has been truly based on concerns about the environment or if it has tried to favor the tourism industry as it appears that large-scale tilapia culture has been competing with the tourism industry for the same location. In a recent newspaper article "Tilapias vs. Turismo", the author, the president of the environment special commission of the mayor's office of Managua and former Minister of Tourism, made clear that the operation of Nicanor S.A. in Lake Nicaragua was in direct competition with tourism in the region. The author suggested that the mere presence of the facilities of Nicanor S.A. destroys the natural beauty of the region, to the detriment of the tourism industry (Chamorro 2005).

As a result, the campaign against tilapia has had an impact; thus, many Nicaraguans are reluctant to eat tilapia because they feel it may be contaminated (Engle and Neira 2003a). This campaign has affected more small and medium-size farms than large-scale farms. Because, small and medium-size producers try to market whole fish domestically, while large farms export frozen and fresh fillets to markets where tilapia is highly regarded.

The numbers of stakeholders in Nicaragua is not large; small and medium-scale tilapia culture in Nicaragua represent a small sector. Ideally, communication among secondary stakeholders should be easy since they are few in number and located within the same city. However, information was not being shared nor discussed between institutions due to the fear of plagiarism. That isolation creates inefficiency through overlap of functions.

Stakeholders' Importance and Influence

Primary Stakeholders. The producers working with IDR and the three producers working on their own were the primary stakeholders for tilapia culture in Nicaragua. However, their situation is quite different. If all support to small and medium scale tilapia culture vanishes, the producers working with IDR would not be able to continue. They need technical assistance, research, extension, and education agents to find solutions to their problems mainly related to input availability and marketing. Besides, it would be almost impossible for the members of the cooperative COOSEMPROTIR, R.L. to operate a fingerling farm and continue its operation without the support of other institutions involved in tilapia culture.

On the other hand, the three producers working alone could stay in business without support. In fact, that is what they have done; they have had the resources and means to access information and inputs without help. To carry out their operations, they have bought inputs from the suppliers of large-scale companies, and paid for technical training.

The primary stakeholders did not have any influence on tilapia culture in Nicaragua. Their total number was too small to have any political power and their budgets did not allow them to fund lobbing activities to advance their cause.

Secondary Stakeholders. Theoretically, none of the secondary stakeholders would be affected if small and medium-scale tilapia culture ceases. IDR carries out other programs; thus, tilapia culture was just one of many. Regarding UNA, the main objective of the farm is fingerling production, but the UNA already showed interest in becoming a supplier to a large company. UNA supplied fingerlings to Nicanor S.A. for a period of time, but the arrangement ended when Nicanor decided to build its own hatchery. Furthermore, UNA could survive by training students who would eventually work in the large companies.

UCA is interested in becoming a producer of tilapia and starting a partnership with a large tilapia farm. In that way, the UCA may play an important role in the development of an export oriented and value added tilapia industry. ADPESCA is a government agency that already focuses on shrimp production rather than tilapia culture, and probably would be better off supporting large-export oriented farms than small and medium-scale producers.

The Panamerican Agriculture School would not be threatened since its involvement in Nicaragua is just one of many different activities. CARITAS has only a minor program in tilapia culture. Its central focus is on vegetable production; the international institution would have no problems continuing without tilapia culture. UCATSE, despite some recent minor involvement, has other priorities than tilapia culture. For example, using " Los Chilamates" facility to offer a program for health education.

Finally, of all the secondary stakeholders, only the CIRA has a sufficient influence to affect the future of small and medium scale tilapia culture. Its political power could be used to undermine any effort to develop small and medium scale tilapia culture as it has demonstrated in its efforts to terminate large-scale tilapia culture.

Producers' Indigenous Knowledge

According to Rajasekaran (1993:1) "Indigenous knowledge is the systematic body of knowledge acquired by local people through the accumulation of experiences, informal experiments, and intimate understanding of the environment in a given culture." Based on this definition, the level of indigenous knowledge among tilapia producers in Nicaragua is very low in general. Producers have not accumulated much experience, conducted informal experiments, nor understood the place of tilapia culture in their environment.

Furthermore, Indigenous knowledge systems are the result of many years of practice and are passed orally through family members over generations. Such time-tested agricultural and natural resource management practices are strategies and techniques developed by local people to deal with local conditions. These practices are obtained in the course of testing and innovating, and represent management skills developed to maximize the use of available resources (Rajasekaran 1993).

The knowledge that tilapia producers have in Nicaragua scarcely reflects those characteristics. The information provided by the interviews suggested that the level of knowledge that tilapia producers have is very basic. Tilapia culture among current producers is an innovation recently introduced as an alternative to traditional crops (Saavedra et al. 2003).

The experience with tilapia culture is recent. It started in 2000 and has yet to be passed over generations. The management practices are not being modified; testing and innovativeness are very limited. Most producers were just learning the basics of tilapia culture. In most cases, they relied heavily on IDR personnel for the management of their ponds. The records gathered during the interviews showed that even producers with six years of experience relied almost totally on the recommendations provided by the IDR.

Even though limited, there was some evidence of testing and innovativeness among producers. For example, two producers decided to use manure to seal the pond soil to reduce seepage.[27] That decision was based on the expectation that the use of plastic would be very expensive without the IDR subsidy. The owners used manure following the advice of a neighbor. Another producer used earthworm humus instead of manure to fertilize their ponds. The producer preferred earthworm humus because it keeps water quality better than manure, provides a source of feed for tilapias (fish feed on

[27] Two partners own this pond.

the earthworms), has more nutrients, and lacks the negative perceptions of using manure alone. Finally, several producers were building small ponds to hold fingerlings during the first stage of production. With this adjustment, producers expected to take better care of the small fingerlings, to use less water, and to improve the daily gain weight at the beginning of the crop.

Description of Production Process

At the time of the study, ponds were built using manual labor, in mainly sandy or clay soils. For that reason, it was necessary to cover the inside of the ponds with plastic. Plastic was installed and sealed using either one of two methods: stapling or melting. The duration of pond construction and plastic installation was variable, depending on the number of workers hired and the physical properties of the soil.

Once the pond was stocked, producers kept the water level and fertility of the pond by adding water and more manure, according to the standards established by the technician. However, several producers did not always comply with the technician's instructions because they did not want to spend too much time pumping water. Others, with easier access to water, practiced water exchange more often and used the fertilized water to irrigate crops planted around the pond.

Another practice was fish sampling. Starting 15 days after the pond was stocked, sampling continues until the seventh month of the production cycle. Sampling was performed with help of the technician and consisted of extracting 50 tilapias, which were weighed and returned to the pond. Then, the technician used the information to adjust the feeding recommendations and determine if the fish were ready to be sold. Despite the apparent utility of sampling, several producers expressed that they did not like to do it because some fish were lost in the process.

On average, harvest started after seven months, and continued for three more months. Producers harvested their ponds to feed their families, share with relatives and friends, sell to neighbors, and in some cases, sell to an intermediary. Once the pond was empty, producers cleaned it, applied lime, made repairs, and prepared it for the next crop.

SWOT Analysis

The analysis of strengths, weaknesses, opportunities and threats provided information about the individual opinions of producers regarding their farms and the surrounding environment. The perceptions about the farm (internal setting) were depicted by the strengths and weakness.

Strengths and Weaknesses.

The producers mentioned the following strengths:

- Five producers considered water accessibility as the main strength in their ponds.
- Five producers considered location as the main strength of their farms. Location in reference to the market (ponds that were located within the town limits); the way in which the air hit the surface of the pond, to a site with a panoramic view, to a site with high temperature, and to the pond located near the house.
- One producer considered simplicity to manage as the main strength of tilapia culture.

The producers mentioned the following weaknesses:

- Four producers believed that their operations had no weaknesses at all.
- Four considered that water supply was the main weakness of their operation.

- One considered that lack of local market was the main weakness of its farm.
- One producer considered that the main weakness of his farm was lacking the appropriate equipment to treat the water coming out of the ponds and flowing into the creek.
- Finally, one producer considered his farm's difficult location as the main weakness of his operation.

The analysis of strengths and weaknesses indicated producers perceived water access (easy or difficult) and location (convenient or inconvenient) as the most relevant internal characteristic of their farms. Those findings confirmed the disparity of conditions faced by the members of the cooperative in Pueblo Nuevo and Los Horcones. Some farms had easy access to water, but were set in an inconvenient location (located in the high part of the watershed). On the other hand, other farms had difficult access to water, but were set in a convenient location (located in the low part of the watershed). Among farms with difficult access to water it was necessary to use electric or gas pumps to fill the ponds. In contrast, in farms with easy access, water was transported by gravity.

Opportunities and Threats.

The analysis of opportunities and threats gives an idea about consumers' expectations and concerns on the effect that external factors could have on their farms.

Producers mentioned the following factors as opportunities:

- Six producers believed that the main opportunity would be the development of the market. With a larger market they would expand and continue their operations.

- Two producers believed that the main opportunity would be to export to international markets.
- One producer believed that the main opportunity would be eco-tourism.
- The revealed threats were:
- Three producers perceived lack of water in the region as a future threat for their enterprises.
- Two producers perceived lack of financial support as a future threat.
- Limited access to good quality commercial feed at a fair price was perceived as a future threat by one of the producers.
- One producer perceived working without IDR support as the main threat.
- Two producers perceived the imposition of a probable water tax by the government as a future threat.
- Two producers perceived lack of future supply of fingerlings as a future threat, if the fingerlings farm was not built.

The analysis of external factors revealed that producers expected that opportunities would come as a result of growth in the export and tourism markets. The threats expected by producers could be related to the reduction of water access in the area due to deforestation of the watershed. Higher water costs due to a new legislation may tax water collection from creek, springs, and underground streams. The possibility that the IDR would disengage from the project, and the risk that the fingerlings farm would not be built were other concerns. Without the IDR, it would be very difficult to have easy access to economical commercial feed and fingerlings.

5. Conclusions

In Nicaragua, at the time of the study, the stakeholders of small and medium scale tilapia culture did not form a well-integrated knowledge system. Each secondary stakeholder worked in isolation and had particular interests. As a result, the needs of producers were not addressed or considered to further develop tilapia culture. Tilapia culture was delivered as an outside technology that small producers could not afford without help.

Small and medium scale tilapia culture in Nicaragua was a highly subsidized, minor economic activity carried out by only few producers. IDR imported and delivered the two main inputs in tilapia culture: commercial feed and fingerlings. Without the IDR, it would be extremely difficult for the members of COOSEMPROTIR to stay in business, since they did not own the resources nor had the potential to attract input suppliers to cover their needs.

The producers working without subsidy faced other circumstances. They had the resources and the means to continue in tilapia culture as long as they generated a small profit. They were also developing their own market niches and taking the product to the consumers. That allowed them to increase the profitability of their operations by eliminating intermediaries. Additionally, they proved that they could gain access to inputs without outside help. However, their future depended on having access to better quality and lower price inputs.

In general terms, the development of small and medium scale tilapia culture in Nicaragua was limited by five factors: flawed development approach by the government, lack of good quality inputs, competition for public funds with the shrimp culture, the campaign of the environmentalists, and the lack of an integrated knowledge system.

The approach executed by the government failed in several ways. INPESCA promoted tilapia culture among small and medium scale producers in the 1980s in a manner that did not build the industry. As one secondary stakeholder stated "what happened was that INPESCA told producers: if you dig a small pond and you fill it with water, we would give you the fingerlings for free." As a result, many producers without any knowledge on aquaculture, allegedly adopted tilapia culture, but that was an illusion. As INPESCA stopped distributing free fingerlings, many tilapia adopters ceased production. Furthermore, tilapia culture was promoted in a region where soils did not hold water well and where keeping the ponds filled at optimum levels was often costly. That resulted in numerous abandoned ponds and the unfortunate perception that tilapia culture was not a good alternative production to traditional crops. Water related problems in Northern Nicaraguan were also limiting factors. Those problems eliminated aquaculture support programs in the Totogalpa region and they remained critical in the project supported by IDR.

The project implemented by INPESCA focused on the use of local feedstuffs. Producers were discouraged from using commercial feeds. That approach led to low production levels that disappointed many producers (Saavedra 2003). For that reason, efforts to develop tilapia culture during the 1990s and 2000s promoted production systems that included the use of commercial feeds to supplement the diet of tilapias. CARE, the institution in charge of the project, supplied producers with the domestically available commercial feed. The results were not good; feed would sink rapidly before fish could eat it. Laboratory tests revealed that the actual amount of protein in the feed was significantly below that listed on the tag. This experience illustrates the effect of the lack of research before delivering the new technology to the producers. If previous trials on feed use were conducted, many producer problems could have been avoided.

Lack of good quality fingerlings and easy access to suppliers were other limiting factors for small and medium-scale producers. Before importing fingerlings from Honduras, the IDR bought them from the UNA, however, complaints by producers about quality made IDR to look for an alternative supplier. Two potential fingerling suppliers were located in Managua, approximately 120 kilometers away. Thus, accessibility also represented a limiting factor for the members of the cooperative if they wish to become less dependent on IDR's support.

Although the members of the cooperative planned to build its own fingerling farm before the IDR departures, that potential solution seemed doubtful. They had a construction budget for U.S.$20,000 but had not planned who and how the farm would operate. The problem became worse since internal conflict among the members escalated as a result of a struggle for the control of the cooperative. The idea of building a hatchery excited the producers, but after interviewing them, it was clear that they had little idea about the management of the farm once its operation starts.

Tilapia culture had lost government support gradually since the middle of the 1980s. INPESCA's promotion of fish culture and shrimp production at the same time ended badly for tilapia producers, since the government diverted funds from tilapia culture towards shrimp culture. The fact that tilapia production was to supply the domestic market and shrimp culture was focused on the export market made a significant difference; shrimp exports were generating foreign currency and tilapia culture was not. That made government officials focus limited funds on shrimp culture rather than tilapia culture. After INPESCA, subsequent government agencies had withdrawn even more from tilapia culture.

The development of small and medium-scale tilapia production has been also undermined by the environmentalists' campaign against large-scale tilapia culture. This campaign has partially been based on blaming tilapia culture for the pollution of the lakes. Thus, if the lakes were polluted, tilapia coming out of them would be polluted as well. For that reason, consumers fear eating tilapia, no matter the origin, wild-caught or farmed, even if they are willing to consume it, especially those with lower incomes, they were only willing to pay a low price, generally the price for wild-caught tilapia. Marketing whole farmed-tilapia for a profit is very difficult for two reasons. On one hand, wild-caught tilapia from the lakes and reservoirs are relatively inexpensive. On the other hand, many fish consumers believed that nearly all tilapia came from Lake Managua and, therefore, it is contaminated in some way.

Those two negative factors are especially critical in large urban areas around lakes Managua and Nicaragua; the largest markets in the country. Consumers' rejection of tilapia stemmed mainly from extended campaigns executed by environmentalist groups that opposed tilapia culture and favor tourism projects in lakes Managua and Nicaragua. Although environmentalists oppose the operation of large-scale farms, the campaign against tilapia culture in the lakes has affected small and medium-scale producers of tilapia culture the most.

The members of the cooperative sold some tilapia in their area because people know how the fish was produced and because other fish species from distant lakes and the ocean were available at higher prices. But those markets were small, and could not support the development of profitable tilapia culture in the region. As a producer expressed, “I like tilapia culture, but to really work on it, I have to have at least three or four ponds; for that, I need a larger market.” That is important, because in order to develop rural aquaculture, producers need to have access to the largest markets in the country.

The results indicated that the development of small and medium-scale tilapia culture is uncertain, but as one stakeholder expressed, “Tilapia culture at all levels will develop, but it will follow the shrimp industry model; large farms will attract input supplier and grow, as the large farms growth, small and medium-scale producers will have access to inputs and will sell their production to the exporters during the peak season, and will supply the domestic market the rest of the year.”

At the time of the study, the members of the cooperative were facing an uncertain future. Marketing their products in their region was a difficult task; in the rural communities, people could buy fish only at low prices that producers could afford only if they had a subsidy. If producers wanted to take their product out of their rural areas, then they had to pay for transportation and offer their product in farmers’ market located in other regions. Based on observations gathered during the study, it can be argued that most producers did not have the ability to market their products. Therefore, for producers marketing fish to the final consumers involved two burdensome activities, one, to pay for transportation, and, two to carry out an activity that they did not enjoy: selling to strangers.

Further studies to develop small and medium-scale tilapia culture should focus on answering several questions. Can all tilapia culture stakeholders come together and form a system? Can the potential producers obtain technical assistance, inputs, and a market on their own? Can they afford to pay for technical assistance and buy inputs without a subsidy? And, finally, do they have the ability and the means to market their own production?

Future interventions in Nicaragua should start by assembling stakeholders and beginning a rational dialogue on the industry. Nicaragua has all the elements to make of tilapia culture an important economic activity; it has research and educational institutions with highly trained personnel on aquaculture and the nation has abundant water resources for fish culture. However, tilapia culture has been promoted while ignoring local conditions and using inappropriate approaches.

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Table 3.1. Characteristics of tilapia producers in, Nicaragua 2005.

Age range	Males	Females	Education
Community Pueblo Nuevo:			
40 – 49	2	0	Elementary school
50 – 59	1	0	Elementary school
60 – 70	2	1	Elementary school
Community Los Horcones:			
30 – 39	2	2	1 Male-technical education
			Others elementary school
50 – 59	1	0	Elementary school

Table 3.2 Water Source and Pond Characteristics, Nicaragua, 2005.

			Area (m^2)				
Producer	Location	Water source	Pond 1	Pond 2	Pond 3	Pond 4	Depth (m)
1	Los Horcones	Spring	450	450	450	50	2
2	Los Horcones	Creek	240				1.5
3	Los Horcones	Creek	300	340	96		1.5
4	Pueblo Nuevo	Well	300				1.8-1.2
5	Pueblo Nuevo	Well	144	35			1.5
6	Los Horcones	Spring	300	120			1.7
7	Los Horcones	Creek	60	30			2-1.5
8	Pueblo Nuevo	Well	450				1.5-1
9	Pueblo Nuevo	Creek	396				1.63-1.25
10	Pueblo Nuevo	Creek	750				1
11	Pueblo Nuevo	Well	384	30			1.8-1

Figure 3.1. The structure of the Aquacultural Knowledge Information System (AKIS)

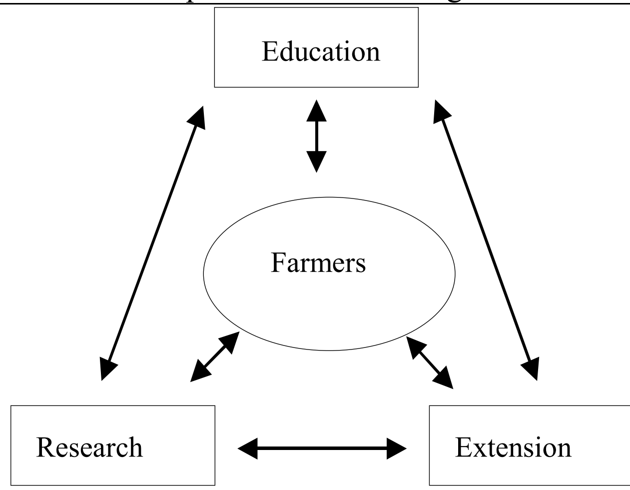

Figure 3.2 Map of Nicaragua, and location of tilapia culture areas, 2005.

SUMMARY

Nicaragua has the abundant natural resources to allow aquaculture to be an important economic activity. The development of aquaculture in Nicaragua may represent a production alternative to traditional agricultural products that do not generate as much wealth as they used to. The drop in prices of traditional agricultural produces has created more poverty and food insecurity in rural Nicaragua. Consequently, international development agencies and the government have promoted aquaculture as a mean to ensure food security in rural areas.

During the early 1980s, the government promoted tilapia, carp, and shrimp culture. The main purpose of the first two species was to ensure food security and income generation in rural areas, whereas, the main objective of shrimp culture was to produce for the international market and generate foreign currency. The promotion of tilapia culture looked promising in the beginning, but the paternalist approach implemented by the government proved wrong. For example, people were adopting tilapia culture because the government was funding everything, from digging the pond to providing fingerlings. Furthermore, the promoted production systems did not include the use of commercial feeds; as a result, production levels were low and producers got discourage. Finally, when the government ran out of funds, the allegedly adopters gave up as they did not want to risk their own funds in an uncertain enterprise.

While the government was withdrawing from tilapia culture, it shifted its focus to shrimp culture. Shrimp culture had private investors interested and willing to fund new projects; furthermore, shrimp products were exported into international markets and generated the scarce and needed foreign currency. At the end, the decision by the government of withdrawing from tilapia culture and focusing on shrimp was simple; to support the activity that attracted international investors and generated foreign currency.

Despite the government unwillingness to support tilapia culture in Nicaragua, other domestic and international institutions are still promoting it. As a result, several enterprises continue to operate. The understanding of how those enterprises operate elucidates relevant data of how tilapia culture has survived in Nicaragua.

In this study, that understanding is based on three analyses, the economic analysis of several production activities, the analysis of Nicaragua's potential in the export market for fresh and frozen tilapia fillets, and, the analysis of the aquaculture knowledge and information system. The economic analysis suggested that most tilapia enterprises generate low net returns, and even losses. Only the producers operation with several inputs subsidized in an 80% enjoyed large net returns, and high IRR. The analysis also suggested that the intervention on the government by offering the subsidy created market distortions that guaranteed production only at short term. The analysis of export opportunities indicated a promising future; the market in the U.S. and Nicaragua's market share were growing. The third analysis indicated that most tilapia producers were operating on a substantial subsidy, have very basic knowledge of tilapia culture management, and lack the skills for marketing their products. Furthermore, producers do not have the political and social power to influence any public policy to further develop tilapia culture in their region.

The further development of tilapia culture requires a comprehensive approach. An approach based on current knowledge among the different stakeholders and the need for appropriate technologies and marketing strategies. Those technologies should be profitable enough to attract private investors and input suppliers. Only then, small and medium scale producers would be able to run their enterprises independently.

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APPENDICES

Appendix A.

Questionnaire for institutional analysis.

Name of the Organization:
Office Address (Include Country and ZIP Code):
Office Telephones: ____
Fax: ____
E-mail Address: ____

Operating nationwide ☐ or regional ☐

Operational since: ____

Status/Nature of Organization: public ☐, private ☐, research ☐, education ☐, extension ☐, other ☐.

Staffing Pattern (number of persons in management and staff positions and allocation by sex n(male/female):

Positions	Male	Female
____________________	☐	☐
____________________	☐	☐
____________________	☐	☐
____________________	☐	☐
____________________	☐	☐
____________________	☐	☐
____________________	☐	☐
____________________	☐	☐
____________________	☐	☐
____________________	☐	☐

Name of Head of the Organization (indicate title of head)

____________________ ☐ ☐

Mission/Long-term Objectives:

Target group/s:
Main Activities/Services:

Please provide a brief description of programs, projects and services that benefit tilapia producers.

Which of these do you consider as a best practice example on the contribution of technology to tilapia producers.

If there are too many projects in which your organization is involved, please select 2-3 projects in each area that you consider to be examples of best practice.

What methodologies and tools have you developed/used in assessing and addressing the needs of tilapia producers?

What are the major constraints that you encounter in the implementation/delivery of these projects/programs/services?

Based on your experiences and analysis of the situation in your country, how can institutions like you be assisted to enable you to carry out your programs/projects/more effectively in the next three years?

What other institutions/organizations in your country have programs/projects and services related to tilapia culture?

Which of these have implemented an example of best practice in improving tilapia producers' economic status?

What are major tilapia culture research, documentation or case studies undertaken by your organization/institute?

What are the major researches/publications/documentation or case studies that were done by other organizations in your country?

What are the major constraints that you encounter in the conduct of research on tilapia culture?

For the next three years, what do you think should be the research priorities/agenda to enhance tilapia producers' economic situation?

Which do you consider are the top five organizations/institutions in your country that can be further strengthened to specialize in the area of research for tilapia culture?

What communication and policy advocacy activities have been undertaken by your organization in the area of tilapia culture?

What are the major constraints that your organization encounters in undertaking communication and policy for tilapia culture?

For the next three years, what policy priorities on tilapia culture should be initiated?

Which do you consider are the top five organizations/institutions in your country that can be further strengthened to undertake communication and policy advocacy on tilapia culture?

What information, expertise, and other resources and contacts for referrals do your organization have on tilapia culture that can be useful for other organizations/individuals to access?

What kinds of services are provided by national and regional networks to promote producer's participation in and benefits from new technologies?

What other services should the networks provide to enhance producers' participation in and benefits from new technologies?

Identify any critical gaps in information sources in your current network that should be addressed now or in the future.

What are the constraints your organization encounters in undertaking networking activities for tilapia producers' technology transfer?

What do you consider are the top five networks in your country/sub-region that can be further strengthened for the development of tilapia culture?

Please indicate programs that had been successfully transferred and commercialized.
Information Furnished by:
Designation/Position:
Date Furnished:

Appendix B.

Questionnaire of socio-economic survey

Date: _________

A. General Information

Name of the respondent____

Owner □ operator □ Caretaker □

Telephone_________________

Address of respondent____

Location of Pond (s)

____

Pond's area:

Nursery pond (s): Area: _________ Depth ________ Number of ponds _____

Rearing pond (s): Area: _________ Depth ________ Number of ponds _____

Total area of fish farm: ____

Water Supply: River: Creek □ Spring □ Well □

Pond Ownership:

	Leased	
	From Private Owner	From Public Source
Area		
Annual rent		
Type of lease:		
Fixed cash		
Share of production		
Share of revenues and costs		
Length of lease (years)		
Lease renewable:		
Yes		
No		

Experience: Years farm in operation ___________________________________

Years experience of operator ________________________________

Stocking/Pond No.

Beginning inventory

Species	No. or lb.	Unit Price	Value
Fry/fingerling			
Growers			
Market size			

Cost or fry per crop

Mortality rate from purchase to stocking _____ _______ _______

No. stocked_____ _______ _______ No. of crops/yr _____ ____

Fry/fingerlings purchased

Species	No.	Unit price	Cost
___________	_____	__________	________
___________	_____	__________	________
___________	_____	__________	________

Source of stocking material:

Location ____

Pick-up ____

Delivered ____

Distance traveled ______________________________________

How is the price of fry/fingerlings determined?

Prevailing price □ bidding □ delivered □ dictated by seller □ other □

Number of stocking per crop ____

Reason for stocking schedule: To optimize production □ Availability of fry □

Feed/fertilizer/other/Pond No.

Feed kind	Kg/ha/crop	Cost/Kg	Frequency of application
___________	_____	_____	______________________
___________	_____	_____	______________________
___________	_____	_____	______________________

Fertilizer kind	Kg/ha/crop	Cost/Kg	Frequency of application
___________	_____	_____	______________________
___________	_____	_____	______________________
___________	_____	_____	______________________

Supplement	Kg/ha/crop	Cost/Kg	Frequency of application
___________	_____	_____	______________________
___________	_____	_____	______________________
___________	_____	_____	______________________

Other	Kg/ha/crop	Cost/Kg	Frequency of application
___________	_____	_____	______________________
___________	_____	_____	______________________
___________	_____	_____	______________________

How knowledge of feeding/fertilization/other technique was acquired:

Experience □ extension agent □ Reading □ Other □

Type of soil ____

____

Labor / pond No.

Labor (man / hour) required for crop.

	Family/Hired/Other	Male/female/child	Total
Pond preparation	________________	________________	____
Stocking	________________	________________	____
Feeding	________________	________________	____
Fertilization	________________	________________	____
Weeding	________________	________________	____
Repair and Maint.	________________	________________	____
Harvesting	________________	________________	____
Processing	________________	________________	____
Marketing	________________	________________	____
Other	________________	________________	____

Payment

Family	Rate / man-day	Food	Share of crop	Other
Male	_____	_____	_____	_____
Female	_____	_____	_____	_____
Child	_____	_____	_____	_____
Hired labor				
Male	_____	_____	_____	_____
Female	_____	_____	_____	_____
Child	_____	_____	_____	_____

Annual salaries and wages of management personnel

	Annual/Monthly salaries	Benefits	Total
Manager	___________________	______	____
Technician	___________________	______	____
Other	___________________	______	____

Harvesting / Pond No.

Production / crop

	Sold		Eaten	Give away	Other (specify)
Species	Kg.	Price/Kg.	(kg.)	(kg.)	(kg.)
_________		_____	_____	_____	_____
_________		_____	_____	_____	_____
_________		_____	_____	_____	_____
_________		_____	_____	_____	_____

Mortality rate from stocking to harvesting (%) __________

Possible causes of mortality:

Sudden change of weather □ Water pollution □ Lack of proper food □ Overstocking □ Disease □ Flood □ Other □

Number of harvests per crop ______

Reason for harvesting schedule:

To optimize production □ To get highest price □ Availability of fry for restocking □ Need for money □

Method of harvesting:
Total drainage of pond □ Using net □ Other (specify) _________________________

Marketing
Marketing Cost / Crop

Type of sale	Ice	Containers	Transportation	Labor	Other
Pond bank	___	_______	______	______	_______
Delivered	___	_______	______	______	_______
Market	___	_______	______	______	_______
Other	___	_______	______	______	_______

Method of payment:
Cash □ Credit □ for how long _______ No. of installments _______
Sale to same buyers: Yes □ Most time □ No □
If yes or most times, state reason: Settlement of credit □ Providing other services □
Proximity □ Other (specify) ____

Loans
Loans borrowed for initial capital expenses □ equipment □ For expansion □ For purchase of fry □ For repair □

Sources of loans	Amount	Annual Interests	Maturity	Purpose
Relatives	______	______	______	______
Lender	______	______	______	______
Bank	______	______	______	______
Government	______	______	______	______
Other	______	______	______	______

What factors accounted for the choice of the particular source:
Accessibility □ Simple procedures □ Fast credit extension □ Services offered □
Only source available □ Other _________________________________

What problems do you encounter in borrowing:
Too much paper work □ Delayed released of loan □ High interest rate □ Lack of collateral □ other ____

Other farm expenses for entire farm

Item	Amount/crop	Annual expenses
Fuel and oil	___________	___________
Electricity	___________	___________
Water	___________	___________
Supplies	___________	___________
Insurance	___________	___________
Taxes	___________	___________
Others (specify)	___________	___________

Inventory of Assets

Item	Acquisition Year / Cost	Economic life	Market value	Use for fish culture %
Ponds				
Levees				
Sluice gates				
Water channels				
Pond excavation				
Well				
Other				
Buildings				
Office				
Residence				
Storage				
Other				
Transportation				
Boat				
Truck				
Other				
Nets				
Gill				
Seine				
Other				
Equipment				
Pump				
Generator				
Feeding machine				
Refrigerator				
Feed mixture				
Other				

Problems and other information

Other crops or livestock

Specie	Area/number	Cost	Estimated market value

What problems are encountered in the industry?

Unfavorable price structure ____

Lack of proper infrastructure ____

Unavailability of credit ____

Shortage of fry ____

High price of inputs such as feed _____ fertilizer _____ ice _____

Fuel _____ Hormone _____ Other _____

Limited market ____

Lack of extension services ____

Lack of skilled workers ____
Other (specify) ____

Can government help to improve the industry? Yes _____ No _____

If yes, in what way

____
____

If no, why not

____
____

% of operator's income from aquaculture ______

Source of other income:

SWOT questions:

What do you think is the main strengths of your operation?

What do you think is the main weakness of your farm?

What opportunities do you see in tilapia production?

What treats do you see in tilapia production?