

**CASE STUDY 8:
DEVELOPMENT OF TECHNOLOGY AND EXTENSION
FOR SMALL-SCALE FISH FARMS IN NORTHEASTERN THAILAND**

A. Background

1. Purpose and Scope

1. This case study was undertaken as part of an Asian Development Bank (ADB) special evaluation study on small-scale freshwater rural aquaculture development. The aim was to examine the processes in developing appropriate technology options for small-scale fish farming and to assess the relevance and role of extension for resource-poor fish farmers.¹ The study drew on the experience of cooperative efforts of the Asian Institute of Technology (AIT), through its Aqua Outreach Program (AOP), and the Department of Fisheries (DOF) of Thailand to develop technology and extension for small-scale household-level fish farming. These efforts were in Northeastern Thailand, the poorest region of the country, and have involved partnerships with local government agencies, nongovernment organizations (NGOs), and farmers. Freshwater aquaculture is relatively new in the area.²

2. Agriculture in developing countries may be divided into green revolution agriculture and resource-poor agriculture. The former is usually found in national agricultural heartlands in fertile areas, either irrigated or rainfed lowlands near major urban areas. The latter is often found in complex, diverse, and risk-prone (CDR) areas, often peripheral areas, where farming systems are much more fragile, as in rainfed dryland, upland, and swampy lowland.³ Northeastern Thailand is a classic example of a CDR region, in contrast with resource-rich Central Thailand, in both agriculture (crops and livestock) and aquaculture.

3. AIT has researched the development of aquaculture for small-scale farmers in Northeastern Thailand in cooperation with DOF since 1981. Their initial research collaboration involved on-farm trials with integration of ducks and fish, and later an on-farm assessment of buffalo manure as a pond fertilizer.⁴ The AOP began as a single project in 1988 with the establishment of a field office at the Udon Thani Freshwater Fisheries Development Center of DOF.⁵ The Department for International Development (DFID) of the United Kingdom wished to disseminate the results of strategic research into small-scale inland aquaculture, which it had funded over the previous decade through AIT, to farmers in Northeastern Thailand. From 1992, the AOP developed into a program of capacity building with national research, development,

¹ This case study was undertaken in consultation with Supawat Komolmarl of the Fisheries Development and Technology Transfer Bureau of the Department of Fisheries of Thailand, and N. Innes-Taylor and Danai Turongruang of the Aqua Outreach Program of the Asian Institute of Technology. P. Edwards led the preparation of this report in collaboration with N. Bestari and R. Pullin.

² Setboonsarng, S. 1994. Evolution of Freshwater Aquaculture in Northeast Thailand: Growth of a New Technology. *Tungkang Marine Laboratory Conference Proceedings* 4: 297–318. Although aquaculture is increasing, most of the increase is by better-off farmers, especially in peri-urban areas, and aquaculture remains underdeveloped in most rural areas.

³ Chambers, Robert, Arnold Pacey, and Lori Ann Thrupp, editors. 1989. *Farmer First, Farmer Innovation and Agricultural Research*. London: Intermediate Technology Publications.

⁴ (i) Edwards, Peter, Kamtorn Kaewpaitoon, Anusorn Meewan, Anant Harnprasitkam, and Chintana Chantachaeng. 1983. *A Feasibility Study of Fish/Duck Integrated Farming at the Family Level in Central and Northeast Thailand*. Bangkok: Asian Institute of Technology.

(ii) Asian Institute of Technology (AIT). 1986. *Buffalo/Fish and Duck/Fish Integrated Systems for Small-Scale Farmers at the Family Level*. Bangkok: AIT.

⁵ Edwards, Peter, and Harvey Demaine. 1988. Completing the Problem-Solving Cycle in Aquaculture: The AIT Aqua Outreach. *Aquaculture Asia* 3(3): 10–12.

and educational institutions also in Cambodia, Lao People's Democratic Republic, and Viet Nam.⁶ Although the AOP has always focused on the development of aquaculture for the rural poor, for the last few years it has worked in partnership with national and subregional institutions at provincial and district levels to support livelihoods through aquaculture, and more recently aquatic resources development.

4. The first major aim of the research partnership between DOF and the AOP was to develop appropriate technology for poor farmers in resource-poor areas of Asia, with Northeastern Thailand as a pilot area, because of its marginal characteristics. The research partnership proceeded along a learning curve as it developed appropriate technology and extension for small-scale farmers. The pilot trials showed that the technologies produced by the research were relevant for pro-poor aquaculture under the social and economic conditions prevailing at the time the research was carried out. The technologies comprised nursing fish fry to large fingerlings in hapas (fine mesh net cages) in the farmer's pond, and supplementing buffalo manure with urea for pond fertilization for growout (farming of fish seed to market size). As the Thai economy expanded rapidly, the opportunity cost of labor and, therefore, of remaining labor on-farm, also rose and a more productive growout technology was needed. This consisted of hapa nursing followed by growout of sex-reversed Nile tilapia in an inorganically fertilized pond. A distance extension system was piloted because there was no conventional aquaculture extension system.

2. Brief History

5. Northeastern Thailand comprises 19 provinces. The AOP has worked in 14 of them with various organizations from 1988 to the present. Total freshwater fish production in 2000 in Northeastern Thailand was 47,929 metric tons (t), with most produced from pond aquaculture (88.3%), followed by rice/fish farming (9.3%), and cage aquaculture (2.4%); there is also a very small amount of aquaculture in ditches.⁷ According to DOF statistics, aquaculture production has increased five-fold in the northeast region over the past decade, from 9,043 t in 1990. However, official statistics on fish production are unreliable. Freshwater fish consumption (total consumption of freshwater fish from all sources) in the northeast, based on a food consumption survey in the early 1990s, was estimated to be six times higher than the DOF figure for freshwater fish production (capture fisheries and aquaculture).⁸ Furthermore, the contribution of small-scale pond aquaculture is likely to be even more underestimated.⁹ Many small-scale farmers do not practice fish farming in the conventional sense of regular stocking and harvesting, and pond draining and filling. They usually harvest small amounts of fish periodically for household consumption and may farm fish for longer than one year if they perceive that they have sufficient fish to meet their needs, and may not stock their ponds regularly. Many farmers may be unable to culture fish year-round because ponds frequently dry up in the dry season (or flood in the rainy season). Widely scattered small-scale farmers purchasing a few hundred to a few thousand fingerlings, usually from an entrepreneur, farming fish in a pond measured in only

⁶ Sources of funds for the AOP comprised funding from DFID complemented with that from the Swedish International Development Cooperation Agency and later by the Danish International Development Assistance; also there were specific research projects facilitated by the AOP and funded by DFID and the European Union.

⁷ Department of Fisheries (DOF). 2003. *Freshwater Fishfarm Production 2000*. Bangkok: DOF. Although aquaculture has increased rapidly, it is from a relatively small production base, considering the large size of the region.

⁸ Mekong River Commission. 1992. Main Report. In *Fisheries in the Lower Mekong Basin (Review of the Fishery Sector in the Lower Mekong Basin)*. Bangkok: Mekong Secretariat. 92 p. Although the comparison was made over 10 years ago, the discrepancy is unlikely to have changed because the methods of collecting data remain the same.

⁹ Edwards, Peter and Harvey Demaine. 1997. *Rural Aquaculture: Overview and Framework for Country Reviews*. Bangkok: Regional Office for Asia and the Pacific, Food and Agriculture Organization of the United Nations.

tens to hundreds of square meters, and selling surplus fish in the village or small local markets are frequently unnoticed or invisible to DOF (footnote 9).

3. Relevance

6. DOF built the first fishery station in Sakon Nakhon in upper Northeastern Thailand in 1942, primarily for the fishery in Nong Harn Lake. Subsequently, DOF stations have been constructed in almost all provinces in the region and are instrumental in promoting seed production. Research on breeding fish and dissemination of seed have been major activities of the fisheries stations. Aquaculture in Northeastern Thailand may have originated through a countrywide program in the early 1950s assisted by the Food and Agriculture Organization (FAO) of the United Nations, based on Mozambique tilapia (*Oreochromis mossambicus*). The aim was to develop inland fish production but although the tilapia became the most popular farmed fish in the mid-1950s, interest waned because of reservations about the quality and flavor of its flesh and also probably because of precocious breeding in ponds which limited its size.¹⁰ With the major exception of the Village Fish Pond Development Project,¹¹ the efforts of DOF have centered mainly on high-input systems using formulated feed and integration of fish, particularly Nile tilapia (*O. niloticus*), with feedlot livestock. Neither of these two systems is appropriate for small-scale farmers, who initially view fish farming as a supplementary occupation, mainly to satisfy household consumption.

4. Biophysical Features

7. Northeastern Thailand covers an area of 168,854 square kilometers, one third of the area of the country, and had a population of 20.8 million in 2000.¹² Most of the region is occupied by the Khorat Plateau, a low plateau with an average elevation of 160–200 meters above sea level. As the plateau has a sandstone base, it generally has nutrient-poor soils. It is characterized by a rather erratic monsoon rainfall regime with most rain in June–October and more or less dry conditions during the remainder of the year. Average rainfall is less than 1,000 millimeters in the southwest, increasing to about 1,800 millimeters in the northeast, but the region is drought prone because the effectiveness of rainfall is reduced by the predominant sandy soils.¹³

8. There are considerable fluctuations in wet-season rice yields because of inadequate supplementary irrigation during droughts; most farmers are unable to develop year-round cultivation of crops because of limited irrigation systems. For purposes of water resource planning, the northeast region has been divided into three major zones: areas irrigable by large reservoirs, which can benefit 8–9% of farm families; areas irrigable by pumping from large rivers, which can benefit a further 10% of families; and the remaining areas inaccessible from

¹⁰ Mekong River Commission. 1992. Thailand Country Sector Review. In *Fisheries in the Lower Mekong Basin (Review of the Fishery Sector in the Lower Mekong Basin)*. Annex 7, p. 1–40. Bangkok: Mekong Secretariat.

¹¹ The Village Fish Pond Development Project is a state-sponsored initiative to support community-based fish production in rehabilitated or newly constructed “village fish ponds” (reservoirs, swamps, and tanks). It started as a pilot project in 1978 but continues as a major initiative of DOF to promote rural aquaculture.

¹² National Statistical Office. 2000. *Population and Housing Census 2000*. Bangkok: National Statistical Office. The total population of the country was 60.9 million.

¹³ Demaine, Harvey, Nick L. Innes-Taylor, Danai Turongruang, Peter Edwards, David C. Little, and Jharendu Pant. 1999. *Small-Scale Aquaculture in Northeast Thailand, a Case Study from Udon Thani*. Bangkok: Aquaculture and Aquatic Resources Management Program, Asian Institute of Technology.

large reservoirs and reliable rivers, which contain 80% of the rural population.¹⁴ In the last mentioned areas, basic village water requirements are met mainly by small tanks or reservoirs, or village ponds, either natural or dug, or by shallow or deep wells, and increasingly by household-level ponds.

9. Farm and household-level multipurpose ponds are common because of unreliable water supply. Drinking water is mostly rainfall collected by the roof of the house and stored in large jars; ponds may be used for bathing and washing clothes and dishes, as well as for livestock and crops. Many such ponds function also as trap ponds for wild fish; they include depressions and pits in and alongside ricefields, serving as sumps into which water and fish are drained at the end of the rice planting season. When the AOP began in 1988, there were many ponds in Udon Thani Province that either were not stocked with fish or were farmed ineffectively. DOF requested AOP to explore how to improve the existing ponds for aquaculture rather than pay for the construction of new ponds.

10. The problem of drought in Northeastern Thailand has intensified over the last 30 years as cash crop cultivation, especially of cassava, kenaf,¹⁵ and sugarcane has led to the clearance of forests from the rolling uplands. Forest resources in Thailand as a whole decreased from 27.3 million hectares (ha) in 1961 to 13.1 million ha in 1995. The reduction of forest cover in Northeastern Thailand has been equally dramatic, declining from 7.1 million ha to 2.1 million ha over the same period. Clearance of forests has increased run-off and incidence of flash floods, reduced water tables, and deposited salt dissolved from upland soil layers in surrounding rice lowlands. Many village ponds, which previously provided adequate wild fish for local consumption, have become shallower and clogged due to sedimentation and growth of aquatic weeds.

5. Socioeconomic Setting

11. The northeast region, because of its biophysical features, is characterized by mainly low-input, low-yield agriculture that does not offer an adequate living to the large numbers of farmers.¹⁶ The difficulty of marketing relatively small amounts of high-value produce from widely scattered farms and the attraction of off-farm employment in the dry season have precluded the optimal use of the few irrigation schemes (which occupy less than 10% of the region) and the more than 80% of rainfed farms. There is some intensive, market-oriented agriculture for vegetables and flowers, often under contract to agribusiness, but it is far from widespread. Nor has the long advocated shift to commercial cattle rearing and fruit growing developed on a widespread scale.

12. Farm households have increasingly sought to augment their earnings through off-farm employment. This was initially a seasonal migration to sugarcane fields and orchards of Central and Eastern Thailand or for temporary urban employment, but more recently there has been a mass exodus of the agricultural labor force. Many young people have moved on a semi-permanent basis, particularly to Central Thailand for employment in the service, construction,

¹⁴ AIT. 1978. *Water for the Northeast: A Strategy for the Development of Small-Scale Water Resources*, Volume 1: Main Report. Bangkok: Asian Institute of Technology. Although this study was carried out over 2 decades ago, the conclusions remain valid because they are based on the geomorphology of the region.

¹⁵ Kenaf is a fiber much like jute, although coarser and less pliable, obtained from the stems of *Hibiscus cannabinus*. It probably originated in Africa but has been introduced into most tropical countries.

¹⁶ Pant, Jharendu, Harvey Demaine, and Peter Edwards. 2001. Promotion of Integrated Agriculture-Aquaculture Farming Systems in Northeast Thailand: Need for Judicious Considerations. *Asia-Pacific Journal of Rural Development* 11(2): 50–63.

and industrial sectors. Older and more skilled workers have also moved as contract workers to seek opportunities in the Middle East and East Asia. Their remittances do offer some financial resources for investment in agriculture and aquaculture, although these are constrained by the reduced availability of the on-farm labor force.

13. The Asian financial crisis in 1997 and subsequent economic recession led to a mass layoff of workers, leading to a return migration of the labor force (footnote 16). However, the highly seasonal and unstable farming systems were unable to provide returning migrants with an adequate livelihood; many households found it difficult to make a living with declining off-farm sources of income.

14. There appears to have been a marked general decline in wild fish, the main source of animal protein in the diet, over the last 3 decades because of siltation of natural waterbodies and increasing pressure on stocks because of human population growth (footnote 13). The practice of trapping wild fish in ricefields is probably as old as rice cultivation itself in Northeastern Thailand, although the culture of fish in ricefields appears to be a relatively new activity in the region and is of limited occurrence.¹⁷ Farmers usually only enhance the natural fishery by raising the height of the ricefield dike and/or excavating a small area to form a trap pond.

B. Development of Appropriate Technology

15. Improvement of the livelihoods of poor farmers depends on the development of appropriate technology. A farming systems research and extension approach was followed to ensure that the technology developed was relevant and would be adopted by small-scale farmers in the region. The approach involved three stages of research (Figure 1).¹⁸

16. The first stage was situational analysis to assess the need for, and the potential benefits from, aquaculture technology for small-scale farming households. Then followed identification of appropriate technologies from a review of relevant knowledge, on-station and on-farm research to further develop a new technology, and adaptive field trials with farmers to test and refine technical recommendations so that they could be readily adopted by the small-scale farmers who received them. Finally, research was carried out on the production of extension materials and ways to disseminate them widely.

1. Relevance of Semi-Intensive Technology

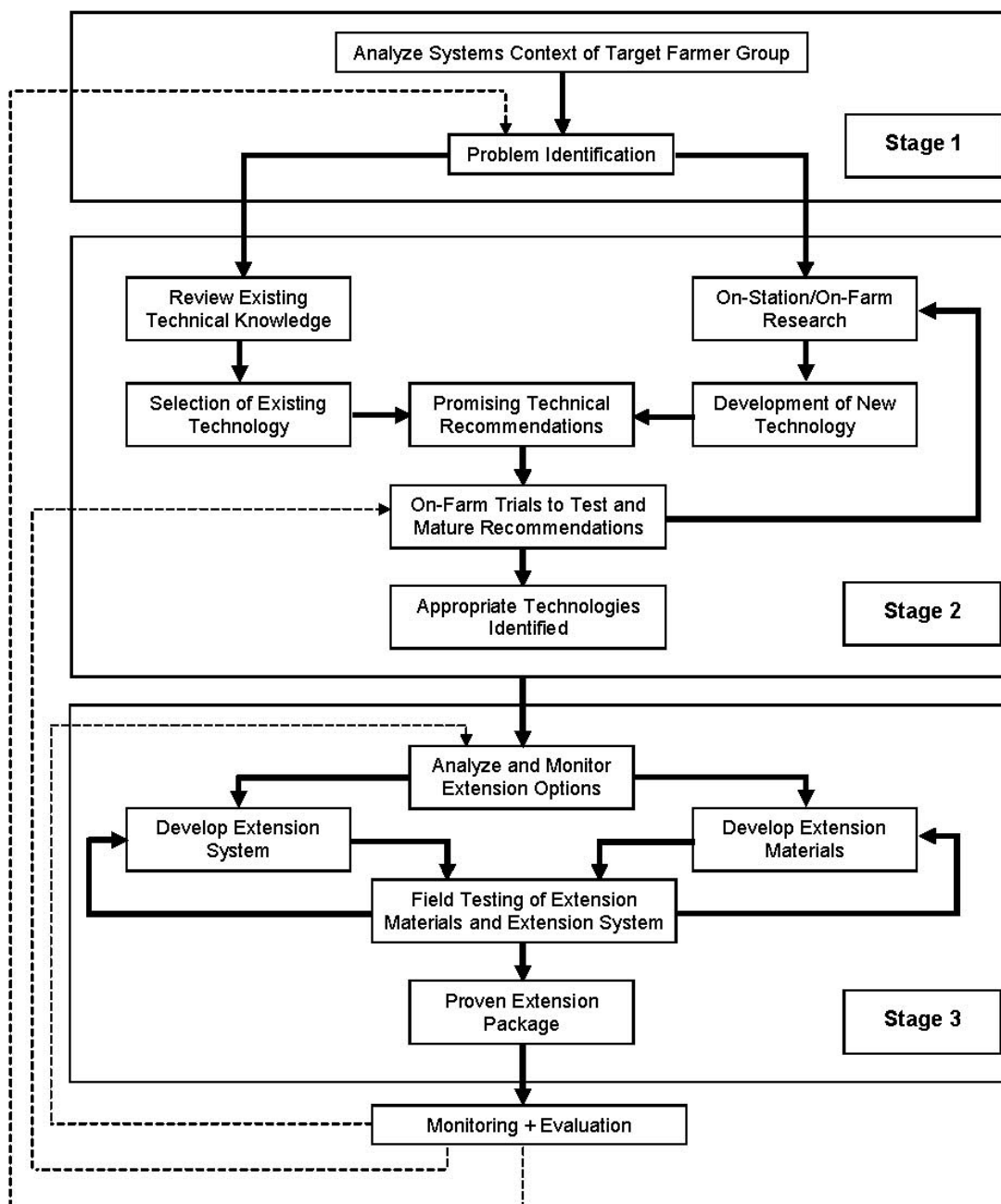
17. Research carried out by AIT and its partners has focused on semi-intensive fish farming systems using low-cost inputs (fertilizers and supplementary feeds) rather than expensive, nutritionally complete formulated feeds that are used in intensive aquaculture (footnote 5). Semi-intensive systems are more appropriate for rural aquaculture to satisfy the needs of small-scale farming households and poor consumers: a semi-intensive system can be developed by modifying a traditional extensively managed ricefield or pond, either a wild fish capture or a culture system, rather than by introducing a completely new system. Nutritional inputs for fish can be low cost, using on-farm products or by-products. If the system is intensified through the use of organic and inorganic fertilizers for fishpond fertilization and supplementary feeds,

¹⁷ Little, David, P. Surinataseree, and Nick Innes-Taylor. 1987. Fish Culture in Rainfed Rice Fields of Northeast Thailand. *Aquaculture* 140: 296–321.

¹⁸ AIT. 1994. *Partners in Development, the Promotion of Sustainable Aquaculture*. Bangkok: Asian Institute of Technology.

production costs may still be substantially lower than the costs of systems that rely completely on formulated feed. With reduced production costs, poor consumers may benefit from low-cost fish that can be made available in the markets at competitive prices.

Figure 1: Farming Systems Research and Extension
(three stages linked together in an iterative process)



Note: Solid line, first round; and broken line, subsequent rounds of development of aquaculture extension packages.

Source: Edwards, Peter and Harvey Demaine. 1997. *Rural Aquaculture: Overview and Framework for Country Reviews*. Bangkok: Regional Office for Asia and the Pacific, Food and Agricultural Organization of the United Nations.

2. Baseline Survey

18. The AOP began in 1988 with a baseline survey carried out in Udon Thani Province to characterize small-scale farmer practices in aquaculture (footnote 13). Interviews of almost 500 fish farming households in 56 villages revealed their relatively limited knowledge of aquaculture, with yields of only 0.38–0.50 t per hectare (ha) per season, equivalent to 43–57 kilograms (kg) from an average pond of 1,136 square meters (m²). Only 6% of farming families in these villages cultured fish, indicating considerable unfulfilled potential (Table 1).

Table 1: Total and Fish Farming Households in 56 Villages of 4 Districts in Udon Thani

District	Total Households	Fish Farming Households (%)
Nong Saeng	1,684	4.6
Nong Wua Sor	2,234	5.6
Kut Jap	1,525	9.8
Kumphawapi	2,265	5.8
Total Survey	7,708	6.3

19. Most farmers obtained small (2–3 centimeter [cm]-long) fingerlings, which were widely available from DOF and private hatcheries (footnote 13). These fingerlings were usually stocked directly into ponds at a very high density, partly in an attempt to offset predation by prevalent, wild carnivorous fish. A polyculture of indigenous and alien carps and tilapia was stocked. Low levels of nutritional inputs were used infrequently and fish were partially harvested throughout the season, mostly for subsistence.

20. Farmers had a relatively poor resource base from which to provide pond nutritional inputs. Manure is used as a fertilizer to enhance the growth of natural organisms in the pond—plankton in the water column and insects and worms on the pond bottom—that provide fish feed. Farmers add supplementary feed to the fishponds to complement the natural food organisms stimulated by the fertilization with manure. Although 41 different types of pond nutritional inputs were recorded, most farmers used only 2–4 types. The most common input was rice bran, used as a supplementary feed, an off-farm input requiring purchase. Farmers milled their rice at village ricemills, which kept the rice bran as payment for rice milling services.¹⁹ The second most common input was buffalo manure, which was used by almost half the farmers who used the animal for ploughing. Very few farmers used pig or poultry manure. Most kept small flocks of scavenging poultry rather than poultry feedlots that would have been readily combined with aquaculture. The few farmers who raised pigs were mainly rice millers with readily available rice bran at marginal cost.

21. Despite being widely recommended as a pond fertilizer, on-station research at AIT and on-farm research in Northeastern Thailand demonstrated the limited value of buffalo manure as a fertilizer for fishponds because of low nutrient and high tannin content. The limited primary productivity resulting from the (low) nutrient content was inhibited by low light penetration into the water because of staining by tannin. Farmers collected about 4 t of fresh buffalo manure over 6 months but obtained only minimal fish yields.²⁰

¹⁹ Rice bran is a valuable supplementary feed, but it cannot be considered as a complete or major feed because it is not a nutritionally balanced feed for fish when used as a major input.

²⁰ Edwards, Peter, Kamtorn Kaewpaitoon, David C. Little, and Nipon Sripandh. 1994. An Assessment of the Role of Buffalo Manure for Pond Culture of Tilapia. *Aquaculture* 126: 97–106.

22. Terrestrial and aquatic vegetation was only seasonally abundant. Farmers commonly used termites as feed for fish but the supply was rapidly exhausted; their rate of use by mostly new entrant farmers far exceeded the termite growth rate. Crop by-products, such as soybean and groundnut meal, were rarely used to feed fish because these crops were not part of the local farming system. Off-farm inorganic fertilizers for ponds and formulated feed for fish were rarely used.

23. The concept of pond fertilization to produce protein-rich "green water" through plankton growth was not widely appreciated—less than 30% of farmers believed the green color to be the most suitable color of pond water for culturing fish. More than 40% thought that clear water, which is infertile, was the most suitable for farming fish.

24. The farmer's fish culture strategy was not very profitable because they (i) stocked small fingerlings that were largely eaten by wild carnivorous fish in the pond, and (ii) added little of nutritional value to the fishponds for any surviving fingerlings to eat. Farmers complained that stocked fish often disappeared and those remaining grew little. Failing to meet aspirations, many farmers abandoned their fishponds, which filled with emergent aquatic plants because sunlight penetrated through the clear infertile water to the pond bottom.

3. Development of Appropriate Seed

25. A precondition for the adoption of fish farming is the ready availability of fingerlings. Expansion of fish farming in Northeast Thailand has been stimulated by the increasing availability of seed over the past 2 decades. Hatcheries were initiated by and originally limited to DOF provincial fishery stations, but are now dominated by private entrepreneurs. DOF has encouraged fish seed production by private hatcheries and has disseminated technical knowledge through a network of fishery stations, one in every province. Fish hatcheries are concentrated in Nong Khai and Mahasarakham provinces, with about 500 and 200 hundred hatcheries, respectively, but there are isolated hatcheries throughout the region. Mobile traders distribute fingerlings by motorcycle and pick-up truck.²¹ Small-scale farmers in the region most commonly stock a mixture of indigenous silver barb (*Barbodes gonionotus*) and alien species: common carp (*Cyprinus carpio*), mrigal (*Cirrhinus mrigala*), rohu (*Labeo rohita*), and Nile tilapia.

26. Because the disappearance of the small fingerlings stocked by farmers in their ponds was a common problem, stocking larger, more predator-resistant fingerlings was a logical goal to improve the survival of stocked fish.²² Wild carnivorous fish were practically impossible to exclude from ponds, as well as being prized by farmers because of their high market value. Where significant numbers of wild fish still occurred in the floodplains of the Mun and Chi river valleys in the southeast part of Northeast Thailand, aquaculture was not relevant: farmers perceived the wild fish more as product than predator. Farmers reported that it was not difficult

²¹ (i) Little, David. 1987. Small-Scale Hatcheries in Northeast Thailand. *Aquaculture and Fisheries Management* 18:15–31. Inghamjitr, Suchart, Phairat Phromtong, and David Little. 1997. Fish Seed Production and Marketing in Northeast Thailand. *NAGA, The ICLARM Quarterly* 20(3/4): 24–27.

(ii) SOS. 1998. *State of the System Report, Fish Seed Quality in Northeast Thailand*. Aqua Outreach Program. Udon Thani, Thailand.

²² Little, David C., Nick L. Innes-Taylor, Danai Turongruang, and Supawat Komolmarl. 1991. Large Fish Seed for Small-Scale Aquaculture. *Aquabyte* 4(2): 2–3.

to prevent wild fish from entering their ponds, but they were unwilling to do so because they believed that some stocked carp and tilapia fingerlings would survive nevertheless.²³

27. Trials were carried out with 18 farmers who were carefully selected because of their relatively poor socioeconomic status and their interest to participate. It proved very difficult to recruit farmers for the trials because the AOP provided only technical assistance, unlike other projects that provided financial support (footnote 5).

28. The AOP developed a farmer-friendly seed nursery technology that was relatively simple, using readily available materials. Nursing fry to fingerlings in conventional nursery ponds has rarely succeeded at the village level in the region because it is a specialized business that requires off-farm inputs and a reliable water supply. Furthermore, most farmers are unwilling to drain ponds for preparation as fry nurseries, considering that water is a scarce resource. Elimination of widespread predatory carnivorous fish using pesticides or quicklime is difficult and costly (footnote 22). The technology consisted of nursing fry for 6–8 weeks in a small nylon net cage (hapa) suspended in a fishpond until they reached a more predator-resistant fingerling size, 6–8 cm, when they were released into the pond for growout.²⁴ The hapa could be placed wherever there was enough water to nurse fry early in the season, either in the corner of a fishpond or in a ricefield trap pond or sump.



Hapa nursing in a fishpond

29. As aquaculture expands in production and area, seed quality has become an issue, especially for new-entrant, small-scale farmers attempting to raise fish, who may fail and lose interest if seed quality is poor.²⁵ Seed quality appears to be affected by many factors: it can suffer physical or physiological trauma at many points from the hatchery, through networks of private seed traders to the farmer's pond. Even seed from broodstock of high genetic potential may not grow well if mishandled prior to stocking in the pond, and certainly will not grow well if the farmer's growout husbandry is poor. A systems approach to this complex issue is required.²⁶

²³ Setboonsarng, Sununtar. 1993. Farmer's Perception Toward Wild Fish: Product not Predator, An Experience in Rice-Fish Development in Northeast Thailand. Paper presented at the Regional Workshop on Integrated Rice-Fish Research and Development in Sukamandi Research Institute for Food Crops, West Java, 6–11 June, 1993.

²⁴ The hapa nylon material is readily available and already used by farmers for making fishing gear or for temporarily holding fish in hapas following harvest. Farmers were advised to nurse a polyculture of fry at a stocking density of 150 per m² in 50–70 cm deep hapas, either 5 or 20 m² in size depending on the size of their growout pond. Feed was a rather expensive high-quality diet (a 2:1 ratio of poultry feed concentrate to fine rice bran by volume) but was necessary because the fish were nursed at high density; however, the quantities fed were small.

²⁵ (i) AIT. 1997. *Issues in Developing Fish Seed Supply*. AIT Aqua Outreach Policy Paper 1. Bangkok: Asian Institute of Technology.

(ii) Little, David. 1998. Seed Quality Becomes an Issue for Fish Farmers in Asia. *AARM Newsletter* 3(3): 10–11.

²⁶ Participatory methods are being used to obtain information on current practices from a broad range of stakeholders to better define researchable issues. (see reference SOS 1998, in footnote 21); MacNiven, Angus. 2003. Action Research: The Human Dimension in Learning How to Improve Fish Seed Quality. *Aquaculture News* May: 18–19). Ongoing studies using participatory action research in Northeastern Thailand should contribute to stakeholder knowledge and enable them to develop self-help competencies so that they will be able to safeguard seed quality.

4. Development of Appropriate Growout Technology

30. Supplementation of buffalo manure with urea was recommended to farmers for fertilizing their fishponds to make “green water.”²⁷ Farmers were recommended to use small amounts of fresh manure daily and limited applications of urea that the farmers were likely to use and able to afford.²⁸ Farmers were also advised to stock fingerlings at a low density, 1–2 fingerlings per m².

5. Farm Level Impact of Trials

31. Using this technology, estimated fish production at the end of the growing season, from summation of farmers' records of fish caught during the growing season and fish harvested on draining the pond, averaged 182 kg from the average pond of 1,136 m², or an extrapolated 1.6 t per ha per season. This was three times the average yield recorded in the baseline survey.

32. The contribution of fish farming to the household economy, according to the baseline survey, was marginal: income from fish was about \$70, a mere 3% of an average annual farm income of about \$2,440 (Table 2). Off-farm earnings were more than 40% of total household income.

Table 2: Contribution of Aquaculture to Annual Farm Income
(farm trials in Udon Thani Province)

Item	Production Value (in \$, unless otherwise specified)		
	Baseline (1988)	Recommended Low Input (1993)	High Input (1995)
Total Income	4,360	4,652	4,957
Farm Income	2,440	2,732	3,037
Off-farm Income	1,920	1,920	1,920
Fish Farming Income	71	178	482
Fish Farming Income (% total income)	1.6	3.8	9.7
Fish Farming Income (% farm income)	2.9	6.5	15.9

33. The recommendations involving nursing and pond fertilization more than doubled the income from fish, increasing its share of total farm income from 2.9 to 6.5%. The recommendations were sufficiently low cost to be accessible to poor farmers with access to a pond. However, with average land holdings of about 8.1 ha (50.5 rai), twice the regional average of 4.5 ha (28 rai) in 1988, the average farm income of families farming fish during the 1989 baseline survey was as much as 80% higher than the regional average gross regional product per capita for rural areas of baht 7,020 (\$278) in 1988 (footnote 27). Thus, the low-input

²⁷ Edwards, Peter, Harvey Demaine, Nick Innes-Taylor, and Danai Turongruang. 1996. Sustainable Aquaculture for Small-Scale Farmers: Need for a Balanced Model. *Outlook on Agriculture* 25(1): 19–26.

²⁸ On-station research at AIT developed a fish production response curve to buffalo manure supplemented with inorganic fertilizers using an optimal total nitrogen loading rate of 4 kg nitrogen per ha per day (footnote 20). Partial budget analysis considering only fertilizer cost and farm gate price of fish gave a benefit:cost ratio of 5 to 6. Only urea was recommended to farmers because triple superphosphate was not available in the project area, but farmers' fish grew well. Adequate phosphorous relative to nitrogen was probably supplied by buffalo manure and rice bran, which farmers continued to use.

package was not attractive to many farmers because it made only a minor contribution to their total income.²⁹

6. Relevance of Integrated Farming

34. A scaled-down integrated feedlot livestock-fish culture system was piloted before the commencement of the AOP with 8 farmers in Udon Thani Province. Thirty egg-laying ducks were confined over a 200-m² pond, so that all manure and spilled feed fell into the pond. This system produced impressive harvests of 100–200 kg of fish. However, most farmers abandoned duck rearing once the AOP had withdrawn its support. The farmers subsequently faced difficulties in obtaining formulated feed ingredients and in marketing small numbers of duck eggs.³⁰ This integrated system was short-lived because it did not take into account market conditions of input supplies and farm outputs.

35. Integrated agriculture-aquaculture farming systems have been promoted as a possible alternative for agricultural development in Northeastern Thailand in recent years. A combination of ricefield, kitchen garden, orchard, and fishpond is believed to offer farmers a more stable livelihood than cultivation of rice alone, or rice and another commercial crop.³¹ However, a survey of households with varying lengths of experience in such integrated farming in Buri Ram and Khon Kaen provinces revealed low fish yields, similar to those reported in the AOP baseline survey, because of limited pond inputs. Although sale of fish in the local market was not yet a problem, farmers experienced difficulties selling fresh fruit and vegetables there. The promotion of integrated agriculture-aquaculture was recommended to be linked with small-scale agroindustries for farmers to have a sustainable livelihood (footnote 16). Extensive poultry production is a traditional activity in Northeastern Thailand but small flocks of scavenging birds are mainly raised as foods for social celebrations and are typically eaten within the household and sold locally. Attempts to intensify poultry production and to integrate manure supply with aquaculture failed mainly because of prevailing social practices and the limited availability of on-farm poultry feed.³²

36. The Bank for Agriculture and Agricultural Cooperatives promoted integrated feedlot livestock-fish farming in Northeastern Thailand, although it was necessary to organize farmer groups to source and mix feed ingredients and distribute formulated feed to member farmers in order to save on purchase of agroindustrial feed. Challenges facing integrated systems include overall profitability and cashflows. While small-scale fish farming may be highly profitable because of the reduced costs of feed and reasonable fish yields, the accompanying small-scale livestock feedlots, such as for poultry production, may not yield any profit. For example, a crop cycle of fish may require the equivalent of four production cycles of broiler chickens, which

²⁹ As is usual with the introduction of a new technology, the adopters of the low-input, low-cost technology were the better-off farmers. Only households with a larger than average resource base of 6 ha in Northeastern Thailand are able to make their living predominantly from agriculture. Most farming households are forced to seek substantial earnings off-farm, which reduces the availability of on-farm labor for aquaculture (footnote 27).

³⁰ Edwards, Peter, Kamtorn Kaewpaitoon, Anusorn Meewan, Anant Harnprasitkam, and Chintana Chantachaeng. 1983. *A Feasibility Study of Fish/Duck Integrated Farming at the Family Level in Central and Northeast Thailand*. AIT Research Report 16. Bangkok: Asian Institute of Technology.

³¹ Wigzell, Sophia, and Sununtar Setboonsarng. 1995. The Diffusion of Integrated Farming in Northeast Thailand. *Thailand Environmental Institute Quarterly Environmental Journal* 3(2): 14–40.

³² Little, David. 1995. The Development of Small-Scale Poultry-Fish Integration in Northeast Thailand: Potentials and Constraints. In *The Management of Freshwater Agro-Piscicultural Ecosystems in Tropical Areas*, edited by J. J. Symoens and J. C. Micha. Brussels: Technical Centre for Agricultural and Rural Cooperation and Royal Academy of Overseas Sciences. p. 265–276.

require cash expenses for the purchase of 1-day-old chicks and feed. Furthermore, farmers faced fluctuating and often low prices for livestock and livestock produce.³³

7. High-Input, Low-Cost Technology



Fertilizing a fishpond

37. Through on-station research, the AOP developed a low-cost, high-input technology package based solely on inorganic fertilization of a Nile tilapia monoculture. This technology option was to improve the attractiveness of aquaculture for potential new entrant farmers. It was also intended to satisfy the desire of several cooperating farmers who had gained confidence that fish could be reared successfully, to increase fish production with significant surplus for sale. A biologically optimal pond fertilization rate of 4 kg nitrogen and 1 kg phosphorous per ha per day was recommended.³⁴ A farmer-managed on-farm trial was carried out by 12 small- and medium-scale farmers in Udon Thani, Nakhon Phanom,

and Sakhon Nakhon provinces in Northeastern Thailand. Their average extrapolated fish yields were almost 6 t per ha per 8-month cycle. Farmers were recommended to nurse sex-reversed Chitralada strain Nile tilapia fry from AIT in a hapa suspended in the pond before stocking the fingerlings at 2–3 per m². Farmers in Northeastern Thailand are often reluctant to fertilize ponds with manure, particularly pig manure, but inorganic fertilization was acceptable to all. The substantial fish yield, more than three times that obtained by farmers with the low-input package described above, was because the fertilization produced intense, green, plankton-rich water. The farm gate value of fish was three times greater than the estimated production cost of the high-input technology.³⁵

38. Although most farmers were satisfied with the 200–250 gram (g) size of fish harvested from the trials, 3 of the 12 farmers expressed a desire for larger, 300–500 g, fish that would fetch a premium price in urban markets. A technical recommendation to make supplementary feed using limited locally available and on-farm resources had been developed by the AOP, but was not commonly adopted because of the labor involved in collecting feed ingredients as well as their limited supply. Three of the eight indicative components of low-cost, semi-intensive fish culture (Table 3) were widespread in farming communities in Northeastern Thailand prior to the start of the AOP. A further four have been developed over the past 15 years through the AOP. The eighth component, cost-effective supplementary feeding would take the technology close to its production ceiling for static water pond culture. One of the three farmers mentioned above

³³ Edwards, Peter, and Geoff Allan. 2001. Review of Feeds and Feeding for Inland Aquaculture in Mekong Region Countries. Consultancy Report for the Australian Centre for International Agricultural Research, Canberra. However, some AOP cooperating farmers who learned how to use inorganic fertilizers for their fishponds to "green" the water either ceased or reduced their use of inorganic fertilizers, and started to integrate fish with feedlot livestock. They reported little to no profit from livestock but benefited from free manure.

³⁴ Lin, C.K., D.R. Teichert-Coddington, B.W. Green, and K. L. Verica. 1997. Fertilization Regimes. In *Dynamics of Pond Aquaculture*, edited by H. S. Eгна and C. E. Boyd. Boca Raton: CRC Press. p. 73–107. Recommendations were to fertilize ponds at a rate of 28 kg nitrogen and 7 kg phosphorus per week as urea and triple superphosphate, respectively.

³⁵ Pant, Jharendu, Phairat Promthong, Chang K. Lin, and Harvey Demaine. 2002. Fertilization of Ponds with Inorganic Fertilizers: Low Cost Technologies for Small-Scale Farmers. In *Rural Aquaculture*, edited by Peter Edwards, David C. Little, and Harvey Demaine. Wallingford, UK: CABI Publishing. p. 117–128.

developed such supplementary feeds to intensify production further once he had learned, and had gained confidence with, basic aquaculture techniques.³⁶

Table 3: Indicative Presence of Aquaculture Technology in the AOP Area
(pre- and post-AOP intervention)

Technology	Pre	Post
Pond Construction	+	+
Herbivorous/Omnivorous Fish Species	+	+
Fish Seed	+	+
Fry Nursing in Hapa	–	+
Stocking Large Fingerlings	–	+
Stocking at Low Density	–	+
Cost-effective Pond Fertilization	–	+
Cost-effective Supplementary Feeding	–	–

+ = widespread, – = uncommon, AOP = Aqua Outreach Program.

C. Extension of Appropriate Technology

39. Once the initial packages of low-cost recommendations had been developed and field-tested with farmers, the AOP began to assess ways to disseminate them widely to farmers through DOF.³⁷ DOF had very few extension officers at the provincial level in Northeastern Thailand and none had been formally trained in extension theory and practice.³⁸ Therefore, AOP explored alternative extension strategies. A distance extension approach was chosen because farmers were literate and mobile and had close links with other government agencies represented at grassroots, commune, and village levels.

40. Doubts were growing about the effectiveness of the conventional training and visit system (TVS) for agricultural extension in developing countries (footnote 9). The TVS is part of the top-down transfer of technology paradigm for agricultural research and development in which technical messages developed largely by scientists on research stations are passed on through a dense network of extension agents in contact with farmers at the village level.

³⁶ One of the three farmers was enterprising enough to produce an effective low-cost diet in adequate quantity to supplement green water produced by high-input inorganic fertilization. He obtained an extrapolated harvest of 6 t per ha per 5-month cropping cycle, a significant increase on 6 t per ha per 8 months obtained with only inorganic fertilizers, and a crop comprising higher-value fish of up to 500 g per piece. He cooked broken rice to form a paste as a binder and when it had cooled he mixed in rice bran, soybean meal, fish meal, and pig oil. The mix was fed to fish in manually prepared moist balls in a feeding tray. He modified the recipe, which he obtained from a fisheries textbook, by reducing the amount of fish meal to lower the cost. He lamented that he was unable to purchase an expensive vitamin and mineral premix but was fortunate that there were adequate micronutrients for fish in his "green water" ponds. He was also enterprising in obtaining off-farm ingredients to prepare his supplementary feed on-farm. He had set up an arrangement through which the feed merchant in the provincial town sent him, by the local bus, ingredients ordered by telephone, resulting in considerable savings in time and expenditure. His cost of production was B16/kg compared to an average farm gate price of B36–40/kg for a 500-g fish.

³⁷ Turongruang, Danai, and Harvey Demaine. 2002. Participatory Development of Aquaculture Extension Materials and their Effectiveness in Transfer of Technology: the Case of the AIT Aqua Outreach Programme, Northeast Thailand. In *Rural Aquaculture*, edited by Peter Edwards, David C. Little, and Harvey Demaine. Wallingford, UK: CABI Publishing. p. 307–321.

³⁸ For a contemporary review of aquaculture extension in Thailand, see Potpitak, K. 1996. Aquaculture Extension Services Review: Thailand. *FAO Fisheries Circular 910*. Rome.

Established throughout Asia, TVS-based extension services are unsustainable financially and unable to cope with the complexity of farming systems in CDR areas.³⁹



Farm gate sale of pond-raised tilapia



Home-made supplementary feed using mainly off-farm ingredients

41. Conventional extension services tend to be crop specific, but governments have been reluctant to establish parallel structures in other sectors, such as fisheries. Until recently, DOF had a maximum of 6 extension agents per province.⁴⁰ The Government is currently attempting to address the human resource constraint in Northeastern Thailand by establishing mobile extension units—using staff of different sectors and an extension agent—to consult with farmers on their farming problems.⁴¹

42. Printed and audiovisual materials were used complementarily: the former to provide the target farmer with the recommended technology, the latter to create awareness and explain where the farmer could obtain printed materials. Printed technical messages were written in straightforward language using local dialects with no technical terms. The aim was to make the messages instantly obvious; they were short and well arranged. An attempt was made to make the materials attractive to gain attention, stimulating to read, and entertaining. The process of developing these materials was lengthy. Awareness was generated in the extension trials using local radio and television, as well as posters in target villages. In one extension trial, messages recorded on audiotape in the form of a folk opera performance were distributed on the air over village broadcasting systems.

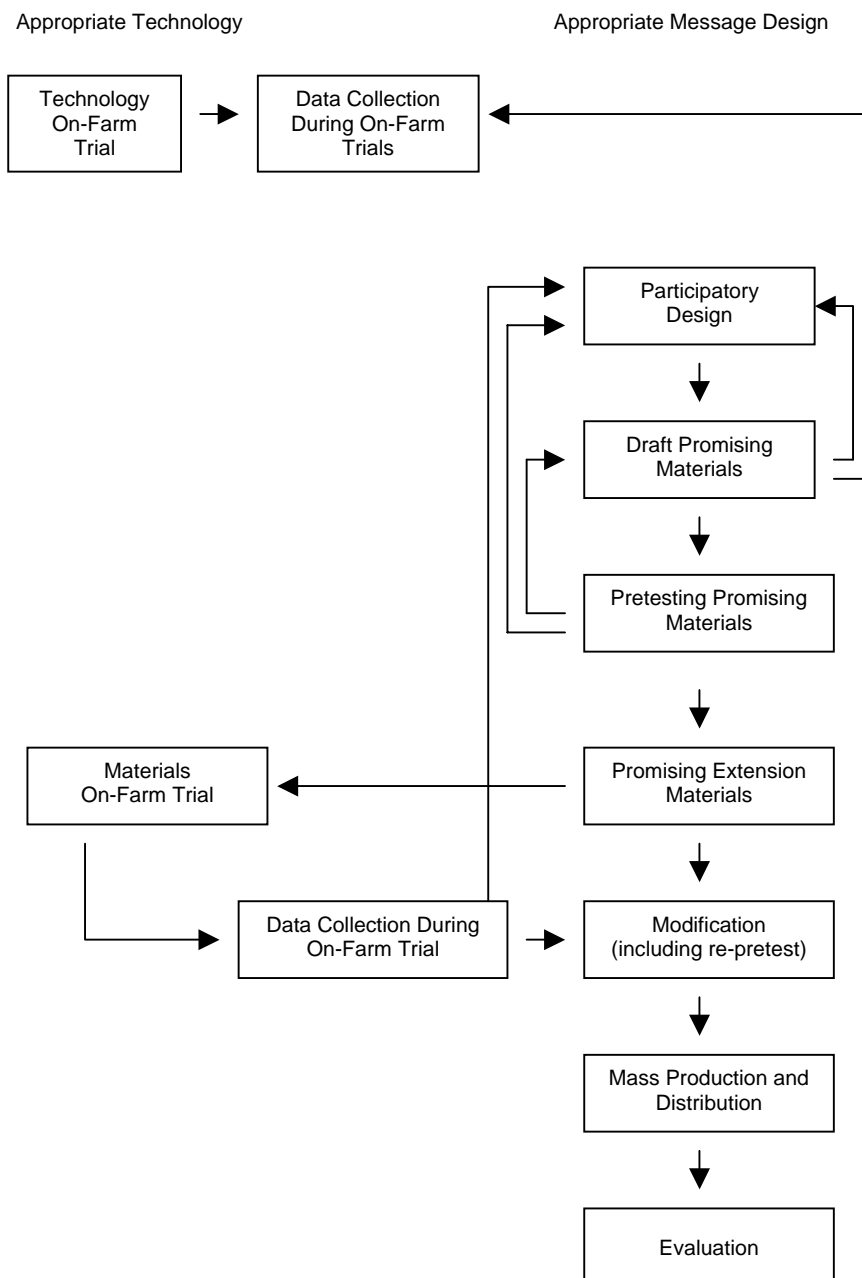
43. Conventional extension materials contain too much information written in a scientific format in too educated a language for farmers to understand. DOF produced 42 different extension materials from 1987 to 1991, 31 in printed form. The language used was central Thai, with many technical terms but even then, only 4–5 had relevant content for small-scale farmers. Furthermore, farmers could only obtain them by traveling to the provincial office (footnote 40).

³⁹ World Bank. 1994. *Agricultural Extension*. Lessons and Practices 6, Operations Evaluation Department. Washington, DC: World bank.

⁴⁰ Komolmarl, Supawat. 1992. *Role of the Department of Fisheries in Inland Aquaculture Development with Emphasis on Northeast Thailand*, M.Sc. Dissertation. Asian Institute of Technology. Bangkok.

⁴¹ Ministry of Agriculture and Agricultural Cooperatives. 2003. *Guidelines to Establish a Mobile Unit*. Bangkok: Ministry of Agriculture and Agricultural Cooperatives.

Figure 2: Iterative Design Process for Appropriate, Small-Scale, Aquaculture Extension Messages



44. It was necessary to develop both appropriate extension materials and channels of extension to farmers based on results of on-farm trials (footnote 37). Figure 2 shows the design process for the development of the AOP extension materials, involving active participation of field staff and farmers to make the materials relevant to farmers' culture, language, learning experience, and lifestyle. They were field tested with farmers who had not been involved in on-farm trials, and modified iteratively several times to make them suitable for the wider farming community. The nonspecialist local government channels comprise the general agricultural extension service, the agricultural bank, health centers, and schools at subdistrict and district

levels. Two sets of extension messages were developed by the AOP, the first a low-input scenario comprising two booklets and two leaflets⁴² and the second comprising two booklets.⁴³

45. The AOP has carried out several studies to evaluate the effectiveness of the distance extension. The evaluation was initially conducted in Udon Thani Province where the low-input technology was developed, but subsequently was done in close collaboration with DOF to develop extension channels (footnote 37). DOF used the existing extension materials in 1994 in six additional districts in three provinces: Udon Thani, Sakhon Nakhon, and Nakhon Phanom. Since 1996, a more comprehensive evaluation was carried out to assess the wider impact in Northeastern Thailand. Over a 6-year period since their initial testing, extension materials were distributed widely to other organizations: the Department of Vocational Education, NGOs, other development projects, and individual farmers. Materials have been distributed during training programs run by DOF, NGOs, and the AOP.

46. The impact studies have shown that carefully designed extension materials developed in dialogue between farmers and government officers, and well tested in terms of content and presentation, can be adopted by small-scale farmers without regular extension advice (footnote 37). Just as important, impact studies showed that such extension materials are more effective than training on its own. About 60% of the 182 farmers who received extension materials in one impact study tried them out, and about 50% continued to use them regularly or when they perceived a need for them. There was also evidence of considerable farmer-to-farmer spread of the technical recommendations.

47. More than 70% of the farmers followed the recommendations to some degree; more adopted the green water recommendation than the nursing recommendation. While fertilization was practiced by 15% of farmers prior to their exposure to the AOP recommendations, almost none had ever used inorganic fertilizers in aquaculture. The introduction of inorganic fertilization into Northeastern Thailand appears to be due to the AOP. More than 80% of farmers who adopted the green water recommendation made changes and adapted it to their context, using less because they could not afford urea or because they had pigs or poultry. However, they adopted the principle of the green water recommendation. This indicates that it is important not to be too prescriptive about technical recommendations so that farmers can better adapt them to their resource base and experience.

48. An estimate was made of the overall impact of the AOP's recommendations in Northeastern Thailand (footnote 37). About 6,000 sets of extension materials were distributed throughout the region in 1991–1995. With a modest 40% adoption among recipients of extension, and the average increase in fish production of 200 kg from an average size pond of just over 1,000 m², the incremental increase in fish production would be 480 t per year worth \$500,000 at the farm gate in 2003 constant prices. Since 1996, DOF alone has distributed a further 6,000 sets of extension materials to farmers. In 2001 and 2002, the DOF Extension Division printed 20,000 sets of each of the booklets on nursing in pond hapas and pond fertilization. Once developed and proven effective, the returns on the dissemination of extension materials are high. The incremental increases in fish yields are significant at about 2 t/ha, and these generate additional revenues of \$2,000/ha/year to farmers, or \$200 per year for small-scale farmers owning 0.1 ha of fishponds.

⁴² Booklets: How to Grow Large Fish, Nursing fFry in a Hapa; How to Grow Large Fish, How to Make Green Water. Leaflets: How to Grow Large Fish, Fish Polyculture; Feed to Make Large Fish, Feed Available at Farm Level. Aqua Outreach Program. Udon Thani.

⁴³ Booklets: How to Grow Large Fish, Greening Water with Chicken Manure and Urea; How to Grow Large Fish, Method of Making Green Water by Using Chemical Fertilizer. Aqua Outreach Program. Udon Thani.

D. Institutional Issues

49. The goal of the AOP is to improve the livelihoods of the rural poor and the immediate objective is to develop processes and capacity of national institutions to achieve this goal (footnote 5). In the context of capacity building, the AOP initially experienced difficulties due to prevailing institutional practices of DOF in the mid-1990s. Although DOF provided the AOP a base in Northeastern Thailand at their Udon Thani fisheries station from 1988, there was little initial interaction between AIT and DOF. At that time, DOF was not convinced that the AOP had much to offer through farming systems research. Development of appropriate technical recommendations would take some time. The AOP requested DOF to recruit field staff of mixed background from agriculture, education, and social science to carry out the baseline survey. There were concerns that DOF staff then assigned to the AOP would have the tendency to offer farmers conventional advice for aquaculture, rather than explore the overall contextual dimensions of the farms. Recruitment of field staff for the AOP through DOF was not possible because they did not have an appropriate academic background in fisheries biology.

50. By 1992, the AOP initiatives had demonstrably addressed the problems faced by small-scale farmers, and thus provided options for DOF to address extension needs in Northeastern Thailand. Extension was the first element of the farming systems and extension process to gain acceptance by DOF when it agreed to pilot the distance extension method in 2 districts in each of 3 provinces (Udon Thani, Nakhon Phanom, and Sakhon Nakhon).

51. The acceptance of on-farm trials as research by DOF proved more difficult than the distance extension approach. Trial farmers from earlier years of cooperation had begun to ask AOP staff how they could increase production to have surplus for sale in local markets. This provided demand-led opportunities for the AOP to field test the high-input inorganic fertilization (which had been developed at AIT under the United States Agency for International Development-funded Collaborative Research Support Program in Pond Dynamics/Aquaculture [footnotes 34 and 35]). As this field test was linked to the promotion of sex-reversed tilapia for stocking, it appealed to DOF, which had a tendency to look for new techniques. Training of DOF staff from several northeastern provinces was carried out by AIT. The need for conducting research with farmers was recognized by DOF, but the central committee reviewing such proposals for research would not have accepted them on conventional scientific merit. Nevertheless, when it was suggested that on-farm trials were not research but actually a step in the extension process, the Extension Division of DOF accepted the approach and provided a budget for the purpose.

52. The period 1995–1998 was one of considerable achievement in capacity building, as the AOP approach and initiatives were introduced to three more provinces: Mahasarakhem, Mukdahan, and Roi Et. By 1997–1998, DOF was interested in further expansion to cover all provinces in Northeastern Thailand. A highly favorable internal evaluation of the AOP and the cooperation between AIT and DOF by an independent group in DOF in 1998 provided support to this expansion.

53. Unfortunately, the capacity-building process stalled in 1998 when two major developments occurred almost simultaneously, the Asian financial crisis and the change in DFID policy. In tightening its budget in response to the financial crisis, the Government cut its spending drastically. Travel by government officials to rural areas, including Northeastern Thailand, was curtailed. The travel restriction halted crucial dialogue between partners. The change in DFID policy toward a strongly pro-poor stance and the relevance of aquaculture to poverty reduction in general, and AIT's role in particular, caused DFID not to consider a further

phase of funding for the AOP. From the mid-1990s, rapid economic growth in Thailand meant that the opportunity costs of staying in low-return agriculture and the kind of aquaculture typified by the first AOP package, were high. The high-input inorganic fertilizer increased operating costs, and thus the approach compromised to some extent the poverty focus of the AOP. Subsequently, the AOP obtained funding from the Swedish International Development Cooperation Agency for a project that began in 2001, focusing on traditional village fishponds (communal waterbodies) and local management of small-scale communal fisheries. Nevertheless, DOF has maintained the distance extension approach in Northeastern Thailand, using materials developed by the AOP.

E. Lessons Learned

54. Research carried out by DOF and the AOP has developed and promoted appropriate systems for small-scale pond aquaculture that have relevance for poor farmers. Prior to the establishment of the AOP, small-scale farmers were obtaining extrapolated fish yields from ponds of only 0.4–0.5 t per ha. Two major problems were identified: (i) stocking readily available small fingerlings, which were mostly eaten by wild carnivorous fish; and (ii) surviving fingerlings failed to grow because of insufficient nutritional inputs. Appropriate technical recommendations were developed by the AOP through farming systems research in partnership with farmers and that considered the farmers' resource base and experience. These recommendations emphasized (i) nursing fry in a hapa in the farmer's pond to produce larger, more predator-resistant fingerlings for subsequent stocking in the pond; (ii) a low-input growout technology to produce fish largely for subsistence; and (iii) a high-input inorganic fertilizer package to fertilize ponds for farmers to produce fish largely for sale.

55. Farmers produced predator-resistant 6–8 cm fingerlings in small hapas suspended in their ponds. Pond nutritional level was increased in the low-input growout technical recommendation by supplementing readily available buffalo manure with a small amount of urea. While this approach tripled fish yields, it provided only a relatively small increase in the overall on-farm income. Thus, this approach was not very attractive in the presence of alternative livelihood opportunities in Thailand's dynamic economy that has increased the opportunity costs of labor, including that of farmers. The subsequent high-input inorganic fertilizer package for growout tripled yields and was more attractive to farmers who could produce and sell surplus fish. The development of an effective low-cost diet to supplement green, protein-rich water by one participating farmer led to a further doubling of yields that were then close to the limit for semi-intensive culture in static water ponds, thus providing a substantial livelihood option for fish farmers.

56. Overall, these technology options have provided cost-effective means of increasing the productivity of fish farms and offered feasible ways of improving fish yields by minimizing feed costs through increased reliance on pond fertilization and supplemental feeding rather than on costly commercial feed. However, this experience showed that technology development could not be assessed as promising from its potential yield gains alone. The social and economic dimensions of the potential recipients, clients, or beneficiaries of technology promotion must be closely assessed in order to determine the relevance and significance of the technology options to their livelihoods.

57. Scaled-down integrated duck-fish culture introduced prior to the AOP failed because it did not fit into the local farming system; it did not take into account market conditions of input supplies and farm outputs. Integrated farming systems, combining livestock and fish farming, do not appear to have relevance for poor farmers in resource-poor Northeastern Thailand at least

until they have gained experience, profited from aquaculture, and gained access to sufficient financial resources to meet the cashflow demands imposed by different crop cycles.

58. The distance approach for extension has been used pragmatically to overcome the lack of extension personnel. The development of the distance approach has taken into account key requisites for effective communications, including local farmers' culture, language, learning experience, and lifestyle.

59. A farming systems research and extension approach is required for aquaculture to benefit small-scale farmers in CDR areas. In this approach, farmers are involved in all stages of the research, including the development and dissemination of extension materials. While this approach has proven effective and pro-poor, the participatory processes and the time taken to develop the extension materials may not be readily acceptable to institutions using entrenched top-down approaches. Farming systems research requires a broad-based multidisciplinary approach to capture the social dimensions, development contexts, and operating environment of targeted farmers. Thus, capacity building for the farming systems research and extension approach should be accompanied by institutional assessment and reforms of existing processes to facilitate the development of approaches that can effectively reach small-scale and poor farmers.