

Small-scale rural aquaculture in Lao PDR.

Provincial Aquaculture Development Project (LAO/97/007)

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The Provincial Aquaculture Development Project (LAO/97/007) is funded as part of a UNDP country programme for rural development. The project is government executed through the Department of Livestock and Fisheries, with technical and management assistance provided by FAO. The project duration is three years (November 1997 – December 2000).

LAO/97/007 follows on from previous UNDP/FAO aquaculture development projects that had started aquaculture activities and established feasibility. During these previous projects it was emphasised that the capacity of the government Livestock and Fisheries service to extend aquaculture on a wider scale was extremely weak. This has been due to a variety of reasons:

- Poor accessibility of rural areas, lack of roads and government vehicles.
- Difficulty in co-ordinating and managing national scale initiatives due to provincial autonomy.
- Previous restrictions on inter-province travel
- Lack of government funding for rural livestock and fisheries extension
- Insufficient staff at Provincial and district level
- Lack of capacity and poor incentivisation/management of district livestock officers.
- Shortage of fish fingerlings and lack of distribution network during peak seasonal demand.

LAO/97/007 is working in five provinces: Oudomxay, Sayaboury, Xieng Khouang, Savannakhet and Sekong Provinces. Within these provinces, there are 14 districts involved with a total of 37 farmer groups (total number of families 440). The target provinces are distributed along the length of the country and incorporate both lowland and upland environments (see Figure 1).

Additional technical assistance and training is also provided to Government Livestock and Fisheries staff in other provinces. The project objectives are to:

- Improve fish fry production from government hatcheries through structural improvements and training
- Encourage fish fry production by farmers/entrepreneurs through extension of simple techniques and farmer training.
- Develop the capacity of Department of Livestock and Fisheries staff to plan and conduct extension of fish culture techniques to farmers.
- Form farmers groups and introduce them to fish culture as part of Department of Livestock and Fisheries extension process.
- Assist farmers and hatchery entrepreneurs in their activities through provision of fish fry, broodstock and access to credit facilities.

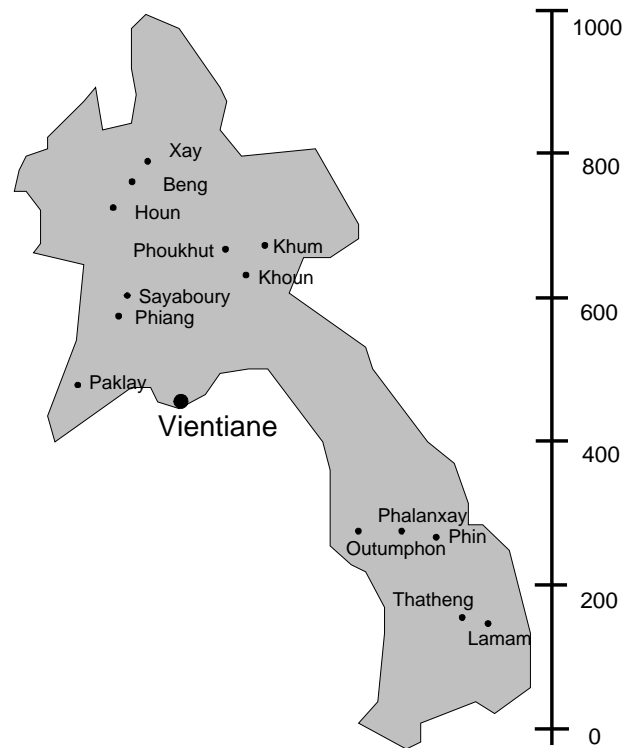
Introduction

Lao PDR has extensive water resources in the form of rivers, lakes and wetlands. Capture fisheries and the collection of aquatic animals during the rainy season are important activities in the country and form an important part of the national diet. Rice cultivation is the predominant agricultural activity and is practised in the form of rainfed, irrigated and hill rice.

Much of the terrain of the country is a mountainous (80%) requiring the terracing of rice fields. Rice is mostly cultivated on a one-crop per year basis, but in some lowland areas where irrigation has been developed two crops per year are possible. The country is characterised by a 6 months dry season (November – April) and an equal period of rain (May – October).

In 1995 World Bank defined a poverty threshold for LAO PDR as an income of 11,472 Kip per person per month (\$1 = 700 Kip in 1995). A survey by LAO/97/007 of household production and consumption in rural households reveals that most households surveyed were on the borderline of this value. Based on the survey of 5 provinces the calculation of household net income year (net income = Income – cost of goods purchased) returned a range of provincial averages between 2,090 - 6,547 per capita per month (1\$ = 2,400 Kip).

Figure 1: LAO/97/007 Project districts



$$\text{Theoretical net income} = \frac{[\text{Value of home produced goods consumed} + \text{Income from sale of goods}]}{[\text{Household expenditure}]}$$

Table 1: Age distribution in rural households of LAO/97/007 provinces

	< 15	16-50	> 51	Unknown
Oudomxay	44%	42%	11%	3%
Xieng Khouang	51%	39%	9%	1%
Sayaboury	64%	25%	11%	1%
Savannakhet	45%	46%	8%	1%
Sekong	37%	47%	8%	8%
Total	50%	38%	10%	2%

Source: LAO/97/007 survey data

Since all the households surveyed are engaged in subsistence farming the net income figure does not attribute any value to home production and consumption. A theoretical net income value can be derived by assigning values to the home produced goods that are consumed within the household. This value more adequately reflects the overall household economy. The average theoretical net income calculated for five provinces ranged between 12,355 – 15,864 per capita per month. Since the Lao currency (Kip) in 1995 was stronger than 1997-1998 so these household values are still almost certainly below the World Bank threshold.

Lao rural families tend to be large with an average of 8 ± 3 persons per household (the range of provincial averages = 6.7 – 8.3). From survey information, 50% of the members of the households surveyed were younger than 15 years and only 10% older than 51 (Table 1.)

Life expectancy is low in LAO PDR with an average life expectancy of 51 years. 30% of the adult population is illiterate and per capita GDP is estimated at \$350 (UNDP, 1996).

Aquaculture and Fisheries

Consumption of aquatic products forms a major part of the Lao diet. During the rainy season these products are collected from all forms of water bodies and wetlands such as rice paddies. During the dry season waters recede rapidly and there is a major effort to collect the remaining animals trapped in shallow ponds etc. Surplus aquatic products produced during the rainy season are preserved in a variety of ways according to cultural preference and prevailing local conditions. The most common forms of preservation are fermenting, pickling, drying and smoking. The preserved products (principally fish) are then utilised throughout the dry season when food is relatively scarce.

Annual per capita fish consumption in Lao PDR is reported to be between 7 – 10 kg. This is lower than neighbouring countries and may reflect the extreme dry season and rapid runoff of water due to the mountainous topography of the country. Equally these values are probably under-estimated since surveys may fail to record the consumption of other aquatic products that are widely consumed. These aquatic products include: snails, insects, tadpoles, frogs, crabs and shrimp. A recent survey of consumption by farmers in target areas for the Provincial aquaculture Development Project (LAO/97/007) has returned fresh fish consumption figures are equal or higher than the higher previous estimates. If the contribution of dried and preserved fish and other aquatic products is included then this raises the total consumption value to 22 kg.capita⁻¹.yr⁻¹. These are presented in Table 2.

Table 2: *Annual consumption (Kg.capita⁻¹.yr⁻¹) of aquatic products in LAO/97/007 target provinces*

	Average	Range of Provincial averages
Fresh fish	9	6.3 – 12.7
Dried fish	2	1.8 – 3.5
Fermented fish	3	1.2 – 5.6
Aquatic animals & amphibians	7	4.4 – 7.7
All aquatic products	22	13.5 – 47.8

Source: LAO/97/007 survey data

Ranking of household consumption by value reveals that fresh fish ranked second after rice in 3 out of 5 provinces and was within top four in all five provinces (clothing and bedding was second in the other cases). Overall from the survey 81 – 97% of households reported that fresh fish was consumed in some quantity during the year..

The target districts surveyed in each province do not return fishing as a significant activity - the principle activity of the households was rice farming. (Of a total of 359 families, 328 families returned rice farming as principle or secondary activity and only one family returned fishing as a secondary activity). Fishing in this instance is generally assumed to be fishing in rivers, rather than occasional collection of aquatic products and fish trapping in streams and rice fields. This latter type of food collection is extensively practised by all families that have access to wet-rice paddy or seasonal water bodies. Of the surveyed group 315 families out of 373 had fishponds, although

this sample is biased since respondents to the survey were generally those people already interested in fish culture.

Table 3: Annual consumption per capita of animal products in LAO/97/007 target provinces

	Percentage consumption by weight of animal product (%)			
	Chicken, duck, turkey, eggs, other birds	Fresh fish, dried fish, preserved fish, tinned fish, amphibians, aquatic animals	Pork, beef, buffalo, goat, dried meat	Reptiles, forest game, insects
Oudomxay	18	25	38	12
Sayaboury	19	34	22	13
Xieng Khouang	26	40	22	4
Savannakhet	12	37	20	22
Sekong	21	55	16	3
All Provinces	24 %	37 %	23 %	15 %

Source: LAO/97/007 Survey data

The relative proportion of aquatic products and other protein sources in the diet of surveyed families is presented in Table 3. Fish consumption reported here principally reflects production from aquaculture and collection from small streams and rice fields.

Fish culture in ponds and rice-fields is practised in many areas and a variety of systems are used, according to the agro-climatic characteristics of the area. Government estimates of the land currently under aquaculture production are presented in Table 4. There are still considerable areas of land that could be developed for aquaculture either as pond culture or as rice-fish culture.

The production figures for pond culture in Table 4 are over-inflated, since most small farmer ponds do not yield as much as

2,500 kg per hectare (see **Production from Pond Fish Culture**). This is due to the low feed inputs to the system and the short grow-out season. The government estimates approximately 2,400 farmers were producing fish in Lao PDR in 1996, although it is likely that this figure is now greatly underestimated.

Markets

Fish culture is becoming increasingly popular in Lao PDR for a variety of reasons. Fish plays an important part in cultural activities of lowland Lao people and is the food of choice for celebrations and festivals. Since fish spoils quickly and the communications network in Lao PDR is poor, transportation of fish from areas of plenty (Mekong river and major tributaries) to more remote areas is restricted. The lack of ice and transportation increases this effect. As a result, during the seasonal migrations of fish up the Mekong, fish prices collapse in some areas (specifically southern Champassak), whilst relatively short

Table 4. Government Estimates of Total Fish (Aquaculture and Fisheries) Production (1996)

	Area (ha)	Production (mT)	Productivity (Kg/ha)
Rivers	254,000	16,986	67
Fish Ponds	3,016	7,540	2,500
Lakes, natural ponds	7,019	3,737	532
Wetlands	27,029	811	30
Cages	-	175	-
Rice-fish	4,563	548	120
Rainfed rice	413,000	6,454	*(15)
Irrigated rice	13,347	54	*(4)
Reservoirs (Irrigation)	34,480	689	22
Reservoirs (Hydro-electric)	48,196	1,060	20
Total	-	38,054	-

Source: Department of Livestock and Fisheries Publication

* (Note: Not all rice production area produces fish – this is especially the case for hill rice.)

distances away markets for fish are still under-supplied. Capture of fish from wet rice-fields and wetlands is a significant activity for Lao people, however this activity is extremely seasonal.

During the dry season fish are difficult to obtain and preserved fish are more commonly consumed. Peak price for fish is during the Lao New Year festival (mid-April), which also coincides with some of the driest weather. Aquaculture is able to provide fish into the dry season after the rains have stopped. This enables the farmer to benefit from a good price for what is often a relatively low quality product.

Survey data suggests that most fish produced from rural aquaculture is consumed in the home or at least is not directly marketed. It is typical for a family to request to purchase fish from a neighbour in order to provide fish for celebrations or festivals.

Rural Lao fish culture requires a relatively low entry cost (self-construction of pond and fingerlings for stocking) and occasional feeding or fertilisation. Part of the popularity of species such as common carp and tilapia is that they will breed in ponds with perennial water and farmers do not even need to purchase fingerlings. Productivity of these ponds is extremely low, but the low financial risk makes this approach popular.

Importation of marine fish (from Thailand and Vietnam) is common although quantities are relatively low. Cultured fish from Thailand can be found in most markets along the Mekong River. Wild caught fish from the Mekong may be landed in Lao but due to the higher price in Thailand are more likely to be sold on the Thai side. This means that high value species are difficult to obtain in Lao PDR.

Land

Land availability for fishpond construction is an issue in upland areas since flat land is primarily used for rice cultivation. The construction cost of fish ponds is prohibitive to most farmers who view aquaculture as a low investment, low risk enterprise. As such, farmers may construct a shallow pond, but are unlikely to invest significant capital in the operation, preferring the lower yield and financial security of a low input system. Tenancy of land is relatively rare in LAO PDR since migration and re-population of areas during and after the war have tended to result in more evenly sized land packages. Previously, large family land holdings were divided amongst children ahead of time due to the concern that government requisition might ensue.

Although Lao PDR has a low population density, the availability of good agricultural land and land suitable for wet rice cultivation is at a premium. Rice-fish culture is currently restricted to one or two provinces where the local people have a cultural heritage of rice-fish culture and/or rice-fish cultivation has been introduced through previous FAO development projects.

Farmers who have no experience of rice-fish culture are often concerned that the construction of channels in their paddies will critically affect their rice yield. Results from some preliminary farmer trials in one province have shown that rice-fish culture actually increased the overall rice yield, even though 10% of the paddy area was reduced by channel construction. This is an interesting example of where changing the system can have spin-off benefits. What is not clear is whether the improved rice yield was derived from fish activities in the rice (stirring up nutrients, predation of rice pests) or whether occasional feeding/fertilisation of the paddy was greater than that which would be normally applied.

This effect is important since it highlights the minimal input nature of Lao agricultural systems – very small changes in inputs can have quite dramatic results on production.

Fish ponds

There is a distinct difference between fish culture practices between peri-urban and rural areas. Peri-urban areas have access to agricultural inputs (feedstuffs and irrigation are often present) and more intensive livestock production (particularly pig and chicken) provides utilisable wastes. Access to technical information and fish seed is also considerably easier due to the proximity of the Provincial livestock office and Provincial fish seed station.

By contrast, rural areas are typified by their self-reliant subsistence agriculture operations. Agricultural surplus is minimal and livestock production is still at a relatively undeveloped stage. Fish culture is constrained by lack of seed, supplemental feed and manures. Technical information and extension services are extremely weak in Lao PDR partly due to the low population density and poor communications between villages. Extension offices exist in Provincial capitals and each district has at least one livestock and fisheries officer. Since the area of each district is nearly equivalent to that of a province in one of the countries bordering LAO PDR, the ability of these officers to contact farmers is extremely limited.

The majority of Lao fish ponds are shallow (water depth less than 50 cm) and are hand constructed. Average fishpond area per household is 2,300 m² (standard deviation 5,200 m², 314 households surveyed) for LAO/97/007 target provinces.

Deeper ponds can be constructed in upland areas by damming valley streams, although for effective construction, this requires earth-moving equipment. Ponds formed from dammed streams often collapse under spate water runoff during the monsoon season, since they usually lack diversion canals.

In situations where farmers are land secure and possibly producing a rice surplus, inputs to the aquaculture system may become more significant. Feeding and fertilisation may be practised more regularly and investment in pond construction becomes more likely. Where machinery is available, this may also be used for pond construction. Typically machine constructed ponds are found along roadsides where soil has been removed for road construction, or machinery operators have been paid to construct ponds in their spare time.

Water supply to ponds is varied but the typical Lao pond is rainfed. Water retention in the ponds is variable but most farmers would expect to stock the pond in June as it fills with rainwater and harvesting takes place between November – February, depending upon water depth and condition of the pond.

Some fishponds which are able to hold water through the dry season until Lao New Year are able to command premium prices.

Fish Fry demand and production

Estimation of the fish fry requirement of the Lao PDR have been made, principally according to the area of ponds, reservoirs and rice-fields that are suitable for fish production (Table 5). These figures may be optimistic since not all the land may be suitable for aquaculture but it does serve as an indication of potential requirements. This is particularly the case with respect to the very low stocking densities employed in the pond and rice-cum-fish aquaculture systems in Lao PDR.

Even if the figures are slightly inflated it is apparent that the fry production in the country is far below the current demand (only 30% of demand is supplied by in-country production). More recent estimates by LAO/97/007 show an increase in production from the Provincial hatcheries but this is still well below the estimated requirement. Since the demand for fish fry in Lao PDR is not satisfied by in-country production there is a significant incentive for the importation of fish fry from adjacent countries. Thailand, Vietnam and China are sources of fish fry into their adjoining provinces. The importation of fish fry is illegal but largely tolerated since the demand is so high. These countries are also able to produce fry at prices lower than that possible within Lao PDR and this also drives the fry importation business.

Since there is a limited amount of time during which aquaculture can be carried out in seasonal ponds such as are typical in Lao PDR, there is a peak requirement for fish fry during the early part of the monsoon season (June). This requires that the large numbers of fish fry required by farmers must be supplied within a relatively short period of time. The only method by which this can be achieved is by the propagation of species that have high fecundity.

Currently, the size of fingerlings required by farmers is in the size range of 3 – 5 cm. Farmers prefer larger fingerlings because of the higher survival rate in their extensive production systems. Small fish fry are easy prey for the aquatic insects and frogs that abound in the fishponds, wetlands and rice fields of Lao PDR. This requires the hatcheries to nurse the fry for about one month or more before sale. The requirement for these larger, nursed fry places a burden on the hatcheries since heavy losses occur in the fry nursery ponds. The hatcheries can produce large numbers of eggs and newly hatched fry, but their capacity to hold the fry is limited by the small area of nursery ponds available.

Table 5: Estimated Fish Fry Production and Demand in Lao PDR (1996)

	Fry Production		Demand
	State Hatchery	Private Enterprise	
Phongsali	-	-	400,000
Luang Namtha	-	30,000	800,000
Borkeo	-	-	500,000
Oudomxay	-	-	700,000
Luang Pabang	563,000	40,000	3,500,000
Hooa Phan	150,000	28,000	670,000
Xieng khouang	450,000	2,500,000	11,000,000
Sayaboury	250,000	-	1,500,000
Vientiane Province	2,000,000	500,000	10,560,000
Saisomboon S. Z.	-	-	-
Vientiane Prefecture	3,500,000	3,660,000	11,000,000
Bolikhamxay	-	-	450,000
Khammouan	150,000	25,000	570,000
Savannakhet	720,000	455,000	5,700,000
Salavan	70,000	10,000	560,000
Champassak	500,000	66,000	3,800,000
Sekong	-	-	300,000
Attapeu	-	-	150,000
Total	8,359,000	7,313,000	52,160,000

Source: Department of Livestock and Fisheries, 1997.

The economies of scale that favour large hatcheries in other countries limit their viability in Lao PDR. Since farmers only take fry away in small numbers, large batch production of fry is limited by the requirement for holding on the hatchery site. Small farmer-based hatcheries are better suited for distribution of small numbers of fry to farmers in their locality and can be assured of sale of all their production since orders are taken in advance.

Fry nursing by farmers has been promoted by the AIT Outreach project in southern Lao PDR (Savannakhet province) for nearly 5 years. It involves assisting small operators in the nursing of fish fry (2,000 fish) in net cages (20 m²) to sell on to other farmers when they reach a marketable size. This has the advantage that the techniques of fry production are not required since they are performed at the provincial hatchery. The small farmers merely take fry and nurse for up to one month and then sell. The economics of the operation are favourable, although the capital cost of the net cage can be a problem. Typically the farmers rent the net cages at a subsidised rate for the nursing period.

Farmers in Oudomxay have nursed fry to fingerling size in Oudomxay as part of LAO/97/007 activities. In this case the cage size was reduced to 4 m² and the farmers only nursed the fry that they would use themselves. This has had the effect of farmers not purchasing fingerlings from foreign traders and relying on fry produced by Lao provincial hatcheries. The advantage of this development is that farmers will now purchase the small 2 week old fry that the hatcheries are able to produce in high numbers. Previously such small fry were unmarketable since mortality was too high after stocking in production ponds or paddies. This demand for small fry is currently localised, but interest is expected to increase further as farmer nursing activities are planned in 5 provinces during 1999.

Aquaculture inputs

Inputs to ponds are generally low due to lack of availability or the tendency to feed other livestock in preference to fish. Fertilisation of the pond is practised, but again the availability of fertiliser varies and there may be some competition between use in rice cultivation/paddy preparation and fishpond preparation. Typically Lao animals are not penned and therefore single point sources of manures are rare. This increases the effort required for manure collection and decreases the likelihood that sufficient fertilisers will be applied to a fishpond.

Integration of livestock over fishponds can be very productive, however, this is only effective where the livestock is fed completely and this is rare in rural Laos. Livestock integration with aquaculture is becoming established in peri-urban areas as more intensive livestock rearing methods are being adopted.

Rice milling in Lao PDR is performed at village level due to the availability of portable machinery. The cost of milling can be paid as money or exchanged for the rice bran produced. Farmers unable to pay for milling will trade their rice bran. The lack of bran prevents such farmers from becoming involved in small animal husbandry (chickens, pigs) or providing inputs to fishponds. Rice mill owners are frequently the most diversified livestock producers, engaging in all species due to the ready availability of bran as an animal feed.

In upland areas the use of boiled cassava as a fish feed is common. Cassava is also widely eaten as a staple. Mixtures of rice bran and cassava give good fish yields especially if farmers practice some fertilisation of the ponds as well.

Fertilisation of fishponds is a relatively common practice, although quantities are often inadequate, resulting in insufficient productivity in the water. Damming of streams may result in excessive flushing of the ponds which may also prevent the establishment of greenwater.

Lime is often unavailable away from Provincial capitals and is approximately three times the price of adjoining countries. Application is uncommon in both aquaculture and agriculture in Lao PDR.

Formulated fish feed (herbivorous fish and catfish pellet) is available in large cities and some Provincial capitals. This feed is expensive since it is imported from Thailand. There is some suggestion that commercial fish feed production may commence in Vientiane Prefecture if the market is considered viable. Paradoxically, in Lao PDR the high price of fish in markets make feeding formulated fish feeds economically viable. The tendency not to use these feeds is due to unwillingness to expose an operation to higher economic risks.

Production from pond culture of fish

A survey of farmers performed by LAO/97/007 returned the following estimated annual yields from their fishponds (Table 6). The average productivity of the surveyed farmers' ponds ranged between 788 – 932 kg.ha⁻¹.yr⁻¹ and median productivity was less at 417 – 708 kg.ha⁻¹.yr⁻¹. Figure 2 represents the productivity of ponds with respect to their area and illustrates that the majority of

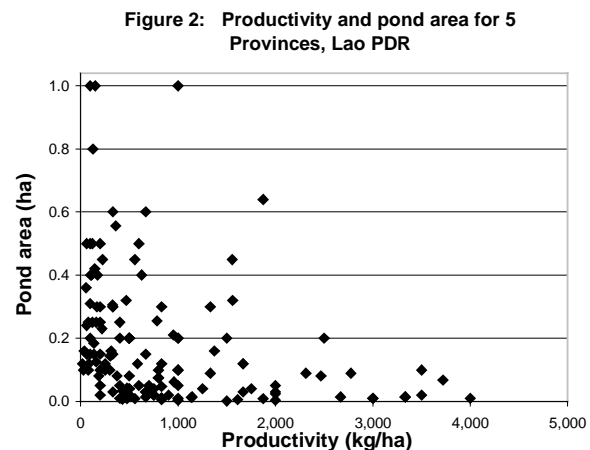
Table 6: Production and productivity of farmers ponds

	Savannakhet	Sayaboury	Sekong	Oudomxay	Xieng Khouang
Number of respondents	28	22	21	14	57
Ave. pond size (m ²)	1,810 ±1,500	930 ±920	2,120 ± 3,740	1,980 ±1,670	2,240 ±2,400
Median pond size (m ²)	1,350	550	750	1,520	1,500
Median production (kg/house)	60	20	50	45	50
Average production (kg/house)	132 ± 227	76 ± 142	84 ± 101	87 ± 87	107 ± 171
Median productivity (kg/ha)	530	708	500	417	500
Average production (kg/ha)	932 ± 954	912 ± 946	809 ± 930	788 ± 883	813 ± 836

Source: LAO/97/007 Survey data

farmers have pond areas less than 0.2 ha. The median production per household ranges between 76 – 132 kg, representing a per capita annual consumption of fish (assuming the fish was all consumed within the family) of 9.5 – 16.5 kg.yr⁻¹. This represents a significant nutritional contribution.

The correlation between pond area and production is low; combined data from a five-province survey returned a correlation coefficient of 0.5 and Savannakhet harvest data 1998 returned only 0.34. This is indicative of the potential influence of factors such as feeding and water depth on the productivity of Lao ponds. The very high productivity (>2,000 kg.ha⁻¹.yr⁻¹) calculated for several survey respondents were all from rather small ponds. This suggests that yield estimates were inflated, or reported pond areas were inaccurate. This is a frequent problem with surveying techniques that require excessive recall from farmers.



Harvest data based on farmer trials return lower yields than those above and are probably more indicative of the typical state of production in rural farmer ponds (Table 7). The yields from these ponds can still be significant sources of fish protein for a household, particularly during periods when aquatic products are not available from rice fields.

The attraction of aquaculture to rural farmers is most clearly observed in situations where capture fisheries are inaccessible or over-exploited.

Table 7: Recorded fish pond productivity from upland and lowland aquaculture project sites

	Upland Xieng Khouang	Lowland Savannakhet
Number of respondents	167	86
Ave. pond size (m ²)	800 ± 700	2,630 ± 2,970
Median pond size (m ²)	600	1,500
Average stocking density	1.1 ± 1.8	0.43 ± 0.18
Median production (kg/house)	15	27
Average production (kg/house)	30 ± 38	49 ± 106
Median productivity (kg/ha)	300	187
Average productivity (kg/ha)	376 ± 431	285 ± 319

Sources:

Xieng Khouang - Recalculated from LAO/89/003 (1991 – 1994)
Savannakhet - LAO/97/007 farmer groups (1998)

Disease

One of the attractions of fish culture that has been expressed on several occasions is that fish are not susceptible to the epizootics that occasionally strike livestock in villages. Haemorrhagic septicaemia, Swine fever, Newcastle disease and Fowl cholera occur frequently in Lao PDR and vaccination is still relatively uncommon due to cost and accessibility to quality vaccines.

During interviews with farmers regarding fish mortality, ulceration and mortality of wild fish (particularly snakeheads and catfish) is commonly mentioned. This is consistent with EUS symptoms. This appears to occur annually during changes between the cool and hot seasons, The responses from farmers surveyed regarding fish mortalities shows approximately 28% had directly observed fish mortalities in their ponds (Table 8).

During 1998 mortalities of cultured Indian carp and Silver barb in farmers ponds have been reported from Sayaboury and Oudomxay provinces by project staff. The impact of fish disease on aquaculture and fisheries on rural populations is presently unquantified. However, the importance of fish and aquatic products in rural Lao subsistence livelihoods warrants further investigation.

Table 8: Reported fish mortality from survey of LAO/97/007 target provinces

Cause of fish mortality	Number of respondents
Unspecified mortality	40
Unspecified disease	29
Ulcerated bodies	14
Red Spots	5
Spots	4
Red scales	1
Predation	2
Mortality at stocking	2
Water too hot	2
Low oxygen	3
Insufficient water	2
No disease returned	269
Total	373

Source: LAO/97/007 survey data

Rice-Fish Culture

Rice cultivation is widespread in the form of rainfed, irrigated (wet rice) and hill rice (dry rice). In many parts of the country the terrain is mountainous requiring terracing of rice fields. Rice is mostly cultivated on a one-crop per year basis, but in areas where irrigation has been developed two crops per year are possible. Rice paddy fisheries and the collection of aquatic animals during the rainy season are important activities in the country and form an important part of the national diet. Rice-fish culture is practised in several provinces and a variety of systems are used, according to the agro-climatic characteristics of the area.

Upland rice-fish

Upland rainfed and irrigated rice fields require terracing which limit the size of individual paddy fields. Farmers are reluctant to cut channels or construct refuges in these fields due to the subsequent loss of production area. In some areas water is supplied to the paddies from small diversion irrigation systems. Where this is present the requirement for deep water and refuges is reduced due to the continual replacement of water in the paddy. The upland areas are also cooler than lowlands and so high temperatures in the paddy water are less of a problem.

Where irrigation is present (usually from stream diversion) rice fish culture is more successful, principally due to the increased availability of fish fry. Typically, *Cyprinus carpio* and *Carassius auratus* are produced and these spawn naturally in the rice fields and adjoining ponds. Since the farmers can produce their own seed fish this activity is popular since cash is not required. Few modifications are performed on the ponds other than the raising of walls.

Fish produced in this system can be harvested and transferred to adjoining ponds for on-growing. This increases the marketability of the fish and income can be generated from the activity provided the farm is close to the provincial or district market.

Where rice fish culture is practised in rainfed fields the only modifications that might be performed are the raising of the walls to increase water depth. In some cases a small channel will be constructed to facilitate fish capture. Typical growing periods are 90-100 days. The size of the fish harvested varies according to the size stocked and farmers prefer a larger (5 - 10g) fish for this reason. Smaller fish are stocked in some cases due to the cheaper price. Stocking densities are typically low, reflecting the high price of fish fingerlings and the limited amount of money

available to the farmers. Since most farmers do not generate cash the purchase of fish fingerlings is frequently not possible. The fish produced from this system is mostly consumed in the home and species include *Cyprinus carpio* and *Carassius auratus* and *Tilapia sp.*; this is another limitation to the system since no income is generated. Those farmers that are able to sell their produce are more able to reinvest in subsequent crops.

There is little reliable data available concerning production levels from rice-fish culture in Lao PDR, but productions of 31 - 640 kg.ha⁻¹.crop⁻¹ have been reported for upland rice-fish production systems. Median production is estimated at 153 kg.ha⁻¹.crop⁻¹ with average individual farmer production of 43 kg.crop⁻¹.

Table 9: Rice-fish production in Xieng Khouang Province (1991-1994)

	Median	Average ± s.d.
Paddy area (ha)	0.15	0.23 ± 0.22
Individual Production (kg/farmer)	21	43 ± 49
Productivity (kg/ha)	153	199 ± 129
Stocking density	0.42	0.47 ± 0.27
Days of culture	90	98 ± 28
Size at harvest (g)	59	75 ± 41
Estimated survival (%)	71	77 ± 54

Source: Data recalculated from LAO/89/003

Information collected from 84 farmer trials in Xieng Khouang during 1991 – 1994 (data recalculated from LAO/89/003) returned overall average yields of $199 \text{ kg.ha}^{-1}.\text{crop}^{-1}$ (st.dev. $129 \text{ kg.ha}^{-1}.\text{crop}^{-1}$). The variation appears to be due largely to the size of fingerling stocked at the beginning of production and not on stocking density. Low yield paddies were stocked with fish of 2 - 5 cm and the highest productions were obtained by stocking 5 - 10 cm fish. The median area cultivated was 0.15 ha (per farmer. This gave an average yield of 43 kg per family (st.dev. 49 kg). Median stocking densities were 0.42 fish.m^{-2} and median survival overall was 71%.

Recent survey data from Xieng Khouang has verified these production figures with an average productivity of $148 \pm 173 \text{ kg.ha}^{-1}.\text{crop}^{-1}$ at average stocking density of 0.5 fingerlings. m^2 (LAO/97/007 survey data). Fingerling stocking size was not recorded but lack of availability of large fingerlings suggests that fish of approximately 3 cm were stocked.

Initial farmer trials (4 farmers) as part of LAO/97/007 activities in Oudomxay (1998) returned yields between $100 - 429 \text{ kg.ha}^{-1}$ with fish stocked in the paddies for between 60 – 160 days.

Lowland rice-fish

Lowland areas of Lao PDR are mostly confined to the Mekong River plain. Rice fields are larger here but there are constraints with availability of water for rice-fish culture. Where soils are relatively impermeable rice-fish culture can be practised in rainfed rice fields. There is a limited amount of irrigated rice production in Lao PDR and these areas are ideal for the development of rice-fish systems provided excessive chemical applications are not used.

The production system in lowland rice does not involve on-growing in ponds, due to the lack of water following the rice production season. Since the lowland areas are warmer growth rates are higher than the cooler uplands.

Since there is little water available during the dry season, the maintenance of broodstock fish is difficult during the dry season, this prevents farmers from producing their own fingerlings.

Constraints

Rice fish culture is popular with farmers due to the integrated nature of the system, however there are some constraints.

Theft of fish from fields is a frequent complaint since the fields are not close to the house. This problem is less frequent with household ponds. Thefts have reportedly reduced with the large-scale take-up of rice fish in some villages.

Flooding is a serious problem in some areas. Due to the mountainous nature of Laos, the runoff following rainfall is high and can cause problems in some areas. Fish loss following flooding has deterred some farmers from pursuing rice-fish culture. In other cases fish are washed out of upper paddies into lower areas resulting in bonus crops for farmers at the lower part of a terraced rice system.

Due to the lack of large livestock culture and limited amounts of feed for livestock, the production of manures is limited. This has limited pond production of fish but may not constrain rice fish culture. Cattle and buffalo in the fields consume Rice straw and natural manuring ensues. This removes the labour aspect of manure collection and transport that is required by pond culture.

Due to their cost, pesticides are not widely employed in upland areas and rainfed rice cultivation, however, they are increasingly being used in the lowland irrigated areas and this is a potential risk in the future.

The high cost of fish fingerlings (20 - 100 Kip each), lack of cash economy and limited availability during the stocking season currently limits the number of farmers able to perform rice fish culture. LAO/97/007 is promoting fingerling production by farmers for stocking into rice-fish systems in upland areas.

Gender and socio-economic issues in aquaculture in Lao PDR

A two month gender and socio-economic study in Lao PDR was performed during 1998 as part of LAO/97/007 activities. During the course of the study, both upland and lowland project areas were visited. Groups interviewed as part of the study included: fish farmers groups, women's groups, extension staff and Agriculture Promotion Bank staff. Ethnicity of rural Lao farmers is an additional issue since the ethnic diversity of the country is so broad.

Socio-economics

General awareness of aquaculture is raised by the presence of extension activities within a village however farmers often adopt a precautionary approach to starting activities on their own. Many farmers expressed the need to observe successful, reliable aquaculture in their village before risking investment of labour or money in aquaculture.

The majority of men and women fish farmers interviewed conducted aquaculture primarily for household food security, with income generation as an added bonus only where surplus fish were produced. Fish production for food security is considered to require low labour intensity once established.

Income generation from fish production may also incur higher labour demand and appears to be possible only in families with a high degree of food security. Since LAO/97/007 requires farmers to have a fish pond or suitable paddy land to take part in project activities, there is a tendency to select farmers with adequate land. Marginalised groups such as the landless or those without land suitable for pond construction are unlikely, or unable, to be included in project activities, although landless rural poor in Lao PDR are not as common as in other countries.

Market demand for fish is high throughout Lao PDR, with the highest prices obtained in provincial markets. Where fish are sold, women control the cash income from the selling of fish at the pond site and in the market, although consultation with their husbands on household expenditure is common. Income distribution within the household is relatively equitable, so income generated from aquaculture is likely to benefit entire households. There are some differences between ethnic groups regarding management of household incomes.

The Agriculture Promotion Bank (APB) is the only source of formal credit for rural farmers, and overall, the group-lending scheme of the APB offers an opportunity for women as collateral requirements have been removed

The APB itself does not yet accept that aquaculture is a sufficiently low risk activity to allow extension of credit to farmers groups. This is partly due to the tendency for farmers to consume their production rather than take it to market. This attitude may change due to high fish prices and increasing rural access to local markets.

Fingerling production shows a good potential as an income generating activity. Few farmers are likely to be able to enter this activity immediately after training. Fingerling production is suitable for farmers that already have ponds and some previous experience of fish culture. Fingerling production in net cages is now established as a successful technology and LAO/97/007 will pursue this with more experienced farmers. Only experienced (e.g. > 3 years) and relatively better off men and women farmers are likely to be able to engage in mini-hatchery enterprises.

The important role of fish in rural food security is diminished by concentration on solely economic criteria when assessing feasibility.

Gender

Both women and men are involved in aquaculture, although each may have different roles at different stages of the fish production cycle. There are few cultural constraints to women's participation in most aquaculture activities. The distance of the aquaculture operation from the house was a constraint to many women in engaging in aquaculture activities. Other domestic chores often conflict with the requirement for feeding and management of fish ponds.

While men often make the major decisions concerning the production system, the production from ponds also depends on the time and effort allocated by women and children for pond management and for feeding of the fish. Men are usually responsible for routine feeding and harvesting the overall yield; women are often responsible for harvesting fish for household consumption. Children often assist with feeding. Due to the demands from domestic chores and child rearing, younger women (under 40) are less able to become involved in aquaculture activities.

While in theory women have access to aquaculture training and extension, in practice their access can often be limited because of gender biases in extension services. Existing village fish farmer groups are largely composed of men and there is scope for inclusion of more women fish farmers in such groups. In many cases women could not be involved in training due to household commitments or lack of awareness of the possibility of attending training courses. The establishment of women fish farmer groups and gender sensitive aquaculture promotion should be pursued either through existing extension structures or through organisations such as Lao Women's Union. Whilst often not involved directly in fish culture, the decision to start the activity was often prompted or supported by women in the household.

Ethnicity

LAO/97/007 is working with 12 ethnic groups (distinguished by name). In many cases the response to survey questions did not include details regarding ethnicity, rather the broader categories of Lao Loum, Lao Theung and Lao Soung (lowland, slope and highland dwelling ethnic groups). The ethnicity of the farmers in LAO/97/007 is presented in the Table 10. In many cases the ethnicity of respondents is not returned specifically but using the more general three categories into which all ethnic groups are broadly classified. The northern ethnic groups of Thai and Leu are considered by the Lao government to be Lao Loum (Lowland Lao - although many live in the valleys of mountainous regions) due to the similarity in lifestyles, although ethnically they are quite distinct.

Since aquaculture suits lowland areas and areas where there is access to wet rice production, there is a natural tendency for Lao Loum, Leu and the Thai ethnic groups to farm fish. The Thai tribes in particular have long tradition of fish culture. Extension of aquaculture to the Lao Soung and Lao Theung tribes is often constrained by topography and their indigenous farming systems (upland dry rice cultivation). Where these groups have migrated into lowland areas there is great potential for the development of aquaculture and these groups seem to be receptive, providing rice cultivation area is not compromised. In some upland provinces (e.g. Luang Namtha & Phongxali) upland Lao have

Table 10. Ethnic group/tribe of respondent households to LAO/97/007 survey

	%
Highland Lao	6
Hmong	7
Midland Lao	20
Gathou	3
Sooway	4
Ahlak	1
Khamou	6
Lowland Lao	74
Thai Dam	7
Poowan	18
Thai Deng	1
Leu	9

started fish culture and it is becoming increasingly popular. The priority in these areas is to improve fry supply and extend basic fry production techniques (the principle species cultivated is the common carp).

Ethnicity is an issues with respect to access to extension training in some areas. Geographically remote areas become even more marginalised when there is a language or cultural barrier between farmers and government staff. This is particularly the case with women in these areas who often do not speak the national language (Lao).

Summary of sustainability issues relating to rural aquaculture in Lao PDR

The sustainability issues that concern small-scale aquaculture in rural Lao PDR can be broadly divided into the following categories:

1. Input constraints
 - Shortage of fish fingerlings
 - Competition for manure
 - Competition for bran and agricultural by-products from other livestock activities
 - Lime unavailable/costly in many areas
 - Farmer tendency to minimize economic risk by limiting purchased inputs
 - Integrated fish culture with livestock uncommon due to lack of penned livestock.
2. Infrastructure and institutions
 - Poor roads and lack of access to markets
 - Reliance on hand constructed ponds
 - Lack of machinery for pond construction
 - Livestock and Fisheries extension service poorly developed and under-funded
 - Is government able to continue extension activity once project has finished?
 - Provincial tendency to focus on peri-urban aquaculture (due to accessibility, private entrepreneur involvement, higher input status, access to markets).
 - Government hatcheries' productivity is low.
 - Private hatcheries not yet established
 - Agricultural Promotion Bank credit system undeveloped and difficult to access
3. Economic development
 - Poorly developed market economy outside of towns.
 - Rural economy largely subsistence.
 - Limited access to long term credit.
 - Fish culture can generate income or be used as for food. In some instances, both roles are used by farmers.
 - Production of fish during dry season exploits high price.
4. Environmental factors
 - Most fishponds are seasonal due to 6 month dry season
 - Seasonal stocking causes peak demand during short period – existing hatcheries are unable to supply this demand.
 - Ponds are shallow and dry quickly, high temperatures may be a problem. Productivity is constrained.

- Availability of flat land for pond construction limited.
- Monsoon season can cause rapid flooding and loss of fish.
- Barrage ponds (dammed streams) in mountain areas may be damaged by spate water run-off.
- Highland areas difficult to access
- Population is more dispersed than in other Asian countries

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