CASE STUDY 7:
OVERVIEW OF SMALL-SCALE FRESHWATER AQUACULTURE IN THAILAND

A. Background

1. This case study was prepared to provide an overview of small-scale freshwater aquaculture in Thailand to illustrate the contextual importance of aquaculture—its historical development, technology and management, markets, development policy and the role of the Government, community-based development initiatives, pertinent safeguards, relevant lessons, and ways to benefit the poor.[1]

2. Fish is the traditional source of animal protein in the Thai diet as indicated by common Thai expressions: *kin kao kin pla leo yang*? (have you eaten rice and fish yet?) and *nai nam mee pla nai na mee kao* (in the water are fish, in the field is rice).[2] The great importance of fish in the Thai diet may be best illustrated by quotations from H.M. Smith, an American who was the first Director General of Fisheries in the country: "fisheries … produce the principal animal food consumed by the Siamese people … there is an enormous consumption of fish in the households of peasants, and probably the chief value of the freshwater fisheries lies … in providing a cheap, readily available and nutritious animal food for the millions of farmers and small tradesmen and their families."[3] Fish is second only to rice for Thais and has good quality, containing easy-to-digest protein, all amino acids required for human growth, unsaturated fat, and vitamins and minerals.[4]

3. Estimated annual per capita consumption of fish based on a field survey of consumers in 1998–1999 was an average of 28.8 kilograms (kg) of which more than 90% was in the form of fresh fish.[5] The highest per capita fish consumption by region was 33.8 kg in Northeastern Thailand. Freshwater fish accounted for 70–90% of the total quantity of fish consumed in all regions. Fish ranked first among animal protein sources, followed by chicken, pork, and beef. The national average fish consumption per capita in 2001 was 33.5 kg according to the statistics of the Department of Fisheries (DOF).[6] This national average hides the large variation between communities with good access to fish and those without. The wide range in fish consumption also mirrors wide differences in income. Very low fish consumption levels of about 3–5 kg per capita occur in remote communities of Northern Thailand. However, these may not include fish obtained and consumed from outside the village.[7]

4. Thailand is situated in the Indochina peninsula of Southeast Asia with an area of nearly 514,000 square kilometers (km^2). It is bounded on the west and northwest by Myanmar, on the north and northeast by the Lao People's Democratic Republic, on the east by Cambodia, and on the south by Malaysia. The country's climate is monsoonal with clearly defined wet and dry

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[1] This case study was undertaken by P. Edwards and Cherdsak Virapat in collaboration with N. Bestari and R. Pullin.
[2] Suraswadi, Plodprasop. 1986. *Role of Aquaculture in Rural Development of Northeast Thailand*. Bangkok: Faculty of Fisheries, Kasetsart University.
[3] Smith, H. M. 1925. *A Review of the Aquatic Resources and Fisheries of Siam, with Plans and Recommendation for their Administration, Conservation and Development*. Bangkok: Ministry of Lands and Agriculture.
[4] Department of Fisheries (DOF). 2000. *Fish Processing*. Bangkok: DOF. (In Thai)
[5] Piumsombun, Somying. 2001. *Production, Accessibility and Consumption Patterns of Aquaculture Products in Thailand. In Production, Accessibility, Marketing and Consumption Patterns of Freshwater Aquaculture Products in Asia, a Cross-Country Comparison.* FAO Fisheries Circular 973. Rome.
[6] Pongpat Boonchuwong, Director of Fishery Economic Division, Department of Fisheries, Bangkok. Personal communication, 2003.
[7] Chaopaknam, B. 1998. *Monitoring and Evaluation on the School Fish Pond Program in Fishery Inspection Region 5*. Technical Paper 13/1998. Bangkok: Office of Inspector-General, Department of Fisheries. (In Thai)

seasons. The rainy season runs from May to October, the cool dry season from November to February, and the hot dry season from March to May, except in the south where there is no pronounced cool season. The annual precipitation varies from 760 millimeters to as much as 4,200 millimeters. Both droughts and floods are common, especially in NortheasternThailand.

5. Thailand has achieved significant economic development in recent years; its gross domestic product (GDP) grew by more than 8% annually in 1990–1996 prior to the Asian financial crisis.[8] Gross national income per capita was $2,020 in 2000, with 13% of the population below the national poverty line.[9] The fisheries sector contributed 1.9% to the GDP in 2000; freshwater fisheries contributed about 10% of the total fisheries contribution.

6. The importance of floodplain fisheries has been dramatically reduced as a consequence of national development programs, especially the construction of multipurpose dams. Although these dams have created reservoirs for water storage to be used in irrigation and/or electricity generation, they have diminished flooding in the floodplains and reduced areas that have served as natural spawning and nursing grounds for most fish species. This, coupled with pollution and environmental degradation, has resulted in a drastic decline of fish populations and catches. The freshwater fish fauna of Thailand is rich because there is a vast network of rivers and canals, especially in the central plains, and numerous swamps, reservoirs, and water storage tanks. However, freshwater fisheries have declined, providing a major stimulus for the relatively recent development of aquaculture in the country.[10]

7. Aquaculture production in Thailand is influenced by geographic factors and the country's tradition of fish culture. Thailand has riverine systems of nearly 120,000 km, 300,000 hectares (ha) of natural lakes, and 255,000 ha of reservoirs. There is a great diversity of freshwater aquaculture systems and species in Thailand, including several that have relevance for small-scale producers and national food security. According to DOF statistics, more than 20 fish species are farmed, with total freshwater fish production of 271,000 tons (t) in 2000.[11] Although data are not compiled by scale and intensity of fish farming, herbivorous and omnivorous fish species with greatest relevance for small-scale aquaculture—such as carps, gouramis, and tilapias—comprise about 60% of the total. With production of 82,000 t in 2000, tilapia are the major herbivorous species. Four farming systems are recognized officially: fishponds, which make up 89% of the total inland aquaculture production; and fish culture in ricefields (7%), in ditches (2%), and in cages (1%). Most freshwater production takes place in the central plains (58%) and least in the south (6%) where marine fish are readily available. The two regions where poverty-focused aquaculture has greatest relevance are Northern and Northeastern Thailand with 19% and 18% of the total inland aquaculture production, respectively, but with 22% and 50%, respectively, of the total number of farms in the country. The Northeastern region has the largest number of small-scale fish farms (Table 1) according to official statistics. These

[8] NSEDB. 2001. *National Income of Thailand*. National Social and Economic Development Board, Bangkok. http://www.nesdb.go.th.

[9] Asian Development Bank (ADB). 2003. *Key Indicators 2003*. Manila: ADB.

[10] Freshwater capture fisheries in Thailand might have passed their climax of development almost 80 years ago due to overfishing. Construction of modern irrigation systems led to further declines. The valuable carnivorous snakehead (*Channa striata*) used to be the most abundant staple food fish. Giant freshwater prawns (*Macrobrachium rosenbergii*) were also abundant and consumed in large numbers. The fisheries may have been adequate for the needs of a relatively small population, but the current overall high level of consumption of freshwater fish depends on aquaculture (Edwards, Peter, Karl E. Weber, Ed W. McCoy, Chintana Chantachaeng, Chintana Pacharaprakiti, Kamtorn Kaewpaitoon, and Samart Nitsmer. 1983. Small-Scale Fishery Project in Pathumthani Province, Central Thailand: A Socio-Economic and Technological Assessment of Status and Potential. *Asian Institute of Technology Research Report 158.* Bangkok: Asian Institute of Technology.

[11] DOF. 2003. *Freshwater Fishfarm Production 2000*. Bangkok.

data are likely to be a gross underestimation because of the difficulty in identifying small and widely scattered aquaculture farms in the region.

Table 1: Freshwater Aquaculture Farms in Thailand

Region	Total	Pond	Ricefield	Ditches	Cages
Total Number of Farms	**256,082**	**239,122**	**11,396**	**4,655**	**909**
Northern	56,455	55,313	233	633	276
Northeastern	127,522	120,180	6,889	101	352
Central	45,390	37,716	4,201	3,217	256
Southern	26,715	25,913	73	704	25
Total Area (hectare)	**96,145**	**68,516**	**25,244**	**2,347**	**38**
Northern	9,627	9,172	316	123	16
Northeastern	29,702	23,642	6,012	39	9
Central	54,313	33,346	18,894	2,062	11
Southern	2,503	2,356	22	123	2
Total Production (metric ton)	**271,012**	**240,907**	**19,936**	**6,707**	**3,462**
Northern	51,016	49,708	244	118	946
Northeastern	47,929	42,324	4,455	16	1,134
Central	156,220	133,481	15,157	6,252	1,330
Southern	15,847	15,394	80	321	52

Source: Department of Fisheries. 2003. *Fisheries Statistics of Thailand 2000*. Bangkok.

8. DOF has been responsible for rural fisheries development since 1982 under the Fifth National Economic and Social Development Plan (1982–1986). Many important projects, such as the Village Fish Pond Development Project (VFPDP) and several projects under royal initiatives, have been carried out.[12] The VFPDP is a state-sponsored initiative in support of community fishpond development projects, which has continued to date. Its objectives are to increase fish production for local consumption to generate local employment and to reduce malnutrition and poverty. Under the VFPDP, the mandate of DOF is to (i) support the rehabilitation or construction of village fishponds (reservoirs, swamps, and tanks); (ii) train local support personnel; (iii) increase the supply of fish seed or fingerlings; and (iv) provide technical advisory services. The rationale of VFPDP stems from aims to strengthen social cohesiveness and develop community awareness, and the fishponds generally serve as core facilities that provide self-help opportunities. Apart from generating direct benefits in terms of fish production and improved water supply, the VFPDP trains villagers to be self-reliant. The dissemination of fish farming technology has resulted in the establishment of many fishponds by private individuals and communal fishponds in villages. In 2001, the Government decentralized authority for management of natural resources, including fisheries in all community waters, to the subdistrict governments, locally known as Tambon Administrative Organizations (TAOs). TAOs have become local institutions responsible for rural development. In the context of these decentralization measures, the DOF's budget for village pond construction was being progressively transferred to TAOs during 2001–2004.

[12] DOF has initiated a variety of rural development models thought to be appropriate for community development to increase fish production in community ponds, public waters, and school ponds. The VFPDP, one of the most important rural fisheries development programs, started in 1978 as a pilot project in 14 villages of 12 provinces in Northeastern Thailand. Although referred to as village fishponds, the water bodies are natural, improved, or engineered multipurpose reservoirs.

B. Historical Development

9. Aquaculture may have started as early as 1691 in Thailand although this was for ornamental gold fish rather than for food.[13] Aquaculture for food fish appears to be a relatively recent development because of the former abundance of wild fish. The native riverine catfish *(Pangasius hypophthalmus)* has been farmed on a small scale in pens and ponds in Central Thailand since the middle of the 19th century. It is generally considered that Chinese immigrants introduced organized aquaculture to Thailand in the early years of the 20th century using fish fry imported by boat from the People's Republic of China. Chinese carps (Chinese silver carp [*Hypophthalmicthys molitrix*] and grass carp [*Ctenopharyngodon idella*]) were cultured on a small scale, mostly in Bangkok where there was a ready market among the large immigrant Chinese population.

10. DOF started to study the lifecycle of the native snakeskin gourami (*Trichogaster pectoralis*) in 1932—its entire lifecycle is carried out in the flooded ricefields—but was unable to convince people to farm it, possibly because wild fish were still abundant. During the 1950s, with technical assistance from the Food and Agriculture Organization (FAO) of the United Nations, DOF imported and disseminated Mozambique tilapia (*Oreochromis mossambicus*) which soon became a popular farmed fish in ponds. However, interest in this fish waned because of reservations about the quality and flavor of its flesh. Later, tilapia farming became established following introduction of Nile tilapia (*Oreochromis niloticus*) in 1965 after His Majesty King Bhumipol received specimens as a gift from His Imperial Highness Emperor Akihito of Japan when the latter was Crown Prince.

11. DOF promoted rice-fish farming in Northern and Central Thailand in the 1950s, but this system is still not well developed to date. An exception is the farming of snakeskin gourami southeast of Bangkok where farmers converted unproductive ricefields in relatively saline soils of the lower Chiengrak-Klong Dan irrigation scheme to an extensive fish farming system. Since the 1960s, DOF has placed great emphasis on the artificial spawning of Chinese carps, common carp (*Cyprinus carpio*), silver barb (*Barbodes gonionotus*), and riverine catfish. The availability of seed of these fish species led to a large increase in aquaculture production.

C. Biophysical Features

12. Water for small-scale rural aquaculture is generally available, especially in floodplain and irrigated areas. However, the water supply for aquaculture is restricted in drought-prone areas in the northeast where there is significant poverty (footnote 2), and in ponds inappropriately located in hilly areas.

13. In areas where agricultural chemicals are used intensively, water is contaminated with pesticides at low concentration.[14] Measurements in 25 river basins, including Bangpakong, Chaopraya, Kok, Pasak, Sakakrang, Songkhla Lake, Tha Chin, and Yom, showed them to have poor average water quality in terms of dissolved oxygen (DO), biochemical oxygen demand, coliform bacteria, and ammonia-nitrogen.[15] The average DO levels in the lower Tha Chin River were reported to be as low as 1 milligram per liter, unsuitable for fish and aquatic organisms.

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[13] Tarnchalanukit, W. 1974. *Aquaculture Manual* (in Thai). Bangkok: Faculty of Fisheries, Kasetsart University.

[14] Yingcharoen, D., and C. Virapat. 1998. *Aquatic Ecology and Fisheries Surveys in the Songkhram River Basin, Nakorn Phanom Province, Thailand*. Project on Wetland Management. Phnom Penh: Mekong River Commission.

[15] Department of Water Resources. 2003. *Records of the First Step in the Year 2003: Think of Water Think of Us*. Bangkok. This was due to overloading of wastewater from household communities, industries, and animal farming. The effects are more pronounced in the dry season.

Water quality in the main rivers in the north (Nan, Ping, Wang, and Yom) remains generally good, especially in the upstream flow from the northern mountains, and the average concentration of DO was more than 5 milligrams per liter. Nonpoint source pollution became significant in many parts of the country during the late 1990s, especially in water from agriculture areas.

14. In some areas, especially in the northeast, saltwater intrusion has a strong effect on freshwater aquaculture. Water temperature is also important for rural aquaculture. In the winter in the north, temperatures may drop to less than 10 degrees Celsius and cause detrimental effects on fish culture. In newly constructed ponds, water turbidity is common.

D. Technology and Management

15. **Seed Supply.** More than 600 million fry of tilapia, the dominant fish in small-scale freshwater aquaculture, both from mixed sex and monosex male (through hormone-induced sex reversal), were produced in 2001. This seed supply represented 45% of the estimated total fish seed produced in the country (1,520 million). The Government's share in producing fish seed was about 17%, two thirds of which were produced in inland fisheries stations.[16] At these stations, seed is produced for various purposes: stocking community ponds, free distribution and sale to fish farmers, and for experiments. Private farms produce and nurse seed to various size classes to meet requirements of fish farmers. For cage culture practices, a relatively large size of seed (20–30 fish per kg or larger than 10 centimeters) is required.

Tilapia hatchery in central Thailand

16. **Major Hatcheries.** For monosex tilapia seed, the main sources are in a few subdistricts of Chonburi and Chachoengsao provinces, and DOF hatcheries. A well-established network of local and distant traders links producers to customers all over Thailand. Demand for tilapia fry was estimated at 400 million in 2000.[17] The major sources of monosex tilapia seed are Charoen Pokaphan Group and other private hatcheries. Large private hatcheries are located in the west at Prachinburi (Namsai Farm), northeast at Udon Thani (Udonpatana Foundation), Khon Kaen (Boonhome Farm), Kalasin (Viboon Farm), north at Chiangmai (Chiangmai Patana Farm), and south at Petchaburi (Manit Farm).

17. **Major Species.** Nile tilapia is currently the major species with 30% of the total national inland aquaculture production, followed by silver barb with 17% and common carp with 2%

[16] DOF started a program to establish fish breeding centers (FBCs) under VFPDP in 1982. At present, there are 162 FBCs in the country based in local communities and sometimes at schools, comprising 84 in the northeast, 36 in the north, 19 in Central Thailand, and 23 in the south. However, only 39 FBCs are currently in operation, with a seed production capability of about 6.8 million fingerlings in 1997. There are some problems regarding resource allocation among local management organizations—there is a lack of continuous input by local management committees and support from the Government, and inefficient transfer of appropriate technology to local operations.

[17] Srisakultiew, P. 2000. Status of Tilapia in Aquaculture. In *Agriculture and Water*. Proceedings of the 12th Asian Agricultural Symposium 2000. Kumamoto: Saburi Co.

(footnote 11). Production data for Chinese carps (less than 1%) and Indian major carps (rohu [*Labeo rohita*], and mrigal [*Cirrhinus mrigala*], at 0.4% each) probably underestimate their importance for the poor because these species are widely cultured, especially in Northeastern Thailand. The availability of Nile tilapia has been a major factor in expansion of small-scale aquaculture. DOF promotes a stocking program of tilapia in various waterbodies throughout the country, such as village fishponds, public waters, irrigated reservoirs, domestic water supply reservoirs, and some multipurpose reservoirs.

18. **Growout Farming.** The average annual yield across all aquaculture farm types in 2000 was about 2.8 t/ha and for ponds, 3.5 t/ha (Table 1). Tilapia and herbivorous and omnivorous carps for small-scale aquaculture are largely farmed in polyculture in ponds. The conclusions of a survey of fish farms (footnote 10), carried out in Pathumthani Province in Central Thailand more than 2 decades ago to identify aquaculture techniques for small-scale farmers, are still relevant: small-scale farmers are constrained by limited on-farm sources of fertilizers and feeds and access to, and affordability, of marketed feed. Of course, without proper pond management, fish production is low: the average yield of 490 poorly managed village fishponds in NortheasternThailand in the mid-1990s was only 416 kg/ha.[18]

19. Large commercial fish farms are either integrated with feedlot livestock and/or use waste food from factory canteens and restaurants or various by-products from agroindustrial factories. Most integrated fish farmers are primarily livestock entrepreneurs who have constructed ponds in the floodplain to raise the level of the animal quarters to prevent animals from drowning in the rainy season. Livestock quarters are located above or adjacent to the pond, such that their manure fertilizes the fishponds and spilled feed provides nutritional inputs for fish. Such integrated farms still provide the bulk of low-value fish for urban consumers. These types of aquaculture are dominated by entrepreneurs in peri-urban areas, especially in the provinces in Central Thailand, and have little relevance for small-scale farmers.

20. Technical constraints facing new entrant small-scale farmers have been largely resolved through research partnerships between the Asian Institute of Technology and DOF. Much of the research was carried out in resource-poor Northeastern Thailand. Although much of Thai aquaculture comprises intensive farming systems, several aquaculture systems with relevance to small-scale farmers were developed over the past few decades in former ricefields, such as farming of snakeskin gourami,[19] Nile tilapia seed production,[20] giant freshwater prawn *(Macrobrachium rosenbergii)* farming, and inland culture of (marine) shrimp (*Penaeus*

[18] Virapat, Cherdsak. 1997. *Preliminary Quantitative Assessment of the Fish Stocking Program in Community Fish Ponds in the Northeast of Thailand*. Technical Paper 27/1997. Bangkok: Inland Fisheries Division, Department of Fisheries.

[19] Most snakeskin gourami production takes place in large converted ricefields in Central Thailand where rice farming was marginal because of poor quality, saline soils in a reclaimed swamp in the Chiengrak-Klongdan district of Samut Prakarn Province (Yoonpundh, Ruangvit, and David Little. 1997. Trends in the Farming of the Snakeskin Gourami in Thailand. *Naga The ICLARM Quarterly* 20(3/4): 18–20).

[20] The major area for tilapia seed production is a small area in three contiguous subdistricts of Chonburi and Chachoengsao provinces in Central Thailand. Former rice farmers produce 2–3 centimeter long seed as swim-up fry in shallow ponds fertilized with manure from feedlot livestock farms; the manure is delivered to the pond side in plastic containers (Little, David, Chang K. Lin, and Warren A. Turner. 1995. Commercial Scale Tilapia Fry Production in Thailand*. World Aquaculture* 269 (4): 20–24).

monodon). Most farmers who grow these species are now better off; many were relatively poor rice farmers before they took up aquaculture.[21]

Converting a ricefield to a fishpond

Chicken feedlot over a fishpond

21. Fish health is a major concern in aquaculture. When fish farmers change their farming practices from extensive and semi-intensive to intensive farming, they inevitably face increased risks of fish diseases. DOF has published guidelines for the proper use of drugs and chemicals for fish disease protection and treatment.[22]

E. Accessing Markets

22. Domestic marketing of freshwater fish is complex, involving several channels and types of markets and parties.[23] In general, the distribution and marketing of freshwater fish is efficient and market access by fish farmers, including small-scale producers, is not a constraint. Fish marketing is primarily in the hands of the private sector, with the exception of a state enterprise, the Fish Marketing Organization, which operates an assembly market in Bangkok. Many private assembly markets have been established in the last few years near production centers as well as in Bangkok and surrounding provinces. Fish trading in assembly markets is done through auctions and negotiations.

23. Prices at the farm gate and in wholesale and retail markets are very competitive, with many buyers and sellers along the intermediation chain. Postharvest support facilities are adequate; freshwater fish are easily delivered from production centers to markets throughout the country. Fish transportation benefits from reliable road networks, which link all districts and provinces. With numerous fish producers and suppliers and equally numerous buyers along the fish marketing chain, prices of freshwater fish are competitive. Market participants include

[21] (i) A novel system to farm tilapia in cost-effective semi-intensive pond culture without the sole use of expensive formulated pelleted feed and without the use of wastes, has been developed (Edwards, Peter, Chang K. Lin, and A. Yakupitiyage. 2000. Semi-intensive Pond Aquaculture. In *Tilapias: Biology and Exploitation,* edited by Malcolm C.M. Beveridge and Brendan J. McAndrew. Dordrecht: Kluwer Academic Publishers.
(ii) In Central Thailand, tilapia weighing up to 400 grams can be produced within 5 months in inorganically fertilized ponds receiving commercial pellets as supplementary feed (Diana, J. S., Chang K. Lin, and Kitjar Jaiyen. 1994. Supplemental Feeding of Tilapia in Fertilized Ponds. *Journal of the World Aquaculture Society:* 25(4): 497–506; and Diana, J.S., C. Kwei Lin, and Yang Yi. 1996. Timing of Supplemental Feeding for Tilapia Production. *Journal of the World Aquaculture Society:* 27(4): 410–419).

[22] Aquatic Animal Health Research Institute. 2002. *Guidelines for Use of Drugs and Chemical Agents in Fish Disease Protection and Treatment*. Bangkok: Department of Fisheries. (In Thai)

[23] See footnote 5 for an overview from which this account is largely derived.

(i) farmers who sell their fish to wholesalers, retailers, or collecting agents, depending on quantities; (ii) fish collectors who act as intermediaries between fish farmers and fish traders by gathering fish from various farms and benefiting from price differentiation by postharvest grading of fish into size categories; (iii) fish agents who earn commission fees from transactions between buyers and sellers at assembly markets; (iv) fish wholesalers who purchase fish from assembly markets or buy directly from fish farmers, and sell to retailers; (v) fish processors who buy fish directly from fish farmers, assembly markets, wholesalers, and other processors; and (vi) fish retailers who sell to consumers.

24. Fish prices vary by location (Table 2). They tend to be lower in Central Thailand (the main region for inland aquaculture) than in the northeast and south. The snakehead fetches the highest prices. Inexpensive tilapia and silver barb, along with Indian major carps (mrigal and rohu) are of more relevance to the poor. Rural markets require relatively small tilapia for consumption, while urban markets require larger tilapia.[24] Price fluctuations at the farm gate and in wholesale markets are generally harmonized because the time lag between harvest, marketing, and final sale to consumers is short. In general, fish prices are higher in January–September than in other months.

Table 2: Average Retail Prices of Freshwater Fish Species in Selected Thailand Provinces in 2000
(baht/kg)

Fish Species	Bangkok	Chantaburi		Udon Thani		Pitsanuloke		Pattani		Songkhla
		Ang Thong	Khon Kaen		Nakon Sawan		Chiangmai		Phuket	
Walking Catfish	23.57	18.88	23.40	36.54	38.19	19.23	28.96	32.84	27.56	37.25	32.62
Snakehead	49.09	44.19	—	56.05	67.10	59.39	49.35	62.24	35.89	—	50.82
Mrigal	10.52	—	—	32.44	28.96	21.64	31.06	30.00	30.00	—	30.00
Tilapia	16.14	16.37	15.22	32.52	35.16	26.42	31.24	31.10	37.77	34.95	38.06
Silver Barb	16.30	13.86	23.32	30.00	33.89	21.23	28.76	29.89	30.67	26.27	34.75
Giant Gourami	15.00	50.00	—	—	—	39.94	41.36	—	—	—	—
Rohu	13.18	20.00	25.00	29.79	35.48	19.28	25.00	29.31	39.23	30.01	30.34
Snakeskin Gourami	44.08	50.00	—	24.35	—	49.09	25.00	—	40.00	—	36.26

— = data not available.
Source: Department of Fisheries. 2003. *Freshwater Fish Farm Production 2000.* Bangkok.

25. Freshwater fish are sold either alive or dead. Valuable carnivorous fish, such as sand goby (*Oxyeleotris marmoratus*), snakehead, and walking catfish are more likely to be marketed alive than less expensive herbivorous and omnivorous fish, which are usually sold on ice. Live fish fetch a premium price of up to 50% over iced or chilled fish. Small fish are sold to low-income consumers in rural areas. These fish are mostly produced by small-scale fish farms. Large fish, preferred by relatively wealthier consumers and by restaurants, are mostly supplied by commercial cage and fishpond operators. Fish are usually sold to fish agents at harvest at the farm gate, although some farmers transport and retail fish themselves.

26. Wholesale markets are mostly in large cities; many also offer retail outlets. Fish are transported early in the morning to wholesale markets, either directly from farms or from assembly markets by wholesalers for distribution to retailers. Retail markets are scattered in

[24] Typically, large tilapia comprise no more than 2 fish/kg, medium sized are 3–5 fish/kg, and small tilapia are more than 5 fish/kg.

Retailing small tilapia in a market

urban and peri-urban areas, generally with numerous stalls supplied with electricity and clean water on a concrete floor inside a traditional open hall. Freshwater fish in retail markets are sold live or dead; whole or in pieces; and fresh or processed, e.g., dried, salted, minced, fermented, and made into fish balls. Freshwater fish are also retailed in supermarkets with a price markup of 40–50% above common retail prices. Wholesalers also export valuable species, such as marble goby and low-value riverine catfish, chilled and frozen, to neighboring countries. Processors and cold storage operators also export carnivorous, herbivorous, and omnivorous species—among the latter mrigal, rohu, silver barb, and tilapia—to the Middle East and riverine catfish to Asia and Europe.

27. The marketing margin, the difference between the price paid by the consumer and that received by the producer, varies by species. The farmers' share of the retail prices for silver barb and tilapia can amount to about 50% and 60%, respectively.[25] Typically, the marketing margin for tilapia of 40% is made up of 16% direct marketing costs and the remaining 24% gross margins shared among fish collectors, wholesalers, and retailers. Retailers pay marketing costs related to cleaning, gutting, and cutting fish prior to sale. Retailers also bear the risk of not selling their fish fresh, a situation that can significantly lower the retail prices.

F. The Roles of Government in Aquaculture Extension

28. The Government has promoted aquaculture for decades, through both research and extension services. The government strategy for promoting small-scale rural aquaculture in the past included the provision of subsidized inputs. The Government has provided substantial support and incentives to farmers by providing free advisory services for the promotion of aquaculture technologies, and subsidized inputs for pond construction, seed, feed, and lime to fish farmers. The Government has, however, realized that subsidies do not necessarily lead to sustainable aquaculture development, and that it is necessary to extend adequate and appropriate information on aquaculture technologies to targeted fish farmers effectively.

29. DOF has played an important facilitating role in rural aquaculture development, planning, and implementation. Its services include aquaculture extension and transfer of fish farming

[25] Most tilapia are for domestic consumption. Marketable size is about 2–3 fish/kg. Tilapia from cage culture are sold to restaurants, food shops, supermarkets, and retail shops in local provinces. Recently, cold storage industries have started to buy tilapia for processing and export. Importing countries include Australia, France, Italy, and the United States. Cold storage industries purchase fish of 400 grams upwards for export markets as frozen products and fish of 100–400 grams for filleting as frozen products or processed products for export.

technologies to farmers.[26] While fisheries organizations or cooperatives may be found in areas where there are considerable aquaculture activities, the roles of these farmers' organizations are primarily related to marketing, an area of common interest among farmers. DOF has not been able to mobilize the support of these organizations to deliver its extension programs because of various shortcomings affecting the farmers' organizations and the aquaculture extension services.[27] Privately managed cooperatives in freshwater aquaculture have generally faced financial and human resource constraints.[28] However, community participation in aquaculture development through village committees, district councils, or subdistrict TAOs has been evident. In this context, fish farmers and villagers participate in planning and making decisions on their community resource use and conservation.

30. The Government is attempting to make the extension system more responsive to farmers' actual needs, particularly by providing information more appropriate to farmers' conditions. In October 2002, it reorganized the overall agricultural extension system and the central responsibilities of DOF in terms of technology development and extension. These are now limited to training functions and providing assistance in the preparation of extension materials in the newly established Bureau of Fishery Technology Transfer and Extension.[29] Under the new extension system, the Department of Agricultural Extension has been mandated to be the sole government agency to organize training as well as farmer selection in all agricultural disciplines, including fish farming. Under the new arrangements, all training activities are decentralized and conducted through the Tambon Technological Transfer Center, which is meant to be a one-stop service center where farmers and local residents can get advice and information, and contact experts in various disciplines.[30]

G. Community-Based Rural Aquaculture Development

31. Community-based aquaculture in Thailand has contributed to the development of self-help initiatives, local ownership, and decision making in the communities. DOF has promoted small-scale and community-based freshwater aquaculture for many years, including through the VFPDP (footnote 12), and there have been both successes and failures. The main factors that

[26] The administrative structure of DOF has two parts: central administration and regional administration. The central administration includes 28 divisions and the regional administration covers 75 provincial fisheries offices (PFOs). The organizational units within DOF that share responsibility for aquaculture management and development include three bureaus and one division (Bureau of Inland Fisheries Research and Development, Bureau of Coastal Aquaculture Division, Bureau of Fishery Technology Transfer and Extension and Feed Quality Control Development Division); four institutes (National Inland Fisheries Institute, National Institute of Coastal Aquaculture, Aquatic Animal Health Research Institute, and Aquatic Animal Genetics Research and Development Institute); 31 fisheries centers; and 75 PFOs.

[27] Potipitak, K. 1996. Aquaculture Extension Services Review: Thailand. *FAO Fisheries Circular 910.* Rome.

[28] Sinchaipanich, C. 1995. *Information on Fisheries Management and Cooperatives of Thailand*. Bangkok: Department of Fisheries.

[29] In the past, the Fisheries Extension Division, the Office of the Fisheries Inspector, and the Fisheries Engineering Division of DOF were the three main organizational units involved in planning, budgeting, and monitoring of extension projects. The Training Division was responsible for setting up curricula and organizing training courses on fish farming techniques of various species, including tilapia. Farmer selection and basic training were carried out by the PFOs located in 75 provinces throughout the country. For advance training, lecturers were drawn from the Fisheries Development Center and fisheries stations in addition to the PFO staff.

[30] These changes in the extension system are in accord with the recent move to decentralize government functions in Thailand. Small-scale aquaculture is expected to receive less direct attention from DOF. There are no more district-level fisheries officers; they have been transferred to the provincial level. The needs of small-scale fish farmers are currently addressed through projects sponsored by Royalty and the mobile units of the Department of Agricultural Extension, which has focused mainly on agriculture to date. The Tambon Technical Transfer Centers are generally weak, with inadequate human resources. The Ministry of Agriculture recently announced that it would reintroduce district fisheries officers, who would be assigned to areas where fish are locally important.

have influenced the success of community-based aquaculture are (i) the demand for and the extent of interest in fish farming; (ii) social capital, including organizational arrangements that contribute to strong community participation, sharing access to resources, and conflict resolution; and (iii) government assistance and partnerships with the communities. Drawing from experience, constraints to rural aquaculture include water shortages, unfavorable biophysical conditions, low natural productivity, and such farm management issues as stocking density, pond management, access to feed, and harvesting methods. Fish farming has also been affected by environmental degradation, limited financial and human resources, inappropriate links between extension and research, and external shocks such as the effects of the Asian financial crisis of 1997.

Villagers harvesting a communal fishpond

Nursing hapa in a school fishpond

32. One of the most promising government support programs for poor communities to increase rural fish production is the School Fishpond Program (the Lunch Program) under Her Royal Highness Princess Maha Chakri Sirindhorn. The target areas are village schools, mainly primary and, to a lesser extent, secondary schools, in remote areas. The main objective of this program is to improve the nutritional status of school children in these areas by providing fish for consumption through self-help initiatives in fish farming. The program, which began in 1992, includes construction of fishponds, aquaculture training, and provision of fish seed and technical advice to schools. The Lunch Program has also piloted an integrated fish-poultry farming project to increase fish production at low cost. Table 3 shows production of the pilot project in 2000. Despite encouraging outcomes, constraints affecting the program include limited water supply, inadequate feed and other inputs, and limited knowledge in fish farming. There is scope for improvement and expansion to take advantage of the village schools as institutions that act as a focal point in remote areas at the grassroots level. There are opportunities for adaptive and hands-on learning in fishpond management and other aquaculture related issues. Through a series of simple activities involving village fishponds or small waterbodies, students and the communities can participate in an experiential learning process that actively demonstrates the potential benefits of improved fishpond management to livelihoods and human nutrition.

Table 3: Pilot Integrated Fish and Poultry Farming Project Production Statistics under the School Lunch Program in 2000

Region	Number of Schools	Layer Chickens	Number of Eggs Produced	Fish Production (kg)	Total Income (B'000)
Northeastern	4	1,250	351,852	405	598
Northern	4	900	246,145	421	459
Central	3	550	147,119	308	231
Southern	1	504	129,936	365	235
Total	**12**	**3,204**	**875,052**	**1,499**	**1,523**

Source: Department of Fisheries. 2002. *Smallholder Aquaculture Research and Development.* Bangkok.

H. Development Policy for Small-Scale Freshwater Aquaculture

33. National development by the Government takes place through the National Economic and Social Development Plan (NESDP). The principal strategic objective of the NESDP is to promote economic development by utilizing natural and human resources to increase production, generate employment, and increase national incomes. The direction of rural aquaculture development has developed from the fifth to the eighth NESDPs. The relevant stated goals were to (i) alleviate malnutrition (NESDP 5, 1982–1986); (ii) accelerate fish culture activities (NESDP 6, 1987–1991); (iii) increase opportunity for establishment of individual fishponds (NESDP 7, 1992–1996); and (iv) increase human resource capacity in managing integrated community fishponds (NESDP 8, 1997–2001).[31]

34. Thailand's National Fisheries Policy on aquaculture aims to (i) increase fish production to meet the demand for domestic consumption; (ii) increase income for fish farmers; and (iii) raise the standard of living of small-scale fish farming households, as well as to increase fish production as export products from coastal aquaculture. Current strategies focus on (i) developing and improving aquaculture techniques by conducting research to increase fish production and to reduce production costs; (ii) conducting research on fish species with high economic potential to improve their desirable characteristics, and to develop good practices for hatcheries and aquaculture farms; and (iii) providing technical services and certifying registered hatcheries and farms.[32]

35. The National Fisheries Policy hinges on the assumption that future rural aquaculture development will remain at a small-scale and subsistence level, mainly for domestic consumption and local household food security, especially for the rural poor. This limits the scope for intensifying the systems. The major role of researchers, therefore, is to find innovative and viable low-cost, low-input technology options for such conditions. Appropriate technology options for small-scale freshwater aquaculture have been developed in Northeastern Thailand

[31] Subcommittee on Nutritional Plan. 1998. *National Food and Nutritional Plan Under the National Economic and Social Development Plan (1997–2001).* Bangkok: Ministry of Public Health.

[32] The main policy goal for inland aquaculture is to provide fish protein for the rural poor, based on providing government support under conditions through which the rural people can participate and eventually become self-reliant. In contrast, the main policy goal of marine aquaculture development is to increase production for export rather than for local consumption.

through research partnerships between DOF and the Asian Institute of Technology, but these options require adaptation to the specific conditions of farmers with limited resources.[33]

36. The Government decentralized authority for management of fishery resources in all community waters to TAOs in 2001. TAOs had previously facilitated aquaculture development in their jurisdictions by requesting government support for fishpond construction, with DOF providing technical assistance. Achievements of these fishpond development initiatives have been variable. Principal shortcomings were inadequate fishpond management, ineffective extension services, deficient comanagement mechanisms and practices for common and shared assets, and poor access at the village level to information on aquaculture. The TAOs still have limited experience in natural resources management and need to develop their credibility and establish the trust of the communities. In the past, the communities did not have the opportunity and experience to make appropriate and enforceable resource management decisions. The TAOs can, and increasingly must, play a role in arbitrating and facilitating the management of community natural resources. There are opportunities for capacity building and for forging close partnerships between the stakeholders in the communities and government services, including fisheries officers and TAO officials, through a participatory learning process and iterative improvements.

37. Currently, the Fisheries Act (1947) prohibits private pond construction in the public domain. However, fish farmers have rights to construct fishponds on their own land (property). Fish farmers can also operate cage culture in public waters. Such fish cage farms have to fulfill certain requirements for obtaining government permission, such as nonobstruction of waterways or transportation, nondisturbance to the public, a suitable location, and approval by district and provincial authorities. Licenses for fish cage farming are normally granted for 5 years. At present, subdistrict governments, Royal Irrigation Department, Royal Forest Department, and the Electricity Generation of Thailand are also involved in authorizing cage culture in their areas of jurisdiction.[34] The Fisheries Act does not require freshwater aquaculture activities operating on private property to register and obtain permission. Nevertheless, the Government requires all aquaculture operators to register with the competent authority and get permission before operating.

38. Fish farmers have traditional rights to access a water supply from rivers and reservoirs. Changes to the Water Law are being considered, with the possible introduction of charges for water, especially for recreational use, such as watering golf courses. Fish farmers have exclusive rights to produce. The Government has no policy to regulate fish producers, unless they farm restricted species, i.e., endangered species listed by laws. However, in the future, the Government will apply concepts and practices guided by the FAO Code of Conduct for Responsible Fisheries[35] and associated guidelines.[36] The code puts emphasis on environmental aspects (effluents and water discharge), drugs and chemicals used in aquaculture, improvement of quality of fish products, preservation of fish products after harvesting, and quality control of fish products.[37]

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[33] *Aquaculture and Aquatic Resources Management*. School of Environment, Resources and Development. Asian Institute of Technology. Available: http://www.serd.ait.ac.th/aarm/

[34] Viwattanachaisate, Y. 2000. Workshop on Cage Culture of Tilapia in the Year 2000. *Thai Fisheries Gazette* 53(1): 81–92.

[35] FAO. 1995. *Code of Conduct for Responsible Fisheries*. Rome

[36] FAO. 1997. Aquaculture Development. *FAO Technical Guidelines for Responsible Fisheries No. 5.* Rome.

[37] Schramm, J. K. 2001. Tilapia Production and Marketing Status and Outlook. In *Tilapia Production, Marketing and Technological Developments*, edited by S. Subasinghe and T. Singh. Proceedings of the 2001 International Technical and Trade Conference on Tilapia. Kuala Lumpur: INFOFISH.

I. Safeguards for Freshwater Aquaculture

39. **Aquaculture Zoning.** Aquaculture zoning can serve as a tool for planning and implementing aquaculture activities to mitigate adverse environmental impacts. For example, in the absence of zoning, the rapid expansion of marine shrimp farms into freshwater areas of several provinces in Central Thailand has generated conflicts in uses of land and water resources. Salinity intrusion was attributed to shrimp farming that affected freshwater ecosystems, ricefields, and orchards. This situation led to the enforcement, from December 1997, of Article 9 of the Environmental Act of 1996 to ban low-salinity shrimp farming in freshwater areas throughout the country.

40. **Integrated Agriculture-Aquaculture.** Integrated agriculture-aquaculture has been practiced for almost a century, initially in Bangkok but at present throughout the country. The most popular systems are fish/poultry culture, fish/pig culture, and mixed culture (fish, pig, poultry).[38] DOF has conducted several programs to increase fish production through integrated farming. The Bank for Agriculture and Agricultural Cooperatives (BAAC), with support from the Belgian Administration for Development Cooperation (BADC), developed guidelines for integrated fish farming in Northeastern Thailand.[39] Integrated livestock/fish farming systems safeguard the environment because the livestock manure is used as organic fertilizer for the fishponds, which also function as waste stabilization ponds.[40] A technology divide has developed over the past decade in which traditional semi-intensive aquaculture using on-farm and locally available agricultural residues is being replaced by relatively high-cost intensive culture using formulated pelleted feed. However, a third system—a semi-intensive system based on inorganic fertilization and supplementary feeding—can effectively intensify fish production for small-scale farmers and reduce the cost of production for large-scale producers. This system is more environmental friendly than intensive production that relies solely on pelleted feed.[41]

41. **Biosafety and Disease Prevention.** Introductions and transfers of alien aquatic species have been made deliberately and accidentally.[42] Alien species were introduced mainly for aquaculture and the aquarium trade and in many cases were imported illegally without adequate quarantine. Freshwater aquaculture is constantly exposed to the risk of possible adverse impacts from introductions of alien species and farmed organisms, particularly from the introduction of diseases and parasites. Enforceable and effective safeguards need to be developed, taking into account practical recommendations for biosafety measures.[43] However, the implementation of aquaculture health management guidelines for transboundary movements of live aquatic animals (such as health certification, quarantine, and diagnostic procedures)

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[38] Potipitak, K. 1995. *Integrated Fish Farming System in Thailand*. Bangkok: Department of Fisheries.

[39] Bank for Agriculture and Agricultural Cooperatives (BAAC) and Belgian Administration for Development Cooperation (BADC). 2002*. Integrated Fish Farming Technical Guidelines for Investment: A Handbook for Credit Officers.* Bangkok: BAAC and BADC.
BAAC and BADC. 2002. *Guidelines for Choosing Activities When Developing Integrated Fish Farming.* Bangkok: BAAC and BADC; Mukdahan Project Office.

[40] Edwards, Peter. 1993. Environmental Issues in Integrated Agriculture-Aquaculture and Wastewater-Fed Fish Culture Systems. In Environment and Aquaculture in Developing Countries, edited by Roger S.V. Pullin, Harold Rosenthal, and Jay L. Maclean. *ICLARM Conference Proceedings 31.* Manila. p. 139–170.

[41] Edwards, Peter, Chang K. Lin, and Amararatne Yakupitiyage. 2000. Semi-Intensive Pond Aquaculture. In *Tilapias : Biology and Exploitation*, edited by Malcolm C.M. Beveridge and Brendan J. McAndrew. Dordrecht: Kluwer Academic Publishers. p. 377–403.

[42] Termvidchakorn, A., C. Vidthayanon, Y. Getpetch, P. Sorrak, and P. Paradonpanichakul. 2003. *Alien Aquatic Species in Thailand*. Bangkok: Bureau of Inland Fisheries Research and Development, Department of Fisheries.

[43] FAO. 2003. *Introduced Species in Fisheries: Responsible Use and Control.* Rome.

depend not only on political will, but also on sustained investments and conducive behavior of farmers, researchers, and the general public, in order to minimize preventable and potentially damaging risks from irresponsible introductions and dissemination of alien aquatic species and farmed organisms.

J. Lessons Learned

42. Fish farming has developed rapidly over the last few decades, partly in response to a decline in capture fisheries and to a rising demand for fish. Small-scale farmers have benefited from the development of aquaculture, although existing data do not allow measuring the socioeconomic benefits to these farmers. Fish are an important component of the Thai diet and contribute significantly to national food security and human nutrition. Fish provide a traditional source of animal protein, fatty acids, and micronutrients.

43. Fish marketing in Thailand is competitive and largely in the hands of the private sector. With good road networks, transportation, supporting infrastructure, and telecommunications, fish and fish products flow freely in the country. This enables Central Thailand to supply fish to deficit areas such as Northeastern Thailand where retail prices of fish are generally higher than in other parts of Thailand. Northeastern Thailand is home to the majority of small-scale farmers in the country, and these small-scale producers have faced increasing pressure to improve farm productivity and reduce production costs to remain competitive in a free market system.

44. The rural poor comprise producers and consumers, and suppliers of labor. In the context of small-scale aquaculture, the rising opportunity cost of labor because of rapid economic development and employment opportunities in Thailand as well as overseas has placed additional pressure on farm productivity, which must rise if fish farming is to remain an attractive livelihood option. This economic environment places restrictions on the appropriateness of technology for small-scale aquaculture. Low-cost and affordable technology does not necessarily provide high returns on labor inputs, while intensive farming can create a demand for financial and other resources that the poor do not have. In many areas of Northeastern Thailand, labor migration to urban areas, particularly to Bangkok and its vicinity, has caused farm labor scarcity. These conditions restrict farm households from adopting labor-intensive farming techniques.

45. DOF has played a major role in the development of aquaculture in the country over the last few decades. DOF started to promote farming of native snakeskin gourami in the 1930s, but did not succeed due to low demand for farmed fish at that time and an abundant supply of and high demand for wild fish. Mozambique tilapia was promoted in the 1950s, but its culture did not succeed because of unfavorable characteristics that constrained on-farm productivity, and the species did not meet consumers' tastes and preferences. However, promotion of Nile tilapia since the 1960s has been a success, and it is now among the major farmed fish species in Thailand.[44] These development milestones have emphasized the importance of demand, market conditions, and the appropriateness of the product to meet the demand. Introduction and promotion of fish species for farming require an astute demand assessment and the ability to sustain a viable supply. Nile tilapia meets the demand of Thai consumers, as well as the needs of farmers to produce fish at reasonable cost to generate attractive returns.

[44] Nile tilapia culture succeeded because the introduced (Chitralada) strain of tilapia had good growth performance (McAndrew, Brendan. 1981. *Electrophoretic Analysis of Tilapia from Dusit Palace Stock, Thailand.* Report THA/75/012/WP6, DOF-UNDP/FAO THA/75/012. Stirling Institute of Aquaculture).

46. DOF has placed great emphasis on the development of fisheries stations, which have catalyzed the development of the private sector's dominant role in seed production and seed supply to support the increasing importance of fish farming. While the Government has played an instrumental role in placing the necessary facilities for initiating and ensuring seed supply to promote fish farming, its role has not hindered the private sector from developing and taking over the seed supply business. Overall, the private sector provides a reliable supply of seed in Thailand, with complementary development initiatives in the feed industry. Without a reliable seed supply, fish farming would not have developed into a major industry. Seed supply has been a major constraint to the adoption of aquaculture in many countries.[45] The Government has sustained its research and development initiatives on fish breeding to maintain good quality broodstock to ensure open public access to farmed species and strains of good performance. The roles of the private and public sectors in seed production and quality assurance are complementary.

K. Ways to Benefit the Poor

47. The primary means used by DOF to reduce poverty through aquaculture, especially in Northeastern Thailand, is the VFPDP. The program, which attempts to increase fish production through community-based management of natural, modified, or engineered water bodies at the village level, has had variable success. However, the recent decentralization of authority for management of natural resources, including fisheries, to subdistrict governments, has offered new opportunities for increasing community participation in making decisions on use of natural resource assets. The VFPDP program recently entered a new phase with assistance from the Swedish International Development Cooperation Agency and the Asian Institute of Technology.

48. DOF also currently assists the rural poor through aquaculture extension services based on the distance extension approach, using technologies appropriate for household-level and pond-based aquaculture.[46] Most local communities and individual farming households have limited resources at their disposal; thus, less technical but demand-led approaches are required to reach poor target groups. Nevertheless, challenges in developing viable technology options for aquaculture continue to emerge in the rapidly changing rural economy.

49. In responding to challenges to make aquaculture benefit small-scale farmers, several factors should be considered: (i) livelihood options of targeted groups, including existing sources of household incomes; (ii) opportunity cost of labor, employment opportunities, and labor market characteristics, including labor migration; (iii) affordability and the extent to which targeted users of technology have access to livelihood assets for fish farming; and (iv) markets and marketing of farm inputs and outputs, and their specific relevance to fish farms. Responding to the challenges requires capacity building of local government agencies and local service providers. Adaptable approaches are needed without relying on rigidly predetermined packages of technology. Analyzing the characteristics of households or small-scale farmers and assessing the specific features of their operating environment are important elements in appraising ways to make aquaculture work for small-scale farmers.

50. Innovative approaches to enhance learning and community participation in the planning and use of water resources for integrated aquaculture-agriculture can improve livelihood options

[45] P. Edwards. 2000. *Aquaculture, Poverty Impacts, and Livelihoods*. Natural Resource Perspectives No. 56. London: Overseas Development Institute.

[46] See Case Study 8: Development of Technology and Extension for Small-Scale Fish Farms in Northeastern Thailand.

and enhance benefits for targeted groups.[47] DOF could support such approaches by targeting agents of learning and information dissemination, such as teachers, students, community-based organizations, village leaders, and extension officers. Understanding relevant features of water resources management and their competing and complementary uses can prevent conflicts and mitigate adverse environmental impacts. Further, addressing issues related to common property rights and access to land and water resources may ease access gaps to critical livelihood assets for the poor to engage in small-scale aquaculture.

51. A promising way to alleviate malnutrition among poor children in remote rural areas is the School Fishpond Program mentioned earlier. While the program provides immediate direct nutritional benefits among students of targeted schools, the benefits go beyond the school boundaries; the program serves as a catalyst in the communities to promote the use of water resources for integrated aquaculture-agriculture. The schools act as a focal point, providing outreach to students, parents, and other members of the communities, and a hub for information exchange and dissemination.

[47] DOF. 2003. *Adaptive Learning in Water Resource Management for Community Fisheries Development. Project Proposal for FAO of the United Nations Technical Cooperation Programme*. Bangkok: DOF.