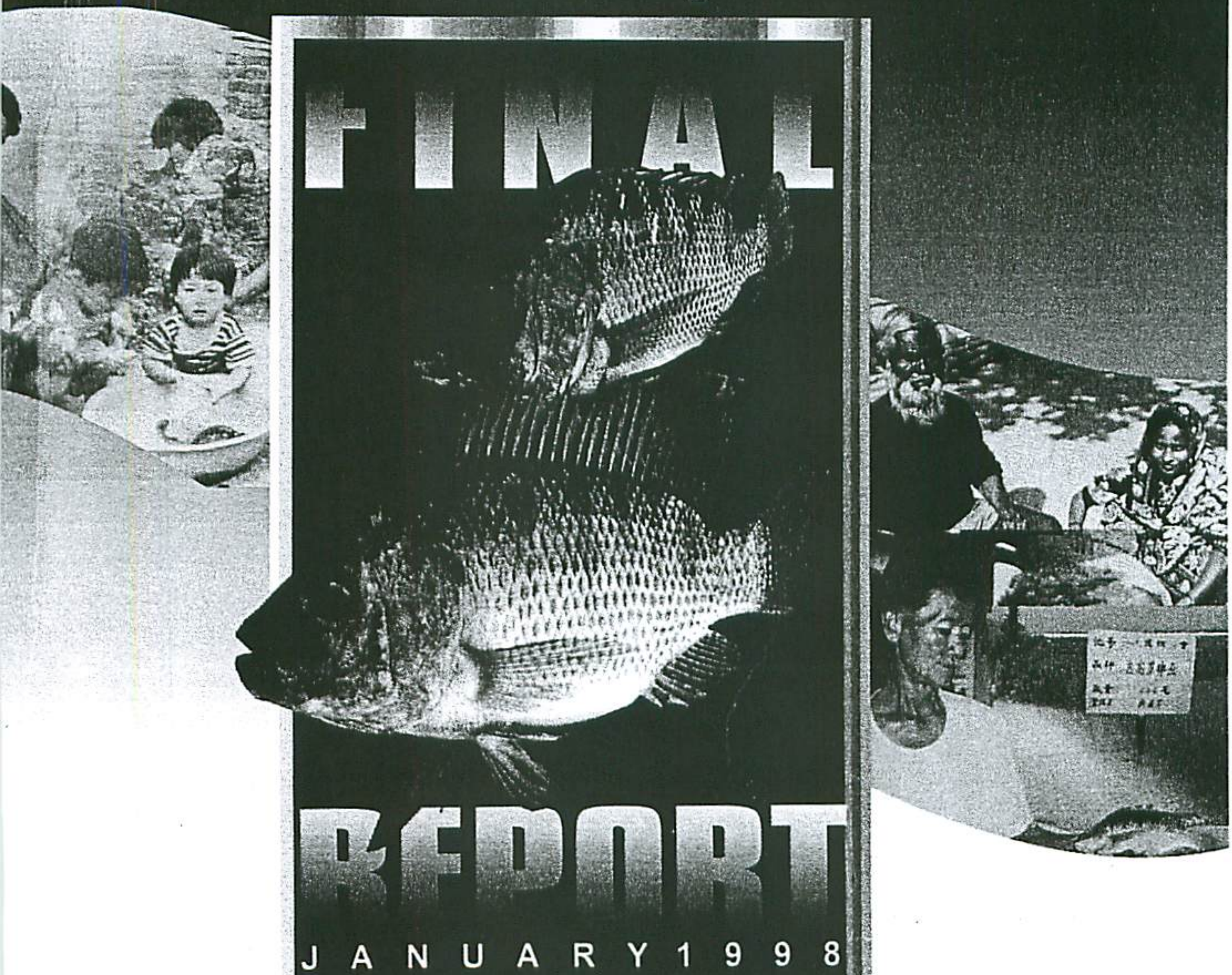
Dissemination and Evaluation of Genetically Improved Tilapia Species in Asia [DEGITA]



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Dissemination and Evaluation of Genetically Improved Tilapia Species in Asia:

Final Report

Prepared by

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in association with

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Dissemination and Evaluation of Genetically Improved Tilapia Species in Asia: Final Report

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Participants of the Initial Planning Meeting for the Dissemination and Evaluation of Genetically Improved Tilapia Species in Asia (DEGITA) Project held during 22-24 September 1994 at the International Rice Research Institute (IRRI), Los Banos, Laguna, Philippines

Participants and guests of the Training/Workshop on: i) Impact evaluation frameworks and models; ii) Methods for analysis of on-station and on-farm experimental data; and iii)Measurement of overall impact: integration of biological and social science perspectives for the DEGITA Project held during 11-30 March 1996 at the University of the Philippines at Los Banos (UPLB), Laguna, Philippines

Part I. Introduction

Chapter 1. Introduction to DEGITA Project

A growing proportion of the world fish supply is coming from aquaculture production. The share of aquaculture production to total fish supply increased from a mere 7 percent in 1975 to more than 19 percent in 1995. Overall, the developing member countries (DMCs) of the Asian Development Bank (ADB) contribute about 80 percent of the world's aquaculture production, and have established priority plans to expand and develop aquaculture.

Currently, there is a worldwide recognition that fish genetic research and breeding programs are effective means of increasing productivity and efficiency of aquaculture production, and their effects are cumulative and permanent. In agriculture, the genetic improvement benefit-cost ratio ranges from 5:1 to 50:1. In aquaculture even higher ratios may be achieved through genetic research because of the relatively low aquaculture productivity base in most countries. Although fish genetics research gained support and momentum only in the 1970s, the possibilities for improving productivity through selective breeding are especially promising because fish have a higher fertility, shorter generation and higher genetic variability than other farmed animals.

The Genetically Improved Farm Tilapia (GIFT) Project, funded by ADB and the United Nations Development Program (UNDP), is a major initiative in applied genetics and breeding in tropical aquaculture in the region. It selected to work on tilapia, a tropical fish species that originated in Africa, due to its worldwide importance in aquaculture and short generation suitable to genetics improvement research. Specifically, the GIFT Project worked on the Nile tilapia because of its wide acceptance as food fish, a cheap source of protein, low external input requirement generating higher profitability and income for farmers, and its growing role as an internationally traded commodity.

The primary objective of the GIFT Project was to improve the breeds of farmed tilapia as a means to increase aquaculture productivity in Asia. Within four years (1988-1992), it developed a tilapia breed that outperformed for growth and survival, in varied farming environments, most widely farmed tilapia strains in Asia. This translates into more crops a year and a substantial increase in production and incomes for fish farmers.

In recognition of the success of the GIFT Project, many DMCs requested ADB and UNDP for financial support for the establishment of an international collaboration for fish genetics research in Asia and for the dissemination of the GIFT strain. UNDP agreed to provide further support for a second phase of the GIFT Project mainly on the technical aspects of fish genetics, establishment of the International Network on Genetics of Aquaculture (INGA) and in planning national fish breeding programs. The ADB complemented and supplemented the UNDP financial support and focus on disseminating the improved tilapia breed to selected DMCs, assessing their on-farm economic performance, evaluating their socioeconomic and environmental impact, transferring the scientific knowledge and information on fish genetics and breeding to DMCs and planning national tilapia breeding programs. This led to a new project designated as "Dissemination and Evaluation of Genetically Improved Tilapia Species in Asia (DEGITA)", under a regional technical assistance (RETA No. 5588) provided by ADB to ICLARM, which became operative on 15 June 1994. The Project was successfully completed on 30 June 1997.

1.1 Project Rationale

It is known that dissemination and adoption of "new technology" is a dynamic and complex process especially at the farm level. The decision to adopt the genetically improved tilapia is not only due to its biological attractiveness such as fast growth and higher survival rate but also to its socioeconomic relevance and acceptability and its possible impact on the environment, especially on biodiversity and ecological integrity.

Hence, it is the primary concern of the DEGITA Project to undertake a performance evaluation of the GIFT strain prior to its widespread dissemination as a means to increase aquaculture productivity, improve rural nutrition and increase farmers income in Asia. In line with the universally accepted rule of diffusion of "new" technology, the DEGITA Project is tasked to determine its economic, social and environmental impacts.

1.2 Objective and Scope

The major objectives of the DEGITA Project were: 1) to carry out genetic, socio-economic and environmental evaluation of the improved tilapia species in Bangladesh, People's Republic of China (PRC), the Philippines, Thailand and Vietnam; 2) to analyze the overall impact of the improved tilapia strain on different groups of society (farmers, consumers, landless laborers, etc.); 3) to disseminate the promising tilapia strain among small fisherfolk in these five countries; and 4) to transfer scientific knowledge and technology for tilapia genetics in order to assist these five countries in planning national tilapia breeding programs.

Primarily, the scope of activities of the DEGITA project were: a) dissemination (following a rigorous quarantine procedures in consonance with the International Code of Practice in Fish Transfers so as to avoid harmful effects to the environments) and assessment of the socioeconomic and environmental impact of improved tilapia strain; b) provision of assistance in the development of national tilapia breeding programs for the five-participating DMCs; and c) capacity building for human resources development through short-term courses, exchange visits and special seminars and workshop for the participating countries' national scientists (to be trained in applied fish breeding and fish breeding), technicians and fish farmers to be knowledgeable in proper broodstock management.

1.3 Methodology

Integrating the disciplines of genetics, economics, sociology and environmental science, a unified methodology was developed to achieve the objectives of the project. The methodology was a combination of ex-ante and ex-post evaluation techniques, and consisted of the following activities:

a) national review of past performance and current status of the tilapia industry;
b) on-station evaluation of GIFT vs. non-GIFT (check) strains;
c) analysis of agroecological and socioeconomic environments of project sites;
d) baseline survey of fish producers, consumers and traders; and
e) on-farm trials of GIFT vs. non-GIFT (check) strains.

The impact evaluation framework used in the DEGITA Project was holistic in nature. Impacts were measured at the household (producers vs. consumers) and country levels using a combination of general equilibrium (GE) analysis, micro system analyses (village studies and farming system analysis), and ecological analysis. The following steps were followed to measure the size and distribution of benefits from tilapia genetic research in general equilibrium setting.

1. Development of "General Equilibrium Model" for each country.

The general equilibrium framework used for evaluating the welfare consequences of technical change was a modification of the "Modified trade expenditure function" approach (Martin and Alston 1994). This modified balance-of-trade function provides money measures (Hicksian) of welfare changes in terms of producer profit and consumer expenditure. The modified balance of trade function shares the fundamental parameters of the behavioral system. It includes the parameters of the profit function, output supply function and the consumer expenditure system. Parameters of the model were calculated primarily with data collected through baseline surveys and review of existing literature. In addition, site specific data on agroecological and socioeconomic environments were used to estimate different parameters of the model.

2. Construction of *ex-ante* impact indicators.

As the project duration was not long enough to capture the *ex-post* impact of genetically improved tilapia technology, *ex-ante* impact assessment method was used to estimate gains from the technology. Data from on-station experiments and on-farm trials were used to construct *ex-ante* indicators of the direct impact of genetically improved tilapia technology such as yield improvement, cost reduction and quality enhancement.

Fisheries simulation models were used to measure the probable direct gain, like per hectare productivity change, under alternative environments and input use levels.

3. Analysis of overall impact.

Behavioral equations designed to represent various systems of interests were solved first to generate changes in prices and any other endogenous variables. Then these changes in prices and other variables together with the measures of ex-ante impact indicators (Step 2) were used in the general equilibrium model (Step 1) to estimate the welfare gain to various groups of society in terms of productivity, nutrition and food security, and income distribution.

1.4 Implementation Arrangement

The Asian Development Bank (ADB) provided a Technical Assistance Grant (RETA No. 5588) of US $600,000 to the International Center for Living Aquatic Resources Management (ICLARM) for implementing the activities of the DEGITA Project. The five participating countries (i.e., Bangladesh, People's Republic of China, the Philippines, Thailand and Vietnam) were selected because they have (i) clear national strategies for aquaculture development, (ii) expressed strong interest in introducing improved tilapia species, (iii) existing facilities and manpower to conduct fish genetics research and breeding, (iv) high demand for tilapia, and (v) lack of external financial support for the dissemination and evaluation of improved tilapia species (ADB 1993). ICLARM and the five participating countries together contributed an approximate amount of US $600,000 to match the ADB grant for the implementation of the project.

ICLARM implemented the DEGITA project as an integral part of the International Network on Genetics in Aquaculture (INGA) and in collaboration with national aquaculture research institutes. The principal collaborating institutions were: 1) Bangladesh Fisheries Research Institute (BFRI), Bangladesh; 2) Shanghai Fisheries University (SFU), PRC; 3) Bureau of Fisheries and Aquatic Resources (BFAR), Philippines; 4) National Aquaculture Genetics Research Institute (NAGRI), Thailand; and 5) Research Institute for Aquaculture No. 1 (RIA No. 1) and Research Institute for Aquaculture No. 2 (RIA No. 2), Vietnam.

An international team at ICLARM and national teams in the participating countries were formed for executing DEGITA activities (Appendix I) These national teams vary considerably in terms of expertise in the relevant disciplines (genetics, economics, extension, hatchery management and environmental science/ecology). Bangladesh had all biologists in its six-member team from BFRI. It had no economist and environmental specialist on its team. China had a multidisciplinary team of 9 members from SFU and from various fish seed farms. BFAR executed the DEGITA activities in the Philippines in collaboration with the regional offices of the Department of Agriculture. The core team had four members from BFAR, including one environmental specialist. Like Bangladesh, the Philippine team had no economist or social scientist on its team. Thailand had a team of 3 members from NAGRI with expertise in genetics and biology but none in economics or social and environmental science. Vietnam had two interdependent teams, one in Hanoi at RIA No. 1 and the other in Ho Chi Minh City at RIA No. 2. These teams consisted of RIA personnel and local university specialists. Both teams had geneticists, biologists and environmental specialists, but only the North Vietnam team had an economist.

1.5 DEGITA Activities

In line with its objectives, the following activities were undertaken under the DEGITA Project: 1) formation of teams; 2) organization of planning meeting; 3) collection of secondary data on tilapia and development of a unified methodology; 4) distribution of the GIFT and test strains; 5) primary data collection through baseline survey of fish farmers, consumers and traders; 6) conduct of on-station and on-farm evaluation; 7) implementation of participatory rapid rural appraisal; 8) conduct of training and review meetings; and 9) analysis of data.

The initial planning meeting of DEGITA was held at the International Rice Research Institute (IRRI), Los Baños, Laguna, Philippines, on 22-24 September 1994. Representatives of the five DEGITA-participating countries, ICLARM and ADB participated in the meeting. Research workplans, major milestones and implementation strategies were discussed and finalized during the meeting.

Secondary data on aquaculture and the tilapia industry were collected in the DEGITA-participating countries. A unified methodology was developed for the evaluation of the performance of the genetically improved tilapia strains, integrating the disciplines of genetics, economics, sociology and environmental science.

The GIFT strain was distributed in 1994 and 1996 to five DEGITA-participating countries for on-station and on-farm performance evaluation (Table 1). GIFT fry/fingerlings produced at ICLARM/BFAR research station in the Philippines were properly distributed and well received by the participating countries. The project provided about 25,000 GIFT fry/fingerlings to collaborating research institutions in Bangladesh, China, Thailand and Vietnam, and about 250,000 to different on-farm trial sites in the Philippines. In addition, about 5,000 Egypt strain fry/fingerlings from BFAR, Philippines was distributed through the project to China, Thailand and Vietnam, following vigorous quarantine procedure in accordance with the fish transfer protocols of INGA.

On-station evaluation of the performance of GIFT strain were conducted in the participating countries excluding Philippines, where it was intensively tested by the GIFT Project. Table 2 shows the experimental sites of the participating countries. These sites represented five out of seven FAO-designed agroecological zones in Asia. Two other zones, warm-arid and semi-arid tropics and cool subtropics are not environmentally suitable for tilapia culture.

The on-farm evaluation consisted of the following activities: 1) analysis of the agroecological and socioeconomic environments of the project sites; 2) baseline surveys of fish producers, consumers and traders; and 3) monitoring of the performance of GIFT and local strains. Maps 1 to 5 show the on-station and on-farm study sites in the participating countries. Table 3 shows the number of samples obtained for each site for the baselines surveys. Project sites for on-farm trials representing a range of agroecosystems and aquaculture systems were selected in the five participating countries. Appendix 2 provides the general characteristics of the DEGITA project on-farm sites in each participating country.

1.6 Organization of the Report

Chapter 2, still under Part I (Introduction) of this report, deals with the review of aquaculture development in the DEGITA-participating countries, emphasizing its significance for the economic development of these countries. Part II (Results) has 3 chapters. Chapter 3 discusses the results of the socioeconomic baseline surveys in the DEGITA-participating countries. Chapter 4 presents the results of the on-station experiment and on-farm trials. Chapter 5 discusses the potential impact of the GIFT technology focusing on the possible socioeconomic and environmental impacts. Part III (Recommendation and Conclusion) have 2 chapters. Chapter 6 assesses the impact of the DEGITA project on the participating institutions and on their aquaculture policies while Chapter 7 provides the recommendations and future implications of the DEGITA-like project. This report summarizes the findings of the DEGITA Project. Based on the results of the DEGITA Project, one detailed technical report to be prepared jointly by the ADB and ICLARM and several articles for the primary journals will be published.

Chapter 2. Review of Aquaculture Development in the DEGITA-Participating Countries

2.1 General Economic Conditions

The prevailing socioeconomic conditions in the DEGITA-participating countries using selected development indicators are shown in Table 4. China is the world's largest fish producing/consuming country with population of 1.2 billion. Bangladesh, the Philippines, Thailand and Vietnam have a population of 117, 70, 59 and 74 million, respectively. Their population growth rates per annum are: Thailand (1.2 percent) and China (1.2 percent), Bangladesh (1.8 percent), the Philippines (2.5 percent) and Vietnam (2.2 percent). The huge population base of China and relatively high population growth rate in the other countries, coupled with declining catch from the wild, is putting considerable pressure on their aquaculture resources to meet the growing local demand.

Per capita GNP in Bangladesh, China, the Philippines, Thailand and Vietnam stood at US $220, 490, 850, 2,110 and 170, respectively, in 1994. Recently, Thailand was reclassified as a Newly Industrialized Country (NIC) as it has a per capita GNP of more than US $2,000/annum. All these countries have posted a per capita GNP increase of more than 4 percent in recent years.

Per capita fish consumption per annum ranged from 9 kg to 32 kg (Bangladesh 9; China 17; the Philippines 32; Thailand 29; and Vietnam 14). Tilapia only comprised only about 1.5 percent to 5.4 percent of the fish consumed (China 1.2 percent; the Philippines 5.3 percent; Thailand 5.4 percent; and Vietnam 1.5 percent). Although data on tilapia consumption is not available for Bangladesh, it is estimated that tilapia accounts for less than 1.0 percent of per capita fish consumption in the country. This indicates that tilapia is not a major fish species consumed in Bangladesh, China and Vietnam, where carps are the main freshwater species consumed.

A very high percentage of the female (Bangladesh 85 percent; China 76 percent; the Philippines 31 percent; Thailand 40 percent; and Vietnam 73 percent) and male population (Bangladesh 54 percent; China 69 percent; the Philippines 53 percent; Thailand 43 percent; and Vietnam 69 percent) were economically active in agriculture which includes aquaculture. This indicates that their economies are highly dependent on the development of their agriculture including aquaculture sector as it generates employment and incomes for a relatively large percentage of their male and female economically active population.

Except in China (8.6 percent in 1990), the incidence of poverty or population in poverty continued to be considerably high in Bangladesh (52 percent in 1985/86), Philippines (41 percent in 1994), Thailand (43 percent in 1988) and Vietnam (51 percent in 1992/93). More people in rural areas, mostly engaged in agriculture-aquaculture activities, are living in poverty in these countries. Due to the high incidence of poverty, the ratio of income of the highest 20% to lowest 20% of the population was 1: 4-10. Income inequality as measured by the Gini coefficient differed substantially. In countries like Bangladesh (0.3), China (0.3) and Vietnam (0.4), income inequality were less pronounced than in the Philippines (0.5) and Thailand (0.5).

Clearly, aquaculture plays a significant role in these countries as most of the people are still highly dependent on the agriculture-aquaculture sector.

2.2 Aquaculture Industry

2.2.1 Aquaculture production

Asia leads the world in aquaculture production. It contributed about 90 percent of the world aquaculture production of 25,490 thousand mt in 1994 (Table 5). About 75 percent of Asia's aquaculture production of 22,928 thousand mt came from these countries (Bangladesh 1 percent; China 67 percent; the Philippines 4 percent; Thailand 2 percent; and Vietnam 1 percent). Hence, their aquaculture production is not only significant in Asia but also to the world.

Asia's aquaculture production yearly growth rate (9.2 percent) from 1984-1994 surpassed that of the world (8.5 percent). This can mainly be attributed to a robust growth of aquaculture production from Asia's major aquaculture-producing countries. Aquaculture production in Bangladesh, China, the Philippines, Thailand and Vietnam registered an annual growth rate of 8.3, 12.9, 5.6, 15.8 and 5.4 percent, respectively, from 1984-1994.

Aquaculture production from Bangladesh, China and Vietnam posted a significant increase in growth rate in 1990-1994 over 1984-1989. Bangladesh, China and Vietnam aquaculture production registered a higher yearly growth of 12.8, 18.6 and 6.5 percent from 1990-1994 as compared to their yearly growth rate of 7.0, 11.9 and 4.5 percent from 1984-1989, respectively. The declining growth rate in recent years (1990-1994) in the aquaculture production of the Philippines and Thailand can be attributed to a sharp decline in their shrimp production. Nevertheless, their aquaculture production still posted positive growth rates. In fact, the 14.1 percent yearly growth rate of Thailand from 1990-1994 can be considered substantial in comparison to the growth in aquaculture production of other countries of the world.

2.2.2 Prices of selected aquaculture products

Prices of fish from aquaculture vary considerably in Asia. Fish cultured in brackishwater are usually priced higher than those reared in freshwater. Even prices of freshwater fish differ substantially depending on whether it is grown in cages or ponds. Fish cultured in cages are priced relatively higher than those in ponds. Consumers are willing to pay a price premium for fish produced in cages. Their perception is that fish produced in cage culture is of a higher quality than those from pond culture.

Among the aquaculture products, tilapia is priced lower relative to the other fish species. Although, tilapia prices were higher than frigate tuna (*Auxis* spp.), roundscad (*Decapterus macrosoma*) and slipmouth (*Leiognathus* spp.), its prices were lower than milkfish (*Chanos chanos*), grouper, cavalla (*Carengoides* spp.), threadfin bream (*Nemipterus spp.*) and Indian mackerel in the Philippines (Table 6). In Thailand, tilapia prices were higher than those for striped catfish (*Pangasius* spp.), but were lower than those for snakehead, silver barb, common carp, and golden price carps (Table 7). Tilapia prices (in US$) increased in the Philippines from 1987 to 1992, but remained more or less constant during the same period in Thailand. The ratio of tilapia price to milkfish price has increased in the Philippines from 0.68 in 1987 to 0.76 in 1992, while the ratio of tilapia price to catfish (*Clarias batrachus*) in Thailand has remained more or less constant at around 0.37 from 1987 to 1992.

Fish prices from different locations of Bangladesh, China, and Vietnam showed that prices of tilapia were relatively moderate compared to more highly regarded species

(Dey and Eknath 1996). In Bangladesh, the average tilapia price of US$1.25/kg in 1995 was one-third the price of major Indian carps. In China, tilapia prices were lower than those of crucian carp, black carp and bream, but higher than those of Chinese carps. In Vietnam, price of small tilapia (with an average size of 100 g) were very low (US$0.45/kg) in 1995 compared to those for other common species like Indian carps (US$0.75/kg). However, larger tilapia (with an average size >250 g), which had a very limited supply, commanded a high market price (US$1/kg).

2.3 History of Tilapia Introduction and Genetic Resources

Among the commercial tilapia species, the Mozambique tilapia (*Oreochromis mossambicus*) was the first tilapia species to be introduced into Asia. It was reported from the Indonesian island of Java in 1939. From the early 1950s until the 1980s, many private individuals, organizations and public institutions *introduced O. mossambicus* in Southeast Asia and South Asia. Due to its slow growth, poor yield and overcrowding in ponds, the fish was rejected by producers. It was also generally unacceptable to consumers due to its dark color and small size. The introduction of Nile tilapia (*Oreochromis niloticus*), with faster growth, bigger size and lighter color, revived interest in tilapia farming in Asia.

China, the Philippines and Thailand are the major tilapia producers among the DEGITA participating countries. The Nile tilapia is also gaining popularity in Bangladesh and Vietnam. In all these countries, demand for tilapia for aquaculture is growing fast and changing the aquaculture commodity mix rapidly.

O. mossambicus was introduced into China from Thailand in 1956 and was polycultured with Chinese carps in ponds for a long time (Li, 1996). Soon fish farmers found the fish unsuitable for culture. It was replaced by African *O. niloticus* that gained entry into China via Hongkong in 1978 (Table 8). *O. aureus*, another commercially important tilapia species, was introduced in 1981 to produce all-male offspring through hybridization with Nile tilapia. *Sarotherodon galilaeus* and Tilapia *zilli* were also introduced in 1991 on an experimental basis. Tilapias are unable to overwinter in natural waters in most parts of China (Tan and Tong, 1979). In China, tilapias are farmed in ponds, tanks and cages mostly in polyculture systems.

The Bureau of Fisheries and Aquatic Resources (BFAR) was responsible for the first introduction *O. mossambicus* into the Philippines from Thailand in 1950. Ten out of a dozen fish survived and were successfully spawned in government hatcheries. Fingerlings were then dispersed to backyard farmers. At it thrives well in brackishwater conditions, it is now an established tilapia species in brackishwater farms in the entire country. In 1972, the Nile tilapia was introduced to the Philippines from Israel and Thailand. The fish were better accepted by fish farmers and consumers than the *O. mossambicus*. This fast tracked the development of the tilapia industry in the country. More strains of *O. niloticus* and other tilapia species were later introduced, both by the public and private sectors, to enhance tilapia farm productivity, increase availability of cheaper protein and income of farmers (Table 9). Tilapia *zilli*, a slower growing species, was not intentionally introduced. It probably came mixed with other introductions (Aypa 1996). Under the GIFT project, ICLARM in collaboration with BFAR brought in Nile tilapia strains from Egypt, Ghana, Senegal and Kenya between 1988 and 1992.

The first introduction of *O. mossambicus* to Thailand came from Malaysia in 1949 and spread to Northeastern Thailand. The Nile tilapia was introduced into the country on 25 March 1965 by His Royal Highness Prince Akihito, the Crown Prince of Japan. This is known as the Chitralada strain in Thailand. The fish, called "pla nil" meaning "black fish" in Thai language, was first distributed to farmers in August 1967. In 1980, another introduction was made of about 1,000 Nile tilapia fingerlings from Israel. As the Chitralada strain was found superior to the Israel strain, the latter was eliminated. In addition to the Chitralada strain, the red tilapia is considered an important commercial strain in Thailand aquaculture. The Thai red tilapia was originally found at the Ubonratchathani Fisheries Development Center in 1968. As a hybrid, this strain is comprised of a gene pool of up to four different species in which *O. niloticus* and *O. mossambicus* are dominant. At Chachoengsao Coastal Aquaculture Development Center, pure broodstock of about 100 pairs of red tilapia strain have been used to produce offspring with an almost pure red color. In 1984, her Royal Highness Princess Maha Chakri Sirindhorn named this fish "red tilapia". The Thai red tilapia has been distributed to many government fisheries stations, fish farmers and natural water bodies throughout the country.

O. mossambicus was introduced in the 1950s into Vietnam (Thien et al. 1997). It became a widely cultured tilapia species in the country. But gradually it lost its importance due to its slow growth performance, smaller size, early maturity, overcrowding and low tolerance to cold temperature during winter months. As such, it was replaced by the Nile tilapia (*O. niloticus*), which was introduced in 1973 from Taiwan and was called "Vietnam" strain. Due to its faster growth, bigger size and lower fecundity, the popularity of *O. niloticus* as a suitable tilapia species to culture gained acceptance quickly. Unfortunately, due to improper management of farms in the 1980s, *O. niloticus* crossed naturally with *O. mossambicus* producing hybrids and lost its purity. Consequently, it lost popularity for culture in certain parts of the country. In an effort to revive and sustain the growth of tilapia in Vietnam, the country joined DEGITA project in 1994. As part of DEGITA activities in Vietnam, the project introduced the GIFT strain and Egypt strains to Vietnam in May 1994 while the Thai strain was made available in April 1994 through a collaborative research program between RIA No. 1 and the Asian Institute of Technology (AIT).

The rapid growth and development of tilapia in Asia is primarily due to the availability of a pool of tilapia genetic resources for the propagation of this fish. However, there is very little information on tilapia genetic resources in Asia. The only published compendium of tilapia genetic resources (Pullin 1988) is limited in scope and is out of date as it contains reports from only four Asian countries (Malaysia, Philippines, Singapore and Thailand) plus some brief information on the history of tilapia, and introductions to and transfers within Asia (Pullin 1997).

2.4 Tilapia Production in Asia and in DEGITA-participating Countries

Tilapia culture is growing rapidly in Asia. It accounted for about 87 percent of globally farmed tilapia in 1994. Asia's tilapia production increased from 154,509 t in 1984 to 519,192 t in 1994, with an annual growth rate of 12 percent (Table 10). China (43 percent), the Philippines (19 percent), and Thailand (11 percent), accounted for most of the farmed tilapia production in Asia.

In Bangladesh, tilapia production statistics are lumped with those of other minor freshwater species as it is not yet an important and widely cultured freshwater species. Nevertheless, it is noted that tilapia production is increasing because of its desirable features: faster growth, high yield, tasty flesh and ease of reproduction. In China, tilapia production from aquaculture increased from 18,100 t in 1984 to 235,940 t in 1994, with an average growth rate of 28 percent per year (Table 10). The contribution of farmed tilapia to total aquaculture rose from less than 0.5 percent in 1984 to about 2 percent in 1994.

Tilapia is the most important freshwater cultured species in the Philippines, accounting for about 60% of the national freshwater aquaculture production in 1994. Tilapia also ranks second to milkfish in terms of fresh and brackishwater farmed fish production in the country, constituting about 23% of the total aquaculture production. Farmed tilapia production in the Philippines increased at an average rate of about 8 percent per year from 1984 to 1994 (Table 10).

Production of farmed tilapia in Thailand has been increasing since 1984 at an average rate of about 15 percent per year. At present, Nile tilapia is the most important freshwater cultured species in Thailand, contributing more than 11 percent to total aquaculture production (Table 10).

Production of tilapia in Vietnam is about 15,000 t, which accounts for about 5 percent of the total fish production from aquaculture. It is estimated that over 10,000 ha of village ponds, 2,000 ha of sewage fed fish ponds and 10,000 ha of brackishwater area are presently utilized for the production of tilapia in Vietnam.

As genetically improved tilapia species are becoming more widely available, it is expected that these countries can sustain and even achieve higher growth rates in tilapia production.

2.5 International Trade in Tilapia

Tilapia is now one of the internationally traded aquaculture products. Asian countries are the major exporters, with the United States as their primary market. In 1995, about 85 percent of the total tilapia imports into USA came from Asia. European markets, which prefer bigger tilapia, are also expanding for Asian tilapia. In Japan, there is a market for 'sashimi' grade tilapia.

Taiwan is the biggest exporter of tilapia in Asia. It exported about 156,000 t live weight equivalent (LWE, obtained by multiplying the product weight by 1.1 for whole frozen fish and by 3.0 for fillets) of tilapia to the USA, with an average C & F (cost and freight) price of US$ 1.26/kg of LWE fish in 1995. This accounted for 66 percent of total tilapia imports to the USA (Table 11). Taiwan is exporting about 35 percent of its total domestic production. Other major tilapia exporters in Asia are Thailand and Indonesia. These countries export less than 5 percent of domestic production. China is the second largest exporter of whole frozen fish to the US. Vietnam has recently entered the world tilapia market. In 1995, average C & F price for tilapia in the USA was the highest for fish from Indonesia (US$ 1.41/kg LWE) and lowest for fish from Vietnam (US$ 0.67/kg LWE). Unlike other Asian exporters, Indonesia exports almost exclusively in fillet form and is a major exporter of frozen tilapia fillets to the USA.

The Philippines, the second biggest producer of tilapia in Asia as well as in the world, has so far been unable to compete with other tilapia producing countries in the tilapia export market. Philippine farmers are incurring a higher cost to produce a kilogram of tilapia compared to their counterparts in other Asian countries. There is also a disincentive to export as tilapia has a high domestic demand and its local market price (about US$ 2/kg in the wholesale market in 1995) is substantially higher than the world market price (C & F price in US in 1995 was US$ 1.4/kg LWE).

2.6 Government Policies

No substantial data were available to analyze government policies affecting aquaculture development in China and Vietnam. Hence, only the policies of Bangladesh, the Philippines and Thailand were reviewed.

2.6.1 Sectoral policies

Like most developing countries, the governments of Bangladesh, the Philippines and Thailand intervene in the aquaculture sector through various sector-specific policies on feed, fertilizer, trade, investment and research. These policies play a crucial role in defining the economic boundaries for aquaculture development in these countries.

1. Feed policy

Feeds for aquaculture, despite recognition in the Philippines and Thailand of their pivotal role in determining economic success or failure, are treated peripherally through the issuance of circulars or memorandum orders. Feed costs accounted for most of the cash requirements of semi-intensive and intensive aquaculture. The Philippines and Thailand have been following an import substitution policy for using local ingredients to reduce the cost of feeds. Because these governments have not been successful in totally eliminating foreign ingredients in locally formulated feeds, feed cost still comprises about 70 percent of the production cost. Bangladesh, where most aquaculture is still extensive, is pursuing a policy of gradually intensifying aquaculture.

The Philippines and Thailand have also resorted to reactionary measures against feed supply shortages rather than drawing up guidelines for and implementing a comprehensive feed policy framework. In Thailand, when black tiger prawn farming was hard hit by the collapse of its export price in 1989, the government offered no specific guidelines on feed subsidy. Instead, the government negotiated directly with feed manufacturers, resulting in a 12.5 percent discount on shrimp feed prices and another 10 percent discount on bulk purchases, provided that each purchase was in cash and not less than one ton. It also required manufacturers to affix price tags on every feed package to prevent the price from escalating without notice (Nambiar 1991a). In the Philippines, it is obligatory on the part of feed manufacturers not only to affix a price tag but also to label every bag of feed on sale with a description of the feed components.

Tariff data on feeds, feed ingredients and feed import quotas were available only for the Philippines. To improve the competitiveness of shrimps in the export markets, tariffs on feeds and feed ingredients have been lowered from a high of 30 percent and 10 percent to 10 percent and 3 percent, respectively. This would reduce the prices of both local and imported feeds. Feed imports are not subject to quantitative restrictions. The government has not completely eliminated such tariffs because: (1) local feed millers need protection, for the continuance of their operations within acceptable profitability levels, from adverse movement of prices; (2) local feed millers can supply the feed requirements of the prawn growers, given appropriate incentives; and (3) production of local feeds should be encouraged as imported feeds carry risks of oxidative rancidity which is implicated in red and blue diseases. Red disease can completely destroy farm output, whereas blue disease lowers the quality and hence reduces the price of shrimps (Clarete and Cortes 1992).

2. Fertilizer policy

In the early 1970s, most Asian governments controlled the fertilizer sector and provided incentives for increased agricultural production through subsidies. The following measures were implemented: government monopolies on procurement and distribution of fertilizer through parastatal institutions, direct fertilizer subsidy programs, regulatory mechanisms for private trade, and controls on input and output pricing.

Acknowledging the increasingly high fiscal cost of such programs, most Asian governments have taken steps, since the late 1970s, to reduce their involvement in the fertilizer sector. An overview of some deregulation and privatization policies is presented in Table 12. Although substantial progress has been made, some barriers that distort the free play of market forces still continue in the form of setting prices of fertilizers produced in factories under government controls, supply of raw materials to factories at subsidized prices, licensing of companies permitted to participate in foreign trade, allocation of foreign exchange to import fertilizers, lengthy import procedures, inadequate port, warehouse and transportation facilities, etc. Because of these, localized shortages of fertilizer and fluctuations in prices at critical times of fertilizer demand are still common in many Asian countries.

The impact of policy changes regarding decontrol of fertilizer markets and privatization would be reflected in the difference in prices paid by farmers and the world market prices under competitive markets. Table 13 provides information on world prices of major fertilizers and the retail trade in selected Asian countries. For phosphate and potash, which are mostly imported, the domestic prices are now closer to world market prices. For urea, however, the domestic prices in Bangladesh are lower than the world market prices. With further reforms towards competitive markets, the price of urea is expected to increase in Bangladesh. This will depress fertilizer consumption in the country.

3. Aquaculture trade policy

Aquaculture trade policies are focused mainly on the promotion and protection of tradable export commodities: shrimps for Bangladesh and Thailand; seaweed and shrimps for the Philippines. These countries are net exporters of fishery products and their trade policies are considered outward-looking, i.e., assigning higher priority to improving foreign exchange earnings than to increasing the availability of produce for domestic consumption. After experiencing a drastic fall in export prices, especially when the Japanese shrimp market crashed in 1989 (Nambiar 1991a), Thailand started to promote domestic consumption of shrimp through: setting up of market places for farmers to sell directly to consumers; holding of Shrimp Fairs to showcase various styles of cooking; and negotiating with potential shrimp importing countries to expand the export markets for Thai shrimps.

All these countries have open trade policies with no quantitative restrictions for those willing to engage in the export, import and local trade of aquaculture commodities. Entry is also nonrestrictive as long as all legal requirements are met. In the process of trading, taxes and duties are applied to every business transaction. In all these countries, however, favorable incentives are given to exporters, whereas importers are penalized by high tariff rates. In the Philippines, a licensed exporter has to pay an export tax of only 0.5 percent of the f.o.b. value of the commodity plus P120 (US $5) per transaction to cover the permit application and gathering fees. The government has a "one-stop-shop" to process all the requirements of the exporter so that transactions are facilitated and costs are reduced. A Philippine importer, however, has to pay a tariff of at least 30 percent for an imported aquaculture commodity. At present the government is debating the mode of import valuation; whether to shift from the current Home Consumption Value (HCV) scheme to a transaction value (TV) or export scheme with the purpose of protecting the interest of local producers. In the HCV scheme, import value is computed based on the domestic wholesale price of the product in the country of origin, whereas the TV scheme valuation is based on actual export prices of the product brought into the country.

4. Aquaculture Investment Policy

Bangladesh, the Philippines and Thailand, with their open-entry investment policies, are encouraging local and foreign investors to engage in a wide range of aquaculture activities to sustain and to enlarge the sector's contribution to national economies. These policies are embodied in the countries' respective programs, projects and incentives for the development of their aquaculture sectors.

Bangladesh is investing heavily in the development of shrimp culture areas and the improvement of shrimp culture techniques and practices in its effort to increase production of shrimp for export. In a scenario of increasing production, investment is anticipated to flow towards modernizing existing processing plants and machinery for product diversification, packaging and marketing. Bangladesh is exporting semi-processed raw materials. Further processing and packaging for distribution has high costs that lead to substantial value addition (Nambiar 1991b). It is important for Bangladesh to capture part of such a value addition process, given its low-income labor force and acute unemployment problems. The Foreign Private Investment Act, 1980, continues to be the framework for the promotion and protection of foreign investment in Bangladesh.

In the Philippines, the Board of Investment (BOI) of the Department of Trade and Industry (DTI) is the government agency that promulgates and administers incentives for the aquaculture sector. The Bureau of Export and Trade Promotion of the DTI is responsible for export promotion, together with various overseas commercial offices. In addition, the Central Bank, Securities and Exchange Commission and the Department of Tourism extend assistance for the promotion of investment in aquaculture. Under Book 1 of the Omnibus Investment Code, an investor may enjoy certain benefits and incentives, provided that the investment is in preferred areas detailed in the Investment Priorities Plan (IPP). An enterprise not listed in the IPP may still be entitled to incentives for Filipino owned enterprise in which at least 50% of the production is for exports; and for an enterprise with more than 40% foreign equity, when at least 70% of the production is for exports. Hence, the government is giving attractive incentives for those investing in aquaculture activities that can generate foreign exchange earnings.

In Thailand, investment incentives in general are covered by the Investment Promotion Act 2520, 1977, and implemented by the Board of Investment. Some of these investment incentives are intended to strengthen the position of Thailand's aquaculture products in the world market and to contribute substantial foreign exchange earnings to its economy (Table 14).

The priority investment areas for all these countries are: upgrading of production and hatchery systems; establishing additional feed mills and modernizing existing processing plants and machinery; strengthening infrastructure facilities such as roads, transportation, communication, power, and ports; and improving skills and technological knowledge and hastening transfer of technologies through research and development.

5. Aquaculture research policy

Wide variations exist among Asian countries in terms of the contribution of aquaculture to employment, production and the national economy. However, the tremendous potential of this sector is unquestionable. This potential could be harnessed only if resources are well managed and research and development (R & D) efforts are promoted vigorously to improve the sector's productivity. Research and development in the crop sector has made significant contributions to national economies in Asia (Evenson and Pray 1991). The aquaculture sector is no different.

A traditional measure of the level of government support for aquaculture research is the aquacultural research-intensity ratio that expresses levels of public research spending as a percentage of the value of the aquacultural product. Aquaculture research investment increased during the 1980s but it is still only around 0.3 percent of the sectoral value of production in Bangladesh, the Philippines and Thailand (Table 15). On the other hand, newly industrialized Asian countries like Taiwan spend about 1 percent of the sectoral value of aquaculture on research. By comparison, more developed countries spend about 2 percent of agricultural gross domestic product (AgGDP) on agriculture research (Pardey 1992). Though there is no specific recommendation regarding "optimal" aquaculture research investment, a variety of operational guidelines concerning "desirable" research investment levels are available. The 1974 UN World Food Conference set a 1985 research investment target of 0.5 percent of AgGDP (UN 1974), while the World Bank (WB) set a target for 1990 of 2 percent (WB 1981). Ruttan suggested that "... a level of expenditure that would push rates of return to below 20 percent would be in the public interest (Ruttan 1980). But with the present low level of investment, the internal rate of return on investment in fisheries and aquaculture research is very high in Asia, more than 100% (Dey and Deb 1990). The evidence in Table 15 makes it clear that Bangladesh, the Philippines, Thailand and their donors continue to underinvest in aquaculture research, despite the likelihood of such high returns.

Aquaculture research, by its very nature, is a long-term undertaking. The level of investment in aquaculture research, thus, should not only be adequate but also be sustained over a long period of time. The available data suggest that the level of funding of research varies widely from year-to-year in Bangladesh, the Philippines and Thailand. The main determinant of this variability appears to be the high instability in foreign aid budgets for research. In countries like Bangladesh, funds are so short that after fixed expenses are covered there is little left for undertaking research.

In all three countries, aquaculture research programs are restricted almost entirely to the biological and technical dimensions of the sector. They fail to address the sector's equally if not more important issues, that are economics, sociological and environmental in nature. These research programs generally do not reflect the need for adjustment in the distribution of research disciplines to keep up with changing priorities.

In these countries, researchers' salaries and benefits are low, often lower than those of comparable administrative positions. Low wages make it difficult to retain staff or to recruit specialists (e.g. economists, computer programmers) in high demand in the private sector or in other nonfishery public sectors.

2.6.2 Macroeconomic policy environment

Incentives or disincentives for aquaculture development are influenced not only directly by commodity specific policies, but indirectly, by economywide policies that under (over) value the exchange rate and distort the relative price of nonaquaculture goods. The available data revealed that the macroeconomic policies of developing countries implicitly tax their agricultural sector by 25 to 30 percent on the average (Krueger et al. 1988). Due to the limitation of data, it has not been possible to estimate the impact of these economywide policies on aquaculture incentives. Such analysis requires the estimation of coefficients like the nominal protection rate for all related commodities (aquaculture and non-aquaculture), elasticities of import demand and output supply and the sustainable level of the current account deficit. As an alternative, we analyzed the trend of the real exchange rates as indicators of the changes in the relative incentives between the aquaculture and nonaquaculture sectors.

The aquaculture sector in Bangladesh, the Philippines and Thailand consists mainly of exportable, importable and potentially tradable commodities. Thus, foreign exchange rates are crucial factors affecting the prices received by the farmers. An under (over) valuation of the real exchange rate will increase (decrease) the relative incentive of tradable to nontradeable sectors.

Table 16 shows the trends from 1981 to 1992 in the nominal and real exchange rates of Bangladesh, the Philippines and Thailand. The real exchange rate was estimated by deflating the nominal exchange rates with the ratio of the country-specific consumer price index (CPI) to the CPI in the US. The nominal value of the Bangladesh Taka and the Philippine Peso have been adjusted downward resulting in annual rates of depreciation of 6 percent and 11 percent, respectively. However, over the decade of the eighties as a whole, there has been virtually no depreciation of real exchange rates in Bangladesh and the Philippines. It is obvious that the substantial depreciation of the Taka and the Peso in nominal terms has been caused by domestic inflation (relative to inflation in the US). Since 1990, the real exchange rate in the Philippines has in fact appreciated considerably, thus eroding the competitiveness of Philippine aquaculture exports. The nominal exchange rate of the Thai Baht did not change during the 1980s, but has recently depreciated to some extent against the US dollar.

These data suggest that economywide policies have provided incentives to aquaculture, particularly for shrimp and other exportables, only in Thailand and not in Bangladesh and the Philippines until the recent financial crisis in Southeast Asia. In fact, these policies penalized the tradable aquaculture sector in the Philippines during 1980s and early 1990s.

2.7 Existing Infrastructure

In Bangladesh, aquaculture research is the main responsibility of the Bangladesh Fisheries Research Institute (BFRI). Since its inception, this Institute has given emphasis to research to develop advanced breeding and production technologies of the commercially important freshwater fish species, including low cost and low input technologies suitable for seasonal water bodies. The recent introduction of the GIFT strain through the DEGITA project in 1994 has further strengthened tilapia research to increase freshwater aquaculture productivity in Bangladesh. BFRI is operating several strategically located satellite research stations and hatcheries dealing mainly with freshwater species. Aside from government-run hatcheries, there are about 400 private-run hatcheries producing mainly seeds of carps. Most of the fry and fingerlings of tilapia are still coming from government-run hatcheries as tilapia is "new" to most fish farmers.

The Fisheries Bureau and the Chinese Academy of Fishery Sciences (CAFS) under the Ministry of Agriculture (MA) are the two government agencies primarily responsible for the research and development of fisheries/aquaculture in China. In addition to its central office, the Fisheries Bureau maintains provincial offices and seed farms throughout China. Most of these seed farms or hatcheries are still run and controlled by the government, though a few are now operating as private hatcheries with Chinese carps as their major output. Tilapia fry and fingerlings are produced mainly in government-run hatcheries. The CAFS is comprised of 18 research units or institutes which deal with both basic and applied research as well as fishery technology development. More specifically, the CAFS, through its various institutes, works in areas such as fish genetics and breeding, physiology, nutrition and fish biology for both marine and freshwater environments. CAFS also does limited research on fresh fish preservation and processing technologies and has several institutes that focus on fishing machinery and vessel design (Fan and Pardey 1992). There are also other active government-run universities doing research in fisheries research and development in China, such as the Shanghai Fisheries University. Though there is a National Agricultural Technical Extension Center (NATEC) under the Ministry of Agriculture which is the principal agricultural extension agency at the national level, linking fisheries research to target clients is the major responsibility of the Fisheries Bureau in China.

Existing fisheries/aquaculture infrastructure or institutions in the Philippines can be classified as those working: 1) for development and management; 2) for research (with special emphasize on aquaculture); and 3) for education and training (Rabanal 1995). Due to institutional changes in the past, the development and management of fisheries/aquaculture in the Philippines is mainly the function of the Bureau of Fisheries and Aquatic Resources, a staff bureau under the Department of Agriculture (DA) at present. Under this arrangement BFAR's functions are as follows: a) formulate plans for the proper management, accelerated development and proper utilization of the country's fishery and aquatic resources; b) undertake studies on the economics of various phases of the fishing industry to form the basis for the formulation of policies and programmes on fisheries and aquatic resources; c) render technical assistance and advisory services on the proper procurement, construction and operations of fishing vessels as well as determination and designation of fish landing points for all commercial fishing boats; and d) recommend plans, programmes, policies, rules and regulations to the Secretary of Agriculture and provide technical assistance in the implementation of the same. Subsequent reorganizations based on government policy to reduce its expenditure led to the transfer of BFAR's regional fisheries workers to the regional offices of the DA. They were further devolved to the Local Government Units by virtue of the New Local Government Code, in which its implementation is in the process of readjustment at present. The contacts between the BFAR and the field have now become more frequent.

The Aquaculture Division of BFAR, the Aquaculture Department (AQD) of the Southeast Asian Fisheries Development Centre (SEAFDEC), the Philippine Council for Aquatic and Marine Research and Development (PCAMRD), International Center for Living Aquatic Resources Management (ICLARM), and Marine Science Institute of the University of the Philippines (MSI-UP) are the major government and non-government institutions undertaking research with special reference to aquaculture in the Philippines. The Aquaculture Division of BFAR is responsible for the formulation and implementation of aquaculture development and research programmes of the Bureau. It has sections on Freshwater Fisheries, Brackishwater Fisheries, Mariculture and Fish Health. In addition, BFAR maintains and operates satellites research stations in strategic locations in the country. Through these facilities, BFAR implements genetic research on tilapia in cooperation with ICLARM and research in brackishwater aquaculture. AQD of SEAFDEC is a regional institution established by an agreement between Japan and the Association of Southeast Asian Nations in 1973. The AQD is one of the three departments of SEAFDEC hosted by the Philippines government. It implements aquaculture research programmes as approved by its governing council. PCAMRD used to be the Fisheries Research Division of the Philippine Council for Agricultural Research and Resources Development (PCARRD). It is one of the sectoral planning councils of the Department of Science and Technology (DOST). Its functions are primarily the formulation of research programmes, coordination and monitoring of research activities on marine and aquatic resources. ICLARM is now one of the research centers under the Consultative Group for International Agricultural Research (CGIAR) system. In the Philippines, the Center is involved in research on coastal area management, aquaculture and on other living aquatic resources. MSI-UP provides academic training in marine sciences. It has strong marine research programmes, particularly on coral and reef fisheries, including seagrasses and seaweeds.

There are several government and private institutions in different parts of the country involved in education and training. Some of these major institutions are: a) College of Fisheries, University of Philippines in the Visayas (UPV); b) Central Luzon State University; c) Bicol University; d) Mindanao University in Marawi City; e) Zamboanga State College of Marine Science and Technology; f) Don Mariano Marcos Memorial State University; g) Silliman University; h) University of San Carlos in Cebu City; and i) Xavier University in Cagayan de Oro City.

In addition to these institutions, there are several existing government- and private-run hatcheries for production of fry and fingerlings of major aquaculture products such as milkfish, shrimps, catfish and tilapia. BFAR is operating most of the government-run hatcheries with the most diversified products. AQD of SEAFDEC is specializing in high value products such as shrimps, seabass and grouper, etc. Private-run hatcheries dominate only in catfish, shrimp and tilapia seed production.

For the past several years, the Thai Department of Fisheries (DOF) is emphasizing the improvement of hatchery and aquaculture techniques to support the rapid development of its aquaculture industry. It was only in the late 1980s that the importance of quality broodstock to aquaculture development was given due recognition in Thailand. The National Aquaculture Genetic Research Institute (NAGRI) was established in 1989 with the following mandate: 1) to develop truly domesticated strains of aquatic animals that are well adapted and give superior yield in aquaculture; 2) to distribute these superior strains to fish farmers; 3) to advise on selective breeding practices and broodstock management at the farm level; and 4) to include research work on fish genetics in the fisheries development plan of Thailand. In addition to its temporary office in the National Inland Fisheries Institute and another research outfit for the development of inland fisheries in Kasetsart University campus in Bangkok, NAGRI is operating four satellites stations strategically located in Thailand. Other institutes outside the umbrella of the DOF concerned with aquaculture research and development, especially in fish genetics, include: Faculty of Fisheries, Kasetsart University; Faculty of Marine Science, Chulalongkorn University; Prince of Sonkhla University; Asian Institute of Technology; Srinakrinwirot University; and Mahidol University. There are also a number of private companies carrying out research on fish genetics for commercial purposes, mainly for their own operation or for the other farms associated with them.

In Vietnam, there are four institutions involved in aquaculture research and development, namely: 1) Research Institute for Aquaculture No. 1 (RIA No. 1) in Bac Ninh; 2) RIA No. 2 in Ho Chi Minh City; 3) RIA No. 3 in Nha Trang; and 4) Research Institute of Marine Products in Hai Phong. In addition, the Institute for Fisheries Economics and Planning formulates aquaculture development plans in coordination with other aquaculture research institutes and conducts environmental and socioeconomic studies of aquaculture. Recently, the Central Government set up an aquaculture extension network to link fish farmers to these aquaculture research institutes in Vietnam. Through this networking, fish farmers will have access to the research outputs and research institutes will be able to receive feedback on the suitability and acceptability of technologies they develop and for designing new technologies. There are about 275 private- and government-run hatcheries to support the growing demand for quality seeds in Vietnam. These hatcheries are producing at least 6 billion fry/fingerlings annually, mostly of carps species. In recent years, the interest has been in the production of tilapia and catfish as demand for these species is growing rapidly in Vietnam. For shrimp farming, there are about 600 backyard marine hatcheries, mostly in the central provinces, to support the seed requirements for black tiger shrimp (*Peneaus monodon*) production. Due to lack of technical knowledge on water quality and hatchery management, these hatcheries are facing serious disease problems. This is constraining the development of shrimp farming in Vietnam.

Part II. Results

Chapter 3. Baseline Surveys

3.1 Fish Farmers (Grow-out Operators)

3.1.1 Profile of freshwater aquaculture farm household

The average age of fish farmers in the DEGITA-participating countries ranges from 40-48 years old, considered the most productive age for farmers in Asia (Table 17). This is an indication of the attractiveness of freshwater aquaculture in most Asian countries that would probably be the source of its rapid growth and development in the near future. As in any farming activity in Asia, male farm operators dominate fish farming in these countries. Nevertheless, there is a growing trend of female participation in fish farming. In fact, females comprised 29 percent of fishpond operators in Thailand. The average education of the fish farmers ranges between 5-7 years. Although it is adequate to effectively manage a fish farm, it would limit the attainment of optimum farm productivity as a higher level of education is necessary for improved farm management and use of new production technologies. Normally, the willingness to venture and take the risk of using new technologies and to innovate increases with the level of education.

Fish farmers are basically crop-based farmers except those operating ponds in China and cages in the Philippines. This shows that farmers engage in fish farming mainly to augment their income from crop farming. The pond operators in China and the cage operators in the Philippines are special cases. In China, large government-managed ponds are given to members of the commune to provide them with the necessary income to support their household needs. In the Philippines, tilapia cage farming is a very profitable venture, though highly capital intensive. Those engaged in tilapia cage farming derive most of their household income from it. The majority of fish farmers have accumulated considerable experience to effectively and efficiently manage their operations, though it continues to attract new entrants. About 60 to 80 percent of fish farmers have more than 3 years of farming experience, except for China and Bangladesh. In China, though it has a long history of tilapia farming, it is attracting more new entrants to the industry. Tilapia farming is at the infancy stage in Bangladesh. The average household size of fish farmers in these countries ranges from 3 to 6 members.

Crop farming, fish farming, animal husbandry and others are the sources of income of the household of fish farmers. Fish farmers and their households in China, the Philippines, Thailand and Vietnam are primarily dependent on agriculture-aquaculture sector for their income (Table 18). Crop farming is the primary occupation of most of the households of fish farmers in Bangladesh, but due to the relatively small area they farm they derive more income outside farming. Fish farming is a major source of income for the household of pond and cage operators in China, cage operators in the Philippines and pond operators in Vietnam, contributing about 73, 52, 60 and 39 percent to their total household income. In Thailand, the households of fish farmers are deriving much of their income from animal husbandry (76 percent) rather than from fish farming (14 percent). As in Bangladesh, this seems to be contradictory as crop farming is also their primary occupation. Actually, there are only a few engaged in animal husbandry, but they are operating on a highly commercial scale.

3.1.2 Freshwater aquaculture production system

Landholdings of fish farmers in these countries consist of crop land, fish farm, garden and others, and varies considerably among countries (Table 19). Those operating fish ponds have bigger land holdings (0.6-4.9 ha) than those operating cages (0.1-1.26 ha). Fish farmers operating ponds and cages in the Philippines have the largest landholding at 4.9 ha and 1.26 ha, respectively. While cage operators in China have the smallest land holding at 0.1 ha. Pond operators in Bangladesh and Vietnam have similar sizes of land holdings at 0.6 ha and 0.7 ha, respectively. Except for pond operators in China and cage operators in the Philippines, crop land comprises a bigger portion of fish farmers' holdings and ranges from 46 to 80 percent. For pond operators, fish farm accounts for as little as 8 percent of the total land holdings in Bangladesh and as much as 87 percent in China.

Fish farmers have tenure security as they own a very high percentage of their fish farm area (56-99 percent), except in China (Table 19). In the Philippines, both fish pond and cage operators own 99 percent of the fish farm area they operate. In China, fish pond and cage operators only own 9 percent and 24 percent, respectively, of the fish farm area they operate. A high percentage is either leased from the government or rented from other operators.

Private- or family-run is the prevalent mode of operating fish farm in these countries. Only in Thailand that 100 percent of pond operators operate in the private or family mode. This indicates that fish farmers in Thailand have the capacity to self-finance their operation. As financial investment is higher in cages than in fish ponds in the Philippines, there are more cage (29 percent) than pond operators (13 percent) managing their operations in joint or in partnerships. In China, joint or partnership is the common mode of operating a fish farm. About 62 and 64 percent of those operating fish ponds and cages, respectively, are working in joint or partnership mode. In Bangladesh and Vietnam, 57 and 43 percent of the fish farmers are operating their fish farms in private/family and in joint/partnership mode, respectively.

As expected, the average size of fish farms varies considerably in the DEGITA-participating countries (Table 20). Fish farmers in Bangladesh have the smallest average size at 500 m^2 and the farmers in the Philippines have the highest at 15,100 m^2 of fishponds. Fish farmers in China, Thailand and Vietnam are operating an average fishpond area of 13,700 m^2, 10,500 m^2 and 1,000 m^2, respectively. As in China and the Philippines, those operating cages are working on a smaller area than those operating fishponds.

Water depth is one of the major factors affecting aquaculture productivity as it influences the growth of natural food, amount of dissolved oxygen and temperature crucial to the growth of fish. Fish farmers in Bangladesh have the shallowest water in ponds both in the dry (0.2 m) and wet (0.2 m) seasons. Other countries have water depth in ponds ranging from 0.9-1.6 m in the dry season and 1.3-1.8 m in the wet season. This indicates that tilapia farmers in China, the Philippines, Thailand and Vietnam have more capacity to increase their productivity through water management than those in Bangladesh, where tilapia is cultured mostly in seasonal ponds.

Fish ponds in Bangladesh and Vietnam are used for multiple purposes including washing, bathing, etc. Hence, ponds are located very close to the farmer's house, at a distance of 13 m in Bangladesh and 118 m in Vietnam. Although fish farms in China (1,059-1,493 m), the Philippines (565-1,300 m) and Thailand (272 m) are located further from their houses, they actually leave a member of their family or hire someone to watch the farm at night. This indicates that most fish farmers, particularly in China, the Philippines and Thailand are realizing the importance of guarding their fish farms against poaching.

Polyculture is more popular than monoculture as a system of culturing tilapia and other freshwater. The majority of fish farmers operating fishponds in Bangladesh (98 percent), China (79 percent), Thailand (92 percent) and Vietnam (87 percent) raise tilapia in polyculture with other fish (Table 21). Only the cage operators in China (100 percent) and pond and cage operators in the Philippines (100 percent) are growing tilapia in monoculture systems. Fish stocking per unit area under the different types of culture (pond, cage/pen) and system of culture (monoculture, polyculture) varies substantially among these countries. Fish farmers in Vietnam have higher fish stocking in pond polyculture at 1,064 fish/100 m^2 relative to those in Bangladesh, China and Thailand with only 387, 292 and 317 fish/100 m^2, respectively. The very high stocking density (over stocking) in Vietnam is a major factor causing low pond productivity in this country, especially in the South (Chung 1997). In polyculture systems, tilapia comprises about 2, 50, 57 and 25 percent of the stocking density of fish farmers in Bangladesh, China, Thailand and Vietnam. This indicates that tilapia is gaining importance in freshwater aquaculture in China, Thailand and Vietnam and is getting a little attention in Bangladesh. Nevertheless, carps remained a very important fish for freshwater aquaculture in these countries. Fish farmers use different sizes of tilapia at stocking. Prolonged cold months in China are forcing hatchery operators to keep the fish for a longer time in the nursery. Hence, larger fish are available for growout operations. In China, fish farmers use an average 41g and 88 g tilapia fingerling for pond and cage operations, respectively. While in the other countries, the average weight of tilapia at stocking ranges only from 0.6-5.4 g/fish.

Shorter culture duration is observed for countries raising tilapia in monoculture than those growing it in polyculture with other fish. In tilapia monoculture in China (cages) and the Philippines (cages and ponds), fish farmers rear the fish to marketable size for only 5 months. In the pond polyculture system in Bangladesh, China, Thailand

and Vietnam, the fish farmers are rearing the fish for 7-8 months. In polyculture, there seems to be a tendency of fish farmers to allow all the fish to reach marketable size, which prolonged the rearing period. Tilapia reared in cages are relatively bigger in size than those grown in ponds in China and in the Philippines. The size of tilapia at harvest in cages averages 460 g in China and 175 g in the Philippines. In ponds, their weight averages only 334 g and 150 g in these countries. This difference can be mainly attributed to differences in farmers' input usage. More quality inputs (high protein feeds) and higher stocking density are used in tilapia cage culture than in pond culture. In Bangladesh, Thailand and Vietnam, the weight of tilapia at harvest from ponds averages 111, 232, 241 g/fish, respectively.

Fish farmers in China have the highest fish production in ponds (41 kg/100 m^2) and in cages (5,665 kg/100m^2), as shown in (Table 21). Fish farmers operating ponds in Bangladesh, Philippines, Thailand and Vietnam only produce 17, 36, 43 and 30 kg/100 m^2, respectively, while the cage operators in the Philippines are able to produce only 540 kg/100 m^2. This implies that aquaculture technology in China is more advanced than in the other countries. It seems that fish farmers in China better understand the technical and biological requirements of fish farming than most of their counterparts in Asia.

Freshwater aquaculture in most of these countries is highly market-oriented. About 94-97, 97, 98 and 88 percent of the fish farmers' production in China, the Philippines, Thailand and Vietnam, respectively, is being marketed. Only fish farmers in Bangladesh have a low marketable surplus (20 percent of their production). Overall, this indicates that fish farmers have cash to support the financial needs of their household and to re-invest in their farming operation.

3.1.3 Costs and returns of fish production

Costs and returns of fish production vary widely due to the differences in the production environment, inputs use level, culture practice and farming system as shown in Table 22. In Bangladesh, freshwater fish farmers' production in ponds/ditches under a polyculture system averages 1,736 kg/ha and generates a gross income of US $1,531/ha per production cycle. Cost of fingerlings accounts for the major cash cost as it comprised about 70 percent of the total cash costs of US $273/ha, excluding labor. Rice bran, lime and fertilizer account for only 8, 4 and 3 percent of the total cash cost. This indicates that fish farmers are culturing fish extensively in freshwater ponds/ditches. Their net return over cash cost (return to labor, management and capital) to fish farmers amounts to US $1,258/ha per production cycle. They incur a cash cost of US $0.16/kg of fish they produce.

The majority of fish farmers in China rear freshwater fish in ponds and in cages. As expected, productivity (production/unit area) of those operating ponds under polyculture (6,593 kg/ha) is higher than those operating under monoculture (5,860 kg/ha) systems. Fish farmers operating tilapia monoculture and polyculture in ponds earn a gross income of US $7,569/ha and US $8,344/ha per production cycle, respectively.

Correspondingly, they incur a total cash cost of US $4,465/ha and US $4,347/ha. Their major cost components are those for fry/fingerlings (28, 30 percent), commercial feed (21, 26 percent), rice bran (30, 16 percent) and land rent (17, 20 percent) which adds up to 96 and 92 percent of the total cash cost for those operating ponds in monoculture and polyculture systems, respectively. Their net return over cash cost (return to labor, management and capital) amounted to US $3,104/ha for pond monoculture and US $3,997/ha for pond polyculture per production cycle. Those operating pond monoculture and polyculture are spending a total cash cost of US $0.76 and US $0.66 for every kg of fish they produce.

For those farming tilapia monoculture in cages, their production averages 5,613 kg/100 m^2 and generates a gross income of US $10,284/100 m^2 per production cycle. Commercial feed is the major cash cost as it comprised about 52 percent of the total cash costs of US $6,138/100 m^2, excluding labor. Their other major cash costs are fry/fingerlings (37 percent) and land rent (6 percent). This indicates that fish farmers in China are intensively culturing tilapia in cages. Their net return over cash cost (return to labor, management and capital) amounted to US $4,146/100 m^2 per production cycle. They incur a cash cost of US $1.09/kg of fish they produce.

In the Philippines, tilapia dominates freshwater aquaculture production and is widely cultured in ponds and cages in a monoculture system. With an average tilapia production of 3,559 kg/ha from ponds, fish farmers are earning a gross income of US $5,565/ha of pond per production cycle, with commercial feed as their major cash cost. It constitutes about 49 percent of the total cash cost of US $2,144/ha, excluding labor. This is a strong indication that farmers are moving away from extensive to a semi-intensive mode of tilapia farming. Fry/fingerlings (13 percent), rice bran (9 percent) and land rent (8 percent) comprise the other major components of the total cash cost. Fish farmers earn a net return over cash cost (return to labor, management and capital) of US $3,421/ha per production cycle and incur a cash cost of US $0.60/kg of fish they produce.

Tilapia cage farmers' production averages 540 kg/100 m^2 from which they earn a gross income of US $853/100 m^2 per production cycle. Costs of commercial feed (67 percent) and (fry)/fingerlings (32 percent) are their major cash cost. Together they comprise about 99 percent of the total cash costs of US $329/100 m^2, excluding labor. These indicate that farmers in the Philippines are intensively culturing tilapia in cages. The net return over cash cost (return to labor, management and capital) to them amounted to US $524/100 m^2 per production cycle. They incur a cash cost of US $0.61/kg of fish they produce.

In Thailand, freshwater aquaculture production is mainly from fishponds under polyculture system. Fish farmers' production averages 6,290 kg/ha with gross income amounting to US $10,239/ha per production cycle. Commercial feed and fry/fingerlings are the major cash cost comprising about 51 and 32 percent, respectively, of their total cash costs of US $2,843/ha, excluding labor. The high percentage of cash cost on feed is an indication that farmers are culturing fish in a semi-intensive mode in Thailand. The net return over cash cost (return to labor, management and capital) to fish farmers averages US $7,395/ha per production cycle in which they incur a cash cost of US $0.45/kg of fish they produce.

Freshwater aquaculture production in Vietnam is also mainly from fishponds under polyculture system. Fish farmer's production averages 3,020 kg/ha and generates a gross income of US $2,132/ha per production cycle. Fry/fingerlings is the major cash cost comprising about 48 percent of their total cash costs of US $811/ha, excluding labor. Manure (16 percent), rice bran (10 percent) and commercial feed (8 percent) are the other major cash costs in fish farming in Vietnam. The dominance of fry/fingerling, manure and rice bran in the cash costs indicates that fish farming is still in the extensive mode in Vietnam. The net return over cash cost (return to labor, management and capital) to fish farmers amount to US $1,321/ha per production cycle. They incur a cash cost of US $0.27/kg of fish they produce.

3.1.4 Constraints to tilapia farming and farmers' perspective

Understanding fish farmers' problems and attitudes are critical for improving their management skills, increasing their productivity and incomes, and even in sustaining and expanding their operations. Fish farmers' problems are categorized into: 1) biological and technical; 2) natural and environmental; and 3) social and economic in nature, as shown in Table 23. High fish mortality, fish diseases, poor seed quality/slow growth, lack of technical assistance/management expertise, small fish at harvest, harvesting difficulty and over growth of weeds are the biological and technical factors affecting fish farmers' operations. Flood, water quality/pollution, drought, typhoon, cold and sulphur upwelling were their natural and environmental problems. Cage/pond vandalism, poaching, high prices of seeds, increasing cost of inputs, high capital requirement, high marketing cost, lack of credit, water supply shortage, proliferation of tilapia farms, farm fragmentation and limited market are the social and economic factors affecting tilapia farming.

Although there are commonalities in fish farmers' problems, they rank the problems differently (rank 1 to 10 or most to least serious) except in a few cases. Fish farmers in China (ponds) and in the Philippines (ponds and cages) rank increasing cost of inputs as their most serious problem. Cage operators in the Philippines also rank poor seed quality/slow growth as another major problem in tilapia farming. In China (cages), Thailand (ponds) and Vietnam (ponds), fish farmers rank cold, poaching and lack of credit, respectively, as their second most serious problems. Socioeconomic problems affect tilapia farming productivity in ponds more seriously than in cages. While cage operators, mostly dependent on natural endowments such as existence of lakes, water reservoir, are greatly affected by natural/environmental and technical/biological factors.

The possible participation of fish farmers in tilapia farming in the future is to expand (20-46 percent), continue/maintain (49-69 percent), discontinue/shift (3-6 percent) and undecided (2-19 percent), as shown in Table 23. With these attitudes, a robust expansion and growth in tilapia production can be expected in Asia as more fish farmers are planning to expand than to discontinue their operations. Those in the DEGITA-participating countries are also actively participating in genetic research in tilapia and they are willing to raise improved breed of tilapia.

3.2 Tilapia Hatchery Operators

This section provides a microlevel analysis concerning the socioeconomic characteristics, farming environment, hatchery practices and management, marketing practices, and problems and perspectives of hatchery operators only for the Philippines as no similar survey was conducted in other DEGITA-participating countries where the private tilapia hatchery is less important. The data are mainly from the BAS-ICLARM (GIFT) 1994 survey of hatchery operators in 17 provinces of Luzon (Map 6).

3.2.1 Socioeconomic profile of hatchery operators

Tilapia hatchery operators have an average age of 52 years and have completed 10-full years of education or have at least completed high school. Most tilapia hatchery operators have security of tenure: 92 percent, owner operators; 3 percent, lessee; and 5 percent, share tenant and majority of them (79 percent) consider hatchery operations as their primary operation, with 56 percent and 23 percent engage on full-time or part-time basis (Table 24).

The households of hatchery operators have at least two sources of income, i.e., farm (hatchery) and non-farm. Overall, the tilapia hatchery operators have ranked hatchery, crop/livestock farming, business/trade/service, salaried employment/wage labor, fish culture (growout), remittance from abroad, pension and others as their 1st, 2nd, 3rd, 4th, 5th, 6th, 7th and 8th sources of their household incomes (Table 25).

Tilapia hatchery operators have a typical household size of 7 members (Table 26). Though male and female members of the household are involved in all aspects of hatchery operation, males have dominance over females. They have obtained their technology from several sources. About 46 percent of the hatchery operators have obtained their technology from institutional source such as GO-NGO technicians (Table 27). About 28, 28, 26, and 8 percent of the hatchery operators have obtained their technology from friends/family members, self-learned, other tilapia operators and formal education/training, respectively.

Sixty four percent of hatchery operators have not availed of any loan to finance their operations (Table 28). The other 36 percent of the operators have obtained loans from their relatives/friends (10 percent), bank (10 percent), private persons (8 percent) and others (8 percent) mainly to defray their operating expenses (50 percent). Majority (74 percent) of those who have obtained loans claim availability of sufficient money to finance their credit needs.

Tilapia hatchery operation can no longer be considered an infant industry in the Philippines as reported earlier by Yater and Smith (1985). About 3, 28, 31, 25, 10 and 3 percent of the hatchery operators claim that it was introduced in their community before 1970, between 1970-75, 1976-80, 1981-85, 1986-90, and after 1990, respectively (Table 29). Cumulatively, 87 percent of the operators claim that tilapia hatchery was introduced in their locality before 1986. This implies that tilapia hatcheries have existed for at least a decade for most of those engaged in them. The recent introduction of hatcheries (especially after 1985) also indicates that the industry is still expanding, though at the declining rate.

Several factors have influenced farmers to operate hatcheries (Table 29). The profitability of tilapia hatcheries has encouraged 20 percent of the existing operators to engage in this activity. Access to training and extension services, additional source of income, ready market, easy to manage, construction of roads, availability of hired labor/improved breed/transportation and others has encouraged only 18, 10, 10, 10, 8 and 8 percent of the operators.

In general, the proximity of operators' farms to their residence, market and sources of inputs affect their productivity and profitability. On the average, their farms are not located very far from their residence (3 km), market for their fry/fingerlings (17 km) and sources of inputs (10 km), as shown in Table 29. On the average, farmers are operating an effective hatchery area of 1.07 ha, 27 percent larger than when they first started it (Table 30).

3.2.2 Hatchery management practices

About 36, 28, 21 and 15 percent of the farmers are operating pond with stagnant water, pond/hapa with stagnant water, pond with flowing water and pond/hapa with flowing water, respectively (Table 30). Normally, hatchery operators are looking for areas with free-flowing water as it results in lower water cost, better water quality and higher productivity.

The majority of hatchery operators (92 percent) obtained their initial broodstock either from BFAR or from other private hatcheries. There has been a reduction of 29 and 20 percent of the operators obtaining their broodstock from BFAR and other private hatcheries while there has been a substantial increase of 300 percent obtaining their broodstock from own-produced fingerlings. This practice of using own-produced fingerlings as broodstock was already noted by Yater and Smith (1985) in three-quarters of their sample operators. Cost reduction, availability of better breed/strain and capability to produce own broodstocks are the factors hatchery operators have considered in changing their sources of broodstock. All hatchery operators claimed that they are using Nilotica species as their broodstock but only 18 percent could specifically identify the strains. This could be partly due to the difficulty of most operators to ascertain the purity of their broodstocks. Though government-run hatcheries are changing their broodstocks every two years, private hatchery operators are changing their broodstocks at most every 1.5 years. This indicates a trend towards maintaining younger-age breeders.

3.2.3 Input use level

Production and marketing inputs, labor and labor-related inputs in tilapia hatchery operation are shown in Tables 31 and 32. Broodstock is excluded in the production and marketing inputs as it is considered part of the capital outlay.

Total production and marketing cost, excluding labor and labor-related inputs, of tilapia hatchery operators amounted to US $1,855 per production cycle (Table 31). Feed accounts for almost 90 percent of the total production and marketing costs of the hatchery operators, with commercial feed and rice bran contributing about 45 percent and 26 percent, respectively. The high dependence of hatchery operators on commercial feed indicates that it graduated from an 'infant industry' status and is now maturing into the 'commercialization' phase. As hatchery operators have already established markets for their fry and fingerlings, production efficiency and productivity improvement are becoming their major objectives. Although fertilizer also serves as food to the fish, it no longer seems to be a significant production input in tilapia hatchery operations. It comprised only about 3 percent of the total production and marketing costs.

Plastic/'buri' bag or 'bayong', oxygen refill, freight/transport and gasoline/diesel/oil/, which constitute the marketing inputs in hatchery operation, have a composite share of 5 percent of total cost of production and marketing. Freight/transport (less than 1 percent) is not as essential a marketing input as plastic/'buri' bag or bayong (2 percent).

In hatchery operations, operators are tapping members of their household more than the labor force outside their household (Table 32). Out of the 118 mandays, members of the household are supplying 59 percent while hired laborers are providing only 41 percent of the labor requirement per hectare for one production cycle. This indicates that hatchery operation is still a family-based enterprise. Overall, 32 percent and 24 percent of the total labor requirement of tilapia hatchery operation is used in guarding the facilities to discourage poachers and in feeding the fish.

In terms of total labor cost, tilapia hatchery operators are incurring US $404 per hectare for one production cycle, of which 57 percent and 43 percent are accounted for by the imputed family labor and hired labor, respectively (Table 32). Specifically, the major labor costs in hatchery operation are incurred in guarding (33 percent), feeding (24 percent), pond preparation (16 percent), harvesting/grading (7 percent) and marketing (5 percent). Other activities are contributing less than 5 percent to the total cost of labor.

3.2.4 Capital outlay requirement

For a typical tilapia hatchery, initial capital expenditure includes expenditure on pond development, building, equipment, vehicle and broodstock. On a per hectare basis, hatchery operators are incurring a total capital outlay of US $41,750 (Table 33). About 60, 9, 5, 25, and 1 percent of this total capital expenditure are accounted for by structure and building (pond, caretaker's house, guard house), equipment (pump/pump line, oxygen tank, grader, scoop net, feeding tray, tub/basin/pail, cooler, weighing scale), net/pole (seine, hapa, bamboo pole), transportation (jeep, tricycle, banca) and broodstock, respectively. However, "new entrants" could readily reduce the high initial capital requirement for setting up a tilapia hatchery by at least 50 percent by constructing simple pond structures and makeshift buildings and only renting vehicles and pumps whenever necessary.

3.2.5 Production and profitability

On the average, tilapia hatchery operators are producing 748,000 fry/fingerlings and generating a gross income of US $6,816 per production cycle per hectare (Table 34). With hatchery operators incurring a total production cost of US $2,505, they are earning a net farm income of US $4,311 per production cycle per hectare. This indicates that tilapia hatchery is now a very lucrative farming operation under 'normal' condition. It is no longer at an 'experimental' stage but is a highly 'commercialized' farming operation.

3.2.6 Factor payment and factor share

An analysis of the share of output accruing to operators and production factors reaffirmed that hatchery operation is lucrative business. A high percentage (63 percent) of gross value of production is considered residual or 'pure profit' to hatchery operators (Table 35). Current inputs (purchased), capital, family labor and hired labor have a share of only 26, 4, 3 and 3 percent of gross value of production, respectively. A substantial percentage of the gross value of production (70 percent) is income for hatchery operators with 4, 3 and 63 percent attributable to their own capital, labor and profit. These results indicate that the tilapia hatchery is most rewarding to operators, then to those engaged in marketing production inputs and last to hired labor.

3.2.7 Marketing/Selling practices

Hatchery operators are selling their fry/fingerlings in: the same barangay- 23 percent; other town, same province- 14 percent; other province, same region- 12 percent; other region- 6 percent; and others (combinations)- 45 percent (Table 36). They are using various modes of transport in selling their fry/fingerlings. The jeepney is their popular choice for transporting the fish (51 percent). About 52, 22 and 26 percent of hatcheries are selling fry/fingerlings on pick-up, delivery mode and others (combination), respectively. The dominance of pick-up mode could be attributed to the entry or participation of traders in the market for fry and fingerlings.

Hatchery operators are receiving payments on the sale of their fry/fingerlings: in cash (on delivery/pick-up)- 71 percent; on credit- 15 percent; and others (combination)- 14 percent. Usually, small-scale operators deal in cash for their fry and fingerlings due to their nature of operation while large-scale operators deal both in cash and credit for they have more production for disposal. In pricing, 86 percent of operators claim that they fix the price of their fry/fingerlings on a "take it or leave it" basis. This implies that there is a high demand for fry and fingerlings with most growout operators experiencing difficulty in obtaining their required stocks.

The total fry/fingerling production of hatchery operators is used in their own growout farms (8 percent), sold (88 percent) and as allowance (4 percent) or contingency for mortality on quantity being sold (Table 37). Wholesalers, retailers, "agent", fish farmers (direct), and others (combinations) share 20, 4, 30, 34 and 12 percent of the quantity being sold. An emerging trend is for the hatchery operators to sell directly to growout operators or fish farmers.

3.2.8 Problems and perspectives of hatchery operators

High fry/fingerling mortality, poor/slow growth of fry/fingerlings, predators and obtaining good quality broodstock are the identified biological and technical problems of hatchery operators. Increasing cost of inputs, water-use conflict (shortage), poaching, high capital requirement and low prices of fingerlings are the major social and economic problems affecting their operations (Table 38). Operators are also facing natural and environmental problems such as frequent typhoon, flood, drought, water pollution and intrusion of salt water.

The majority (59 percent) are planning only to continue at the current scale of their operations (Table 39). Only about 26, 3, 3, and 10 percent are contemplating to expand, discontinue, expand but shift to other species and undecided, respectively. Hatchery operators in the country can be considered "progressive" farmers as a very high percentage (97 percent) are bestowing interest and only 3 percent are unwilling to try new breeds of tilapia. However, in terms of percentage of area used to try new breeds, tilapia operators are exercising caution or the "wait and see" attitude.

3.3 Consumers

3.3.1 Expenditure and food consumption pattern

The level of household expenditure and its allocation for food and non-food items are considered crude indicators of the state of development of a country. The higher the level of expenditure and its proportion for non-food items the higher the level of development of that country.

As Thailand is economically more developed than the other DEGITA-participating countries, it has the highest household expenditure of US $5,160/annum, in which a higher percentage is spent on non-food (71 percent) than food (29 percent) items (Table 40). Household expenditure of fish farmers in Bangladesh, China, the Philippines and Vietnam amounts to only US $917, 2,859, 4,687 and 594/annum, respectively. A higher percentage of household expenditure of fish farmers in Bangladesh (73 percent) and Vietnam (57 percent) is spent on food items than those in China (37 percent) and the Philippines (42 percent).

3.3.2 Fish consumption and preference pattern

Only freshwater fish species consumption data is available for Bangladesh, Thailand and Vietnam, while consumption of all fish species data is available for China and the Philippines. Generally, fish producers in rural areas have higher fish consumption per capita per annum than non-producers in rural and urban areas in most DEGITA-participating countries (Table 41). This indicates the importance of fish farming to supply the nutritional protein requirement of fish producers in rural areas.

Consumers in Bangladesh (21.3 kg) have higher consumption of freshwater fish per capita per annum than those in Thailand (18.6 kg) and Vietnam (13.9 kg). In these countries, carp is the traditional freshwater species consumed. As carp share remained high in their total freshwater fish consumption, it continued to be a major freshwater fish species being consumed in Bangladesh (28 percent) and Vietnam (45 percent) but not in Thailand (11 percent). Tilapia is slowly replacing carp as the major freshwater fish species consumed in Thailand. Its share is estimated to be about 28 percent of total freshwater fish species in this country. Even in Bangladesh and Vietnam the share of tilapia at 16 percent and 21 percent of the total freshwater fish consumption, respectively, is already considered high. This indicates that tilapia is becoming more acceptable in major carp-consuming countries.

Per capita fish consumption per annum in China and the Philippines amounts to 35.8 kg and 44.6 kg, respectively. Carp is the major fish species consumed, comprising about 51 percent of fish consumption in China, while tilapia constitutes only 11 percent of the total fish consumed in this country. In the Philippines, tilapia is replacing milkfish as a major fish species being consumed. Tilapia constitutes about 40 percent of total fish consumed while milkfish accounts for only 12 percent. There seems to be an upward bias in tilapia consumption estimates in the Philippines. This is probably due to the inclusion of more rural than urban consumers in the sample as tilapia is widely available in the rural areas. The emerging pattern of higher tilapia consumption is traceable to its increasing acceptability as food fish and highly affordable price for most consumers.

Overall, the per capita fish consumption estimates for all fish species as well as for tilapia obtained from the baseline survey were relatively higher than their national consumptions levels as discussed earlier. Higher fish consumption, and tilapia consumption in particular, can be attributed to the fact that we have bigger sample from the rural areas (fish-growing areas) than urban areas and the survey sites were the fish-growing areas and tilapia was one of the species being cultured.

Consumers in Bangladesh have high a preference for ilish (54 percent), rohu (32 percent) and tilapia (7 percent), as shown in Table 42. In China, consumers have a high preference for tilapia (29 percent), crucian carp (12 percent) and grass carp (10 percent). In the Philippines, consumers have a high preference for tilapia (65 percent), milkfish (11 percent) and threadfin bream (5 percent). Snakehead, tilapia and hybrid catfish are the most preferred species for 43, 30 and 21 percent of the consumers, respectively, in Thailand. Common carp (25 percent), mrigal (17 percent), rohu (16 percent) and tilapia (15 percent) are the major fish species consumers preferred in Vietnam. In all these countries, tilapia is the species of choice for most consumers. This has a significant implication on the development of the tilapia farming industry not only in all DEGITA-participating countries but also in Asia, as tilapia is now a widely and highly accepted food fish.

Most consumers of the DEGITA-participating countries have a higher preference for bigger tilapia with sizes ranging from 2-4 fish/kg. However, consumers in Bangladesh have a higher preference for 5-7 fish/kg size of tilapia. This can be attributed to the cooking style of tilapia, i.e., it is cooked whole and each member of the family would like a whole fish. This is also the case in other tilapia-consuming countries in Asia.

3.4 Fish Traders

3.4.1 Market structure

The fish marketing structure in Asia is fast evolving. China and Vietnam are now encouraging the participation of the private sector (i.e., traders, wholesalers and retailers) as in Bangladesh, the Philippines and Thailand. It used to be a government controlled activity in China and Vietnam (North).

In the DEGITA-participating countries, fish traders, wholesalers and retailers are the major players in marketing of fish. Fish traders usually buy fish in bulk directly from fish producers and sell it to wholesalers or retailers. It is for the latter to sell fish directly to consumers. There is now an emerging pattern for producers to sell the fish directly to wholesalers/retailers and to consumers to increase their earnings. In essence, fish producers themselves form part of the fish marketing structure in these countries.

3.4.2 Marketing costs and margin

Fish marketing is fast becoming a major economic activity in Asia. In the DEGITA-participating countries, fish traders are buying and selling fish amounting to 99-4576 kg/month (Table 43). Fish traders in Bangladesh and the Philippines are buying and selling about 99 kg and 2,996 kg of fish per month, respectively, while fish traders in Thailand are buying about 3,139 kg and selling only 2,996 kg of fish per month. Though they are consuming less than 1 percent of their inventory, they consider the difference as their trading losses due to pilferage, defective weighing scales and shrinkage. The average monthly gross sale of fish traders amounts to US $142 in Bangladesh, US $4,326 in the Philippines and US $4,576 in Thailand.

Other than the fish they buy, shop rental, labor and fish containers account for the major marketing costs of fish traders in Bangladesh, Philippines and Thailand, respectively. Correspondingly, this comprises about 30, 33, 42 percent of the total marketing cost of fish traders in Bangladesh (US $10), the Philippines (US $102) and Thailand (US $103). Fish traders in these countries are aware of preserving the quality of fish as a means of increasing their profit. Ice accounts for 19, 25, and 39 percent of the marketing cost of fish traders in Bangladesh, Philippines and Thailand, respectively.

Fish trading is a very lucrative economic activity for traders in the Philippines and Thailand but not yet in Bangladesh. This is mainly due to the large trading volume they are handling in the Philippines and Thailand. Fish traders are earning a monthly income of US $600 in the Philippines and US $641 in Thailand. This is sufficient to cover the financial needs of their household and for them to live a decent lives. If fish traders in Bangladesh can increase the volume of the fish they trade, it can also be a lucrative business in this country. Fish traders in Bangladesh (US $0.19) earn a comparable margin/kg of fish traded to those in the Philippines (US $0.27) and Thailand (US $0.20).

Chapter 4. Comparative Performance of GIFT Strain

4.1 Results of On-Station Experiment

Assessment of the on-station performance of the GIFT strain were limited to four-DEGITA participating countries; Bangladesh, China, Thailand and Vietnam, as it was already rigorously tested on-station (nationwide) in the Philippines, with superior performance over the existing commercial strains.

4.1.1 Strains used and test locations

On-station performance of the GIFT strain was tested against the 'best' available strains in the DEGITA-participating countries. In Bangladesh, the evaluation of the performance of the GIFT strain vs. existing strains (Thai strain and red tilapia strain) was conducted at the BFRI Freshwater Station in Mymensingh. The GIFT strain was introduced to Bangladesh from the Philippines in July 1994 through the DEGITA Project, and the control strains were introduced to the country in 1987 from Thailand.

Five strains of Nile tilapia were used in the experiment in China: 1) GIFT strain; 2) Egypt strain; 3) "78" strain; 4) "88" strain; and 5) American strain. The GIFT and Egypt (ICLARM introduced to the Philippines in 1992 from Egypt) strains were imported from the Philippines under the DEGITA project in July 1994. The "1978" and "1988" strains were introduced into China in 1978 and 1988 from Sudan and Egypt, respectively. The American strain was introduced into China in 1991 from the USA. Under on-station conditions, several other experiments on the GIFT strain were also conducted in China: a) variations in the catching rate of GIFT, "78", "88" and Egypt strains; b) variations of low lethal temperature of GIFT, "78", "88" strains; c) fingerling culture performance of five species/hybrids of tilapias in brackishwater; d) culture performance of hybrids from different strains combination of *Oreochromis niloticus* x *O. aureus*; e) efficiency of sex-reverse of GIFT strain by methyltesterone (MT); and f) morphological variation among strains of Nile tilapia.

In Thailand, the 1995 on-station experiments on the performance of the GIFT strain against existing strains (Chitralada strain, Chitralada I strain) were conducted in Kamphaengphet Inland Fisheries Station in the North and Nakhonpanom Inland Fisheries Station in the Northeast. While the 1996 experiment, which used sex-reverse GIFT (SRT GIFT), sex-reversed Chitralada I (SRT Chitralada I) and genetically modified tilapia (GMT) strains, was conducted in Surin Fisheries College in the Northeast and Pitsanulok Genetic Center in the North. The GIFT strain was introduced into Thailand in July 1994 from the Philippines under the DEGITA Project. The Chitralada strain, widely distributed and cultured, was introduced into Thailand in March 1965 from Japan, with the original stock being kept in the Chitralada Palace. The Chitralada I strain was a strain developed from 3 generation of within family selection of the Chitralada strain by the International Development Research Centre of Canada (IDRC)-Thailand project that outperformed the present culture stock by 17 percent for growth. SRT GIFT and SRT Chitralada I strains were sex-reversed strains of GIFT and Chitralada I, respectively. The GMT was a genetically male tilapia developed by the Overseas Development Administration (ODA) Fish Genetics Projects. It was an offspring of the YY-male crossed with ordinary female of the Egypt Manzala strain.

In Vietnam, the on-station evaluation of the performance of the GIFT strain against the control strains (Egypt, Thai and Vietnam strains) was carried out at RIA No. 1 and No. 2. The GIFT and Egypt strains were imported in May 1994 from the Philippines under the DEGITA Project. The Thai strain was introduced into Vietnam in April 1994 from Thailand through a research collaborative program between RIA No. 1 and the Asian Institute of Technology (AIT), and the Vietnam strain which was introduced in 1973 originated from Taiwan.

In all countries except Vietnam, GIFT strain from the 3rd generation of selection was used in the on-station trials. GIFT strain from 2nd and 4th generation of selection were used to determine its on-station performance in Vietnam.

4.1.2 Descriptive analysis of the comparative performance of the GIFT and control strains

The comparative growth performance of GIFT strain and local strains of *O. niloticus* under on-station conditions in Bangladesh was assessed in five test environments: hapa, cistern, nursery, cage and pond. The GIFT strain had significantly higher average weight at harvest than the existing strain in all these test environments (Table 44). In nursery conditions, the average weight of GIFT strain was 52 percent higher than existing strain. In growout environments in hapa (in pond), cistern, cage and pond, the GIFT strain average weight was significantly higher than the existing strain which ranged from 36-81 percent. However, it was noted that average weight of the GIFT strain reared as separate (203 g) and mixed (205 g) groups in cages was not significantly different.

In China, the average weight of the GIFT strain was consistently higher than the existing strain across test locations but with considerable variations at the fingerling stage (Table 45). In comparison to the "88" strain, while the GIFT strain average weight was only 1.3 percent higher in Huzhou (Hz), it was 22.1 percent higher in Guangdong (Gd) at the fingerling stage. In Qingdao (Qd), with "78", American and Egypt strains, the GIFT strain was 8.3, 14.7 and 18.2 percent higher in average weight.

At a yearling stage (one-year old), the GIFT strain was generally superior than the existing strains in cages and in tanks, but not in ponds. In cages, average weight of the GIFT strain was 16-45 percent higher than the control strains in Qingdao and Huzhou but it was 15 percent lower compared to "88" strain in Guangdong. In tanks, the average weight of the GIFT strain was consistently higher than the existing strains in Qingdao but not in Shanghai (Sh). In Qingdao, it was 1, 15-22, 45 and 51 percent higher than the American, "78" , "88" and Egypt strains, respectively. In comparison to "78" (tank 2,3) the GIFT strain was 5 percent higher in average weight, but was 9 and 20-31 percent lower than the "78" (tank 1) and "88" strains in Shanghai.

In ponds, the average weight of the GIFT strain was 6, 10 and 20 percent higher than the "78", "88" and Egypt strains, respectively, in Huzhou. In Guangdong, the average weight of GIFT strain was only 5 percent higher than the "88" strain. At two-year old stage in ponds, the average weight of the GIFT strain was 19 percent higher than the "78" strain in Qingdao and 11 percent and 9 percent higher than the "88" strain in Huzhou and Guangdong, respectively.

In China, the 1995 experiment on the variation on the catching rates showed that the GIFT strain (67 percent) has a significantly higher catching rate than the "78" (23 percent), "88" (38 percent) and Egypt strains (22%). Also, the 1996 experiment showed similar results (GIFT strain, 82 percent; "88" strain, 62%). The experiment on the low lethal temperature indicated that it ranged from 11.0 °C to 8.4 °C, 9.8 °C to 7.4 °C and 11.0 °C to 7.4 °C for the GIFT, "78" and "88" strains, respectively. Comparison of 50% individuals (Lt_{50}) among three strains suggested that tolerance of the GIFT strain to low temperature was worse than the control strains, and there was no significant differences between "78" and "88" strains. For the fingerling culture performance of five species/hybrids of tilapia in brackishwater, *O. aureus* had the highest survival rate, followed by GIFT, red tilapia and hybrid of "78" strains. In terms of growth and yield, the GIFT strain was the best and red tilapia was second. For the culture performance experiment of hybrids from different strain combinations of *O. niloticus* x *O. aureus*, the best was GIFT (female) x *O. aureus* (male); "Thai" (female) x *O. aureus* (male) was second; and "88" (female) x *O. aureus* (male) was the worst. In experiments on the efficiency of the sex-reverse of the GIFT strain by methyltesterone (MT), the male rate reached 93.5% at 10 ppm MT and 100% at 20 ppm MT. The male rate in control group (without MT) of the GIFT tilapia was 56%, and in control group of hybrid tilapia was 77 percent. For the experiment on the morphological variations among strains of Nile tilapia, the identification accuracy for the different strains arranged in decreasing order were America > Gift > "88" > "78" > Egypt. The principal component analysis (PCA) revealed that there were no apparent differences among the Gift, "88", "78" and Egypt strains in the one-year age group, but there were significant differences between America and Gift, "88", "78" strains in the two-year age group. The characters separating America and other strains were D5-8, D7-8, body depth, snout length and total length.

Two runs of on-station trials in ponds were conducted in Thailand. In 1995, the GIFT strain displayed genotype x environment interaction (Table 46). While the average weight of 122 g of the GIFT strain was 38 percent higher in Nakhonpanom, its average weight of 113 g was 24 percent lower in Kamphaengphet compared to Chitralada I strain. However, the GIFT strain was consistently superior to the Chitralada strain with average weight higher by 41-93 percent in these two test locations. In 1996, the sex-reversed GIFT strain was consistently inferior to the sex-reversed Chitralada I. Its average weight was 10 percent and 32 percent lower than the sex-reversed Chitralada I strain in Surin and Pitsanulok, respectively. While the growth performance of the sex-reversed GIFT strain was slightly better in Pitsanulok, it was inferior in Surin compared to GMT strain. Overall, the GIFT strain was definitely superior compared to the control strain with a long history of propagation (Chitralada strain) than with newly established strains (Chitralada I and GMT strains) in Thailand.

In Vietnam, the GIFT strain superiority over the existing strains was not conclusive at the nursery stage (Table 47). Even in RIA No. 1 where the GIFT strain obtained 7-11 percent higher average weight than the existing strains in 1994, the latter strains had higher average weight than the GIFT strain in 1995. In RIA No. 2, the GIFT (5.8 g) strain had significantly higher average body weight only with Egypt (4.8 g) strain but not with Viet (6.0 g) and Thai (6.2 g) strains. The superiority of the GIFT strain over the existing strains was more pronounced in the growout stage. In RIA No. 1, the GIFT strain had consistently higher average body weight, ranging from 6 percent to 22 percent, than the existing strain over the three year-period (1994-1996). Though in RIA No. 2, the

GIFT strain's average weight was 2 percent lower compared to Thai strain, its average weight was 7 percent and 23 percent higher than Viet and Egypt strains, respectively. Apparently, the GIFT strain achieved superiority over the existing strain not during the nursery stage but at the growout stage.

All test strains (control) were aggregated as non-GIFT strain in determining the cross-country comparative performance of the GIFT strain in ponds and in cages under on-station conditions. The results of the cross-country comparative performance of the GIFT strain vs. non-GIFT strain are shown in Table 48. In terms of average (final) weight at harvest, the GIFT strain was only significantly (statistically) higher compared to non-GIFT strain in Bangladesh (ponds and cages) and in Vietnam (ponds). The superiority of the GIFT strain over the non-GIFT strain was not statistically evident in China and Thailand. In fact in cages, though not statistically significant, the GIFT strain average weight was 15.2 percent lower than the control strain in China. Though not also statistically significant, the GIFT strain average weight at harvest in ponds was relatively higher than the control strain in China and Thailand by 14.3 percent and 25.9 percent, respectively.

The proportion of male in the GIFT strain was lower by 1-20 percent compared to the non-GIFT strains in most DEGITA-participating countries, except in on-station trial in cages in Bangladesh; wherein the proportion of males in the GIFT strain was statistically higher by 9.5 percent than that in the non-GIFT strain. However, the proportion of males in GIFT strain was significantly lower than the control strain in Thailand. The survival rate of the GIFT strain was better than the non-GIFT strain by 0.4-21.7 percent, except in ponds in China where it was 4.3 percent lower than the non-GIFT strain. The mean difference in survival rate between the GIFT and non-GIFT strains was statistically significant only in cages in Bangladesh. Production per unit area or yield of the GIFT strain was significantly higher than that of the non-GIFT strain in both ponds and cages in Bangladesh. Other variables affecting the growth performance of GIFT strain in comparison to non-GIFT strain were not statistically different.

4.1.3 Statistical analysis of the comparative performance of the GIFT and control strains

In the previous section, a descriptive comparison has been made to assess the comparative performance of the GIFT strain relative to other strains under on-station conditions in different countries. It is sufficient to point out that generally the GIFT fish seem to have a higher rate of growth. Though the descriptive comparison is a useful indicator, such comparisons are not strictly valid. They do not take into account different husbandry practices (stocking size, input use level, rearing period, etc.), culture conditions (water temperature, water depth, etc.), and other factors like male-female ratio. This sub-section discusses the results of the regression analysis undertaken to analyze the effects of differences in genetic quality of the strain used on growth rate and survival after accounting for the differences in input use level, production environment and male-female ratio.

We estimated regression models for average growth and survival rate based on the on-station experimental data from Bangladesh, China, Thailand and Vietnam. In these equations, four sets of independent variables were used: total protein applied per fish as a measure of input use level; water temperature and rearing period to represent production environment; binary "GIFT" dummy variables (1 for the GIFT strain, 0 otherwise) for each country to account for the differences due to genetic quality of the strains used; and male-female ratio. As Vietnam used GIFT fish from two different generations of selection (2nd and 4th), two binary GIFT dummies were used for Vietnam; one dummy variable to represent the difference between the GIFT of 2nd generation selection and existing strains and another variable to represent the difference between the GIFT fish of 4th generation of selection and existing strains. As both the equations (average weight and survival rate) have the same sets of independent variables, we estimated the regression coefficients by using the seemingly unrelated regression methods suggested by Zellner (1962). Table 49 shows the percentage change in average weight at harvest and survival rate, after accounting for the wide heterogeneity of input use levels, production environments and other factors. The magnitude of impact of the GIFT strain over the existing strains varied among various countries according to the history of tilapia introduction, environments and farmers' experience. In Bangladesh, where Nile tilapia has a short history with very limited broodstock management, the GIFT strain appears to be 42 percent superior, in terms of growth, to local strain. In China, the GIFT strain did not show superior performance relative to local strains under on-station conditions. This is plausible because in China there are good existing strains obtained directly from Africa (the origin of Nile tilapia) and there is a longer history of tilapia farming, greater climatic variation and, hence, the possibility of both natural and artificial selection of existing strains to local environments. In Vietnam, the GIFT fish of 4th generation of selection had 40 percent higher growth rate compared to existing strains. However, the GIFT fish of 2nd generation of selection did not show statistically significant superior performance in terms of growth. The on-station data did not show any superiority of the GIFT strain over existing strains in terms of survival.

4.2 Results of On-Farm Trials

4.2.1 Strains used and test locations

In most cases, strains used in the on-station evaluation were also used in the on-farm evaluation with emphasis on the a widely culture tilapia strain in the different test locations. The test locations for on-farm trials were representative of the various agroecological zones or growing environments and culture methods of the participating countries.

In Bangladesh, the GIFT strain's on-farm performance was evaluated against the Thai strain under pond culture system in six test locations: Trishal (Mymensingh), Manikganj (Dhaka), Chandina (Comilla), Jessore Sadar (Jessore), Paikgacha (Khulna), and Mithapokur (Rangpur). In addition, the on-farm performance of the GIFT strain was also evaluated under polyculture systems with silver barb, silver carp and mirror carp at a stocking density of 20,000 fish/ha..

The GIFT strain's on-farm performance in China was compared with "1978", "1988" and hybrid (Nile tilapia x blue tilapia) in three provinces: Qingdao, Huzhou and Guangdong. In Qingdao farmers used cages, while they used ponds in Huzhou and ponds and tanks in Guangdong.

On-farm performance of the GIFT strain over Israel, Thai and "farmer" (unidentified) strains was assessed in ponds and cages, whichever was commercially used, in the 13 test locations (Pangasinan, Pampanga, Nueva Ecija, Tarlac, Bulacan, Laguna, Batangas, Rizal, Camarines Sur, Iloilo, Negros Occidental, Davao del Norte and South Cotabato) representing the various agroecological zones of the Philippines. Among the test strains, only the Israel strain is commercially and widely cultured strain.

In Thailand, the on-farm performance of the GIFT strain was evaluated over the "local" (probably Chitralada) strain in ponds in four test locations (provinces) with varied growing environments: Nakhonpathom, Suphanburi, Chiangmai and Nakhonpanom.

On-farm performance of GIFT strain in Vietnam was compared with the Thai strain in 6 test locations (Thanh Tri, Ha Noi, sewage-fed area; Quang Ninh, brackishwater area; Nam Ha, village pond area; Vinh Phu, village pond area; Ha Bac, village pond area; and Nam Dinh, village pond area) in the north and 3 test locations (Cai Be, Tien Giang, fishponds in Mekong River Delta; Tan Uyen, Song Be, fishponds in Dong Nai River Delta; Can Gio, Ho Chi Minh City, brackishwater area) in the south.

As in the on-station trials, the GIFT strain's on-farm performance was tested against the best available strain in the DEGITA-participating countries. In Bangladesh and China, GIFT strain from the 3rd generation of selection was used in the on-farm trials. GIFT strain from 4th generation of selection was used to determine its on-farm performance in Thailand and Vietnam. In the Philippines, GIFT strain from the 4th generation of selection was used.

4.2.2 Descriptive analysis of the comparative performance of GIFT and control strains

In Bangladesh, the on-farm performance of the GIFT strain in ponds was superior to the control strain. At harvest, the average weight of the GIFT strain (108 g) was substantially higher by 77 percent in comparison to the control strain (61 g) as shown in Table 50. Even the GIFT strain's male proportion and survival rate were slightly higher than those in the control strain. Overall, the yield of GIFT strain (1,590 kg/ha) was 77 percent higher than the control strain (900 kg/ha). In the polyculture system, highest production at 3,463 kg/ha was attained in the combination of GIFT, silver barb, silver carp and mirror carp at a ratio of 2:6:1:1 (Treatment 2) and lowest production in only GIFT strain (Treatment 1) at 2,152 kg/ha. In the combination of GIFT, rajpunti, silver carp and mirror carp at a ratio of 6:2:1:1 (Treatment 3), fish yield was about 2,980 kg/ha.

Although the yields obtained in Treatment 2 and Treatment 3 were not significantly different, both were significantly higher than the yield in Treatment 1.

In China, the on-farm performance in terms of average weight of fish at harvest of the GIFT strain in cages and tanks was consistently better than the control strain, but not so in ponds (Table 51). The average weight of the GIFT strain (308 g) was 17 percent higher than the "1978" strain (264 g) in cages. In tanks, the average weight of the GIFT strain (27 g) was 23 percent better than the hybrid strain (22 g). In ponds, the average weight of the GIFT strain (246 g) was 6 percent lower than the "1988" strain (260 g). However, the GIFT strain had 47 percent higher average weight than the hybrid strain (167 g) in ponds. Male proportion in GIFT strain was substantially lower by 10-34 percent than the control strain, except in cages. Survival of GIFT strain was only slightly higher than the control strains in cages and tanks but slightly lower in ponds. Overall, the yield performance of the GIFT strain was better than the control strains. In cages, ponds and tanks, the yield of GIFT strain was 25, 4-16 and 29 percent higher, respectively, than the control strains.

The on-farm performance of the GIFT strain was generally superior than to the control strains in the Philippines (Table 52). At harvest, the average weight of GIFT strain (161 g) was 19 percent higher than the non-GIFT strain (135 g) in cages. In ponds, the GIFT strain (67 g) has 28 percent higher average weight than the non-GIFT strain (52 g). There was no substantial difference in the proportion of male between GIFT and control strains. As the GIFT strain has consistently higher survival rate and generally higher average weight at harvest, it registered higher yield than the control strains. In cages, the GIFT strain (23,551 kg/ha) has 54 percent higher yield than that of the non-GIFT strain (15,285 kg/ha). In ponds, the GIFT strain (1,361 kg/ha) has 49 percent higher yield than the non-GIFT strain (912 kg/ha).

In Thailand, on-farm performance of the GIFT strain in ponds was superior than the control strain (Table 53). At harvest, the average weight of the GIFT strain (119.63 g) was substantially higher by 49 percent than the "local" strain (80 g). Also, the GIFT strain had higher male proportion (7 percent) and survival rate (24 percent) than the "local" strain. As all these parameters positively influenced yield, the yield of GIFT strain (2,829 kg/ha) was considerably higher by 38 percent than the "local" strain (2,044 kg/ha).

On-farm performance in ponds of the GIFT strain was better than the control strain in Vietnam (Table 54). At harvest, the average weight of the GIFT strain (70 g) was 30 percent higher than the Thai strain (53 kg). However, the differences in the proportion of male and survival rate were not substantial between GIFT and Thai strains. In effect, the yield of the GIFT strain (743 kg/ha) was 33 percent higher than the Thai strain (558 kg/ha).

To determine the cross-country comparative performance of the GIFT strain under on-farm conditions in the DEGITA participating countries, all control strains were aggregated as non-GIFT strain as shown in Table 55. The average (final) weight at harvest of the GIFT strain was only significantly higher compared to non-GIFT strain in ponds in Bangladesh and the Philippines and cages in China. The superiority of the GIFT strain over the non-GIFT strain was not statistically detected in ponds and tanks in China and cages in the Philippines and ponds in Thailand and Vietnam. However, in all these countries and growing environments, the average weight of the GIFT strain was 11-77 percent higher than that of the non-GIFT strain.

The mean of male proportion of the GIFT strain was significantly higher than that of the non-GIFT strain in Bangladesh (ponds), but it was significantly lower in China (ponds). Although the differences in means of male proportion between GIFT and non-GIFT strain in other DEGITA-participating countries under the other culture environments were not statistically significant, the GIFT strain has generally lower means. On the other hand, survival rate of GIFT was significantly better than the non-GIFT strain only in cages in China and in ponds in the Philippines. Generally, the survival rate of the GIFT strain was higher than non-GIFT strain in most DEGITA-participating countries ranging from 0.3-26.8 percent, except in ponds in China where it was lower by 0.8 percent. Yield of GIFT strain was consistently higher than non-GIFT strain in all the DEGITA-participating countries, though it was statistically significant only in ponds in Bangladesh and cages in China. Except the stocking density in ponds in Thailand, there were insignificant differences in the means of other variables affecting the growth performance of the GIFT strain in comparison to the non-GIFT strain.

Overall, the GIFT strain showed superiority over non-GIFT strain under on-farm conditions in terms of average weight at harvest and yield, although these were not statistically different in all the countries.

4.2.3 Statistical analysis of the comparative performance of the GIFT and control strains

Production per unit area or yield of a tilapia farm depends on the stocking density, average weight at harvest and survival rate. Growth and survival rates are again dependent on various factors: input use levels, production environments, and genetic characteristics of the strain used. We estimated regression models for average growth and survival rate of each participating country based on on-farm trial data. As Thailand and Vietnam used the same strain (Thai strain) as control, we combined the Thailand and Vietnam data sets to increase computational efficiency. We estimated growth and survival equations for each country/country group using the seemingly unrelated regression method (Zellner 1962). After accounting for the wide heterogeneity of input use level, production environments and other intrinsic and extrinsic factors, the percentage change in average weight at harvest due solely to the mean superiority of the GIFT strain over the existing non-GIFT strains was highly significant across different countries (Table 56). The magnitude of the effect of the GIFT strain on growth rate, however, varied among countries, ranging from 18.48 percent in China to 66.45 percent in Bangladesh. In terms of survival, the GIFT strain showed higher survival compared to the existing strains in China (3.28 percent) and the Philippines (12.75 percent).

We also tested whether the difference in average yield at harvest between GIFT and existing non-GIFT strains is due to neutral or non-neutral technical change Results show that the GIFT strain is neutral with respect to feed use, i.e., increase in output due to the GIFT strain per unit of feed used is constant across feed use levels, in all countries except Bangladesh. As the existing strain in Bangladesh is of very poor quality, this difference in results is plausible. The scale neutral characteristics of the GIFT fish imply that small operators, who cannot use enough feed and fertilizer, as well as large scale operators, who normally use higher doses of feed and fertilizer, will benefit equally from the adoption of the GIFT strain.

4.3 Relative Production Cost of GIFT and non-GIFT Strains

The relative production cost of GIFT and non-GIFT tilapia farming in the DEGITA-participating countries are shown in Table 57. These results are based on on-farm trials conducted in the DEGITA-participating countries. The GIFT strain had higher yield than the existing strain in all the countries: Bangladesh - 78 percent; China - 25 percent (cage) and 9 percent (pond); the Philippines - 54 percent (cage) and 49 percent (pond); Thailand - 38 percent; and Vietnam - 33 percent. As the GIFT strain was not given additional inputs or can be raised within the existing resource capabilities of fish farmers, cost of production per kg of fish will not necessary increase due to the adoption of the GIFT strain. In fact, analysis indicates that fish farmers can lower the cost of production per kg of fish as much as 36 percent in Bangladesh, 7-20 percent in China, 33-35 percent in the Philippines, 28 percent in Thailand, and 22 percent in Vietnam, by merely replacing their existing strains with the GIFT strain. As more fish farmers are expected to adopt the GIFT strain, it is highly probable that there will be a downward pressure on the market price of tilapia due to increased supply. Tilapia will then be more affordable to most consumers. Even with a relatively lower price, fish farmers may still realize higher farm income as they will have a lower cost of production.

4.4 Yield Potential of GIFT and non-GIFT Strains

This section reports the yield potential of GIFT and non-GIFT existing strains; we address the question, what is the maximum yield that can be obtained for different strains keeping in view the constraints imposed by the environmental factors? The yield potential of a technology may be interpolated from yield of experimental plots (e.g., Herdt and Mandac 1981) or the most efficient farmer in a sample (e.g., Kalirajan and Flinn 1983). The former was adopted in this study to find out the yield potential of the GIFT strain compared to the existing non-GIFT strains in Asia.

We fitted stochastic frontier models of average weight at harvest for GIFT and non-GIFT strains based on the on-farm experimental data from Bangladesh, China, Philippines, Thailand and Vietnam using the maximum likelihood estimation technique. The estimated frontier models show the maximum body weight that can be obtained using GIFT and non-GIFT strains from a specific level of inputs. Table 58 reports yield potential of the GIFT strain and the best existing strain under pond culture system in different countries based on estimated frontier models. The yield potential of the GIFT strain is more than 50 percent higher that that of the best existing strain, ranging from about 54 percent higher in Vietnam to about 97 percent higher in Bangladesh.

4.5 Yield Gap for GIFT Strain

Yield of GIFT tilapia in any country/region would depend on, among many other factors, genetic potential of the strain and on the prevailing production constraints that deviate the potential yield from the actual farm yield (yield gap). The yield gap, defined as the difference between the yield observed on experiment stations and actual yields on farmers' fields, has two components. Yield gap I is the difference between the yield observed on experiment stations and the best practice yield on farmers' fields (or potential farm yield). Yield gap II is the difference between best practice (potential) and actual yields on farmers' fields.

We estimated yield gap II for the GIFT tilapia and the results are reported in this section. We estimated potential farm yield, as reported in the previous section, by fitting a stochastic frontier model of average weight at harvest based on on-farm data using the maximum likelihood estimation technique. We estimated average farm yield based on ordinary least squares (OLS) estimates of average weight (at harvest) function. Yield gap II ranges from around 3000 kg ha^{-1} in China to around 850 kg ha^{-1} in the Philippines, which has a shorter growing period and poorer production environment (Table 59 and Figure 1). These estimated gaps show the extent to which yield might be increased through the invention of economic technology to overcome constraints such as disease, temperature extremes, water shortage, poor water quality and so forth.

Chapter 5. Potential Impact of GIFT Technology

5.1 Socioeconomic Impact/Welfare Consequences

5.1.1 Methodology

The approach used in this project for evaluating the welfare consequences of technical change is based on a modification of the "Modified balance-of-trade function (or Distorted Trade Expenditure Function) approach (Martin and Alston 1994). The basic form of the modified balance-of-trade function used here in defined for a single representative fisheries household economy as

$$H^{i} = e(P, u^{i}) - g(P, V, \lambda) - f \quad \text{..} \quad (1)$$

The function e is the expenditure function of a representative household for a given vector of domestic prices P and a level of utility exogenously specified at level u^i in order to define Hicksian money-metric measures of welfare change. The function g defines the maximum profit or quasi-rent generated from production in the household economy for given domestic prices, P, a vector of technology variables λ, representing the state of the available technology (i.e. GIFT vs. existing strain). Finally, f is an exogenous financial inflow (outflow) from (to) non-fisheries/aquaculture sector.

An exact money-metric measure of the welfare consequences of technical change (i.e. GIFT technology) was obtained from equation (1) by comparing the net expenditures required to achieve a given level of utility u^i, under the initial technology λ°, and under the new technology λ_1. An equivalent variation version of the measure is defined with the utility level in the expenditure function held at the level associated with technical change:

$$H_1^\circ - H_0^\circ = H(P_1, V_1\, \lambda_1, u^i) - H(P_o, V_o, \lambda_0, u^i) \quad .... \quad (2)$$

The function presented in equation (1) and its change presented in equation (2) were extended to different types of household economy (e.g., adopter-producer, nonadopter-producer and consumer) and national economy.

The modified balance of trade function defined in equation (1) is related to, but distinct from, the behavioral system. It includes the parameters of the consumer expenditure system and profit function. However, the level of consumer utility is endogenous in the behavioral system, whereas it is held constant in the expenditure function used for the evaluation of consumer welfare in equation (1).

For national economies, behavioral model of supply relations, Marshallian demand equations, market clearing conditions, and income-expenditure conditions were solved first to generate changes in vectors of prices of non-traded commodities and quantities. Then these changes in prices and other variables, together with specified changes in technology, were used for welfare evaluation in a second step. For household economics, the vector of prices were assumed as exogenous (given).

We considered 4 to 5 subsectors of fish economies for different countries (Table 60). As tilapia sector is the principal sector for all countries, other fish commodities were aggregated into 3 to 4 groups to keep the model simple, yet retain the rigor of our suggested approach.

We assume that fish production can be represented by a normalized quadratic profit function. The supply functions for different fish groups are obtained by differentiating profit function with respect to the effective prices. The slopes of the supply functions were inferred from the local elasticities and the relevant base period price and quality variables, and then the intercepts were obtained by subtraction to calibrate the production system to the base data set.

An Almost Ideal Demand System (AIDS) representation (Deaton and Muellbauer 1980) was used on the consumption side. The demand system was parameterized based on local price and income elasticities of demand and on other relevant base period data (e.g., price, quantity, expenditure share etc.).

5.1.2 Supply and demand elasticities

Supply elasticities

Due to unavailability of supply elasticity estimates for fish sectors, and lack of resources and time to estimate these elasticities, subjective elicitation process was used to come up with benchmark estimates. The preliminary benchmark estimates were presented to various experts for validation to come up with validated estimates. Appendix Tables 3.1 to 3.5 present validated supply elasticities.

Demand elasticities

Research on demand for fish by species or species group is of recent vintage and very few reliable studies have been done so far on this issue in any country in the world, none in the DEGITA participating countries. We estimated fish demand responses by species groups for Bangladesh based on 5,667 individual households data collected by the Bangladesh Bureau of Statistics.

We followed a three-stage budgeting framework in modelling household behavior. The estimating model developed includes estimation of food demand function in the first stage, estimation of fish demand (as a group) function in the second stage, and estimation of demand for individual species (species group) in the final stage. In the first stage, the household makes decision on how much of the predetermined total income is to be allocated for food consumption conditional on prices of food commodities, non-food expenditure and various household characteristics. In the second stage, the household makes decision on how much of the total food expenditure is to be allocated for fish consumption. In the third stage, the household allocates the amount of fish expenditure for individual fish (fish group).

Tables 61 and 62 show the uncompensated (Marshallian) own price elasticities and income elasticities, respectively, of various fish groups in Bangladesh. As expected, own price elasticities are negative and all are close to unity except for big fish. As big fishes are expensive and considered as luxury goods, we have higher (in absolute term) price elasticity compared to other species groups. Among all species groups, small fish has lowest and big fish has highest own price elasticity in absolute terms. Estimated own price elasticities do not show much variation across location (rural vs urban) and income classes. Results reveal that income elasticities are higher for poorer people than the rich, which is expected. Income elasticity is lowest for small fish and highest for live fish.

Based on the results of the Bangladesh study and available studies on demand for fish as a group (not by species) in other countries, we generated preliminary estimates of demand elasticities for fish by species for all the participating countries. Preliminary estimates were presented to various experts for validation in order to come up with validated estimates, given in Appendix Tables 3.6 to 3.10.

5.1.3 *Ex ante* impact indicators

Results of on-station and on-farm trials show that the GIFT strain increases yield through higher average weight at harvest and, for some countries (China and Philippines), through higher survival rate. On-farm results indicate that the GIFT strain would have substantially higher yield compared to existing strains, ranging from 24 percent higher in China to 67 percent higher in Bangladesh (column 4 of Table 63). Bigger fish also get higher market price. Thus, the GIFT-type technical change is one that increases the "effective" quantity of a good associated with a given physical quantity, and there is a corresponding change in the effective price of the good (tilapia fish). Thus, we have calculated the overall technological index of the GIFT strain by combining the quantity and quality effects. Estimated technological index varies from 34 percent in China to 100 percent in Bangladesh (column 6 of Table 63). However, farmers may not be able to realize all the productivity gain. We have calculated technological index under two adoption scenarios: Scenario I representing early stage of adoption curve and Scenario II representing the later stage of adoption curve. In Scenario I, it is expected that the rate of adoption would be lower but the productivity gain to the adoptor would be higher. In Scenario II more and more aquaculture farmers are expected to adopt the technology, but as the GIFT strain would be cultured in poorer farms the average productivity gain to the adoptors would be lower. Table 63 shows the technological index both at the national and adopting farm levels under Scenarios I and II.

5.1.4 Simulation results : impact of GIFT strain

The model presented and discussed in section 5.1.1 was solved using the Excel Solver option, and two technical change experiments (described Section 5.1.3) were conducted. The results are described below.

<u>Impact on tilapia prices</u>

Due to the adoption of GIFT technology, the prices of tilapia would decrease in all the countries. As the price elasticity of demand for tilapia is elastic (close to -1 in absolute terms), the rate of decrease in the price of tilapia would be lower compared to the rate of increase in productivity. In the Philippines, a 15 percent increase in average national productivity of tilapia (Scenario I) would result in about 11 percent decrease in tilapia price, while a 20 percent increase in national productivity of tilapia (Scenario II) would decrease tilapia price by about 14.5 percent. A similar trend is observed in all the participating countries under both technical change scenarios (Table 64). These decreases in prices are in conformity with our previous findings that the cost per kilogram of fish produced would decrease due to the adoption of GIFT strain (Section 4.3 and Table 57).

Impact on profitability

Profitability of tilapia farming would be increased due to the adoption of GIFT strain, and the level of increase in profitability for the adoptor would be higher during the early stage of adoption (Scenario I) than during the later stage of adoption (Scenario II). As more and more farmers would adopt the technology, the supply would increase and the relative price of tilapia would decrease. These effects, combined with the relatively lower increase in average productivity gain due to adoption of the GIFT strain in poorer quality farms, would reduce the level of increase in profitability. In the Philippines, the 40 percent increase in productivity due to GIFT strain would result in about 84 percent increase in profitability (from a US $4,052 per farm of 1.6 ha to US $7,452) during the early stage of adoption and profitability would only increase by about 17 percent during the later stage of adoption (Table 65). Similar trends are expected to be observed in other countries.

On the other hand, profitability of tilapia farming would be decreased for non-adopting farmers due to lower market price of tilapia. However, as the GIFT technology is scale neutral, non-adopting farmers are expected to follow the early adoptors. The government should remove supply side constraints, if any, so that every farmer has access to the technology and each of them faces the same "effective" price of tilapia fingerlings.

Impact on production

Adoption of GIFT strain is expected to increase tilapia production in particular and overall fish production in general. In the Philippines, the 15 percent increase in average national tilapia productivity would increase national tilapia production by about 16 percent during the early stage of adoption (Scenario I), as shown in Table 66. In Thailand, the 8 percent increase in average national tilapia productivity would result in a 9 percent increase in tilapia production in the country under Scenario I. These higher increases in production (e.g., 16 percent increase in production from 15 percent increase in productivity) reflect both the direct impact of the productivity shock on the output of the tilapia sector, and the indirect effect through increased profitability.

At the household level, production of other fish species would decrease marginally for GIFT-adopting farmers, while for non-adopting farmers it would increase marginally in all countries (i.e., Bangladesh, China, Thailand and Vietnam) culturing fish in polyculture system (Table 67). These results are biologically in conformity with the findings of Stickney (1978), Yashouv (1969) and Reich (1975). Because of this and as tilapia has no major competitor in the resource use in the Philippines, it is expected that adoption of the GIFT strain would increase tilapia production at the national level in all countries without decreasing production of other species (Table 66).

As indicated in the previous sub-section, production of tilapia is expected to be marginally decreased for non-adopting farmers as the profitability of non-GIFT tilapia would decrease due to the lower relative price of tilapia.

Impact on consumption

We analyzed the effect of GIFT technology on different types of farm households (GIFT adopting fish farmers, non-GIFT adopting fish farmers and consumers). As fish consumption of our surveyed consumers differs from the national average due to the reasons given in Section 3.3.2, we have considered two types of consumers: sampled consumers and national average consumers. The GIFT-type technical change is expected to increase tilapia consumption in all types of household (GIFT adopting fish farmers, non-GIFT adopting farmers and consumers), except for the non-adopting farmers of the Philippines, for whom the negative effect of lower income would probably be higher compared to the positive effect of the lower market price of tilapia. In China, where national average consumption of tilapia is about 1 kg/year/household, GIFT technology is expected to increase average tilapia consumption by about 7 percent (Table 68). In the Philippines, average tilapia consumption per household is expected to increase from 10 kg/year/household to about 12 kg/year/household due to the GIFT technology. Like tilapia consumption, overall fish consumption is also expected to increase for all non-producing consumers and GIFT adoptors, and even for most of the non-GIFT adopting tilapia producers; though the level of increase is expected to be very small, ranging from almost 0 percent in China to about 3 percent in Thailand.

Overall economic gain

At the household level, overall welfare gain would increase for all consumers and GIFT adopting fish producers as a result of the GIFT technology. For subsistence farmers in Bangladesh with 500 m^2 pond area under polyculture system, GIFT technology would increase the overall economic gain by about US $5-6/household/year. In the Philippines, overall economic gain of GIFT adoption, with 1.6 ha of pond area under tilapia monoculture, would be about US $1,500 to US $3,500/household/year, depending on the level of productivity gain. Although the overall gain to an average consumer in the DEGITA-participating countries would be very low (often less than US $5 per year per household, except in the Philippines) due to the relatively low level of tilapia consumption per household (Table 69), the overall economic gain to all consumers in a country is very high due to very large number of tilapia consumers (Table 70). Results indicate that, except for Thailand, more than 50 percent of the total economic gain due to GIFT technology would go to consumers; the share is about 40 percent in Thailand.

Distribution of economic gains among different groups of producers and consumers

Distribution of the economic gains from technological change in any commodity among various strata of the society depends on, among other factors, the institutional and policy environments within which it is introduced. GIFT technology offers an opportunity for increasing production through more productive use of resources. Whether the opportunity is used and how the associated benefits are distributed among different classes of the population are largely a question of institution, government policies and social structure.

As the baseline survey results indicate that tilapia production is dominated by small- and medium-scale farmers employing extensive or semi-intensive production system (see Chapter 3 of the report), the major portion of the producers' benefit is expected to go to them. In Bangladesh, where tilapia is being cultured mostly in seasonal ponds under extensive culture system by poor farmers with an average farm size of 0.6 ha (fish farm of 0.05 ha), most of the producers' gain would go to small farmers.

Except in the Philippines, tilapia is consumed mainly by relatively poor people because of its relatively low price. Table 71 shows that tilapia accounts for more than 30 percent of total fish consumption for relatively poorer consumers (2nd expenditure quartile) in China and Thailand, while tilapia accounts for only about 18 percent of total fish consumption for the richest people in China and for about 20 percent for the richest in Thailand. And as the price elasticity of demand for low valued fish like tilapia is higher for poor people than for the rich (Table 61), the major portion of the consumers' benefit will go to relatively poorer (not to the very poor who can not afford to buy any fish) consumers in all the DEGITA-participating countries, except in the Philippines. As richer consumers are consuming more tilapia in the Philippines, both in terms of the absolute level of consumption and share of total fish consumption, they are expected to get the larger share of the total consumers' benefit.

5.1.5 Impact on input market

Impact of GIFT technology on input market has been discussed below based on the results of baseline surveys. We could not analyze the effect on input market through the model described in section 5.1.1, as parameters of input demand functions were not available and we could not estimate those due to lack of time and resources.

Impact on labor market

Table 72 shows the share of hired labor in the total labor used in tilapia production. Except for the Philippines, almost all the pre-harvest labor for tilapia culture comes from family sources. As adoption of GIFT strain does not require additional care, it is expected that the same structure of labor use will be found in most of the countries even after the introduction of the GIFT technology. This implies that demand for pre-harvest labor is not expected to increase due to adoption of the GIFT technology in all the

DEGITA-participating countries, except in the Philippines. However, with the increase in production due to adoption of the GIFT strain, demand for labor in harvesting and post-harvesting activities will be increased in countries like China, the Philippines and Thailand.

Impact on feed markets

As strain is technology neutral with respect to feed use (see Section 4.2.3), demand for feed is not expected to increase under the present level of stocking density. Farmers would be able to increase production of fish and profitability of fish farming simply by replacing the existing strain of Nile tilapia with the GIFT strain. Thus, use of GIFT strain will not directly affect the demand for feed. However, if farmers increase their stocking density and thereby increase feed requirement per unit area, and increase their area under tilapia operation, overall demand for feed would increase.

5.2 Environmental Impact

Aquatic diversity is crucial for human survival. In the light of increasing per capita consumption of fish and seafood, fish farming/culture systems will have to become progressively more intensive, the yield of cultured organisms have to be increased, feed conversions ratios reduced, stress and disease tolerance increased, etc. Selective breeding can contribute to achieving some or all of these. However, in order to work towards the above goals breeders require at their disposal a library of germplasm from which to select; hence the need to conserve genetic biodiversity. The GIFT strain of Nile tilapia is a product of such a breeding program, and it is imperative that introduction of this selected strain does not overly influence genetic diversity and thereby limit the scope of future breeders.

In the 1990s our concerns on environmental perturbations, the need to sustain environmental integrity as well as on issues on biodiversity have, quite justifiably, intensified manifold. Governments and donor agencies have embraced the basic recommendations arising from the 1992 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and scientists are duty bound to evaluate fully when to make recommendations regarding new introductions and/or transfers.

The GIFT fish is an improved strain of *Oreochromis niloticus* developed by selective breeding for a number of desirable characters. In this section the possible environmental impacts of the popularization of the GIFT fish, as a potentially major culturable species in Asia, is evaluated in the context of available information on tilapia performance and its impacts in Asia as well as based on data that have been generated from the baseline surveys, rapid rural appraisal and on-station and on-farm trials of the DEGITA project. As such it entailed a large conceptual component, not by choice but merely by virtue of the questions posed associated with any form of introduction.

5.2.1 Environmental impact of tilapia introduction

In order to identify ecological impacts of the introduction of tilapias into the five countries (Bangladesh, People's Republic of China, Philippines, Thailand and Vietnam), 521 fish farmers representing various agroecological and socioeconomic environments in these countries were asked whether the introduction of tilapia caused displacement or reduction in catch or landings of the existing species found in their natural waters. It was found that tilapia introduction did not cause displacement of existing fish species in the natural waters of most of these countries, except in the Philippines.

In Bangladesh, the lack of impact of tilapia introduction on existing species can be attributed to its low population in open waters. As tilapia is not yet a popular fish to culture, an insignificant number escaped into open waters of Bangladesh. Only in Kaptai lake, a large reservoir in Bangladesh, the decline of the indigenous carp (Indian carp) fishery is attributed to an increase in tilapia landings. However, it is not very clear to what extent tilapias are responsible for the reduction of carp landings. Tilapias account for only about 1 percent of the total fish, and a thorough study of other factors has not yet been undertaken, including the effect of the increased use of disruptive gear, landing of indigenous carps during their spawning migration, etc.

As tilapias cannot overwinter in most parts of China, these species cannot survive in natural waters, such as lakes and rivers. Even in areas where tilapia can overwinter in natural waters, such as the Hainan island and the southern part of Guangdong Province, so far there is no report that tilapias have become a part of inland capture fisheries.

In Thailand, fish farmers observed no displacement of existing species found in the natural waters, except perhaps in some lakes and reservoirs from where we did not have any sample respondents.

In the northern part of Vietnam, tilapias are not found in natural lakes, reservoirs and river systems because of low winter temperatures. Even in the southern part of Vietnam, where winter temperature is not low, fish farmers observed no displacement of existing fish species found in the natural water bodies.

In the Philippines, majority or 84 percent of fish farmers claimed that tilapia is not causing displacement of existing species found in its natural waters (Table 73). However, about 16 percent claimed that either some natural species have been displaced by tilapias or the landings of existing species reduced substantially after the introduction of tilapia in open waters. Unlike in the other DEGITA-participating countries, it has been a yearly regular program of the Philippine government to stock its natural waters with millions of tilapia as a means to increase fish productivity. Due to this deliberate stocking and substantial escapement from ponds, cages and pens, tilapia quickly dominated open waters. This resulted in an increase in tilapia landings and reduction in existing species like freshwater mullet, freshwater sardines, freshwater goby, catfish, carp, gourami, snakehead and shrimp. However, reduction of landings of the existing species were observed in only 5 out of 15 provinces surveyed and most of these 5 provinces have lakes or reservoirs.

To substantiate the data on assessing the environmental impact of tilapia introduction, the DEGITA-Philippines formed a multi-disciplinary team from the government and non-government agencies. Six regions representing various agroecological zones of the country were designated as pilot study areas, namely, Ilocos, Central Luzon, Southern Tagalog, Bicol, Western Visayas and Southern Mindanao. As much as 90 percent of the tilapia production of the country comes from these regions. The team employed a Rapid Rural Appraisal (RRA) technique to gather the necessary data as summarized in Table 74.

The RRA team did not find any displacement of native species by tilapias, except in lakes and reservoirs. In some lakes, however, it is alleged that unique or peculiar species of commercial value are being threatened with the introduction of tilapia. Examples are the small goby, *Mirogobius lacustris,* of Laguna de Bay; the *Herengula tawilis* of Taal Lake; the *Mistichthys luzonensis* (Sinarapan or tabios) in Lakes Buhi and Bato and the small cyprinids in Lake Sebu. Tilapia dominates in most of these lakes.

However, other authors are cautious in their evaluation of the effect of tilapia introduction on native species (Gindelberger 1983; De Silva 1987). The only direct evidence that the decline and/ or near extinction of native species was brought about due to the introduction of tilapia was a laboratory study which indicated that the tilapia feeds on Sinarapan, and the increase in landings of tilapia coincided with a decline of the former. Apart from the fact that the laboratory study was inconclusive, other probable factors responsible for near extinction of Sinarapan are damming of the river flowing from the lake, intensification of the fishing effort and, more importantly, the introduction of destructive gear such as motorized push nets which destroyed the beds of the aquatic macrophyte, *Vallisneria*, the breeding grounds of Sinarapan (Gindelberger 1983).

The balance of evidence seems to suggest that the decline of native species in various lakes in the Philippines and in the Kaptai lake in Bangladesh was probably the result of a number of factors, the least influential of these being the presence of the exotic tilapia. In spite of their rather wide scale introduction into Asian waters, there is no explicit evidence to indicate that tilapias have been overly destructive environmentally. There is no evidence to indicate that these species have in any way affected biodiversity. Admittedly, there have been isolated instances in which tilapia introductions have been implicated in certain faunal changes. Perhaps in these instances the introduced tilapias happen to be present at the site but were not the primary cause of the changes. On the other hand, it is argued that tilapias introduced into Asia have occupied "vacant niches" and consequently are not detrimental to the indigenous fauna (Fernando and Holick 1982). The introduced tilapias also have very generalized food habits. They are non-predatory and tend to change their food habits to suit availability (Maitipe and De Silva 1985). All of the above factors are indirectly indicative of the minimal negative influences that the introduced tilapias could have on the environment. However, this is no reason for complacency and our vigilance and objective assessment of their influence on the environment and on biodiversity needs to be monitored and assessed continuously, at least periodically. Equally, this supposed success does not provide a passport to further introductions.

5.2.2 Environmental impact of tilapia culture

In Asia, tilapias are mostly extensively cultured in ponds. So far, there has been no study indicating that tilapia pond culture is causing environmental degradation or imbalances. Only in the Philippines are tilapia now intensively cultured at a highly commercial scale in cages. In Bangladesh, China, the Philippines, Thailand and Vietnam, no related negative environmental impact has yet been associated with tilapia culture in ponds. This can be attributed to low levels of input use which released an insignificant amount of organic load into the surrounding environment. In fact, tilapia is observed to clean up stagnant water in stagnant ponds and in sewage area better than any other fish species in Vietnam.

Even the DEGITA-Philippine RRA team found that in Pantabangan Reservoir, Nueva Ecija (Central Luzon), a man-made water body in which tilapia was introduced in 1974 and fish cage in 1982, tilapia culture has not been associated with any negative environmental impact but has rather contributed to the enrichment of its fishery and improvement of the socioeconomic conditions of the surrounding communities.

However in natural water bodies such as Lake Sampaloc and Lake Mohicap in San Pablo, Laguna, Laguna de Bay in Rizal/Laguna provinces, Taal Lake in Batangas (Southern Luzon), Lake Buhi and Lake Bato in Camarines Sur (Bicol) and Lake Sebu in South Cotabato (Southern Mindanao) where tilapia cage culture dominates, it has resulted in rapid siltation and shallowing of these lakes (due to uncollected and unserviceable structures used in cages and fish corals like old bamboos, nets and woods) and deterioration of water quality due to intensive use of feeds.

In addition, conflict on water use and conversion of productive ricelands into fish ponds are the emerging environmental issues associated with tilapia culture in the Philippines. Allowing tilapia cage culture in lakes greatly reduced the open fishing area for lakeshore fishermen, jeopardizing their source of livelihood, hampering navigation and posing hazards to domestic use like bathing, as unserviceable materials are left to decompose in the water. Conversion of ricelands into ponds is primarily an economic issue rather than an environmental one. As tilapia pond culture is becoming more profitable than rice farming, farmers are opting for the former. However, massive conversion will eventually result in environmental problems as the ecosystem of the community may drastically change. All these negative repercussions on the environment, however, can be expected for any other aquaculture activities.

5.2.3 Potential environmental impact of the GIFT strain

It has been pointed out that tilapia, in particular *O. niloticus*, plays an important role in regard to food security in Asia, and in particular with respect to the relatively poorer sectors of the community. In order to meet the increasing demand for such an aquatic product, in the light of the apparent decreasing performance of the existing stocks in Asia due to introgressive hybridization and other factors pointed out earlier, the improvement of the genetic quality of the cultured stocks was seen as an obvious means of increasing production and thereby meeting the increasing demand for this product (Pullin and Capili 1988). The GIFT strain is the result of a carefully conducted genetic selection and improvement program (Eknath et al. 1993), and its performance in different countries under the existing farming practices has been presented in this report.

It is sufficient to point out that the GIFT strain has a higher rate of growth, indicating that it has the potential to give higher yields under existing, semi- intensive farming conditions in Asia.

As GIFT strain perform better than the strains already available in Asia, it is expected that there will be a demand for its popularization in countries where *O. niloticus* culture is already practised. However, before embarking on extensive distribution of this selected strain of *O. niloticus* the scientific community will be duty bound to ensure that its spread will

(a) not overly damage environmental integrity, and

(b) not affect biodiversity.

Admittedly, it is not easy to find direct answers to the above questions. However, we are able to make an objective assessment, based on our existing knowledge and experience, of these issues and come up with plausible and pragmatic conclusions.

<u>Impact on environmental integrity</u>

As pointed out earlier, the success of tilapiine fish as a culturable group, and in particular selected species such as *O. niloticus*, is because it is a species which is effective and responsive irrespective of the intensity of the culture practice. It is a species which can obtain its nutrition from the natural food supply, if the latter production is induced through simple fertilization, or entirely from artificial diets or a combination of both. It is a species which can be cultured in relatively poor quality waters, even in septage ponds (Edwards et. al 1990). By and large, the great majority of tilapiine culture in Asia is small scale, literally back-garden pond culture, where the inputs are fertilizer and readily available agricultural by-products such as rice bran and kitchen waste. Tilapiine culture ponds are rarely drainable. They essentially constitute closed systems and rarely discharge effluents into surrounding natural waters, except under flood conditions.

All forms of culture, whether terrestrial or aquatic, perturbs the environment to some degree. The culture of tilapiine fish is no exception to this. However, because of the nature of the existing tilapia culture practices, this group probably perturbs the environment minimally, in comparison to most other forms of culture. Culture of "GIFT Fish" is unlikely to deviate to any great extent from the existing forms of tilapia fish culture. As such its culture should not overly influence the existing environmental integrity in most countries.

Influence on biodiversity

Introductions, translocations and transfers of species beyond their natural range of distribution could potentially affect biodiversity in the new region, and instances that this has occurred in respect of aquatic species are well documented. It is perhaps best exemplified by the controversial introduction of *Lates niloticus* into Lake Victoria, Africa (Ogutu-Ohwayo 1992). Such undesirable examples are also known from Asian waters, e.g., the almost complete disappearance of the native cyprinid flock (*Barbus* spp.) in Lake Lanao, Philippines (Frey 1969). It is in this regard that the international scientific community embarked on developing guidelines on fish introductions (Turner 1988) and commenced addressing the issue with a broader perspective (Courtneay & Stauffer 1984; De Silva 1989). Needless to say issue is far from settled. In the most recent treatment of the subject Bartley et al. (1996) defined "species' to include different races, strains, genetically differentiated populations, or products of genetic manipulation. On the other hand, Woodworth et al. (1994) defined genetically modified fish as, "fish that have had their genetic material altered in a way that does not occur naturally".

As pointed out earlier, none of the introduced tilapia fish have, to our knowledge, been responsible for the extinction or near extinction of any indigenous species. Some tilappiine species are more widespread than others. Moreover the commonly targeted nuisance species *O. mossambicus* has in fact invaded degraded wetlands, particularly in estuarine areas and discarded shrimp ponds, the acreage of which is on an almost exponential increase in Asia.

GIFT fish is a strain of *O. niloticus* and according to the definition of Woodworth et al. (1994) it is not a genetically modified organism. *O. niloticus* is widely distributed in Asia already and there are no reports, even anecdotal ones, that it has been responsible for the decline of indigenous species. As such it may be argued that the GIFT strain may not be harmful either. Contrary to this it may be suggested that the GIFT strain, because of its genetic superiority, may be more invasive and increase its range of distribution and thereby bring about detrimental effects which were not evident with *O. niloticus*. Of course the reverse could also occur because of its rather specialized traits of fast growth, etc. In our view, however, obtaining an objective answer to such a speculative proposition may take a decade or more. Should we be postponing a practical and a proven means of poverty and malnourishment alleviation until we satisfy our scientific fantasies? The answer is a firm no.

Part III. Recommendation and Conclusion

Chapter 6. Impact of the DEGITA Project

6.1 Formation of National Tilapia Breeding Programs

All the DEGITA-participating countries have committed to continue and sustain the genetic improvement, multiplication and distribution of the GIFT strain to fish farmers through their national tilapia breeding program.

In Bangladesh, the BFRI will work as the lead center to maintain the purity of the GIFT strain and to develop improved genetic selection techniques for quality seed production and culture management. To fast track the distribution of the GIFT strain, few hatcheries of the Department of Fisheries (DOF) and non-government organizations (NGOs) in different strategic locations in Bangladesh will be designated for seed production and training of extension workers and farmers. A replacement program of existing tilapia strain with the GIFT strain will be initiated first in the Mymensingh region in collaboration with the Mymensingh Aquaculture Extension Project (MAEP). The government, through the BFRI, is requesting ICLARM to continue the financial and technical support for the extension of DEGITA-like activities in Bangladesh, due to high culture potential of the GIFT strain.

The National Tilapia Seed Farm of Qingdao and Guangdong were identified as primary stations for germplasm preservation of the GIFT strain in China, for its safekeeping and further improvement. About 10-20 secondary stations will be established in the major tilapia-producing provinces for mass production of the GIFT strain to supply the seed requirement of fish farmers. To protect the purity of the GIFT strain, the Aquatic Seeds Inspection Center of Shanghai Fisheries University will provide inspection and certification of the genetic resources of the GIFT strain in China. Measures such as continuous genetic selection of tilapia, periodic introduction of original strains, and the institutionalization of national tilapia breeding programs will be introduced in China to prevent the pool of tilapia genetic resources from deteriorating. These measures are necessary for China to further improve farmers' productivity, boost and sustain its fast growing tilapia industry and to continue to be the world's leading tilapia producer.

The pioneering effort to establish the Philippine National Tilapia Breeding Program (PNTBP) was initiated in 1993, way ahead of the other DEGITA-participating countries, through the collaborative effort between the Bureau of Fisheries and Aquatic Resources/National Freshwater Fisheries Technology Research Center ((BFAR-NFFTRC), Central Luzon State University/Freshwater Aquaculture Center (CLSU-FAC), ICLARM and the Institute of Aquaculture Research of Norway (AKVAFORSK) through Norwegian Center for International Agricultural Development (NORAGRIC/NORAD). The primary objectives of the PNTBP are: 1) to sustain a long-term natural selection breeding program for tilapia; 2) to institute broodstock management program to prevent inbreeding; and 3) to disseminate the improved tilapia genetic materials to fish farmers. Tilapia farmers are encouraged to use the GIFT strain to increase their farm productivity. BFAR launched the Program on Fish Varietal Regeneration (PFVR) in 1993, another program in support of the PNTBP. PFVR is a flagship program in support of the development of the aquaculture sector in the country. It focuses on the importance of selective breeding. integrated broodstock selection, genetic management, improved nutrition and proper broodstock management techniques.

The GIFT Foundation International (GFI) has been formed to sustain the activities of the GIFT Project, especially on tilapia genetic research, in the Philippines. The GFI is currently organizing a network of private hatcheries for the mass production of the GIFT strain. This is expected to facilitate the dissemination of improved tilapia strains to fish farmers, which is crucial in increasing the productivity of freshwater aquaculture in the country.

Thailand has very strong genetic research in tilapia with the National Aquaculture Genetic Research Institute (NAGRI). This Institute has developed Chitralada I and other strains parallel to the development of the GIFT strain in the Philippines. With the availability of the GIFT strain through the DEGITA project and encouraged by its growth performance over their local strains, Thailand is pursuing the development of a national tilapia breeding program primarily anchored on the GIFT strain. Since September 1996, Thailand has undertaken mass seed production of the GIFT strain in its Pitsanulok Genetic Center for distribution to interested fish farmers throughout the country. Production and culture of all-male GIFT strain is also a priority in Thailand, in line with research result indicating the superiority in growth performance of male over female tilapias. The addition of the GIFT strain to the pool of tilapia genetic resources provides Thailand the opportunity to develop the "best" tilapia strain for increasing farmers' productivity and profitability in tilapia farming.

The GIFT strain, introduced to Vietnam through the DEGITA project, is kept and maintained in Research Institute for Aquaculture No. 1 (RIA No. 1). The GIFT strain, however, is available to other institutes for further research and development as well as to private hatcheries for multiplication and distribution to fish farmers. RIA No. 1 and No. 2 are taking the lead in developing a national tilapia breeding program in Vietnam primarily anchored on the GIFT strain.

6.2 Impact on Institution

6.2.1 Training (HRD)

A total of six principal scientists and technical staff of the BFRI were involved in DEGITA-Bangladesh activities. In preparation for disseminating the GIFT strain, a total of 30 field level staff of the Department of Fisheries and NGOs and 30 fish farmers were trained on "GIFT tilapia culture and management" under the DEGITA project in Bangladesh. They were expected to conduct a similar training as a strategy to fast track the promotion, dissemination and adoption of GIFT strain in Bangladesh.

In China, a total of 14 principal scientists and technical staff were involved in the maintenance, multiplication and distribution of GIFT strain from 6 different agencies, namely, Shanghai Fisheries University, National Tilapia Seed Farm of Qingdao, Aquatic Seed Farm of Huzhou, National Tilapia Seed Farm of Guangdong, Fisheries Extension Station of Jiaoshou (Qingdao), and Fisheries Extension Station of Guangdong.

As DEGITA project is viewed as an extension of the GIFT project in the Philippines, the technical staff of BFAR, CLSU-FAC, NGOs and fish farmers were given sufficient training on all aspect of GIFT strain broodstock management and culture under the training component of the GIFT project.

At least five principal scientist and technical staff of the DOF-NAGRI were involved in the implementation of DEGITA activities in Thailand. In addition, a total of 25 Fisheries Biologists of the Department of Fisheries (DOF) were trained on "Culture and broodstock management of improved tilapia breeds" in preparation for the widespread dissemination of the GIFT strain in Thailand under the DOF-DEGITA program of activities on 21 June 1996. At the farm level, 40 fish farmers were trained on "Culture of improved tilapia breeds".

A total of 11 (RIA No. 1- 4, RIA No. 2- 5, Hanoi Agricultural University- 2) principal scientists and technical staff implemented the DEGITA activities in Vietnam. They are encouraged to carry out further selective breeding work to improve tilapia productivity in Vietnam, with the government providing them the necessary support.

Through short training courses on genetics and economic analysis, field work (surveys and on-station/on-farm trials) and the free exchange of technical information between and among those involved in DEGITA activities, the principal scientists and technical staff were given the opportunity to upgrade their skills and knowledge, not only in tilapia genetics but also in other disciplines such as economics, sociology and ecology.

6.2.2 Cross-country collaboration

The DEGITA project, as an integral part of INGA, provided opportunities for exchange of scientific information among the aquaculture scientists (biological and social) and among collaborating countries as well as the transfer of not only the GIFT strain but also other fish species. For example, Bangladesh (BFRI), the Philippines (BFAR) and Thailand (NAGRI) recently received common carps from Vietnam (RIA No. 1) for research on carp breeding.

6.2.3 Multi-disciplinary spirit

As the implementation of the DEGITA project required a multi-disciplinary research team to understand fully the consequences of the transfer or dissemination of the GIFT strain, scientists in biological sciences, such as genetics and aquaculture, learned to interact with their counterparts in the social sciences, such as economics and rural sociology. In all DEGITA-participating countries, scientists have greater awareness and appreciation for working in a multi-disciplinary team as it provided them "new" perspective in pursuing their scientific interest.

6.3 Impact on Policy

All the collaborating institutions in the DEGITA-participating countries committed to establish their own national tilapia breeding programs using the GIFT strain as foundation stock in their effort to replicate the process of producing an improved strain to further boost tilapia production in their respective countries. Through a policy dialogue, DEGITA-collaborating institutions generated considerable support from government and non-government organizations to undertake massive reproduction of the GIFT strain for dissemination to fish farmers while they are in the process of developing their own genetically improved tilapia strains. In addition, the governments of all these countries are recognizing the importance of improved tilapia strain in increasing their overall aquaculture production, increasing availability of cheaper protein, improving nutrition in rural areas and increasing income of fish farmers.

Chapter 7. Recommendation and Future Implications

7.1 Review of Project Implementation

7.1.1 ADB review mission

A Review Mission (the Mission) from the Asian Development Bank (the Bank), composed of Mr. Zhou Weidong (Fisheries Specialist/Mission Leader) was fielded from 26-31 March 1996 in the Philippines and from 15-19 April 1996 in Thailand to: (i) conduct a review of the status of overall TA progress; and (ii) discuss with officials and the project coordinator of ICLARM, national project coordinators, scientists and fish farmer beneficiaries of the participating countries issues affecting TA implementation and measures required to be adopted by ICLARM and participating countries to accelerate progress of the project.

The findings of the Mission were discussed with the concerned officials and scientists of ICLARM at a meeting held at ICLARM's Headquarters on 23 April 1996. The following is a summary of the major findings and conclusion/recommendations of the Mission:

Major findings

The RETA has so far been implemented satisfactorily. All activities including distribution of genetically improved tilapia to five participating countries and evaluation of growth performance, socioeconomic and environmental impacts under the RETA program are being satisfactorily carried out as scheduled. The Project developed a unified methodology to evaluate the performance of genetically improved tilapia strains by integrating the disciplines of genetics, economics, sociology and environmental science. The research framework can be applied in studying the impact of agriculture/aquaculture technology during the technology development phase in different countries.

The preliminary on-station evaluation results have proven that the growth performance of the GIFT strain developed under RETA No. 5279 is better than all existing local tilapia strains in all five participating countries. The study also indicated that the GIFT strain has demonstrated a great potential to contribute to increase of fish productivity and income of fish farmers in participating countries. The positive evaluation results and active participation of national research groups and farm beneficiaries showed the need for further development of genetically improved tilapia, massive production of the improved tilapia and establishment of national tilapia breeding programs. However, the Mission noted that the Project has so far provided very limited information on the environmental impact evaluation of the improved tilapia strain due to limited time inputs. Therefore, the Mission requested ICLARM to provide adequate guidance to participating countries on the environmental study to generate more information on the environmental impact of the improved tilapia strain (GIFT) on local ecosystems.

The Mission participated in a training workshop held in Los Baños, Philippines, on the analysis of socioeconomic, environmental and genetic data analysis. The technical staff and economists of five participating countries attended the training workshop. The workshop has improved the analytical and data processing skills of national participants in the project. Under the Project, training on applied fish breeding and genetics and proper broodstock management were effectively conducted. About 50 national scientists and 100 local technicians and fish farmers have so far received the training.

The Mission considers that the RETA has been implemented satisfactorily. All research activities were carried out as planned. There are no major issues identified by the Mission which are affecting the project implementation. The initial results of the evaluation of the genetically improved tilapia appear promising and encouraging. The Mission is confident that the Project will be successfully completed on schedule and the objectives of the Project will be achieved. The Bank will continue to closely monitor the progress of the Project, send representative to attend the final regional workshop to review the final outcomes of the RETA and provide necessary assistance to facilitate the successful completion of the Project.

7.1.2 In-house Review at ICLARM

The DEGITA project provided ICLARM an opportunity to re-examine its strategies in working in research partnership with the National Aquatic Research Systems (NARS) in Asia. Experiences of the DEGITA Project were discussed and reviewed in an in-house review held at ICLARM on 18th January 1997.

Experiences/Lessons learned

All collaborating institutions and scientists that participated in the DEGITA project have provided their "best" in terms of resources and expertise for the successful implementation of project activities in their respective countries. As in any research cum development project, however, several difficulties were encountered in the implementation of DEGITA activities.

Wrong perception/attitude of collaborators: Although all collaborators were in agreement with the significance of the DEGITA project for their aquaculture development, particularly in the tilapia industry, some perceived the project as an external one and not part of their national program. In other words, DEGITA was not their project but ICLARM's project in their country. At the level of researchers, most perceived it as an opportunity to advance their professional careers, though some did not. Hence, considerable effort and resources were wasted to establish the right perception concerning the DEGITA project.

Lack of human resources at NARS: In all DEGITA-participating countries, members of the research team came mainly from an institute or agency identified in the proposal stage of the project, mostly dealing with biological research on fisheries/aquaculture. As the DEGITA project required a multi-disciplinary team to implement its activities, most of the collaborating institutions lacked expertise in the field of social sciences, ecology/environmental science and data management.

Inability to attract expertise from other National Institutes: The lack of required human resources was aggravated by the inability of the lead institutes to attract expertise from other national institutes. Despite the "best" effort of DEGITA national project leaders, they failed to recruit experts in social science, ecology/environmental science and data management, especially in Bangladesh and Thailand. Other than those committed prior to the launching of the project, most of the experts from other institutes were expecting pecuniary benefits which the Project found difficult to provide due to a limited budget. This situation forced ICLARM scientists and staff to take substantial responsibilities, especially in the assessment of the socioeconomic and environmental impacts of the introduction of improved tilapia species in these countries.

Management of financial resources: All collaborating institutes in the DEGITA project spent in accordance with the approved budget items. ICLARM and some of the collaborating institutes, however, have encountered problems on how to prioritize the budget. For example, it was not possible to buy existing secondary data on household expenditure/consumption (products of household and income expenditure surveys) in some participating countries, though the data set was necessary for analyzing the impact of the GIFT strain.

Success factors: Excellent leadership of the national leaders of the collaborating institutions and continued strong support from the Bank and ICLARM management brought about the successful implementation of DEGITA activities. ICLARM is highly commending the active participation of Mr. Weidong Zhou, ADB Fishery Specialist, in closely monitoring the activities of DEGITA and providing the necessary adjustment and focus of the project milestones.

Implications

In future implementation of collaborative research activities like the DEGITA project, the following issues need to be considered. At the project/program level, care should be taken during project planning to account for the following: 1) human resources of the collaborating institutions; 2) inter-institute relationship within the collaborating country; 3) leadership of the project leader and commitment of scientists or researchers; and 4) explicit and detailed budget/financial plan. In addition, participation of students (possible graduate level) and junior researchers may be encouraged, without compromising project output, as most senior researchers have difficulty in devoting adequate time to the project.

At the Center level (ICLARM), there is a need to develop research programs matching the research priority of NARs with that of ICLARM so as to avoid conflict during project implementation. Also, ICLARM must initiate the training of junior NARS scientists through graduate programs for the Center to have warm bodies not only in its existing research activities but also for the future.

7.1.3 Review of DEGITA activities in INGA meetings

Progress of the DEGITA project was presented and reviewed during the second and third Steering Committee Meetings of the International Network on Genetics in Aquaculture (INGA) held in India (1995) and in Egypt (1996), respectively. Encouraged by the outcome of the DEGITA project, six carp-producing Asian members of INGA (Bangladesh, China, India, Indonesia, Thailand and Vietnam) agreed to have similar research collaboration on carps.

7.2 Future Research/Policy Implications

The research program of ICLARM and its partners has demonstrated the enormous gains in economic performance of farmed tilapia that are possible from a systematic selection program. All evidence indicates that the GIFT fish is superior to other existing strains of tilapia used in Asia, and has a higher yield potential. Analysis also indicates that the GIFT strain will benefit both producers and consumers and it may be virtually scale-neutral (i.e., small scale as well as large scale operators can benefit). However, it is important to recognize that the establishment of a research base necessary for the rapid development of a tilapia industry in Asia has just began.

As per capita income and population are increasing in Asia and as the supply of fish from capture fisheries is decreasing, demand for freshwater fish like tilapia is increasing at a rapid pace. In order to reduce, if not eliminate, this demand-supply gap, the research community needs to make further progress in increasing and sustaining the productivity of tilapia farming in the near future. It is important to realize that GIFT fish include new, good genes for future breeding programs and, they are the starting point for GIFT-base national breeding programs (with or without other genetic material). In order to sustain the present achievement in genetic research, proper steps (institutional and technical) have to be taken to (i) have self-sustaining national tilapia breeding programs in various tilapia producing Asian economies and (ii) maintain the integrity of the improved strain. Research on appropriate husbandry practices, nutrition, production of mono sex population, and the environment are clearly needed

These research needs are being address by various groups in the region, mostly public and development organizations, though on a scale that may not yet match the pace of expansion in tilapia farming. Unfortunately, fish breeding and other associated research appears to have come of age when overall funding from public sources to agricultural research has been declining. It is, therefore, imperative that the public sector build appropriate alliances with the private sector.

It is also essential to recognize that the final outcome of any technological improvement depends equally on policy and institutional environments within which it is introduced. Appropriate government policies should aim at ensuring an incentive structure that reflects the true social opportunity cost of resource use in tilapia culture. It is likely that the market will fail to allocate resources efficiently in the tilapia sector in the presence of externalities (e.g. pollution of aquatic environment, displacement of existing fish species or loss of fish biodiversity, etc.) and absence of perfect market conditions. Under such conditions, government interventions are necessary in providing public goods (research, extension and infrastructure) and access to information and inputs (e.g., credit, availability of quality fry/fingerlings during the early stage of adoption, etc.) to "get the price right".

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Table 1. Record of tilapia germplasm disseminated to different DEGITA-participating countries from the Philippines.

Recipient Country	Institution	Date	Details of Germplasm	No. of fingerlings (pcs.)
Bangladesh	Bangladesh Fisheries Research Institute (BFRI), Mymensingh	(1) July 1994	GIFT strain III generation selection	1,000
		(2) August 1996	GIFT strain V generation selection	413
People's Republic of China	Shanghai Fisheries University (SFU), Shanghai	(1) June 1994	GIFT strain III generation selection	4,000
		(2) September 1994	(a) GIFT strain II generation selection	1,000
			(b) Egypt strain	4,000
Thailand	National Aquaculture Genetic Research Institute (NAGRI), Bangkok	(1) October 1994	GIFT strain III generation selection	2,000
		(2) February 1996	GIFT strain IV generation selection	8,000
Vietnam	Research Institute for Aquaculture No. 1 (RIA No. 1), Hanoi	(1) May 1994	(a) GIFT strain II generation selection	1,050
			(b) Egypt strain	1,100
	Research Institute for Aquaculture No. 2 (RIA 2), Ho Chi Minh City	(2) January 1996	GIFT strain IV generation selection	8,000

Table 2. On-station sites and their characteristics in each of the DEGITA-participating country.

Country	Name of Station & Place	Agro-ecological Zones
Bangladesh	1) Fisheries Research Institute, Mymensingh	warm humid tropics
China	1) Shanghai Fisheries University, Shanghai	warm cool humid subtropics
	2) Guangzhou National Tilapia Seed Farm Guangdong	warm cool humid subtropics
	3) Huzhou Aquatic Seed Farm, Huzhou, Zhejiang Province	warm cool humid subtropics
	4) Jinzhou National Tilapia Seed Farm, Qingdao, Shandong	warm arid and semiarid subtropics
	5) Taipinghu Reservoir, Anhui	warm subhumid subtropics
Thailand	1) Kampangphet Inland Fisheries Station	warm subhumid tropics
	2) Nakhonpanom Inland Fisheries Station	
	3) Surin Fisheries College	
	4) Pitsanulok Genetic Center	
Vietnam	1) Research Institute for Aquaculture No. 1 (RIA No: 1)	warm humid tropics
	2) Research Institute for Aquaculture No. 2 (RIA No: 2) Ho Chi Minh City	

Table 3. Sites for baseline surveys and the samples for each site in the DEGITA-participating countries.

Country/Province/ District	Socioeconomic survey	Traders' survey	Consumers' survey
Bangladesh	86	34	28
Manikgonj	15	4	6
Mithapukur	15	12	6
Comilla	13		
Jessore	14	4	6
Paikgacha	14	5	5
Mymensingh	15	9	5
China	90		92
Zheijiang	31		32
Shandong	35		22
Guangdong	20		21
Anhui	4		17
Philippines	128	45	36
Iloilo	13	7	4
Laguna	12	3	4
Pampanga	8	3	4
Pangasinan	11	3	1
Bulacan	10	3	3
Tarlac	10	3	1
Nueva Ecija	18	6	3
Rizal	9	1	4
Batangas	6	3	2
Albay	4	1	2
Camarines Sur	8	3	2
South Cotabato	8	2	2
Davao del Norte	8	3	3
Negros Occidental	3	4	1
Thailand	80	40	80
Nakhon Pathom	20	10	20
Suphan Buri	20	10	20
Nakhon Phanom	20	10	20
Chiang Mai	20	10	20
Vietnam	137		221
Hai Phong	20		39
Nam Ha	20		40
Ha Noi	20		35
Ho Chi Minh City	25		35
Song Be	27		37
Tien Giang	25		35

Table 4. Selected socioeconomic indicators of the DEGITA-participating countries.

Item	Bangladesh	China	Philippines	Thailand	Vietnam
Population (million)					
1995	116.9	1,204.9	70.3	59.4	74.0
Population growth rate 1990-95 (%)	1.8	1.2	2.5	1.2	2.2
Per capita GNP (Us $)					
1993	220	490	850	2110	170
1994	230	530	960	2210	190
1994/1993 (%)	4.5	8.2	12.9	4.7	11.8
Per capita fish					
Consumption/annum (kg)	9.00	16.66	32.00	28.95	14.32
Tilapia	-	0.20	1.70	1.55	0.21
Others	-	16.46	30.30	27.40	14.11
Tilapia (%)	-	1.2	5.3	5.4	1.5
Others (%)	-	98.8	94.7	94.6	98.5
Economically active population in agriculture in 1994 (%)					
Female	84.9	76.1	30.5	39.7	72.6[a]
Male	54.4	69.2	52.8	43.1	69.1
Population in poverty[1]	1985/86	1990	1994	1988	1992/93
Total (%)	51.6	8.6	41.3	43.2d	51.0
Urban (%)	56	0.4	28.8	27.8	27.0
Rural (%)	51	11.5	53.7	49.3	57.0
Income ratio of highest 20 percent to lowest 20 percent (1989-94)	4.2	7.3	10.6	8.8	5.5
Gini coefficient	0.3	0.3	0.5	0.5	0.4[2]

- Data not available

[a]Year = 1985.

[1]Based on the concept of an "absolute" poverty line, expressed in monetary terms, i.e., the income or expenditure level below which a minimum nutritionally adequate diet plus essential non-food requirements are not affordable.

[2]Source: Deininger and Squire, 1996

Source: ADB, 1996

Table 5. World, Asia and DEGITA-participating countries aquaculture production (000 mt), 1984-1994.

Year	World	Asia	Bangladesh	China	Philippines	Thailand	Vietnam
1984	10414	8726	117	4093	495	112	119
1985	11189	9370	124	4504	512	136	130
1986	12296	10349	134	5048	488	128	133
1987	13203	11110	150	5705	578	174	141
1988	14581	12375	155	6659	613	219	143
1989	15160	12880	163	7274	649	260	151
1990	15710	13336	170	7518	692	292	155
1991	17346	14790	178	8676	718	353	178
1992	19825	17446	230	10763	765	371	190
1993	22816	20422	253	13278	799	457	195
1994	25490	22928	270	15377	814	519	205
Growth rate (%)							
1984-89	7.84	8.15	6.95	11.91	5.88	17.02	4.45
1990-94	12.42	14.07	12.78	18.57	4.31	14.11	6.46
1984-94	8.53	9.24	8.26	12.88	5.60	15.83	5.42

Source: FAO, 1996

Table 6. Wholesale price (US$/kg) of major fish species in the Philippines, 1987-1992.

Fish species	1987	1988	1989	1990	1991	1992
Milkfish	1.12	1.14	1.46	1.55	1.67	1.86
Grouper	1.39	1.61	2.09	-	-	2.76
Tilapia	0.77	0.70	-	-	-	1.41
Frigate tuna	0.68	0.67	0.81	-	-	0.98
Roundscad	0.68	0.66	0.83	0.81	0.85	0.86
Cavalla	1.16	1.30	1.55	-	-	2.08
Slipmouth	0.68	0.78	0.98	0.91	0.90	0.77
Threadfin bream	0.92	0.95	1.14	1.15	1.34	1.35
Indian mackerel	0.85	0.88	1.15	1.05	1.18	1.23

Source: Fishery Statistics (1983-1992), Bureau of Agricultural Statistics, Philippines.

Table 7. Farm prices (US$/kg) of freshwater fish in Thailand, 1987-1992.

Fish species	1987	1988	1989	1990	1991	1992
Batrachian walking catfish (*Clarias batrachus*)	0.99	1.18	1.11	1.22	1.16	1.26
Gunther's walking catfish (*Clarias macrocephalus*)	1.64	1.72	1.50	1.48	1.44	1.33
Striped snake-head (*Ophicephalus striatus*)	1.17	1.30	1.24	1.47	1.62	1.80
Tilapia (*Oreochromis niloticus*)	0.36	0.42	0.41	0.47	0.44	0.47
Striped catfish (*Pangasius sutchi*)	0.35	0.31	0.34	0.35	0.35	0.38
Thai silver carp (*Puntius gonionotus*)	0.61	0.64	0.51	0.69	0.72	0.73
Jullien's golden price carp (*Probarus jullieni*)	0.58	0.66	0.88			0.76
Common carp (*Cyprinus carpio*)	0.98	0.76	0.87	0.63	0.68	0.89

Source: Office of Agricultural Economics, Thailand

Table 8. Introduction of tilapia to China.

Species	Year	Origin	Number of fish	Culture status
O. mossambicus	1956	Thailand	-	Discarded
	1957	Vietnam	-	Discarded
O. niloticus	1978	Sudan	22	Widely cultured
		Egypt	-	Mixed with other strain
	1988	Egypt	9	Cultured in few area
	1991	USA	-	Kept in 3 stations
	1994	Philippines	5000	Gift strain under evaluation
			2000	Egypt strain under evaluation
O. aureus	1981	Taiwan	250	-
	1983	USA	33	Used for hybridization program; widely distributed
Red tilapia	1973	Israel	4100	-
S. galilaeus	1981	Africa	-	Kept in expt'l hatcheries
Tilapia zilli	1981	Africa	-	Kept in expt'l hatcheries

- Data not available.
Source: Tan and Tong (1989); Li (1996)

Table 9. Introduction of tilapia to the Philippines.

Species	Year	Origin	Agency
Oreochromis mossambicus	1950	Thailand	BFAR (*a)
O. hornorum x O. mossambicus	1971	Singapore	Private Sector
O. niloticus (Uganda)	1972	Israel	LLDA (*b)
O. niloticus (Egypt)	1972	Thailand	BFAR
Tilapia zillii	1973(?)	Taiwan (?)	?
O. aureus	1977	USA	CLSU (*c)
O. niloticus (Ghana)	1977	Israel	CLSU
O. niloticus (Ghana)	1977	Singapore	BFAR
O. aureus (Israel)	1977	Singapore	BFAR
O. aureus (Israel)	1978	Singapore	SEAFDEC (*d)
O. niloticus (Ghana)	1979	Singapore	SEAFDEC
O. niloticus (Ghana)	1979	Israel	SEAFDEC
Red tilapia (hybrid)	1979	Taiwan	SEAFDEC
Red tilapia	1981	Taiwan	Private Sector
O. aureus (Israel)	1982	Israel	Private Sector
O. niloticus (Ghana)	1982	Israel	Private Sector
Red tilapia	1982	Taiwan	Private Sector
O. niloticus	1983-84	Taiwan	Private Sector
O. niloticus (Egypt)	1987	Thailand	BFAR
O. niloticus	1988	Ghana, Africa	ICLARM (*e)/BFAR
O. niloticus	1988	Senegal	ICLARM/BFAR
O. niloticus	1988	Egypt	ICLARM/BFAR
O. niloticus	1989	Egypt	ICLARM/BFAR
O. niloticus	1989	Kenya	ICLARM/BFAR
O. niloticus	1992	Egypt	ICLARM/BFAR

*a. *Bureau of Fisheries and Aquatic Resources*
*b. *Laguna Lake Development Authority*
*c. *Central Luzon State University*
*d. *Southeast Asian Fisheries Development Center*
*e. *International Center for Living Aquatic Resources Management*

Source: Adapted from Aypa (1996)

Table 10. Tilapia production (t) and percent share in aquaculture production of DEGITA-participating countries and Asia, 1984-1994.

Year	China	Philippines	Thailand	Asia
1984	18,100	30,908	10,300	154,509
1985	23,800	42,640	16,542	190,617
1986	29,500	55,819	19,245	191,245
1987	34,800	75,769	17,456	230,154
1988	39,000	75,046	19,130	252,070
1989	89,473	81,675	21,509	297,754
1990	106,071	76,142	22,895	331,766
1991	119,852	76,570	27,800	352,295
1992	157,233	91,173	43,547	421,830
1993	191,257	96,339	54,114	483,924
1994	235,940	94,322	59,514	519,192
Growth rate[1]	27.84	7.84	14.57	12.15
	Percent share of tilapia in aquaculture production (excluding seaweeds)			
1984	0.45	8.96	9.20	1.83
1985	0.54	13.16	12.18	2.11
1986	0.61	17.86	14.99	1.94
1987	0.63	21.44	10.00	2.17
1988	0.60	20.94	8.73	2.14
1989	1.25	21.68	8.27	2.41
1990	1.45	19.14	7.85	2.62
1991	1.43	17.98	7.87	2.50
1992	1.52	22.19	11.74	2.56
1993	1.51	23.20	11.83	2.51
1994	1.60	23.31	11.46	2.40

[1] Estimated by fitting semi-logarithmic trend lines on three yearly moving average of the time series for the respective countries.
Source: FAO, 1996

Table 11. Tilapia exports by product of selected Asian countries to USA, 1995.

Country	Products						Total live weight equivalent[1]	
	Whole frozen		Fillets		Fillet frozen			
	Quantity (kg)	Price (US$/kg)	Quantity (kg)	Price (US$/kg)	Quantity (kg)	Price (US$/kg)	Quantity (kg)	Price (US$/kg)
China	245,318	1.27	2024	4.26	69,894	3.92	245,318	1.27
Indonesia	-	-	-	-	545,960	4.22	1,637,880	1.41
Taiwan	11,940,634	1.42	-	-	804,468	2.88	15,548,100	1.24
Thailand	39,667	1.00	-	-	423,644	2.86	2,892,045	0.94
Vietnam	10,929	0.74	-	-	-	-	12,022	0.67
Total US import	13,300,340	1.42	1,463,513	2.46	2,167,692	1.88	53,226,696	1.4

[1]Live Weight Equivalent = whole fish weights are multiplied by a factor of 1.1, and fillet weights are multiplied by 3.0.
Source : American Tilapia Association (1996)

Table 12. Overview of policy changes in the fertilizer sector of selected Asian countries.

Country	Year of initiation of policy changes	Restrictions in fertilizer trade	Production capacity owned by the gov't. (%)	Fertilizer trade operated by the gov't (%)	Pricing policy	Subsidies
Bangladesh	1978	Import controlled by State-designated trading companies	100	0	Ex-factory price set by government	None since 1973
Philippines	1986	5 percent excise duty on fertilizer manufacture in the country	77	50	No intervention	None since 1992
Thailand	1990	No restriction	0	0	No intervention	None

Source: FADINAP, 1994. Agrochemical News in Brief, various issues, ESCAP/FAO/UNDP

Table 13. Domestic retail prices of fertilizer in comparison with world prices, 1993.

Market	Price of fertilizer (US $/ton)				Domestic production of fertilizer as a percent of consumption 1990-1991)		
	Urea	Triple super phosphate	Diammonium phosphate	Muriate of potash	N	P	K
International market							
FOB	129	150	145	108	-	-	-
C & F	163	178	190	132	-	-	-
Domestic market							
Bangladesh	103	195	-	163	107	24	0
Thailand	202	-	-	-	0	0	0
Philippines	187	-	267	196	48	190	0

Sources of basic data: FAO and Social Science Division, IRRI

Table 14. Incentives for fishery industry promotion, Thailand.

Condition	Incentive
1. Aquatic animal feeds industry and fish/shrimp culture, with minimum 60 percent Thai shareholding and with over 2 and 1 million Baht investment capital, respectively	50 percent import tax reduction for machinery that are obliged to pay more than 10 percent import tax; income tax reduction for 200 percent of actual cost paid for transportation, water and electricity; and 25 percent of investment cost for installation of water and electrical supplies deductible from net benefits
2. Seafood canning industry, with minimum 60 percent Thai shareholding for export only and over 10 million Baht investment capital	Exemption from import tax of raw materials for 5 years; 50 percent reduction on import tax for machinery; corporate income tax exemption granted for 6 years and 50 percent reduction for the next 5 years; and reduction of transportation, water and electricity supply and installation costs as in 1.
3. Shrimp processing (boiled or fried) with minimum 50 percent Thai shareholding, 95 percent export and over 5 million Baht investment capital	Same incentives as in 2.
4. Aquatic animals processing (ground fish meal), with minimum 60 percent Thai shareholding and over 1 million Baht investment capital	Same incentives as in 2.
5. Cold storage, with 60 percent Thai shareholding and over 5 million Baht investment capital	50 percent tax exemption on machinery as in 1 but no exemption granted for paying corporate income tax .

Source: Nambiar 1991a

Table 15. National aquaculture research expenditure in selected Asian countries.

Year	Country	Research Expenditure	
		Actual (US $000)	As Percentage of value of production (%)
1980	Philippines	1051.5	2.50
	Taiwan	917.2	0.48
	Thailand	520.0	1.00
1986	Bangladesh	492.6	0.26
	Philippines	1903.7	0.47
	Taiwan	2322.8	0.77
	Thailand	936.0	0.60
1987	Bangladesh	704.4	0.29
	Philippines	1805.0	0.43
	Taiwan	3536.7	0.84
	Thailand	1088.0	0.44
1988	Bangladesh	778.8	0.24
	Philippines	2045.6	0.36
	Taiwan	3633.9	0.85
	Thailand	1548.0	0.36

Sources: Fisheries Research Institute, Bangladesh; Department of Fisheries, Thailand; Davy 1993

Table 16. Nominal and real exchange rates (against US$) of Bangladesh, the Philippines and Thailand, 1981-1992.

Year	Bangladesh		Philippines		Thailand	
	Nominal	Real	Nominal	Real	Nominal	Real
1981	17.99	26.34	7.90	14.82	23.00	21.65
1982	22.12	30.56	8.54	15.43	23.00	21.83
1983	24.62	32.09	11.11	18.84	23.64	22.33
1984	25.35	31.18	16.70	19.65	27.16	26.53
1985	28.00	32.22	18.61	18.42	26.30	25.97
1986	30.41	32.10	20.39	20.40	25.72	25.40
1987	30.95	30.95	20.57	20.57	25.29	25.29
1988	31.73	30.18	21.10	20.18	25.70	25.74
1989	32.27	29.24	21.74	19.42	25.58	25.49
1990	34.57	30.56	24.31	20.06	25.52	25.30
1991	36.60	31.45	27.48	19.91	25.40	24.83
1992	38.95	33.06	25.51	17.48	25.50	24.66
C.V.(percent)	19.87	5.45	33.09	9.79	4.88	6.53
Growth rate(percent)	5.95	0.65	10.70	1.67	0.76	1.13

Sources of basic data: FAO and Social Science Division, IRRI

Table 17. Socioeconomic profile of fish farmers in DEGITA-participating countries, 1996.

Characteristic	Bangladesh	China		Philippines		Thailand	Vietnam
	Pond	Pond	Cage	Pond	Cage	Pond	Pond
Age (year)	40	43	40	47	46	44	48
Gender (percent)							
Male	97	100	96	95	94	71	87
Female	3		4	5	6	29	13
Education (year)	6	5	6	6	7	5	7
Primary occupation (percent)							
Fish farming	-	77	13	23	92	11	37
Crop farming	44			48	4	54	32
Animal husbandry	1			1	-	19	25
Others	55	23	87	28	4	16	6
Fish farming experience							
<3 years	a	69	87	20	13	40	35
>3 years	a	31	13	80	87	60	65
Household size (no.)	5	4	3	5	6	5	5

a= Data not available.
Source: DEGITA Field Surveys, 1996

Table 18. Sources and their shares to household income of fish farmers in DEGITA-participating countries, 1996.

Source	Bangladesh	China		Philippines		Thailand	Vietnam
	Pond	Pond	Cage	Pond	Cage	Pond	Pond
Fish farming	4	73	52	30	60	14	39
Crop farming	27	5	4	19	8	5	31
Animal husbandry	11	a		33	1	76	21
Others	59	21	44	18	31	5	9
Total	100	100	100	100	100	100	100

a= Less than 1 percent.
Note: Figures in the parenthesis are percent share to total income.
Source: DEGITA Field Surveys, 1996

Table 19. Land use and general characteristics of fish farms in the DEGITA-participating countries, 1996.

Item	Bangladesh	China		Philippines		Thailand	Vietnam
	(Pond/ditch)	Pond	Cage	Pond	Cage/pen	Pond	Pond
Total area (ha)	0.60	1.58	0.09	4.91	1.26	3.79	0.68
Crop land (percent)	80.0	12.0	77.8	45.8	38.1	55.7	64.7
Fish farm (percent)	8.3	86.7	22.2	30.8	42.9	27.7	14.7
Garden (percent)	5.0			13.6	5.6	4.7	19.1
Others (percent)	6.7	1.3		9.8	13.4	11.9	1.5
Fish farm area by tenure (percent)							
Owned	96	9	24	75	99	99	56
Bidden		48	43				37
Rented-in	4	43	22	25	1	1	7
Others			11				
Type of operation							
Private/family	57	38	36	87	71	100	57
Partnership/Joint	43	62	64	13	29		43

Source: DEGITA Field Surveys, 1996

Table 20. Physical characteristics of fish farms.

Item	Bangladesh	China		Philippines		Thailand	Vietnam
	(Pond/ditch)	Pond	Cage	Pond	Cage/pen	Pond	Pond
Size of fish farm	0.05	1.37	0.02	1.51	0.54	1.05	0.10
Water depth (unit) ha. (m)							
Dry season/low	0.2	1.4	1.6	0.9	4.2	1.2	0.9
Wet season/high	0.6	1.8	1.6	1.3	5.6	1.8	1.4
Distance of fish farm from the house (m)	13	1493	1059	565	1300	272	188

Source: DEGITA Field Surveys, 1996

Table 21. Tilapia farming and production disposal practices of fish farmers in DEGITA-participating countries, 1996.

Practices	Bangladesh	China		Philippines		Thailand	Vietnam
	Pond/ditch	Pond	Cage	Pond	Cage/pen	Pond	Pond
Type of culture (percent)							
Monoculture (tilapia)	2	21	100	100	100	8	13
Polyculture	98	79				92	87
Stocking density (fish/100m^2)							
Monoculture (tilapia)		231	14200	359	6757		
Polyculture	387	292				317	1064
Tilapia (percent)	2	50				57	25
Chinese carps (percent)	43	31				a	32
Indian carps (percent)	42					21	24
Silver barb (percent)	11					4	a
Others (percent)	2	19				18	19
Size of tilapia at stocking (g)	5.4	41	88	0.97	1.60	0.59	3.53
Culture duration of tilapia (month)	7	7	5	5	5	8	8
Size of tilapia at harvest (g)	111	334	460	130	175	232	241
Total production (kg/100m2)	17.4	41.1	5665.0	35.6	540.0	43.1	30.2
Consumption (percent)	49	6	3	1	1	2	11
Marketable surplus (percent)	20	94	97	97	97	98	88
Given away (percent)	31			2	2		1

[a] Included in others.
Source: DEGITA Field Surveys, 1996

Table 22. Costs and returns of fish farmers in DEGITA-participating countries, 1996.

Item	Bangladesh	China	Philippines	Thailand	Vietnam
A. Pond: monoculture (1 ha)		n=13	n=80		
Gross returns (US $)		7569	5565		
Yield (kg/ha)		5860	3559		
Cash costs ((US $))		4465	2144		
Stock		1263	269		
Rice bran		1318	200		
Commercial feed		929	1051		
Manure		36	113		
Fertilizer			147		
Lime		3	49		
Pesticide		1	39		
Land rent		737	162		
Others		177	115		
Net Return (cash costs) or					
Net Return (labor/mgt/cap)		3104	3421		
Cash cost/kg of fish (US $)		0.76	0.60		
B. Pond: polyculture (1 ha)	n=86	n=48		n=12	n=137
Gross returns ((US $))	1531	8344		10239	2132
Yield (kg/ha)	1736	6593		6290	3020
Cash costs ((US $))	273	4347		2843	811
Stock	192	1298		916	391
Rice bran	22	674		57	79
Commercial feed		1123		1450	62
Manure		127		35	132
Fertilizer	7				3
Lime	11	30		69	
Land rent		863		11	
Electricity		157		175	
Equipment rental		26		10	
Others	40	48		121	144
Net Return (cash costs) or					
Net Return (labor/mgt/cap)	1258	3997		7395	1321
Cash cost/kg of fish (US $)	0.16	0.66		0.45	0.27
c. Cage: monoculture (100 sq.m)		23	48		
Gross returns ((US $))		10284	853		
Yield (kg/100 sq.m)		5613	540		
Cash costs ((US $))		6138	329		
Stock		2252	106		
Commercial feed		3219	222		
Land rent		383			
Equipment rental		193			
Others		91	1		
Net Return (cash costs) or					
Net Return (labor/mgt/cap)		4146	524		
Cash cost/kg of fish (US $)		1.09	0.61		

Source: DEGITA Field Surveys, 1996

Table 23. Rank of major problems of fish farmers and their future involvement in tilapia farming.

Problems and Involvement	China		Philippines		Thailand	Vietnam
	Pond	Cage	Pond	Cage/pen	Pond	Pond
Major problems (rank)						
Biological and technical						
High fish mortality	4	6		5	4	
Fish diseases		5		10	5	2
Poor seed quality/slow growth		10	9	1		4
Lack technical assistance/ management expertise	9		6		6	3
Small fish at harvest			8	6	7	
Harvesting difficulty	10					
Overgrowth of weeds					10	
Natural and environmental						
Flood			5		2	5
Water quality/pollution				2	3	9
Drought	5	8	7		5	
Typhoon			10	2	9	
Cold	2	1		9		
Sulphur upwelling				4		
Social and economic						
Pond/cage vandalism					1	
Poaching			4		8	7
High prices of seeds	3			3	8	
Increasing cost of inputs	1	3	1	1		
High capital requirement	9		3	5		
High marketing cost	6	4				
Lack of credit	7			8		1
Water supply shortage			2		10	
Proliferation of tilapia farms	8	7				
Farm fragmentation						6
Limited market	6	2				10
Future involvement in tilapia farming						
Expand	22	25	46	20	27	
Continue/maintain	57	50	49	69	59	
Discontinue/shift	3	6	3	7	4	
Undecided/no response	18	19	2	4	10	

Source: DEGITA Field Surveys, 1996

Table 24. Socioeconomic characteristics of tilapia hatchery operators, Philippines, 1994.

Characteristics	Number	Percentage
1. Age		
Young (<= 40 years)	12	31
Old (> 40 years)	27	69
Average (years)	52	
2. Educational attainment		
No education	2	5
Elementary	13	33
High school	8	21
College	16	41
Average (years)	10	
3. Tenure status		
Owner	36	92
Lessee	1	3
Share tenant	2	5
4. Years of experience		
Beginner (1-2 years)	3	8
Experienced (3-8 years)	12	31
Old-timer (> 8 years)	24	61
Average (years)	10	
5. Extent of occupational involvement		
Primary occupation	31	79
Full-time	22	56
Part-time	9	23
Secondary occupation	8	21
6. Income adequacy of hatchery operation		
Adequate	28	72
Not adequate	11	18

Source: BAS-ICLARM Field Survey, 1994

Table 25. Rank of household income sources and allocation of income from hatchery operations, Philippines, 1994.

Item	Rank
1. Income sources	
Hatchery	1
Crop/livestock farming	2
Business/trade/service	3
Salaried employment/wage labor	4
Fish culture (growout)	5
Remittance from abroad	6
Pension	7
Others	8
2. Income allocation on different expense items	
Food	1
Rice	(1)
Meat	(2)
Fish	(3)
Vegetable	(4)
Fruits	(5)
Education	2
Clothing	3
Medical	4
Re-investment in hatchery	5
Housing maintenance	6
Savings	7
Furniture/appliances	8
Others	9

Source: BAS-ICLARM Field Survey, 1994

Table 26. Gender participation in hatchery operations of household members of hatchery operators, Philippines, 1984.

Activities	Household members[1]		All
	Male	Female	
1. Tilapia seed production (%)			
0	-	74	-
1	46	21	39
2	26	-	20
>2	28	5	41
Average	2.00	0.36	2.36
2. Tilapia seed marketing (%)			
0	3	72	3
1	59	26	44
2	15	-	23
>2	23	2	30
Average	1.74	0.33	2.07
3. Other on-farm activities (%)			
0	69	82	59
1	26	18	33
2	3	-	3
>2	2	-	5
Average	0.41	0.18	0.59
4. Off-farm activities (%)			
0	82	85	80
1	10	3	3
2	5	5	3
>2	3	7	14
Average	0.28	0.49	0.77
5. Non-farm activities (%)			
0	72	74	56
1	23	15	31
2	-	3	5
>2	5	8	8
Average	0.33	0.49	0.82
Average household size (no.)	4.76	1.85	6.61

[1]Include hatchery operators.
Source: BAS-ICLARM Field Survey, 1994

Table 27. Source of technology, year of last training and subject matter, and subject of interest of tilapia hatchery operatiors, Philippines, 1994.

Item	Number	Percentage
1 Source of technology		
Friends/family members	11	28
GO-NGO technicians	18	46
Other tilapia operators	10	26
Self-learned	11	28
Formal education/training	3	8
2. Training		
No training	28	72
With training	11	18
Before 1986	3	27
1986-1990	2	18
1991-1994	6	55
3. Training coverage		
Hatchery production and management.	5	42
Tilapia breeding practices	8	67
Tilapia genetics	1	8
Marketing practices	3	25
4. Interest to attend (further) training		
No interest	13	33
With interest	26	67
Subject of interest:		
Feeds and feeding	1	4
Modern breeding technique	11	42
Growout production technique	11	42
Fishpond design	2	8
Economics of tilapia hatchery	1	4

Source: BAS-ICLARM Field Survey, 1994

Table 28. Sources, purposes and sufficiency of available credit for hatchery operators, Philippines, 1994.

Item	Number	Percentage
1. Source of credit		
Formal/non-formal sources	14	36
Relatives/friends	(4)	(10)
Bank	(4)	(10)
Private	(3)	(8)
Others	(3)	(8)
None	25	64
2. Purpose of credit		
Capital investment	2	14
Operating expenses	7	50
No response	5	36
3. Sufficiency of credit		
Sufficient	10	74
Insufficient	29	26

Source: BAS-ICLARM Field Survey, 1994

Table 29. Year of introduction, number of hatchery operators, encouragement factors, reasons for selecting site, source of water, and distance of the hatchery farm from the residence, major inputs and markets, Philippines, 1994.

Item	Number		Percentage
1. Year of introduction			
Before 1970	1		3
1970-75	11		28
1976-80	12		31
1981-85	10		25
1986-90	4		10
After 1990	1		3
2. Number of hatchery operators	Past	Present	Percent change
1-9	30 (77)	19 (49)	-37
10-19	6 (15)	3 (8)	-50
20-29	2 (5)	5 (13)	150
30 and above	1 (3)	12 (30)	1100
Average	5	30	500
3. Factors that made hatchery operation attractive			
Highly profitable	8		20
Access to training and extension services	7		18
Additional source of income	4		10
Ready market	4		10
Easy to manage	4		10
Construction of roads	3		8
Availability of hired labor/improved breed/transportation	3		8
Others	6		16
4. Reason for choosing site			
Proximity to residence	18		46
Only site available	14		36
Recommended/suitable site	8		20
Pollution free	7		18
Abundant supply of natural food	5		13
No need to buy the land	5		13
Not overcrowded	4		10
Others	8		20
5. Source of water			
Pump	18		46
Irrigation	9		23
Irrigation and pump	3		8
River	4		10
Spring/reservoir	3		8
Others	2		5
6. Average distance of farm (km)			
Residence	3		
Nearest market	17		
Source of inputs	10		

Source: BAS-ICLARM Field Survey, 1994

Table 30. Average effective area, number of hatchery operators, type of tilapia hatchery operation and source of broodstock, Philippines, 1994.

Item	Past	Present	Percent change
1. Effective area			
Owner	0.81	1.06	31
Lessee	1.50	2.00	33
Share tenant	0.90	0.90	0
Average area (ha)	0.84	1.07	27
2. Type of hatchery operation			
Pond with flowing water	9 (23)	8 (21)	-11
Pond with standing water	14 (36)	14 (36)	0
Pond/hapa with flowing water	6 (15)	6 (15)	0
Pond/hapa with standing water	10 (26)	11 (28)	10
3. Source of broodstock			
BFAR	21 (54)	15 (38)	-29
Private hatchery	15 (38)	12 (31)	-20
Others	3 (8)	12 (31)	300
4. Species/strain of broodstock used			
Nilotica (general)	39 (100)	39 (100)	0
Aurea	3 (8)	4 (10)	33
Israel	3 (8)	3 (8)	0
Israel/Aurea/Taiwan/Thailand	4 (10)	4 (10)	0
5. Broodstock ratio of male to female			
1:3	10 (26)	10 (26)	0
1:7	5 (13)	6 (15)	20
1:10	14 (36)	12 (31)	-14
Others	10 (25)	11 (28)	10
6. Average stocking density (fish/m^2)	0.84	0.91	8
7. Frequency of changing broodstock			
No response	1 (3)	1 (3)	0
As necessary	8 (20)	3 (8)	-62
Less than a year	8 (20)	11 (28)	38
Every year	19 (49)	20 (51)	5
Every 1.5 years	3 (8)	4 (10)	33
Average rearing period (day)[1]	41	39	-5

[1]One production cycle
Source: BAS-ICLARM Field Survey, 1994

Table 31. Production and marketing inputs utilization in tilapia hatchery operation per hectare per production cycle, Philippines, 1994.

Inputs	Per hectare		Percent cost
	Quantity	Cost (US $)	
1. Feed (kg)			
Commercial feed	1 261	827.90	44.64
Home-made feed		13.59	0.73
Rice bran	5 702	479.39	25.85
Copra meal	439	133.74	7.21
Soybean meal	256	117.44	6.33
Flour	128	88.09	4.75
Others	37	8.13	0.44
Sub-total		1668.28	89.95
2. Fertilizer (kg)			
Chicken manure	1 305	24.43	1.32
16-20-0	67	14.96	0.81
45-0-0	59	11.30	0.61
14-14-14	2	0.50	0.03
Sub-total		51.19	2.77
3. Miscellaneous items			
Pesticide	-	1.15	0.06
Lime	-	2.02	0.11
Electricity/light	-	10.42	0.56
Food for laborers	-	6.60	0.36
Permit/license fee	-	1.30	0.07
Land rent/lease fee	-	12.40	0.67
Sub-total		33.89	1.83
4. Marketing items			
Plastic/buri bag/bayong	-	45.42	2.45
Oxygen refill	-	16.37	0.88
Freight/transport	-	4.31	0.23
Gasoline/diesel/oil	-	32.40	1.75
Sub-total		98.50	5.31
5. Others	-	2.79	0.15
Grand total		1854.65	

Source: BAS-ICLARM Field Survey, 1994

Table 32. Labor and labor-related inputs in tilapia hatchery operation per hectare per production cycle, Philippines, 1994.

Item	Per hectare		Percent man-day	Percent cost
	Man-day	Cost (US $)		
A. Hired labor	48.61	174.97	41.03	43.31
Pond preparation				
Drying	3.27	10.92	2.76	2.70
Poisoning	0.57	2.21	0.48	0.55
Repairing dike	4.56	15.69	3.85	3.88
Water filling	4.04	11.95	3.41	2.96
Fertilization	0.47	1.45	0.40	0.36
Net/hapa preparation and installation	2.48	9.43	2.09	2.33
Procurement of broodstock	0.54	1.83	0.46	0.45
Stocking	0.92	3.17	0.78	0.78
Feeding	10.71	39.58	9.04	9.80
Cleaning nets	1.86	6.11	1.57	1.51
Guarding	13.54	52.90	11.43	13.10
Draining	0.95	3.24	0.80	0.80
Harvesting/grading	3.14	11.11	2.65	2.75
Marketing	1.56	5.38	1.32	1.33
B. Family labor	69.85	229.00	58.97	56.69
Pond preparation				
Drying	4.55	10.31	3.84	2.55
Repairing dike	2.06	7.21	1.74	1.79
Water filling	1.50	5.38	1.27	1.33
Fertilization	0.97	3.59	0.82	0.89
Net/hapa preparation and installation	2.18	7.18	1.84	1.78
Procurement of broodstock	2.38	8.28	2.01	2.05
Stocking	2.81	9.73	2.37	2.41
Feeding	17.69	56.03	14.93	13.87
Cleaning nets	1.45	5.00	1.22	1.24
Guarding	24.07	81.34	20.32	20.13
Draining	1.06	3.44	0.89	0.85
Harvesting/grading	4.83	16.56	4.08	4.10
Marketing	4.30	14.96	3.63	3.70
C. Total labor				
Pond preparation	118.46	403.97	100.00	100.00
Drying	7.82	21.23	6.60	5.25
Poisoning	0.57	2.21	0.48	0.55
Repairing dike	6.62	22.90	5.59	5.67
Water filling	5.54	17.33	4.68	4.29
Fertilization	1.44	5.04	1.22	1.25
Net/hapa preparation and installation	4.66	16.61	3.93	4.11
Procurement of broodstock	2.92	10.11	2.46	2.50
Stocking	3.73	12.90	3.15	3.19
Feeding	28.40	95.61	23.97	23.67
Cleaning nets	3.31	11.11	2.79	2.75
Guarding	37.61	134.24	31.75	33.23
Draining	2.01	6.68	1.70	1.65
Harvesting/grading	7.97	27.67	6.73	6.85
Marketing	5.86	20.34	4.95	5.04

Source: BAS-ICLARM Field Survey, 1994

Table 33. Capital investment (in pesos) in tilapia hatchery operation per hectare, Philippines, 1994.

Item	Average no. of units	Cost (US $)	Percent cost
1. Structure/Building			
Pond	14.93	21820.95	52.27
Caretaker's house	0.61	1664.73	3.99
Guard house	0.13	1367.14	3.27
Sub-total		24852.82	59.53
2. Equipment			
Pump/pump line	1	2542.21	6.09
Oxygen tank	1	379.69	0.91
Grader	0.74	158.17	0.38
Scoop net	3.67	101.64	0.24
Feeding tray	2.72	211.15	0.51
Tub/basin/pail	8.16	84.69	0.20
Cooler	0.15	15.65	0.04
Weighing scale	0.03	53.09	0.13
Sub-total		3546.29	8.5
3. Net/Pole			
Seine	0.87	425.92	1.02
Hapa	18.54	1342.48	3.22
Bamboo pole	23.67	441.95	1.06
Sub-total		2210.35	5.3
4. Transportation[1]			
Jeep	-	7787.10	18.65
Tricycle	-	2654.69	6.36
Banca	-	190.84	0.46
Sub-total		10632.63	25.47
5. Broodstock	8407	507.48	1.22
Total		41749.57	100

[1]Computation is based on per unit cost.
Source: BAS-ICLARM Field Survey, 1994

Table 34. Costs and returns per hectare per production cycle of hatchery operators, Philippines, 1994.

Item	Quantity	Value (US $)
Returns		
Gross production ('000 pcs)	748	6816.37
Cash cost		
Feed		1668.28
Commercial feed (kg)	1 261	827.90
Home-made feed (kg)		13.59
Rice bran (kg)	5 702	479.39
Copra meal (kg)	439	133.74
Soybean meal (kg)	256	117.44
Flour (kg)	128	88.09
Others (kg)	37	8.13
Fertilizer		51.19
Chicken manure (kg)	1 305	24.43
16-20-0 (kg)	67	14.96
45-0-0 (kg)	59	11.30
14-14-14 (kg)	2	0.50
Pesticide	-	1.15
Lime	-	2.02
Gasoline/diesel/oil	-	32.40
Electricity/light	-	10.42
Food for laborers	-	6.60
Permit/license fee	-	1.30
Land rent/lease fee	-	12.40
Plastic/buri bag/bayong	-	45.42
Oxygen refill	-	16.37
Freight/transport	-	4.31
Hired labor (man-day)	49	174.96
Others	-	2.79
Non-cash cost		
Family labor	70	229.00
Depreciation	-	246.18
Total cost		2504.79
Net farm income		4311.58

Source: BAS-ICLARM Field Survey, 1994

Table 35. Factor share to total value of fry/fingerlings production per hectare per production cycle of hatchery operators, Philippines, 1994.

Item	Value (US $)	Percent
Gross value of production	6816.37	
Current inputs (purchased)	1837.94	26.96
Capital	250.11	3.67
Owned	246.18	3.61
Hired	4.31	0.06
Labor	403.97	5.93
Family	229.00	3.36
Hired	174.96	2.57
Residual	4323.97	63.44
Land rent	12.40	0.18
Surplus	4311.56	63.25
Farm family income	4786.76	70.22

Source: BAS-ICLARM Field Survey, 1994

Table 36. Marketing/selling practices of tilapia hatchery operators, Philippines, 1994.

Item	Percentage
1. Place of sale	
Same barangay	23
Other town, same province	14
Other province, same region	12
Other region	6
Others	45
2. Mode of transport	
Jeepney	51
Pick-up/Truck	22
Boat	4
Others	23
3. Mode of sale	
Pick-up	52
Delivery	22
Others	26
4. Mode of payment	
Cash on delivery	71
Credit	15
Others	14
5. Price determination	
Operator	86
Buyer	4
Others	10

Source: BAS-ICLARM Field Survey, 1994

Table 37. Tilapia fingerling disposal as percentage of total production and source of price information of hatchery operators, Philippines, 1994.

Item	Percentage
1. Disposal method	
Used on-farm	8
Sold	88
Wholesaler	(20)
Retailer	(4)
"Agent"	(30)
Fishfarmer (direct)	(34)
Others	(12)
As allowance	4
2. Source of price information	
Word of mouth	49
BFAR	33
Middlemen/agent	10
Other operators	10
Prevailing price	8
Self-discretion/own-pricing	5
Others	14

Source: BAS-ICLARM Field Survey, 1994

Table 38. Problems in tilapia hatchery operation of sample respondents.

Problems	Percentage	Rank
1. Biological and technical		
High fry/fingerling mortality	54	1
Poor/Slow growth of fry/fingerlings	18	8
Predators	13	9
Obtaining good quality broodstock	3	17
2. Social and economic		
Increasing cost of inputs	49	2
Water-use conflict (shortage)	26	5
Poaching	21	6
High capital requirement	23	7
Low prices of fry/fingerlings	13	10
No buyers/market	5	13
Vandalism (net/pond destruction)	5	14
Proliferation of tilapia hatchery	3	15
Insecurity of tenure (land)	3	15
No government subsidy	3	15
High cost of water	3	16
Old age	3	16
3. Natural and environmental		
Frequent typhoon	41	3
Flood	29	4
Drought	10	11
Pollution (water)	8	12
Intrusion of salt water	5	13

Source: BAS-ICLARM Field Survey, 1994

Table 39. Farmers' perception of future involvement, encouragement and drop out factors in hatchery operation and willingness to try new breed/strain and as contact person on extension activities.

Item	Percentage
1. Future involvement in hatchery operations	
Expand	26
Continue	59
Discontinue	3
Expand but shift to other species	3
Undecided	10
2. Reasons for expansion:	
Profitable/good source of income/high demand	76
Easy to manage	10
Secured water supply	5
Access to technology	3
Availability of improved breed	3
Experience	3
3. Reasons for discontinuation:	
Old age	50
Lack of capital	25
Low price (fingerlings)/flood/typhoon	25
4. Willingness to try 'new' breed	
Willing	97
Not willing	3
5. Percentage of area to try 'new' breed[1]	
Below 50 percent	28
50 percent	28
100 percent	44
6. Willingness as contact on extension activities	
Willing	90
Not willing	10

[1]Average percent area = 66 percent.
Source: BAS-ICLARM Field Survey, 1994

Table 40. Household food and non-food expenditure in DEGITA-participating countries, 1996.

Expenditure item	Bangladesh	China	Philippines	Thailand	Vietnam
Total expenditure/annum (US$)	917	2859	4687	5160	594
H size	5.39	4.24	6.49	4.65	5.4
Food (percent)	73	37	42	29	57
Rice	40	6	9	5	30
Fish	11	7	11	2	8
Meat	3	6	9	5	8
Vegetable	6	4	2	1	a
Fruit	5	3	2	1	a
Egg	2	1	a	1	4
Others	6	10	9	14	7
Non-food (percent)	27	63	58	71	43
Housing (maintenance)	2	32	7	20	
Clothing	6	8	10	4	8
Health (medical)	3	2	5	5	6
Education	6	4	16	12	13
Social activity	7	5	4	6	10
Durable asset	b	8	4	11	
Others	2	4	12	13	6

[a] Food item included in other
[b] Non-food item included in other
Source: DEGITA Field Surveys, 1996

Table 41. Fish per capita consumption per annun in DEGITA-participating countries, 1996.

Fish consumption	Bangladesh[1]	China[2]	Philippines[2]	Thailand[1]	Vietnam[1]
A. Rural (producer)	n=10	n=41	n=7	n=27	n=137
Fish consumption/ annum (kg)	21.5	39.8	72.6	17.0	12.9
Tilapia	3.1	2.3	39.5	5.1	2.6
Carps/milkfish	6.5a	31.6a	2.3 b	1.3a	5.9a
Others	11.9	6.0	30.8	10.6	4.5
B. Rural (non-producer)	n=18	n=24	n=20	n=22	n=84
Fish consumption/ annum (kg)	21.2	24.1	39.7	18.7	15.4
Tilapia	3.7	5.6	15.9	5.8	3.4
Carps/milkfish	5.6 a	4.3a	7.1b	2.8a	7.1a
Others	11.9	14.2	16.7	10.2	4.9
C. Urban (non-producer)		n=27	n=9	n=31	
Fish consumption/ annum (kg)		40.0	33.9	20.0	
Tilapia		5.0	5.8	5.0	
Carps/milkfish		10.7a	3.2 b	2.4 a	
Others		24.2	24.9	12.6	
D. Total	n=28	n=92	n=36	n=80	n=221
Fish consumption/ annum (kg)	21.3	35.8	44.6	18.6	13.9
Tilapia	3.5	4.0	18.0	5.3	2.9
Carps/milkfish	5.9a	18.3 a	5.2 b	2.1a	6.3 a
Others	11.9	13.5	21.4	11.2	4.7

[1] Refers to consumption of freshwater fish species only.
[2] Refers to consumption of all available fish species.
a=carp and b=milkfish consumption.
Source: DEGITA Field Surveys, 1996

Table 42. Fish species and tilapia size preference of household in DEGITA-participating countries, 1996.

Item	Bangladesh	China	Philippines	Thailand	Vietnam
Fish preference (percent)					
Tilapia	7	29	65	30	15
Snakehead				43	
Mrigal				2	17
Ilish	54				
Rohu					16
Rui	32				
Grass carp		10			12
Milkfish			11		
Common carp		1		3	25
Crucian carp		12			
Hybrid catfish				21	
Mandarin		8			
Longtailed		8			
Mackerel		6			
Threadfin bream			5		
Others	7	26	19		15
No preference				1	
Tilapia size preference (percent)					
2-4 fish/kg	39	91	58	65	77
5-7 fish/kg	50	9	29	31	20
8-10 fish/kg	11		9	2	1
>10 fish/kg			3	1	
No preference				1	2

Source: DEGITA Field Surveys, 1996

Table 43. Monthly market transaction, costs and margins of fish traders in Bangladesh, Philippines and Thailand, 1996.

Item	Bangladesh	Philippines	Thailand
Gross sales (sold)			
Value (US $)	142	4326	4576
Quantity (kg)	99	2239	2996
Inventory (bought)			
Value (US $)	113	3624	3832
Quantity (kg)	99	2239	3139
Net sale (value)	29	702	744
Marketing cost (US $)	10[a]	102	103
Fish container			43.12
Permit		6.37	0.40
License	0.25	1.87	0.32
Shop rental	3.01	6.07	10.40
Electricity	1.89	2.10	0.68
Ice	2.54	19.81	39.92
Transport		13.78	1.04
Labor cost			
Hired		33.47	2.36
Family		2.25	4.72
Other cost	2.44	16.03	
Marketing margin	19	600	641
Margin/kg of fish	0.19	0.27	0.20

[a]Cost of labor (hired+family) is not included due to unavailability of data..
Source: DEGITA Field Surveys, 1996

Table 44. Comparative performance of GIFT and non-GIFT strains under on-station conditions in Bangladesh.

Parameter/Strain	Nursery	Growout				
	Hapa	Hapa	Cistern	Cage	Pond	
					1	2
Final weight						
GIFT	8.38	134.09	88.86	203.48	134.20	141.40
Thai	5.50	95.48	63.55	112.30	85.34	
Red tilapia						104.17
Mixed[a]						
GIFT				205.03		
Thai				122.20		
percent change						
GIFT/Thai	52.36	40.44	39.83	81.19	57.25	
GIFT/Red Tilapia						35.74
Mixed[a]						
GIFT/Thai				67.78		
Rearing period (day)	60	89	107	180	180	180

percent change = GIFT average wt / control average weight - 1 x 100
[a]GIFT and Thai strains were reared together in cages.
Source: DEGITA-Bangladesh on-station experimental data. 1995-1996

Table 45. Comparative performance of GIFT and non-GIFT strains under on-station conditions in China.

Parameter/systems/	Fingerling stage			One-year old				Two-year old		
strain	Qd	Hz	Gd	Qd	Hz	Gd	Sh	Qd	Hz	Gd
Average weight (g)										
Cage										
GIFT	0.78	6.19	2.10	74.2	30.8	67.2				
"78"	0.72	5.87		64.2	21.3					
"88"		4.61	1.72		21.8	79.3				
American	0.68			58.6						
Egypt	0.66									
Tank (1)										
GIFT				15.2			32.3			
"78"				13.2			35.4			
"88"							46.5			
American				15						
Tank (2,3)										
GIFT				294.2			76.1			
"78"				285.9			72.3			
"88"							94.5			
American				240.8						
Egypt				141.5						
Pond (1,2)										
GIFT					188.6	176.2		319.1	271.0	440.6
"78"					178.8			267.9		
"88"					172.1	167.1			243.5	405.0
Egypt					156.7					
percent Change										
Cage										
GIFT/"78"	8.3	5.5		15.6	44.6					
GIFT/ "88"		1.3	22.1		41.3	-15.3				
GIFT/American	14.7			26.6						
GIFT/Egypt	18.2									
Tank (1)										
GIFT/"78"				15.2			-8.8			
GIFT/ "88"							-30.5			
GIFT/American				1.3						
Tank (2,3)										
GIFT/"78"				22.5a			5.3			
GIFT/ "88"							-19.5			
GIFT/American				45.4a						
GIFT/Egypt				51.3a						
Pond (1,2)										
GIFT/"78"					5.5			19.1		
GIFT/ "88"					9.6	5.4			11.3	8.8
GIFT/Egypt					20.4					
Rearing period (day)										

percent change = GIFT average wt / control average weight - 1 x 100
[a]Estimated using the original values and not from the average of GIFT strain.
Note: Qd = Qingdao; Hz = Huzhou; Gd = Guangdong; and Sh = Shanghai
Source: DEGITA-China on-station experimental data, 1995-1996

Table 46. Comparative performance of GIFT and non-GIFT strains under on-station conditions in Thailand.

Parameter/Strain	1995		1996	
	Kamphaengphet	Nakhonpanom	Surin	Pitsanulok
Average weight (g)				
GIFT	113.44	121.56	143.87[a]	266.12[a]
Chitralada	58.70	86.15		
Chitralada I	149.59	88.16	159.37[a]	392.58[a]
GMT			157.99	261.94
percent change				
GIFT/Chitralada	93.25	41.10		
GIFT/Chitralada I	-24.12	37.89	-9.73	-32.21
GIFT/GMT			-8.94	1.60
Survival				
GIFT	76.38	64.07	53.33[a]	64.20[a]
Chitralada	88.30	48.93		
Chitralada I	83.26	68.92	38.33[a]	40.20[a]
GMT			43.33	52.40
Rearing period (day)	215	190	184	154

percent change = GIFT average wt / control average weight - 1 x 100

[a]Sex-reversed strain.

Source: DEGITA-Thailand on-station experimental data, 1995-1996

Table 47. Comparative performance of GIFT and non-GIFT strains under on-station conditions in Vietnam.

Parameter/strain	Nursery[a]			Growout[b]			
	RIA No.1		RIA No.2	RIA No. 1			RIA No.2
	1994	1995	1995	1994	1995	1996	1995
Ave. weight (g)							
GIFT	20.88	11.13	5.79	250.5	158.3	148.6	177.7
Egypt	19.53	11.39	4.84	206.1	133.2	123.0	144.3
Viet	18.73	13.99	5.97	223.8	149.7	126.4	166.0
Thai		13.58	6.20		137.8		180.8
percent Change							
GIFT/Egypt	6.91	-2.28	19.62	21.54	18.84	20.81	23.15
GIFT/Viet	11.48	-20.44	-3.02	11.93	5.74	17.56	7.05
GIFT/Thai		-18.04	-6.61		14.88		-1.71
Survival rate (percent)							
GIFT	93.6	90.0	97.7	70.5	64.0	66.0	78.0
Egypt	91.8	96.0	99.5	41.5	46.0	71.0	73.0
Viet	97.3	94.0	98.3	69.0	90.0	61.0	76.0
Thai		90.0	98.2		63.0		71.0
Rearing period (day)							

percent change = GIFT average wt / control average weight - 1 x 100

[a]Rearing was done in suspended hapas in ponds.

[b]Rearing was done in ponds.

Source: DEGITA-Vietnam on-station experimental data, 1995-1996

Table 48. Cross-country comparative performance of GIFT and non-GIFT strains under on-station conditions among DEGITA-participating countries.

Strain/ Parameter	Bangladesh		China		Thailand	Vietnam
	Pond	Cage	Pond	Cage	Pond	Pond
GIFT	n=4	n=6	n=13	n=4	n=3	n=10
Stocking density (fish/m^2)	2.0	5.0	1.5	200.0	1.0	1.4
Initial weight (g/fish)	6.7	10.0	20.4	1.9	4.2	9.4
Final weight (g/fish)	134.0	168.6	212.8	67.2	117.8	180.1
Protein [feed] (g/fish)	100.9	53.9	231.2	159.5	0	93.0
Male proportion (percent)	33.5	54.8	53.1	47.5	52.2	50.6
Survival rate (percent)	95	95	78	84	68	69
Yield (kg/ha)	2545	8052	2872	112404	787	1664
Culture duration (days)	180	135	109	89	180	141
Non-GIFT	n=4	n=6	n=21	n=4	n=6	n=24
Stocking density (fish/m^2)	2.0	5.0	1.4	200.0	1.0	1.4
Initial weight (g/fish)	6.4	10.1	13.6	2.7	3.2	9.4
Final weight (g/fish)	85.5	103.9	186.3	79.3	93.6	155.4
Protein (g/fish)	55.1	34.2	287.3	211.7	0	142.3
Male proportion (percent)	34.0	45.3	56.9	48.3	64.9	53.7
Survival rate (percent)	90	92	82	69	68	67
Yield (kg/ha)	1539	4758	2268	105457	656	1449
Culture duration (days)	180	135	101	89	180	144
Mean difference						
Stocking density (fish/m^2)	0	0	0.1	0	0	-0.05
Initial weight (g/fish)	0.31	-0.13	6.84	-0.82	1.02	-0.04
Final weight (g/fish)	48.5***	64.7***	26.6	-12.1	24.2	24.7*
Protein (g/fish)	45.8***	19.7	-56.1	-52.2	0	-49.3*
Male proportion (percent)	-0.5	9.5*	-3.8	-0.8	-12.7**	-3.1
Survival rate (percent)	5.0	3.8*	-3.5	14.5	0.27	2.6
Yield (kg/ha)	1.0a***	3.3a***	604	6947	130	216
Culture duration (days)	0	0	8	0	0	-3
percent Change						
Stocking density (fish/m^2)	0	0	7.4	0	0	-3.55
Initial weight (g/fish)	4.9	-1.3	50.3		32.4	-0.43
Final weight (g/fish)	56.7	62.3	14.3	-15.2	25.9	15.9
Protein (g/fish)	83.2	57.5	-19.5	24.5	0	-34.6
Male proportion (percent)	-1.47	21	-6.7	-1.6	-19.6	-5.7
Survival rate (percent)	5.6	4.2	-4.3	21.7	0.4	3.9
Yield (kg/ha)	65.4	69	26.6	6.6	19.9	14.9
Culture duration (days)	0	0	7.9	0	0	-2.1

[a]Yield in t/ha

percent change = GIFT / control - 1 x 100

Source: DEGITA on-station experimental data, 1995-1996

Table 49. Percentage change in average weight at harvest and survival due to GIFT strain in another ponds; results of on-station experiments, 1994 -1996.

Country	Average Weight	Survival
Bangladesh	+42.09	NS
China	NS	NS
Thailand	+35.17	NS
Vietnam		
GIFT : 2nd generation selection	NS	NS
GIFT : 4th generation selection	+40.52	NS

Note : NS - not statistically significant.
Source: DEGITA on-station experimental data, 1995-1996

Table 50. Comparative performance of GIFT and non-GIFT strains under on-farm conditions in Bangladesh.

Parameter	Pond		
	GIFT	Non-GIFT (Thai)	Percent change
	n=23	n=21	
Stocking density (fish/m^2)	2	2	0
Initial fish weight (g)	3.35	2.99	12.04
Final fish weight (g)	107.61	60.65	77.42
Proportion of male (percent)	40.34	38.33	5.24
Survival rate (percent)	74.35	74.14	0.28
Yield (kg/ha)	1590	900	76.67
Rearing period (day)	174	173	0.15

Source: DEGITA-Bangladesh on-farm trial data, 1995-1996

Table 51. Comparative performance of GIFT and non-GIFT strains under on-farm conditions in China.

Parameter	Cage		Pond			Tank	
	GIFT	GIFT/78 (percent)	GIFT	GIFT/ Hybrid (percent)	GIFT/ 88 (percent)	GIFT	GIFT/ Hybrid (percent)
	n=10	n=10	n=7	n=3	n=4	n=2	n=2
Stocking density (fish/m²)	133.33	0	2.02	-13.43	8.62	24.40	0
Initial fish weight (g)	52.20	-2.82	16.43	1871[a]	-38.24	0.64	-20.00
Final fish weight (g)	307.98	16.75	245.62	46.73	-5.63	27.29	23.49
Proportion of male (percent)	56.20	0.18	49.62	-34.13	-10.05	51.50	-23.13
Survival rate (percent)	94.56	6.84	91.84	-1.57	-0.12	96.44	3.09
Yield (kg/ha)	389346	25.21	4645	16.00	3.74	6151	28.71
Rearing period (day)	111	0	127	4.91	-3.39	99	0

[a]Average initial weight of hybrid strain used was only 0.83 g.
Source: DEGITA-China on-farm trial data, 1995-1996

Table 52. Comparative performance of GIFT and non-GIFT strains under on-farm conditions in the Philippines.

Parameter	Cage			Pond		
	GIFT	Non-GIFT	Percent change	GIFT	Non-GIFT	Percent change
	n=5	n=5		n=58	n=50	
Stocking density (fish/m²)	21.39	21.39	0	2.40	2.14	12.07
Initial fish weight (g)	6.33	6.33	0	0.76	0.76	0
Final fish weight (g)	161.08	135.37	18.99	66.96	52.13	28.44
Proportion of male (percent)	55.41	55.87	-0.83	48.17	46.87	2.77
Survival rate (percent)	68.31	58.51	16.75	69.99	55.19	26.83
Yield (kg/ha)	23551	15285	54.08	1361	912	49.37
Rearing period (day)	118	118	0	126	127	-0.79

[a]Survival rate of Thai strain was only 18.6 percent.
Source: DEGITA-Philippines on-farm trial data, 1995-1996

Table 53. Comparative performance of GIFT and non-GIFT strains under on-farm conditions in Thailand.

Parameter	Pond		
	GIFT	Local	Percent change
	n=13	n=2	
Stocking density (fish/m²)	4.92	6.25	-21.00
Initial fish weight (g)	1.22	2.14	-42.75
Final fish weight (g)	119.63	80.15	49.25
Proportion of male (percent)	69.62	65.00	7.10
Survival rate (percent)	47.60	40.17	18.51
Yield	2829	2044	38.45
Rearing period (day)	250	256	-2.24

[b]percent change in weight of fish corrected with the initial weight.
Source: DEGITA-Thailand on-farm trial data, 1995-1996

Table 54. Comparative performance of GIFT and non-GIFT strains under on-farm conditions in Vietnam, 1996.

Parameter	Pond		
	GIFT	Thai	Percent change
	n=7	n=6	
Stocking density (fish/m²)	2.04	2.00	2.14
Initial fish weight (g)	1.31	1.01	29.49
Final fish weight (g)	69.55	53.46	30.10
Proportion of male (percent)	52.29	52.67	-0.72
Survival rate (percent)	47.77	45.86	4.18
Yield	743	558	33.11
Rearing period (day)	152	139	9.92

Source: DEGITA-Vietnam on-farm trial data, 1995-1996

Table 55. Cross-country comparative performance of GIFT and non-GIFT strains under on-farm conditions among DEGITA-participating countries.

Strain/Parameter	Bangladesh	China			Philippines		Thailand	Vietnam
	Pond	Cage	Pond	Tank	Cage	Pond	Pond	Pond
GIFT	n=23	n=10	n=7	n=2	n=5	n=58	n=13	n=7
Stocking density (fish/m^2)	2.0	133.3	2.0	244.1	21.4	2.4	4.9	2.00
Initial weight (g/fish)	3.4	55.2	16.4	0.6	6.3	0.8	1.2	1.3
Final weight (g/fish)	107.6	308.0	245.6	27.3	161.1	67.0	119.6	69.6
Protein [feed] (g/fish)	42.7	152.6	109.8	12.7	47.2	37.1	29.2	2.8
Male proportion (percent)	40	56.	50	52	55	48	70	52
Survival rate (percent)	74	95	92	96	68	70	47.6	70
Yield (kg/ha)	1593	389a	4645	6151	23551	1361	2829	743
Culture duration (days)	174	111	127	99	118	126	250	152
Non-GIFT	n=21	n=10	n=7	n=2	n=5	n=50	n=2	n=6
Stocking density (fish/m^2)	2.0	133.3	2.1	244.1	21.4	2.1	6.3	2.04
Initial weight (g/fish)	3.0	56.8	15.6	0.8	6.3	0.8	2.1	1.0
Final weight (g/fish)	60.7	263.8	220.5	22.1	135.4	52.1	80.2	53.5
Protein (g/fish)	36.1	157.8	103.9	12.9	52.1	45.0	4.1	2.7
Male proportion (percent)	38	56	64	67	56	47	65	53
Survival rate (percent)	74.	89	93	94	58	55.2	40.2	46
Yield (kg/ha)	896	311a	4275	4779	15285	912	2044	558
Culture duration (days)	173	111	127	99	118	127	256	139
Mean difference								
Stocking density (fish/m^2)	0	0	0.1	0	0	0.3	-1.3**	-0.4
Initial weight (g/fish)	0.4	1.6*	0.9	-0.2	0	0	-0.9	0.3
Final weight (g/fish)	47.0***	44.2***	25.2	5.2	25.7	14.8***	39.5	16.1
Protein (g/fish)	6.6	-5.2	5.9	-0.2	-4.7	-7.9	25.2	0.1
Male proportion (percent)	2.***	0	-14**	-16	-1	1	4.6	0.4
Survival rate (percent)	0	6***	-1	2	10	14.8***	7.4	2
Yield (kg/ha)	697***	78a***	370	1372	8266	448	786	185
Culture duration (days)	0.2	0	0	0	0	-1	-6	13
percent Change								
Stocking density (fish/m^2)	0	0	-2	0	0	12	-21	2
Initial weight (g/fish)	12.2	-2.8	5.6	-20.0	0	2.8	-42.8	29.5
Final weight (g/fish)	77.4	16.8	11.4	23.5	19.0	28.4	49.3	30.1
Protein (g/fish)	18.4	-3.3	5.65	-1.4	-9.0	-17.5	620.3	3.5
Male proportion (percent)	5.3	0.2	-22.2	-23.1	-0.8	2.8	7.1	-0.7
Survival rate (percent)	0.3	6.8	-0.8	3.1	16.6	26.8	18.5	4.2
Yield	77.9	25.2	8.7	28.7	54.1	49.1	38.5	33.1
Culture duration (days)	0	0	0	0	0	-0.7	-2.2	9.9

[a]Yield in t/ha.

Source: DEGITA on-farm trial data, 1995-1996

Table 56. Percentage change in average weight at harvest and survival due to GIFT strains; results of on-farm trials, 1995-1996.

Country	Culture System	Average Weight	Survival
Bangladesh	Pond	+66.45	NS
China	Pond/Cage	+18.48	+3.28
Philippines	Pond	+36.80	+12.76
Thailand/Vietnam	Pond	+32.35	NS

Note : NS - not statistically significant.
Source: DEGITA on-farm trial data, 1995-1996

Table 57. Relative production cost (mono culture) of tilapia farming in DEGITA-participating countries, 1996.

Item	Bangladesh Pond (ha)	China Cage (100m2)	China Pond (ha)	Philippines Cage (100m2)	Philippines Pond (ha)	Thailand Pond (ha)	Vietnam Pond (ha)
Gift:							
Gross returns (US$)							
Value	1434	7124	5992	373	2123	2405	609
Yiled (kg)	1593	3893	4645	236	1361	2829	743
Cash costs (US $)	463	4191	3548	168	1385	1510	427
Fry/fingerling	75	2222	1399	33	183	286	325
Commercial feed		1968	2149	135	1032	918	
Rice bran	375				88	161	48
Fertilizer							
Organic	13				22	69	54
Inorganic					60	76	
Non-Gift:							
Gross returns (US$)							
Value	806	5693	5515	242	1423	1737	458
Yield (kg)	896	3111	4275	153	912	2044	558
Cash costs (US $)	405	4191	3523	168	1375	1517	411
Fry/fingerling	75	2222	1428	33	163	286	318
Commercial feed		1968	2095	135	1033	877	
Rice bran	316				102	220	46
Fertilizer							
Organic	15				25	57	48
Inorganic					51	76	
percent Change (GIFT/Non-GIFT)							
Yield	77.8	25.1	8.7	54.2	49.2	38.4	.33.2
Cash cost	14.3	0	0.7	0	0.7	-.0.5	3.9
Cost/kg	-35.7	-20.1	-7.3	-35.2	-32.5	-28.0	-22.0

Source: DEGITA on-farm trial data, 1996

Table 58. Actual and potential yield of GIFT and non-GIFT strains under pond culture system.

Country	Initial body weight (gm/fish)	Production cycle (days)	Protein applied (kg/ha/cycle)	Potential yield (kg/ha)	
				Non-GIFT	GIFT
Bangladesh	3.18	174	712	1488	2928
China	16.00	127	1923	4368	7952
Philippines	0.76	126	733	976	1808
Thailand	1.34	250	516	1888	3440
Vietnam	1.17	146	52	1824	2800

Note : Stocking density = 2 fish/m^2
Survival rate = 80%
Source: DEGITA on-farm trial data, 1996

Table 59. Yield gap II for GIFT strain under pond culture system.

Country	Potential yield (kg/ha)	Actual yield (kg/ha)	Yield Gap II (kg/ha)
Bangladesh	2928	1776	1152
China	7952	4832	3120
Philippines	1808	976	832
Thailand	3440	1920	1520
Vietnam	2800	1568	1232

Note : Stocking density = 2 fish/m^2
Survival rate = 80%
Source: DEGITA on-farm trial data, 1996

Table 60. Different fish sub-sectors in different DEGITA participating countries.

Country	Sub-Sectors				
	1	2	3	4	5
Bangladesh	Tilapia	Carps	Livefish	Ilish	Others
China	Tilapia	Carps	Crustaceans/ molluscs	Other high value	Other low value
Philippines	Tilapia	Milkfish	Crustaceans/ molluscs	Other high value	Other low value
Thailand	Tilapia	Carps	Crustaceans/ molluscs	Other high value	Other low value
Vietnam	Tilapia	Carps/other freshwater	Crustaceans/ molluscs	Marine	

Table 61. Uncompensated own price elasticity of demand for fish by species and income groups.

Income Group	Species Group			
	Ilish	Live	Big	Small
		Rural		
1st Quartile	-1.09	-1.25	-0.92	-1.10
2nd Quartile	-1.18	-1.35	-1.58	-1.05
3rd Quartile	-1.21	-1.37	-2.03	-1.03
4th Quartile	-1.22	-1.35	-1.96	-1.02
		Urban		
1st Quartile	-1.14	-1.53	-1.81	-0.98
2nd Quartile	-1.17	-1.41	-2.65	-0.95
3rd Quartile	-1.18	-1.41	-2.25	-0.94
4th Quartile	-1.21	-1.34	-2.02	-0.93

Table 62. Income elasticity of demand for fish by species and income groups.

Income Group	Species Group			
	Ilish	Live	Big	Small
		Rural		
1st Quartile	1.82	1.87	1.17	1.48
2nd Quartile	1.30	1.48	0.99	1.00
3rd Quartile	1.00	1.15	0.80	0.75
4th Quartile	0.69	0.79	0.59	0.51
		Urban		
1st Quartile	1.18	2.04	1.60	0.89
2nd Quartile	0.85	1.23	1.36	0.60
3rd Quartile	0.67	0.95	0.93	0.45
4th Quartile	0.46	0.58	0.57	0.28

Table 63. *Ex ante* indicators of direct impact of GIFT technology.

Country	% increase in av. wt.	% increase in survival rate	% increase in yield	% increase in price due to bigger fish	Overall technologies index (%)	Technological index at national and farm level			
						Scenario I (low adoption)		Scenario II (high adoption)	
						Farm	National	Farm	National
Bangladesh	67	0	67	20	100	50	20	40	25
China	18	3	24	8	34	20	8	15	10
Philippines	37	13	62	13	82	40	15	30	20
Thailand	32	0	32	10	46	25	8	20	10
Vietnam	32	0	32	10	46	25	10	20	12

Table 64. Changes in the prices of tilapia production due to the adoption of the GIFT strain.

Country	Technical change scenario	Base (US $)	After technical change (US $)	Percent change
Bangladesh:	I	0.90	0.78	-13.39
	II	0.90	0.75	-16.14
China:	I	1.55	1.44	-6.99
	II	1.55	1.42	-8.60
Philippines:	I	1.76	1.56	-11.30
	II	1.76	1.50	-14.50
Thailand:	I	1.04	0.97	-6.49
	II	1.04	0.96	-7.98
Vietnam:	I	0.67	0.64	-5.12
	II	0.67	0.63	-6.07

Table 65. Changes in the profitability of fish production per farm due to adoption of GIFT strain(1996 price).

Country	Technical change scenario	Adoptor			Non-Adoptor		
		Base (US$)	After technical change (US $)	Percent change	Base (US$)	After technical change (US $)	Percent change
Bangladesh:	I	74	78	5.76	74	72	-2.30
	II	74	70	-5.19	74	67	-9.54
China	I	5770	7278	26.14	5770	4986	-13.59
	II	5770	6070	5.19	5770	5565	-3.55
Philippines	I	4052	7452	83.93	4052	2881	-28.89
	II	4052	4739	16.96	4052	3485	-13.98
Thailand	I	3943	4420	12.10	3943	3788	-3.94
	II	3943	4231	7.30	3943	3753	-4.80
Vietnam	I	94	108	14.82	94	92	-2.00
	II	94	99	5.55	94	93	-1.26

Table 66. Changes in fish production at the national level due to the adoption of the GIFT strain.

Country	Technical change scenario	Fish group	Base (000mt)	After technical change (000mt)	Percent change
Bangladesh	I	All species	1091	1092	0.09
		Tilapia	5	6	21.89
		Others	1086	1086	-0.01
	II	All species	1091	1092	0.12
		Tilapia	5	6	27.41
		Others	1086	1086	-0.01
China	I	All species	20719	20747	0.14
		Tilapia	236	255	8.03
		Others	20483	20492	0.05
	II	All species	20719	20754	0.17
		Tilapia	236	260	10.04
		Others	20483	20495	0.06
Philippines	I	All species	2067	2086	0.91
		Tilapia	113	131	15.88
		Others	1954	1955	0.05
	II	All species	2067	2092	1.21
		Tilapia	113	137	21.20
		Others	1954	1955	0.06
Thailand	I	All species	1994	2007	0.68
		Tilapia	90	98	8.35
		Others	1903	1909	0.32
	II	All species	1994	2010	0.85
		Tilapia	90	100	10.44
		Others	1903	1911	0.39
Vietnam	I	All species	1150	1152	0.15
		Tilapia	15	17	12.23
		Others	1135	1135	-0.01
	II	All species	1150	1152	0.18
		Tilapia	15	17	14.69
		Others	1135	1135	-0.01

Table 67. Changes in fish production per farm due to the adoption of the GIFT strain.

Country	Technical change scenario	Fish group	Adoptor			Non-Adoptor		
			Base (kg)	After technical change (kg)	Percent change	Base (kg)	After technical change (kg)	Percent change
Bangladesh	I	All species	92	101	9.27	92	92	-0.23
		Tilapia	15	25	67.93	15	14	-5.33
		Others	77	75	-2.16	77	78	0.77
	II	All species	92	99	7.12	92	92	-0.29
		Tilapia	15	22	49.73	15	14	-6.47
		Others	77	76	-1.18	77	78	0.91
China	I	All species	8086	9561	18.24	8086	8005	-1.00
		Tilapia	6446	8169	26.73	6446	6208	-3.69
		Others	1640	1392	-15.11	1640	1797	9.60
	II	All species	8086	9119	12.78	8086	7987	-1.22
		Tilapia	6446	7585	17.67	6446	6154	-4.54
		Others	1640	1535	-6.42	1640	1833	11.80
Philippines	I	Tilapia	5000	7821	56.42	5000	4709	-5.81
	II	Tilapia	5000	6839	36.77	5000	4629	-7.43
Thailand	I	All species	4239	5058	19.32	4239	4196	-1.02
		Tilapia	2614	3535	35.22	2614	2526	-3.37
		Others	1625	1523	-6.25	1625	1670	2.77
	II	All species	4239	4857	14.57	4239	4186	-1.25
		Tilapia	2614	3291	25.91	2614	2506	-4.13
		Others	1625	1565	-3.68	1625	1680	3.39
Vietnam	I	All species	287	312	8.58	287	287	-0.06
		Tilapia	76	104	36.42	76	74	-2.72
		Others	211	208	-1.45	211	213	0.90
	II	All species	287	306	6.67	287	287	-0.07
		Tilapia	76	97	27.39	76	74	-3.22
		Others	211	209	-0.80	211	213	1.06

Note: Scenario I - Early adoption; low adoption but high productivity improvement for adoptor
Scenario II - Late adoption; high adoption but low productivity improvement for adoptor

Table 68. Changes in the fish consumption per household of fish producers and consumers due to technical change.

Country	Technical change scenario	Fish group	Adoptor			Non-adoptor			Consumers: National average			Consumers: Sampled consumers		
			Base (kg)	After technical change (kg)	Percent change	Base (kg)	After technical change (kg)	Percent change	Base (kg)	After technical change (kg)	Percent change	Base (kg)	After technical change (kg)	Percent change
Bangladesh	I	All species	109	115	5.25	109	109	0.35	45	45	0.11	107	108	0.81
		Tilapia	12	14	19.58	12	14	15.67	1	1	17.65	19	22	14.47
		Others	97	100	3.47	97	96	-1.55	44	44	-0.29	88	86	-2.14
	II	All species	109	111	2.15	109	110	0.50	45	45	0.11	107	111	3.40
		Tilapia	12	15	20.92	12	14	19.50	1	1	17.65	19	23	19.95
		Others	97	97	-0.18	97	95	-1.86	44	44	-0.29	88	88	-0.17
China	I	All species	199	199	-0.24	199	197	-1.09	71	71	-0.07	90	90	-0.11
		Tilapia	11	12	6.55	11	12	6.00	1	1	6.52	19	20	3.74
		Others	188	187	-0.63	188	185	-1.51	70	70	-0.15	71	70	-1.14
	II	All species	199	198	-0.28	199	196	-1.32	71	71	-0.06	90	90	-0.12
		Tilapia	11	12	8.18	11	12	7.55	1	1	8.43	19	20	4.63
		Others	188	187	-0.77	188	185	-1.84	70	70	-0.16	71	70	-1.39
Philippines	I	All species	330	347	5.24	330	229	-30.61	192	192	0.11	207	210	1.80
		Tilapia	148	164	10.33	148	122	-18.01	10	12	15.84	35	41	16.01
		Others	182	184	1.09	182	107	-40.90	182	180	-0.78	171	169	-1.13
	II	All species	330	353	6.93	330	208	-36.92	192	193	0.44	207	212	2.44
		Tilapia	148	169	13.66	148	115	-22.26	10	12	21.41	35	43	21.38
		Others	182	184	1.42	182	93	-48.90	182	180	-0.74	171	169	-1.47
Thailand	I	All species	142	144	1.38	142	137	-3.37	145	146	0.65	133	135	1.84
		Tilapia	28	30	6.89	28	29	2.66	8	9	7.72	24	26	7.64
		Others	114	114	0.03	114	108	-4.85	137	137	0.24	109	110	0.56
	II	All species	142	144	1.72	142	136	-4.07	145	146	0.72	133	136	2.09
		Tilapia	28	30	8.60	28	29	3.38	8	9	9.56	24	26	9.38
		Others	114	114	0.03	114	107	-5.90	137	137	0.20	109	110	0.49
Vietnam	I	All species	69	69	0.07	69	69	-0.51	72	72	0.08	81	81	0.08
		Tilapia	14	15	10.50	14	15	10.00	1	1	9.71	17	19	10.52
		Others	55	54	-2.58	55	53	-3.18	71	71	-0.06	64	62	-2.69
	II	All species	69	81	18.00	69	68	-0.87	72	72	0.13	81	81	0.26
		Tilapia	14	18	27.71	14	16	11.79	1	1	12.62	17	19	12.76
		Others	55	64	15.53	55	53	-4.09	71	71	-0.06	64	62	-3.06

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Table 69. Household level economic surplus due to technical change.

Country	Technical change scenario	Adoptor (US $)	Non-Adoptor (US $)	Consumer (US $)	
				National average	Sampled consumers
Bangladesh	I	5.87	-0.17	0.13	2.45
	II	4.36	-2.08	0.16	3.05
China	I	1508.10	-850.60	0	1.25
	II	645.10	-1037.05	0	1.27
Philippines	I	3428.70	-1423.36	0.86	6.30
	II	1525.24	-1803.54	1.13	8.27
Thailand	I	610.82	-212.51	1.68	0.56
	II	368.59	-259.27	2.09	0.70
Vietnam	I	14.37	-1.50	0.06	0.52
	II	10.55	-1.76	0.07	0.62

Table 70. National level economic surplus due to technical change.

Country	Technical change scenario	Producer (US $)	Consumer (US $)	Total	% Share	
					Producer	Consumer
Bangladesh	I	420661	305222	725883	58	42
	II	514986	379525	894511	58	42
China	I	60789451	21636295	82425746	74	26
	II	75213499	26950480	102163979	74	26
Philippines	I	26474674	7886059	34360734	77	23
	II	34652090	10339814	44991904	77	23
Thailand	I	6838918	9864826	16703744	41	59
	II	8499515	12225114	20724629	41	59
Vietnam	I	1469424	884863	2354287	62	38
	II	1751932	1059597	2811530	62	38

Table 71. Tilapia consumption in non-producers' household by expenditure class.

Expenditure quartile	Monthly per capita tilapia consumption (kg)			Share of tilapia in total fish consumption (%)		
	China	Philippines	Thailand	China	Philippines	Thailand
1	0.09	0.69	0.33	18.25	25.52	17.46
2	0.48	1.07	0.59	33.66	25.18	39.41
3	0.44	1.67	0.36	26.98	35.29	25.62
4	0.27	1.58	0.32	21.75	44.95	20.49
5	0.20	4.76	0.32	18.34	53.33	20.69

Source : Consumption Survey

Table 72. Hired labor as percentage of total labor.

Country	Pre-Harvest	Harvest
Bangladesh	2	5
China	8	40
Philippines	51	56
Thailand	0.6	29
Vietnam		7

Source : Household Survey

Table 73. Influence of tilapia introduction on species in natural waters, Philippines.

Item	percent of farmers		Species
Displacement or reduction of existing fish species			
Yes (percent)		15.87	
Batangas	2.38		Freshwater mullet, freshwater sardines, freshwater goby
Bulacan	6.34		Catfish, carp, gourami, freshwater goby, snakehead
Laguna	5.56		Therapon, freshwater goby, shrimp
Davao del Norte	0.79		Catfish
South Cotabato	0.79		-
No (percent)		84.13	

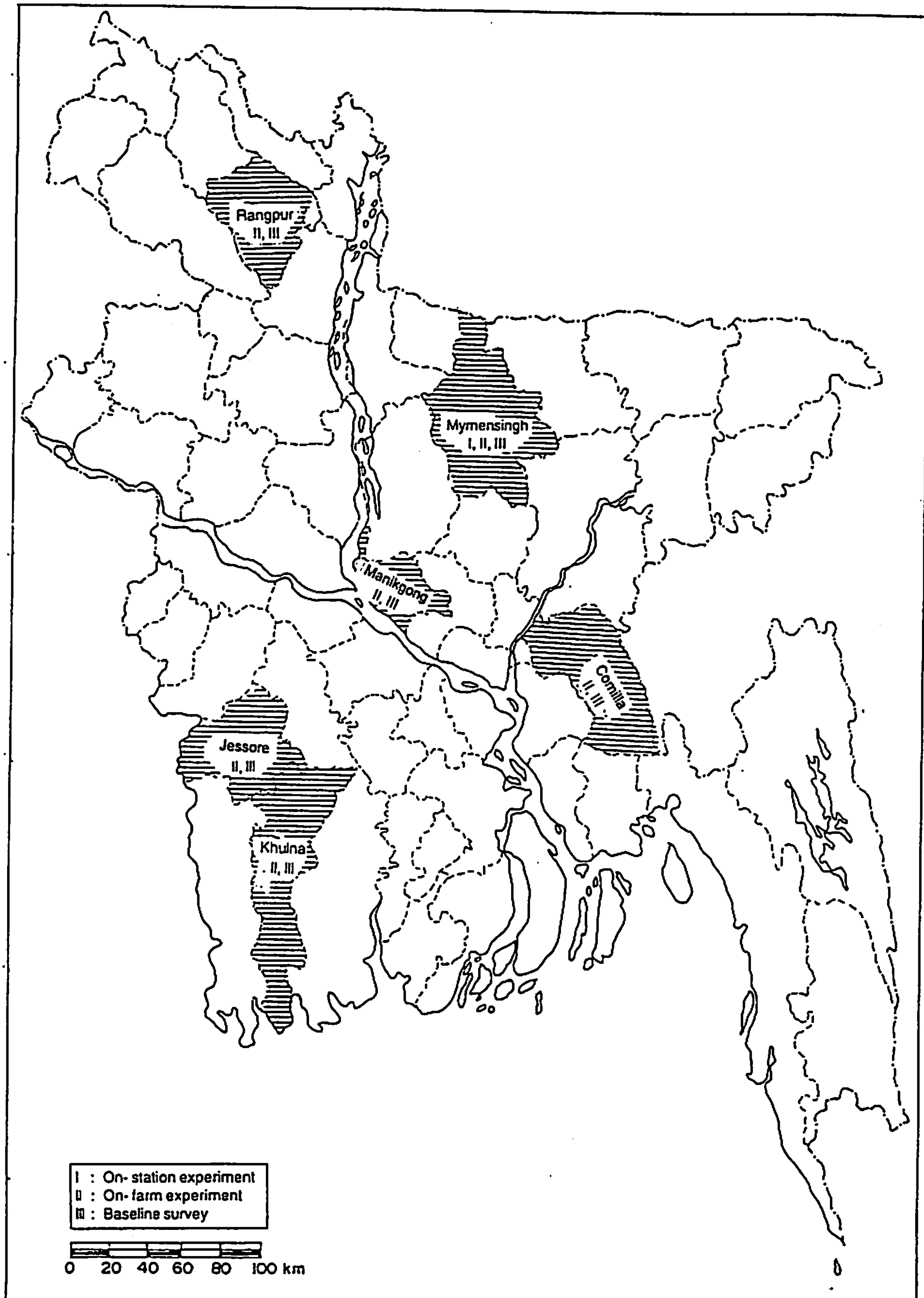
Source : Baseline Survey, 1995/1996

Table 74. Biological and ecological impact of tilapia Introduction in some lakes/reservoir of the Philippines.

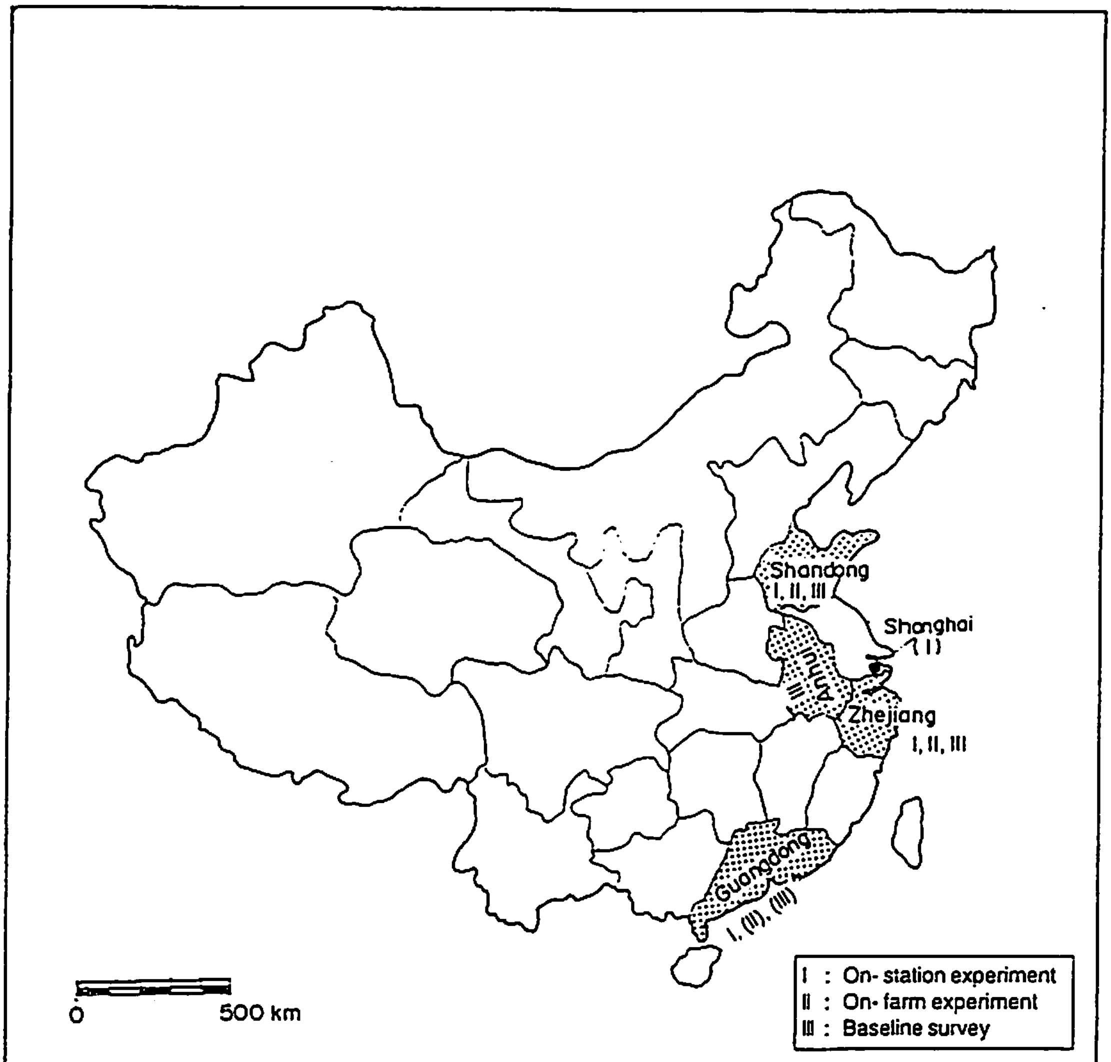
NAME OF BODY OF WATER/LOCATION	AREA (ha)	YEAR OF TILAPIA INTRODUCTION	AREA USED FOR AQUACULTURE (PERCENT)	POSITIVE IMPACT	NEGATIVE IMPACT
Laguna de bay (Laguna and Rizal Provinces)	89,076	1955	10	a) Augmented existing fish stock for open fishing b) Helped in the recovery of some native fisheries c) Increased production d) Tilapia dominated fish catch by 25-30 percent over other species	a) Decline of indigenous small gobies Mirogobius lacustris b) Competed with native species on food and space c) Organic load which makes water quality deteriorates
Sampaloc Lake (San Pablo, Laguna) Mohicap Lake (San Pablo, Laguna)	104 ?	1965 1972	70 10	a) Increased productivity of fish per unit space and time b) Augmented natural existing fish population	a) Organic load leading to gradual shallowing of the lake, and b) Water quality deterioration resulting to upwelling and fish kill
Taal Lake (Batangas)	24,356	1974	10	a) Augmented fish population b) Increased productivity of the lake	a) Alleged to cause the decline of a native species, Herengula tawilis b) Aquaculture activities may cause water quality deterioration if not regulated
Bato and Buhi Lakes (Camarines Sur)	5,592	1974 and 1995	60	a) Increased fish production and productivity of the lake	a) Decline in population of a goby species known as the "smallest" commercial fish in the world" Mystychthis luzonensis b) may overpopulate the lake
Lake Sebu (South Cotabato)	354	1974	70	a) Increased productivity of the lake	a) Organic load resulting to gradual shallowing poor water quality, and upwelling resulting to fish kill
Pantabangan Reservoir (Nueva Ecija)	8,000	1974	<1	a) Increased reservoir productivity for fisheries	a) Loss of some native species with less commercial value like gourami

Source: Rapid Rural Appraisal, 1997.

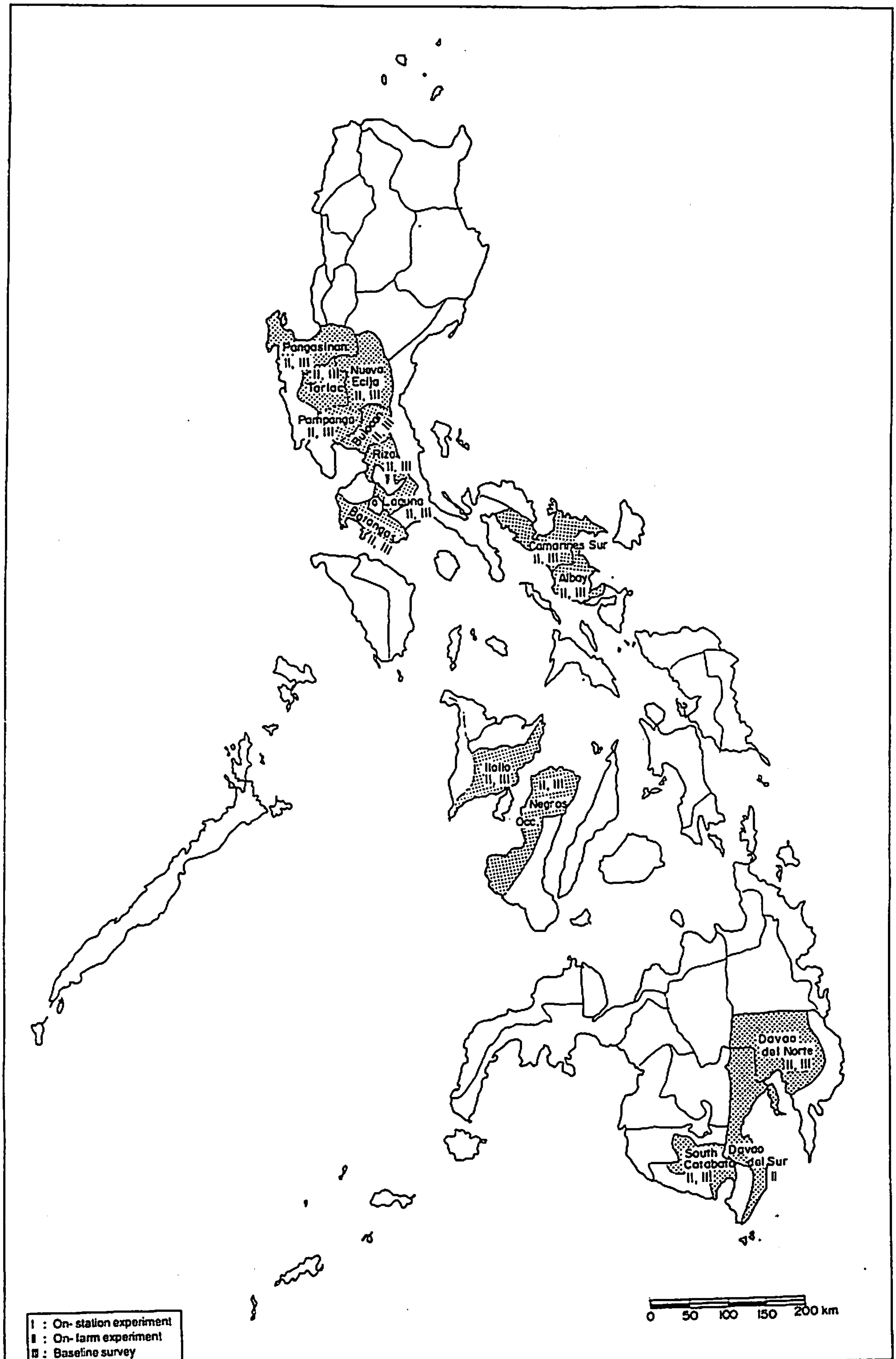
MAPS and FIGURE



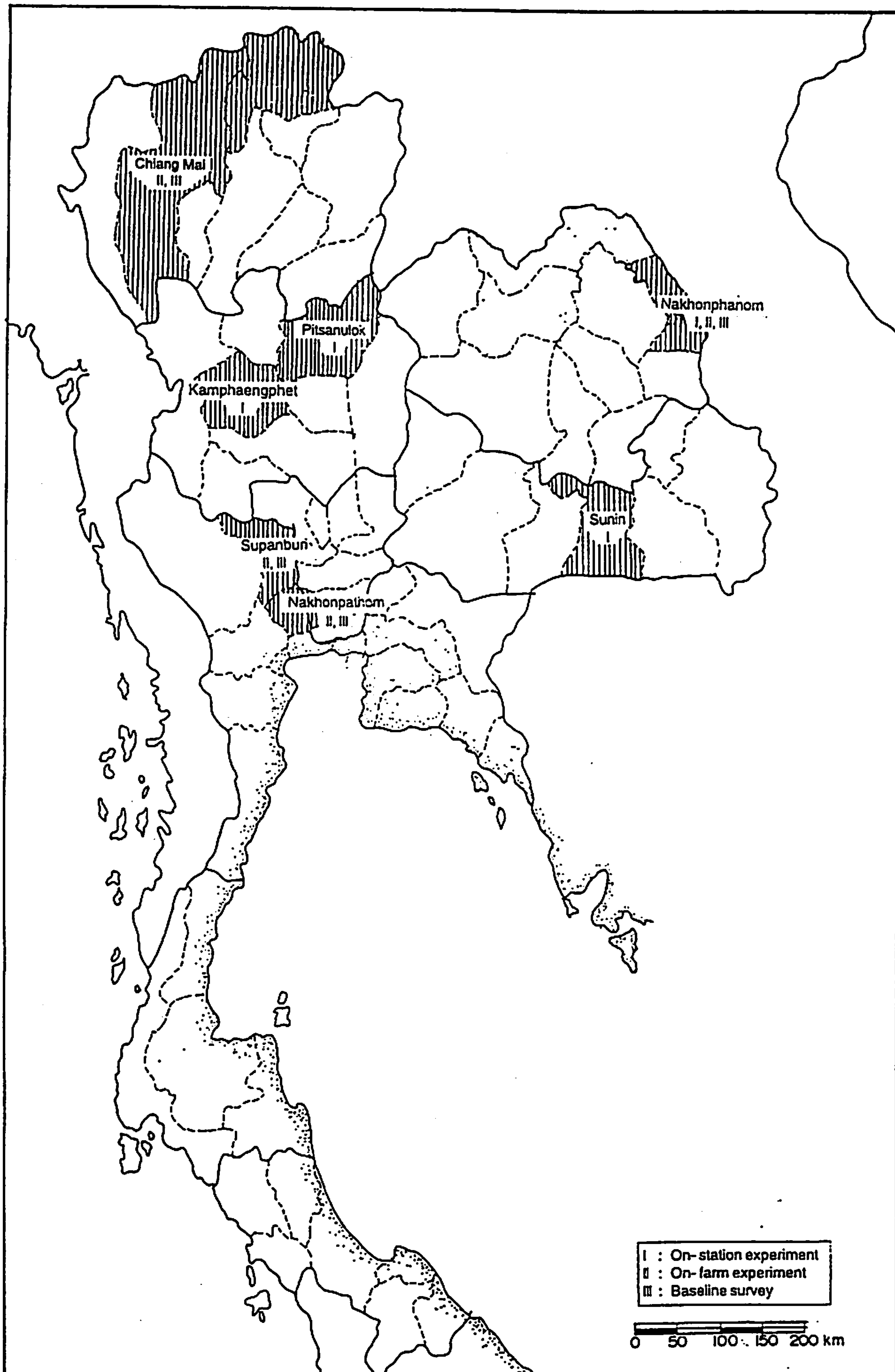
Map 1: Study sites in Bangladesh



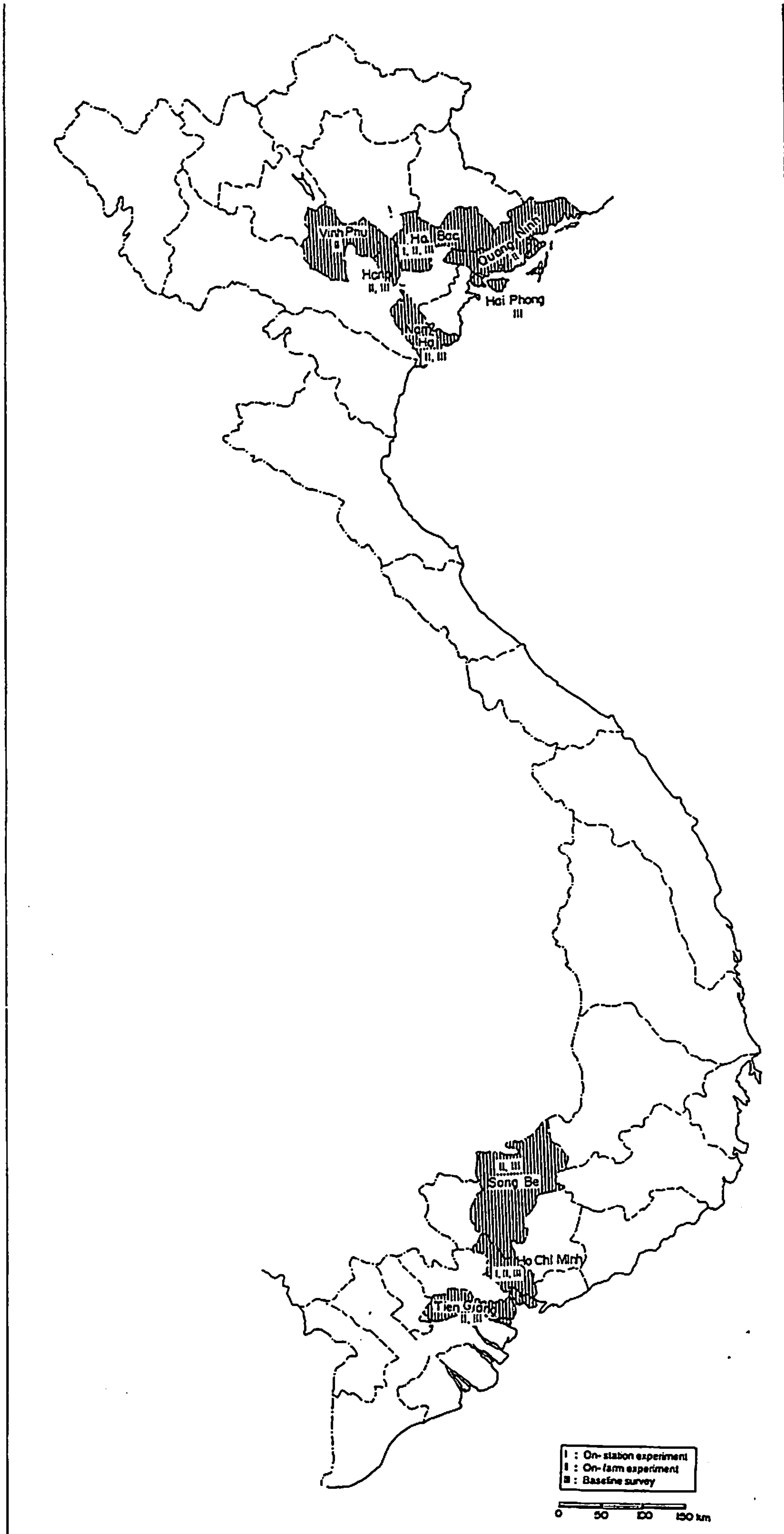
Map 2: Study sites in China



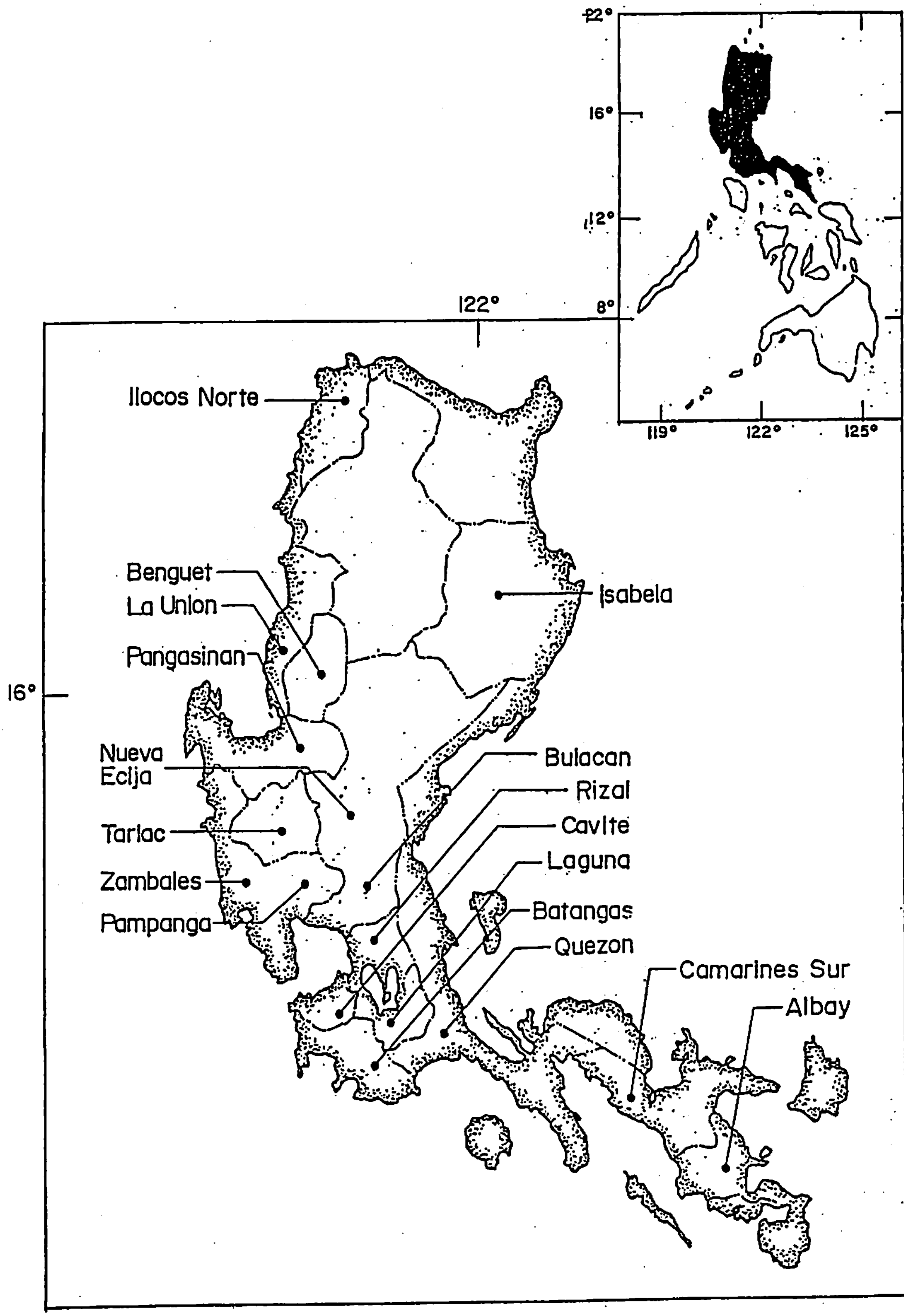
Map 3: Study sites in the Philippines



Map 4: Study sites in Thailand



Map 5: Study sites in Vietnam



Map 6: Sites for the Hatchery Operators' Survey in the Philippines, 1994.

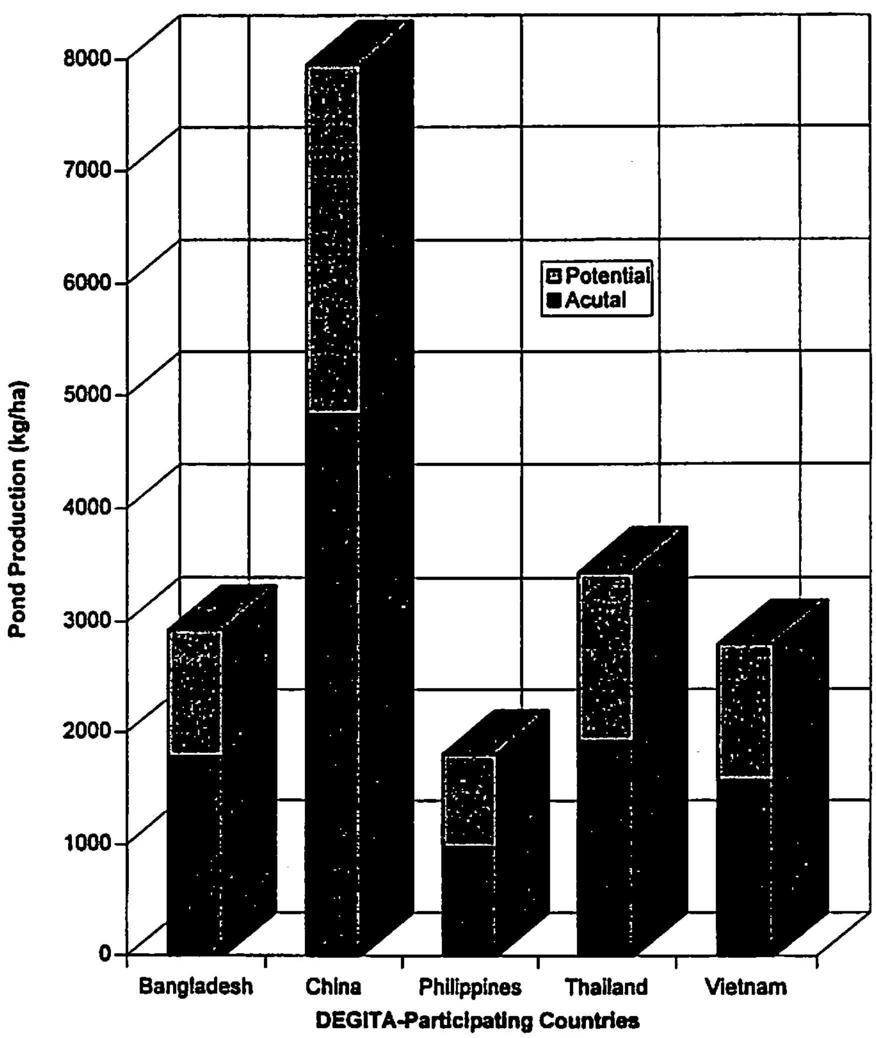


Figure 1. Yield Gap II for GIFT strain

APPENDIX 1

Appendix 1

Members of DEGITA Teams

INTERNATIONAL TEAM

NAME	EXPERTISE	INSTITUTION
1. Dr. Madan Mohan Dey (Project Leader)	Resource Economics	ICLARM
2. Dr. M.V. Gupta (Project Director, April 1996 - June 1997)	Aquaculturist	ICLARM
3. Dr. D.V. Seshu (Project Director, June 1994 - July 1995)	Geneticist	ICLARM
4. Dr. R.S.V. Pullin (Project Director, Aug. 1995 - April 1996)	Fish biologist	ICLARM
5. Dr. Reg Noble (Part time)	Ecologist/Environmental Specialist	ICLARM
6. Dr. Sena de Silva (Part time)	Environmental Specialist	ICLARM
7. Dr. A.E. Eknath	Geneticist	ICLARM
8. Mr. Gaspar Bimbao	Economist	ICLARM
9. Ms. Lourdes Velasco	Statistician	ICLARM
10. Ms. Urbana Cadiz	Statistician	ICLARM

BANGLADESH

NAME	EXPERTISE	INSTITUTION
1. Dr. M. G. Hussain	Geneticist	Bangladesh Fisheries Research Institute (BFRI)
2. Mr. Shahidul Islam	Geneticist	BFRI
3. Mr. A. H. M. Kohinoor	Aquaculturist/Extension Specialist	BFRI
4. Mr. S.C. Mahata	Hatchery Specialist/Geneticist	BFRI
5. Ms. M. B. Tanu	Aquaculturist	BFRI
6. Mr. Zulfikar Ali	Aquaculturist	BFRI

CHINA

NAME	EXPERTISE	INSTITUTION
1. Dr. Li Sifa	Geneticist	Shanghai Fisheries University (SFU)
2. Dr. Li Jiale	Geneticist	SFU
3. Mr. Li Chenghong	Geneticist	SFU
4. Mr. Zhao JInliang	Geneticist	SFU
5. Mr. Lu Guoging	Geneticist	SFU
6. Ms. Lu Yong	Economist	SFU
7. Mr. Han Fenjing	Hatchery Manager/Engineer	Jinzhou National Tilapia Seed Farm
8. Mr. Chen Peixian	Hatchery Manager/Engineer	Huzhou Aquatic Seed Farm
9. Mr. Ye Wei	Hatchery Manager/Engineer	Guangzhou National Tilapia Seed Farm

PHILIPPINES

NAME	EXPERTISE	INSTITUTION
1. Ms. S. Aypa	Aquaculturist	Bureau of Fisheries and Aquatic Resources (BFAR)
2. Mr. Ruben Reyes	Geneticist/Hatchery Specialist	BFAR
3. Ms. Precy Regaspi	Aquaculturist	BFAR
4. Mr. Abundio Galicia, Jr.	Environmental Specialist	BFAR

THAILAND

NAME	EXPERTISE	INSTITUTION
1. Mr. Panu Tavarutmaneegul	Geneticist/Biologist	National Aquaculture Genetics Research Institute (NAGRI)
2. Dr. Nuanmanee Pongthana	Geneticist	NAGRI
3. Ms. Pitchaya Chinaupavarat	Geneticist	NAGRI
4. Dr. Saran Wattanutchariya	Economist	Kasetsart University
5. Dr. Somkit Tugsinavisutti	Economist	Kasetsart University
6. Dr. Yont Musig	Environmental Specialist	Kasetsart University

VIETNAM (North)

NAME	EXPERTISE	INSTITUTION
1. Dr. Tran Mai Thien	Geneticist	Research Institute for Aquaculture (RIA) No. 1
2. Mr. Nguyen Cong Dan	Geneticist	Research Institute for Aquaculture (RIA) No. 1
3. Mr. Dinh Van Trung	Geneticist	RIA No. 1
4. Dr. Do Kim Chung	Economist	Hanoi Agriculture University (HAU)
5. Mr. Nguyen Trong Dac	Economist	HAU
7. Dr. Mai Dinh Yen	Environmental Specialist	HAU
8. Dr. Nguyen Huu Tuong	Environmental Specialist	HAU

VIETNAM (South)

NAME	EXPERTISE	INSTITUTION
1. Dr. Nguyen Van Hao	Geneticist	Research Institute for Aquaculture (RIA) No. 2
2. Mr. Pham Khan	Aquaculturist	RIA No. 2
3. Mr. Hoang Minh Duc	Aquaculturist/Hatchery Specialist	RIA No. 2
4. Ms. Nguyen Thi Ngoc Tinh	Geneticist	RIA No. 2
5. Mr. Nguyen Van Tu	Aquculturist/Extension Specialist	Thu Duc Forestry and Agriculture University (TDFAU)
6. Dr. Trinh Troung Giang	Environmental Specialist	TDFAU

APPENDIX 2

Appendix 2

On-Farm Study Sites

Appendix Table 2.1. On-farm study sites and their characteristics in Bangladesh.

	SITES/DISTRICTS					
	Rangpur	Mymensingh	Manikgong	Comilla	Jessore	Khulna
Land alleviation	Medium low	Medium low	Low	Low	High	Medium low
Floodplain	Tista	Old Bramaputra	Jamung	Meghna	Ganges	Tidal saline
Mail soil type	Non-calacareous grey (non-saline)	Non-calcareous dark grey	Non-calcareous grey (non-saline)	Non-calcareous dark grey	Calcareous dark grey	Non-calcareous grey (seasonally saline)
Agro-ecological zones	3	9	8	19	11	13
Rainfall total: mean (mm)	2154	2253	1671	2165	1625	1853
No. of months with rainfall 7200 mm	5	5	5	5	4	4
Mean annual temperature (°C)	24.6	25.3	25.4	25.6	25.8	26.7
Date when min. temp. fall <15°C (mean)	25 Nov.	01 Dec.	30 Nov.	06 Dec.	23 Nov.	07 Dec.
Date when min. temp. fall <15°C (St. D)	7	7	8	12	9	10
Last date when min. temp. fall <15°C (mean)	03 Mar.	19 Feb.	13 Feb.	01 Feb.	11 Feb.	19 Jan.
Last date when min. temp. fall <15°C (St. D)	25	12	16	17	17	14
Length T min. <15°C: mean (days)	97	80	75	57	80	42
Length T min. <15°C: St. D (day)	28	14	18	19	19	20

Appendix Table 2.2. On-farm study sites and their characteristics in China.

	Sites			
	Shandong	Zhejiang	Anhui	Guangdong
River System	Yellow	Changjiang	Changjiang	Pearl
Agroecological zones	warm arid and semi arid sub tropics	warm cool humid sub tropics	warm sub humid sub tropics	warm cool humid sub tropics
Annual average temperature (^{o}C)	12.8	15.9	16.4	22.0
Yearly precipitation (mm)	400-800	1000-1500	1000-1500	1600-2000
Tilapia culture system	pond, cage	pond, cage	pond, cage	pond
Consumption of aquatic products (kg/caput/year)	1.58	1.50	10.16	9.94

Appendix Table 2.3. On-farm study sites and their characteristics in the Philippines.

Region/Province	Climatic Zone Type	percent Exposure to Typhoon	Major Tilapia Culture System(s)
I			
Pangasinan	I	32	Pond (mono and polyculture)
III			
Nueva Ecija	I	16	Pond (mono and polyculture), cage (monoculture), rice-fish
Tarlac	I	16	Pond (monoculture)
Pampanga	I	16	Pond (monoculture)
Bulacan	I	16	Mono (monoculture)
IV			
Rizal	I	16	Cage (monoculture), pond (monoculture)
Laguna	I	16	Cage (monoculture)
Batangas	I	16	Cage (monoculture)
V			
Albay			
- Eastern Part	II	19	Pond (monoculture),
- Western Part	IV	16	Cage (monoculture)
Camarines Sur			
- Eastern & Northern Part	II	19	Cage (monoculture), Pond (monoculture)
- Southern & Western Part	IV	16	
VI			
Iloilo			
- Northern Part	I	19	Pond (mono and polyculture)
- Southern & Western Part	I	7	
Negros Occidental			
- Northern Part	III	7	Pond (monoculture)
- Western, Central & Southern Part	I	7	

Appendix Table 2.3 .(continued)

Region/Province	Climatic Zone Type	percent Exposure to Typhoon	Major Tilapia Culture System(s)
XI			
Davao Norte			
- Eastern Part	II	1	Pond (monoculture)
- Western Part	IV	1	
Davao Sur			
- Eastern Part	II	1	Pond (monoculture)
- Western Part	IV	1	
South Cotabato	IV	1	

Type I - There are two pronounced seasons: dry from November to April; wet during the rest of the year. The localities of this type are protected from the northwest (NW) monsoon; some are protected from the trade winds by mountain ranges. However, the controlling factor is topography in those areas open only to the Southwest (SW) monsoon and cyclonic storm.
Average temperature : 27.0°C
Average rainfall : 100.56 in

Type II - There is no dry season with a very pronounced maximum rain period from November to January. These regions are along or very near the eastern coast which are sheltered neither from the Northeast monsoon and the tradewinds nor from cyclonic storms.
Average temperature : 26.8°C
Average rainfall : 129.08 in

Type III - Seasons are not very pronounced; relatively dry from November to April and wet during the rest of the year. The maximum rain periods are very pronounced, with the short dry season lasting only from one to three months. These localities are only partly sheltered from the northeastern monsoon and trade winds and open to the southeast monsoon or at least to frequent cyclonic storms.
Average temperature : 27°C
Average rainfall : 77.26 in

Type IV - Rainfall is more or less evenly distributed throughout the year
Average temperature : 26.8°C
Average Rainfall : 101.84 in

Appendix Table 2.4. On-farm study sites and their characteristics in Thailand.

Sites/Provinces	Major Culture System	Average Farm Size (ha)	
		Pond	Paddy cum fish
Northern			
Chiang Rai	pond	0.20	-
Chiang Mai	pond	0.09	-
Phetchabun	pond, paddy cum fish	0.23	3.82
North-Eastern			
Nakhon Phanom	pond, paddy cum fish	0.13	0.36
Nong Khai	pond	2.10	-
Udon Thani	pond, paddy cum fish	0.26	1.45
Central			
Chachoengsao	pond, paddy cum fish	0.79	5.62
Chon Buri	pond	0.74	-
Samut Prakarn	pond, paddy cum fish	2.72	6.02
Regional Average			
Northern	pond	0.16	1.66
Northeastern	pond, paddy cum fish	0.21	0.61
Central	pond, paddy cum fish	0.96	5.82
South	pond	0.05	-

Source: Department of Fisheries, Ministry of Agriculture and Cooperatives, Thailand

Appendix Table 2.5. On-farm project sites and their characteristics in Vietnam.

Study Site	Province	Ecology
	North Vietnam	
1. Do Son	Hai Phong	Brackish water area
2. Thuy Nguyen	Hai Phong	Brackish water area
3. Dong Mai	Quang Ninh	Brackish water area
4. Thanh Tri	Hanoi	Sewage area
5. Huu Bi	Nam Ha	Village pond (low land)
6. Vu Di	Vinh Phu	Village pond (mid land)
7. Song Cau	Habac	Village pond (low land)
8. Lang Giang	Habac	Village pond (low land)
	South Vietnam	
9. Can Gio	Ho Chi Minh City	Brackish water area
10. Thu Duc	Ho Chi Minh City	Village pond (suburban)
11. Cai Be	Tien Giang	Delta
12. Tan Uyen	Song Be	Village pond

APPENDIX 3

Appendix 3

Validated Supply and Demand Elasticities

Appendix Table 3.1. Summary of validated supply elasticity estimates in Bangladesh.

Species	Supply elasticities with respect to the price of		
	Tilapia	Carps/big fish	Other
Tilapia	.4	-.2	-.2
Carps/big fish	-.2	.5	-.3
Other	-.2	-.3	.5

Appendix Table 3.2. Summary of validated supply elasticity estimates in China.

Species	Supply elasticities with respect to the price of				
	Tilapia	Carps	Crustaceans	Other high value	Other low value
Tilapia	0.50	-0.20	-0.20	-0.05	-0.05
Carps	-0.20	0.55	-0.20	-0.10	-0.05
Crustaceans	-0.20	-0.20	0.65	-0.20	-0.05
Other high value	-0.05	-0.10	-0.20	0.40	-0.05
Other low value	-0.05	-0.05	-0.05	-0.05	0.20

Appendix Table 3.3 Summary of validated supply elasticity estimates in the Philippines.

Species	Supply elasticities with respect to the price of				
	Tilapia	Milkfish	Crustaceans	Other high value	Other low value
Tilapia	0.50	-0.20	-0.20	-0.05	-0.05
Milkfish	-0.20	0.60	-0.30	-0.05	-0.05
Crustaceans	-0.20	-0.30	0.65	-0.10	-0.05
Other high value	-0.05	-0.05	-0.10	0.25	-0.05
Other low value	-0.05	-0.05	-0.05	-0.05	0.20

Appendix Table 3.4. Summary of validated supply elasticities in Thailand.

Species	Supply elasticities with respect to the price of				
	Tilapia	Carps	Crustaceans	Other high value	Other low value
Tilapia	0.50	-0.20	-0.20	-0.05	-0.05
Carps	-0.20	0.55	-0.20	-0.10	-0.05
Crustaceans	-0.20	-0.20	0.65	-0.20	-0.05
Other high value	-0.05	-0.10	-0.20	0.40	-0.05
Other low value	-0.05	-0.05	-0.05	-0.05	0.20

Appendix Table 3.5. Summary of validated supply elasticities in Vietnam.

Species	Supply elasticities with respect to the price of			
	Tilapia	Carps	Crustaceans	Others
Tilapia	0.50	-0.25	-0.15	-0.10
Carps	-0.25	0.6	-0.15	-0.20
Crustaceans	-0.15	-0.15	0.70	-0.40
Others	-0.10	-0.2	-0.40	0.70

Appendix Table 3.6. Summary of validated demand elasticity estimates in Bangladesh.

Species	Demand elasticities with respect to price of					Fish expenditure elasticity
	Tilapia	Carps/other big	Livefish	Ilish	Others	
Tilapia	-1.00	0.05	0.00	0.05	0.20	0.70
Carps/other big	0.05	-1.50	0.40	0.05	0.05	0.95
Livefish	0.00	0.40	-1.45	0.05	0.00	1.00
Ilish	0.05	0.05	0.05	-1.20	0.10	0.95
Others	0.20	0.05	0.00	0.10	-1.10	0.75

Appendix Table 3.7. Summary of validated demand elasticity estimates in China.

Species	Demand elasticities with respect to price of					Fish expenditure elasticity
	Tilapia	Carps	Crustaceans	Other high value	Other low value	
Tilapia	-0.80	0.10	0.025	0.025	0.10	0.55
Carps	0.10	-0.75	0.025	0.025	0.10	0.50
Crustaceans	0.025	0.025	-1.50	0.20	0.025	1.225
Other high value	0.025	0.025	0.20	-1.50	0.025	1.225
Other low value	0.10	0.10	0.025	0.025	-0.75	0.50

Appendix Table 3.8. Summary of validated demand elasticity estimates in the Philippines.

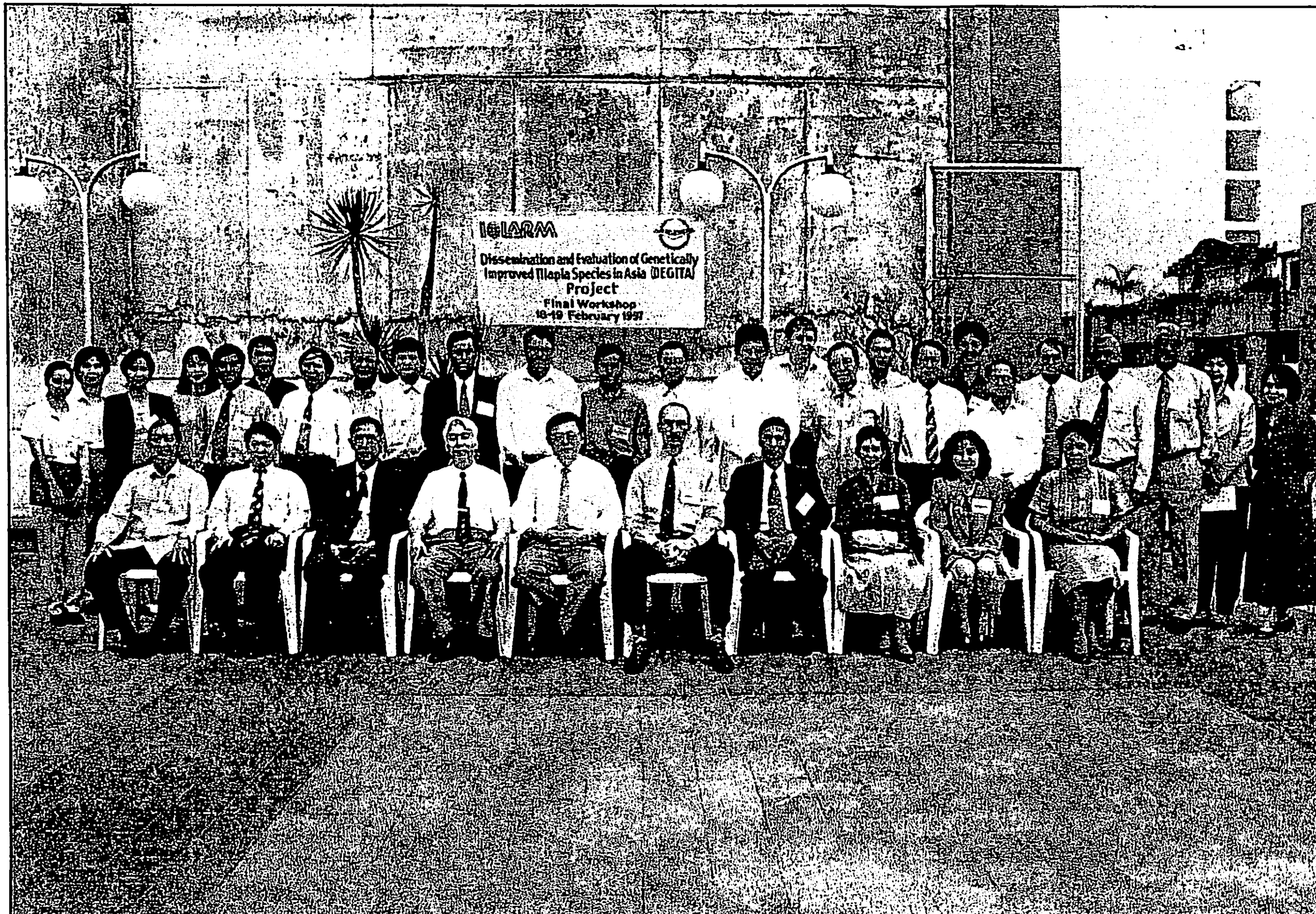
Species	Demand elasticities with respect to price of					Fish expenditure elasticity
	Tilapia	Milkfish	Crustaceans	Other high value	Other low value	
Tilapia	-1.00	0.10	0.05	0.05	0.10	0.70
Carps	0.10	-1.20	0.15	0.15	0.05	0.75
Crustaceans	0.05	0.15	-1.50	0.15	0.05	1.10
Other high value	0.05	0.15	0.15	-1.50	0.05	1.10
Other low value	0.10	0.05	0.05	0.05	-0.75	0.50

Appendix Table 3.9. Summary of validated demand elasticity estimates in Thailand.

Species	Demand elasticities with respect to price of					Fish expenditure elasticity
	Tilapia	Carps	Crustaceans	Other high value	Other low value	
Tilapia	-1.0	0.10	0.05	0.05	0.10	0.70
Carps	0.10	-1.10	0.05	0.05	0.10	0.70
Crustaceans	0.05	0.05	-1.50	0.15	0.05	1.20
Other high value	0.05	0.05	0.15	-1.50	0.05	1.20
Other low value	0.10	0.10	0.05	0.05	-0.80	0.50

Appendix Table 3.10. Summary of validated demand elasticity estimates in Vietnam.

Species	Demand elasticities with respect to price of				Fish expenditure elasticity
	Tilapia	Carps	Crustaceans	Other fish	
Tilapia	-1.40	0.25	0.15	0.25	0.75
Carps	0.25	-1.50	0.20	0.20	0.85
Crustaceans	0.15	0.20	-1.60	0.25	1.00
Other high value	0.25	0.20	0.25	-1.40	0.7



Participants and guests of the Final Workshop for the DEGITA Project held during 18-19 February 1997 at the International Center for Living Aquatic Resources Management (ICLARM), Makati City, Philippines