4 Geography and investment of fish ponds

4.1 Introduction

This chapter outlines the results of a district wide analysis of the geography of fish ponds in Savannakhet province. The analysis provides a starting point for a detailed study of the use, management and development of aquaculture, and a basis on which to critically assess the main orthodoxies of living aquatic resources management and development presented at the end of the previous chapter. This builds directly on the approach taken by Fairhead and Leach (1996) in their assessment of forestry in West Africa by empirically reviewing environmental orthodoxies using a range of methods. The study is therefore based within a geographical political ecology of Zimmerer and Bassett (2003) by incorporating scale to analyse local processes across wider landscapes. The meso scale level of analysis in this chapter provides an opportunity to critically examine the link between the historical context and global orthodoxies of aquaculture development outlined in the previous chapter and the decision making processes of district and provincial planners who contribute to national level planning and policy.

Systematic accounting of either aquaculture or capture fisheries in Laos has never been a priority of the central government. This is evidenced by the complete omission of any records of living aquatic resources in agriculture and forestry statistics (NSO 2000; NSC 2001). There has been some effort to account for local capture fisheries around the country through catch per unit effort (CPUE) surveys and community fishery projects (e.g. Chomchanta *et al.* 2000; Baird *et al.* 2003; Roberts and Baird 1995). However, as Coates (2002) notes, any data that has been produced has historically been 'divorced' from planning. As such, living aquatic resource development by both government and non government organisations has focused on aquaculture with little empirical justification.

The following critiques two major development orthodoxies: (1) that fish ponds provide a production system equally accessible to all rural communities and (2) that there is a linear progression or ladder of intensification of living aquatic resource use from capture fisheries to aquaculture. In addressing these aims the chapter first determines the extent and the level of investment in aquaculture in three districts of Savannakhet Province and then analyses how this level of investment relates to the location of existing ponds. Analysis is based on a spatial analysis from Geographical Information System (GIS) built from the first systematic survey of fish ponds in Laos.

4.2 Methodology

The pond survey was conducted during the dry season, from November 2001 to February 2002. District staff were trained and employed to conduct the survey in the three districts of Outhomphone, Chumphone and Khantabouli. The position of the ponds was recorded using GARMIN 12-XL Global Positioning System (GPS) units made available by the Department of Forestry. Basic characteristics of the ponds and aquaculture over the previous 12 months were recorded on a survey (See Appendix A). The questions referred to feed, species, stocking rate, flooding, water source and quantity harvested.

Teams of two staff members were allocated lists of villages that they had to visit over a two week period. Ponds were identified by the village committee and interviews then conducted with the heads of the households. In the event that that the household head was not there the next most senior member of the household was interviewed. Data were then entered into an Access database and analysed using ArcGIS software.

4.3 Characteristics of study districts

Three districts of Savannakhet Province – Outhomphone, Chumphone and Khantabouli – were selected for this thesis based on their close proximity to each other and the different extents of water resources (Figure 4-1). The extensive wetland areas of Chumphone district flood annually damaging rice crops providing one of the most abundant areas in the country of fish and other aquatic animals. It is also one of the wealthiest areas of Savannakhet Province. Conversely Outhomphone was selected because of its lack of aquatic resources and relatively poorer communities. Khantabouli district was selected because of its variety of aquatic resources including the Mekong River. It also has the main urban centre of Savannakhet town.

Chumphone district contains one of the most complex wetland areas in Southern Laos with around 50 oxbow lakes and 40 other large water bodies (Claridge 1996). This network of wetlands covers almost half the area of the district, extending from the Se Bung Hiang in Sonbouli district along the Se Chumphone to the elevated woodland areas of Outhomphone and Atsaphanthong districts (see Appendix A). These wetlands flood annually as water backs up from the Se Bung Hiang. In addition the area has also been subject to extensive irrigation development over the last decade. The two largest water bodies, Souie and Bac reservoirs are the most productive fishery areas in the district as well as providing the main source of water for irrigation.

Outhomphone district is characterised by its lack of perennial water resources. There has been only minimal development of irrigation (see Appendix A).[14] A small number of projects are located on small streams close to villages, irrigating small areas of rice fields. Most of the rain-fed wet rice is located in open dry woodland across the district, characterised by poor soils. This means that there is little opportunity for developing perennial water bodies. There is, however, an extensive network of small intermittent streams across the plateau. As a result the exploitation of living aquatic resources is highly seasonal, limited to the months between July and November.

Khantabouli district is comprised of a combination of dry woodland areas and extensive wetlands on the Huay Somphoie floodplain. This catchment includes two large natural lakes, two small reservoirs and many seasonal ponds (Claridge 1996). The area of rain-fed wet-rice is approximately the same size as that found in Outhomphone and there is only a small amount of irrigated rice, found mainly along the Mekong River (see Appendix A).

In these districts the United Nations World Food Programme identified all three districts as “better off” in their national assessment of poverty and vulnerability to food insecurity (WFP 2001). The second national consumption survey (LECS II), however, identified Outhomphone as “poor” while the provincial committees identified Chumphone as “poor” (NSO and SPC 1999). None of these assessments are based on aquatic resources. District staff noted, however, that Chumphone was considered vulnerable because of the extensive damage caused to rice crops from annual flooding and Outhomphone was selected because of the low consumption of living aquatic resources. As such

[14] The few small reservoirs found in Outhomphone are small-scale stream weirs or large ponds constructed by the military, who are based around Seno in large numbers. Some irrigation is present around these weirs and ponds, however are highly localized (Pers. Obs.).

perceptions of vulnerability and poverty appear to be implicitly linked to the availability of aquatic resources.

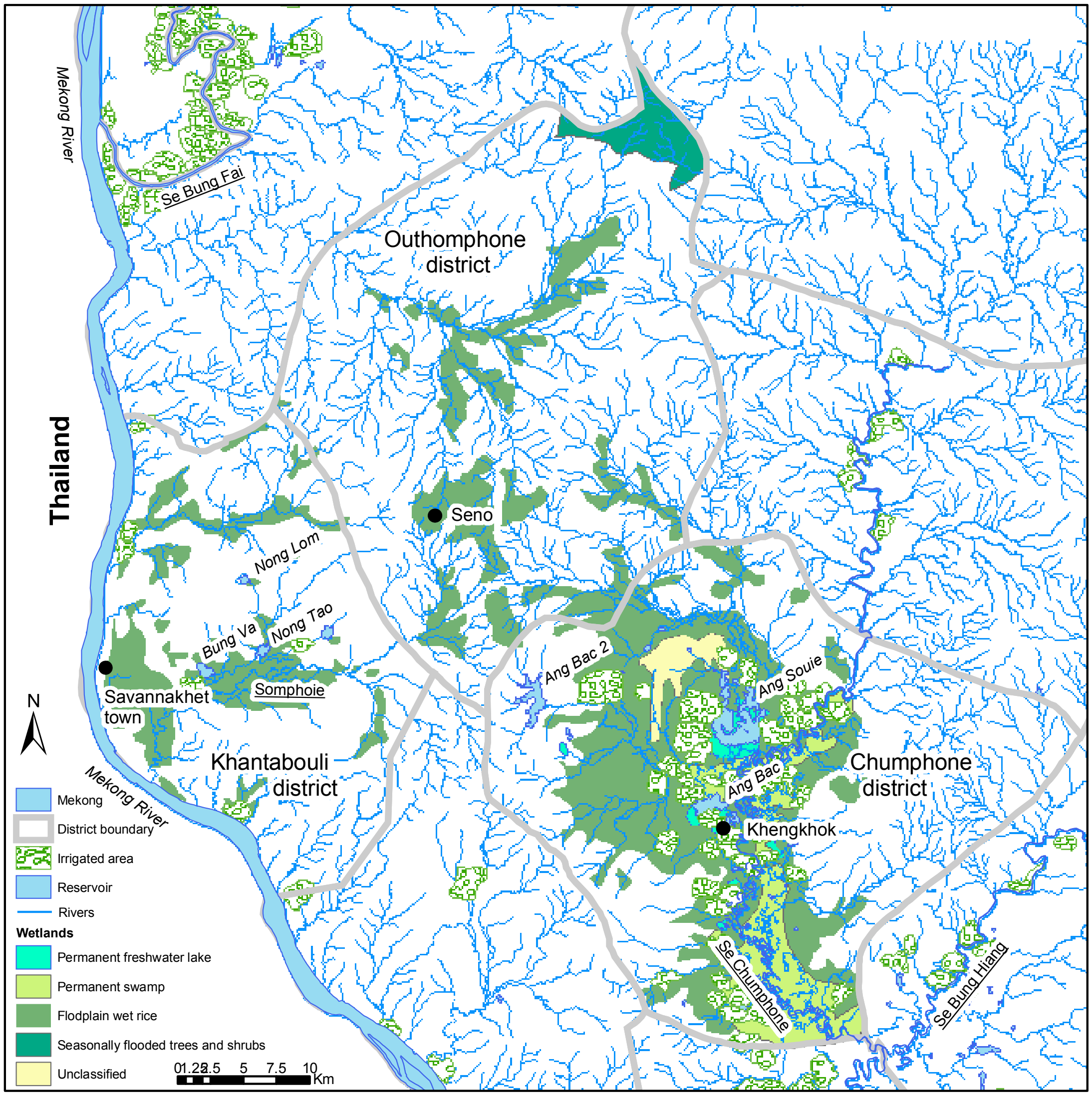

Figure 4-1. The extent of aquatic resources in three study districts.

Map projection: WGS 1984, UTM zone 48 north

(Source: Wetland classification – MRC, Irrigated area and reservoirs – MAF, Administrative boundaries – WHO)

4.4 Characteristics of fish ponds and aquaculture

This section outlines the existing number, type and spatial extent of fish ponds across the three districts. The analysis explores the diversity of activities carried out in fish ponds along the aquaculture-capture fisheries continuum.

4.4.1 Patterns of fish ponds development

Of the three districts Outhomphone has the most ponds with 1601 followed by Khantabouli and Chumphone (Table 4-1). This indicates a strong division in the need for aquaculture between areas rich and poor in water resources. The results also highlight the rapid increase in pond construction since 1980 across the entire area. The rate of growth was especially high during the 1990s over which time the number of ponds in the three districts increased by over 550% (Figure 4-2). Outhomphone district saw the largest increase, rising from 316 ponds in 1990 to 1161 ponds in 2001. This coincided with the start of the UNDP/FAO Provincial Aquaculture Project and the AIT Aqua Outreach project (See Chapter 3).

Table 4-1.Area of fish ponds

	Chumphone	Khantabouli	Outhomphone	All Ponds
N	364	383	1601	2348
Mean (m^2)	896	694.3	918	877.8
S.D.	1017.4	875.6	930	938.7
Minimum	20	25	30	20
Maximum	5000	5000	5000	5000
Number of owners	260	245	1053	1558
Average Total Area (ha) per Owner	1254.3	1086.9	1394.8	1701
Total pond area (ha)	32.6	26.6	146.9	206.1
Average ponds per owner	1.4	1.56	1.52	1.5
Maximum	5	21	15	21
SD	0.76	1.67	1.34	1.32

Overall the ponds are relatively small. The average size of ponds is 878 m^2 which is smaller than the average size of ponds in Northeast Thailand at 11719 m^2 and North Vietnam at 1506 m^2 (Demaine *et al.* 1999; Luu *et al.* 2002). It is also considerably smaller than the average size of ponds found by Funge-Smith (1999) in Savannakhet of 3300 m^2. The size of fish ponds is dependent on the type of agro-ecosystem as well as socio-economic status (Luu *et al.* 2002; Barman *et al.* 2002). However, the average area of ponds per farmer across all three districts is 1701 m^2 which may reflect the non specific digging of ponds for fish culture as an artefact of road construction. This is plausible as most of the laterite for road construction is excavated from land immediately adjacent to roads, a feature common across the country. It therefore appears that the range of pond sizes is as much a function of location as it is the capability of farmers.

In all three districts the majority of ponds produced fish exclusively for consumption. Interestingly, 20% of ponds in Khantabouli produce fish exclusively for market (Figure 4-4). This reflects the relatively easy access of villagers in this district to the large urban market of Savannakhet town, described in detail in the next chapter.

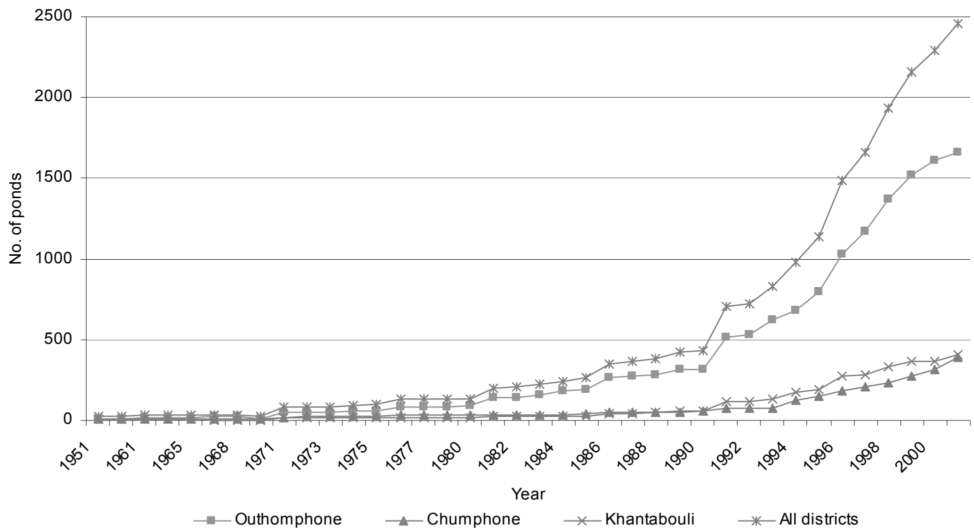

Figure 4-2. Development of fish ponds from 1950-2001. Note: Responses on the age of fish ponds ranged to as old as 400 years. It is assumed that these ponds have not been constructed but are instead naturally occurring and their age reflects the age of the establishment of the village.

The spatial pattern of development is presented in Figure 4-3. In 1982 ponds were located along major roads, most notably Route 9 west of Seno, and the road leading northeast from Seno to Atsaphone District. By 1992 ponds had been dug along Route 13 heading north from Seno. The number of ponds also increased in urban areas of Savannakhet town and Seno. Between 1992 and 2002 there was a large increase in the number of ponds across all three districts expanding out of areas with existing ponds. Two patterns are evident from this development. The first is ribbon development, mainly along major roads. The second can be described as developing around both district centres and areas with an existing concentration of ponds. In Chumphone district, however, a far more diffuse pattern of development is evident between 1992 and 2002. Both district and provincial agricultural staff agree that this reflects the construction of ponds as an artefact of irrigation canal development.

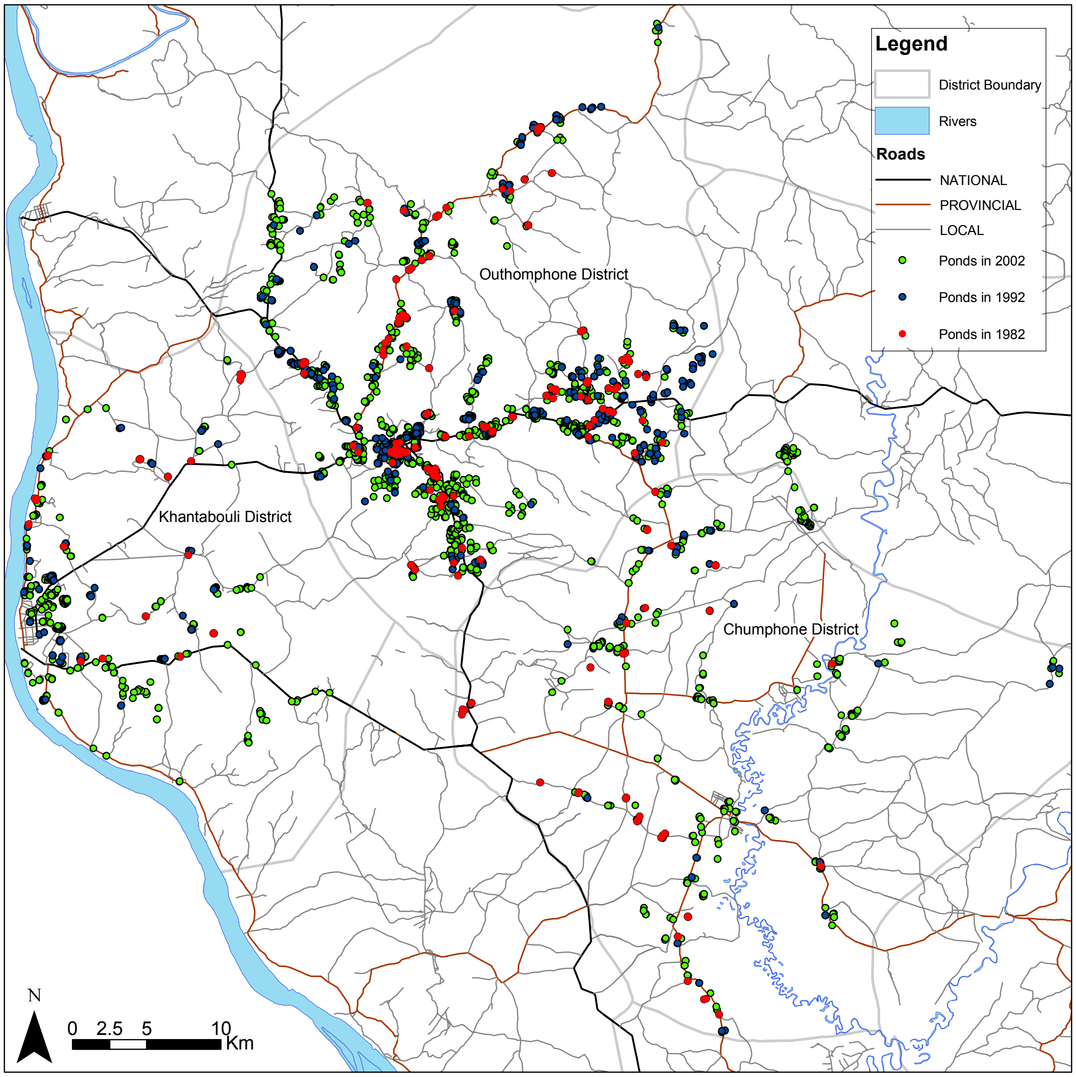

Figure 4-3 Fish pond development patterns.

Map projection: WGS 1984, UTM zone 48 north

(Source: Administrative boundaries and roads from WHO, Rivers from MRC)

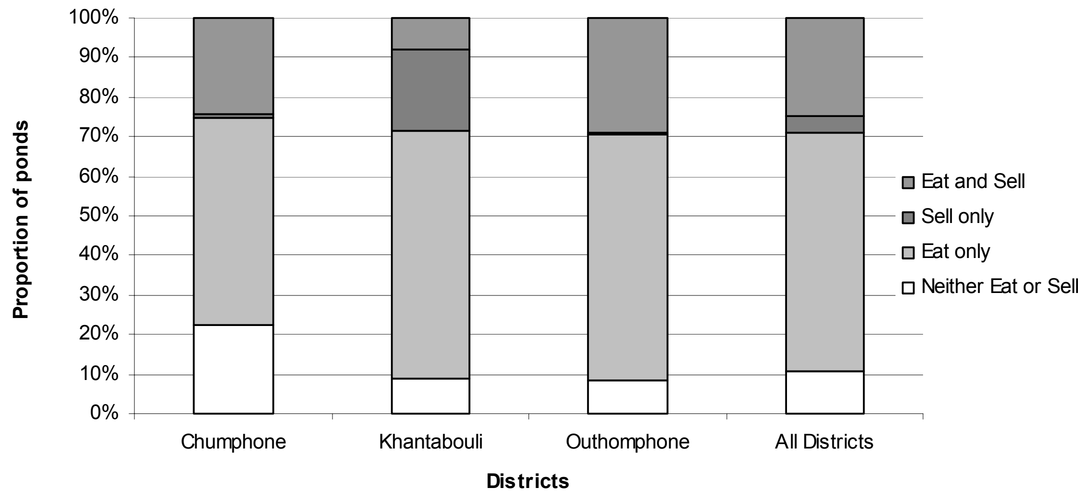

Figure 4-4. Different uses of fish grown in ponds.

4.4.2 Species stocked

Fish ponds are stocked in a number of different ways. The majority of ponds are stocked with exotic species. However, approximately one fifth of all ponds have native species in them (Table 4-2). Overall, only 3.5% of ponds were recorded as having no fish at all.

There is a distinct difference in stocking strategies in each of the districts. In Chumphone, nearly one quarter of ponds have no exotic species and over half the ponds have native species. In Outhomphone and Khantabouli districts around 20-24% of ponds have native species. This relatively high proportion of native fish in ponds highlights the variety of stocking strategies and the variety of local environmental conditions that allow the recruitment of fish from the wild. Even in Outhomphone, the driest of the three districts, nearly 10% of all ponds in the district are exclusively comprised of native species.

In Outhomphone there is a relatively low numbers of ponds with both exotic and native species. In Khantabouli and Chumphone, by comparison, there are a relatively high proportion of ponds stocked exclusively with native species. This is an expected finding. The extensive flooding in both districts enables native fish to easily recruit to fish ponds, especially those located in rice fields. For farmers investing in exotic species, there is a trade off. Predatory species, such as *Channa striata* and *Clarias macrocephalus,* are present in 7-54% of all ponds (Table 4-4). These are widely considered pests, consuming stocked fingerlings. However, they offer an alternative species which, according to farmers across all districts, are valued more highly in taste and market value. Furthermore, the prevalence of native species in ponds highlights the complexity of the aquaculture-fisheries continuum.

Table 4-2. Type of ponds by district

Type of pond	Chumphone		Khantabouli		Outhomphone		All	
	n	%	N	%	n	%	n	%
Inactive	3	0.8	19	5.0	72	4.5	83	3.5
Culture	157	43.3	274	71.5	1327	82.9	1758	74.9
Capture and culture	130	35.8	95	24.8	60	3.7	285	12.1
Capture	73	20.1	6	1.6	142	8.9	221	9.4
Total	363	100	383	100	1601	100	2347	100

The species stocked in ponds is directly influenced by the availability of fingerlings. The supply of fingerlings is widely considered the main constraint to aquaculture development in Laos (Funge-Smith 2000; Litdamlong *et al.* 2002). The main supply of fingerlings in Savannakhet is from Thailand. It is estimated that in 1995 92% of all fingerlings stocked came from across the border (Haitook 1997). The most prevalent species are *Puntius goniotus* (Silver Barb), *Cyprinus carpio* (Common Carp) and *Tilapia nilotica* (Tilapia) (Table 4-3). These species are well established in Northeast Thailand. *P. gonoitus* was the main species promoted by the UNDP/FAO Provincial Aquaculture Project and *T. nilotica* was promoted by the AIT Aqua Outreach project.

The spatial distribution of these three main species as well as *Cirrhinus cirrhosus,* are similar, stretching evenly across all three districts (Figure 4-5, Figure 4-6, Figure 4-7 and Figure 4-8). The lesser species are less extensive. *Labeo rohita* (Figure 3-5), *Aristichthys nobilis* (Figure 4-11) and *Clarius batrachus* (Figure 4-12) are stocked predominantly in areas along main roads in Outhomphone. *L. roihita* and *A. nobilis* are also stocked around Seno. These less extensively stocked species are prevalent along major roads which may reflect the coverage of fingerling traders coming from Thailand and Savannakhet town. It therefore appears that there is a wider availability of different species available in Outhomphone. In comparison, the two native species surveyed, *Channa striata* and *Clarias macrocephalus* are distributed throughout each of the districts (see Figure 4-13 and Figure 4-14).

Table 4-3. Frequency of main culture and capture species in fish ponds

Species	Chumphone		Khantabouli		Outhomphone		All Ponds	
	N	%	n	%	n	%	N	%
Number of ponds	**364**	***100***	**383**	***100***	**1901**	***100***	**2348**	***100***
Cyprinus carpio (Common carp)	157	*43.1*	293	*76.5*	990	*61.8*	1440	*61.3*
Aristichthys nobilis (Bighead carp)	38	*10.4*	99	*25.8*	236	*14.7*	373	*15.9*
Puntius goniotus (Silver barb)	175	*48.1*	276	*72.1*	999	*62.4*	1450	*61.8*
Cirrhina mrigala (Mrigal)	48	*13.2*	152	*39.7*	521	*32.5*	721	*30.7*
Tilapia nilotica (Tilapia)	180	*49.5*	337	*88.0*	912	*57.0*	1429	*60.9*
Clarius batruchas (Hybrid walking catfish	7	*1.9*	19	*5.0*	37	*2.3*	63	*2.7*
Labeo rohita (Rohu)	14	*3.8*	18	*4.7*	43	*2.7*	75	*3.2*
Hypophthalmichthys molitrix (Silver carp)	131	*36.0*	38	*9.9*	400	*25.0*	569	*24.2*
Other culture species	28	*7.7*	20	*5.2*	5	*0.3*	53	*2.3*
Channa spp. (Snakehead)	187	*51.4*	64	*16.7*	172	*10.7*	423	*18.0*
Clarius macrocephalus (Walking catfish)	189	*51.9*	28	*7.3*	174	*10.9*	391	*16.7*
Other native species	73	*20.1*	50	*13.1*	141	*8.8*	264	*11.2*

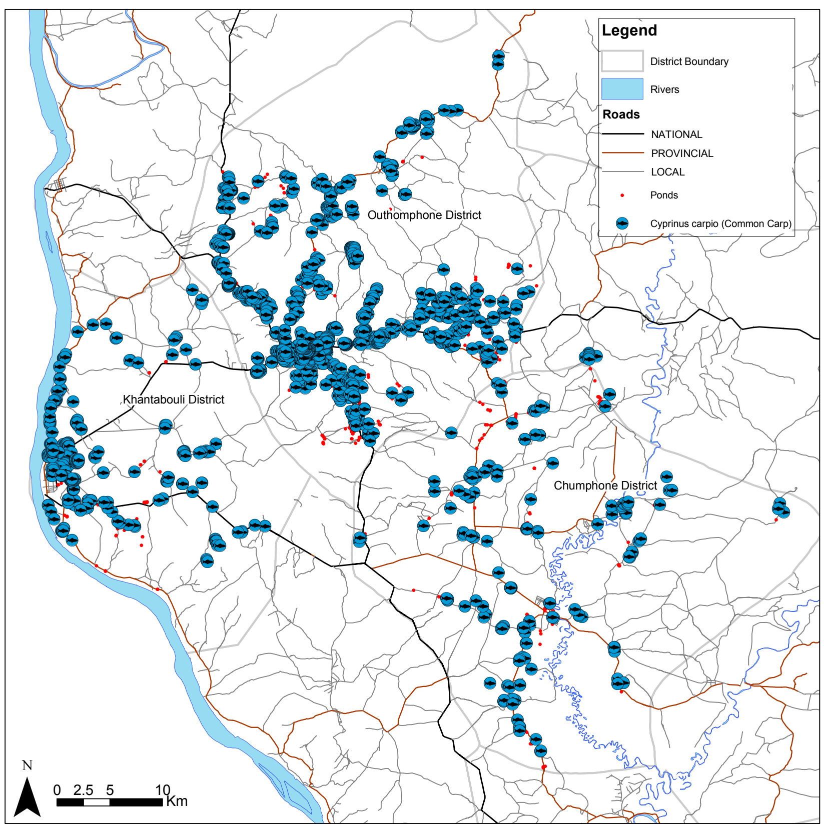

Figure 4-5 Distribution of *Cyprinus carpio* (Common Carp, exotic species)

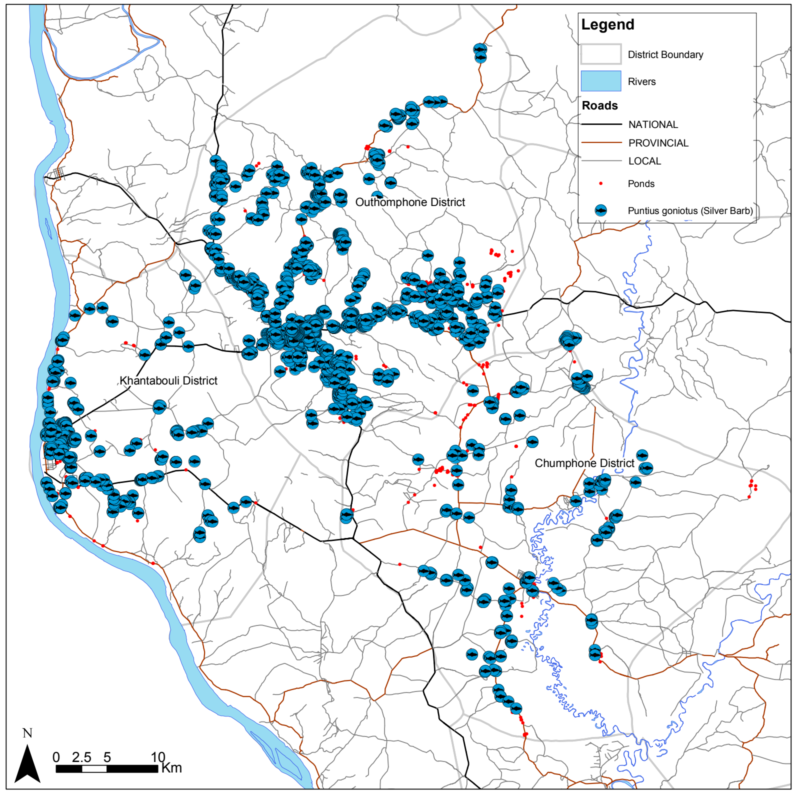

Figure 4-6 Distribution of *Puntius goniotus* (Silver Barb, exotic species)

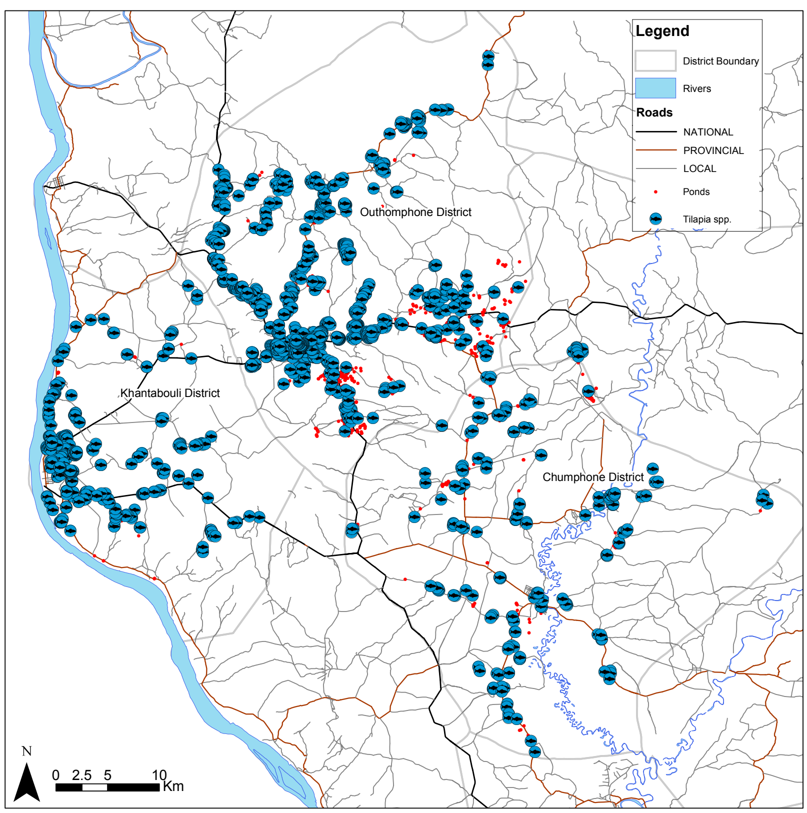

Figure 4-7 Distribution of *Tilapia spp.* (Silver Barb, exotic species)

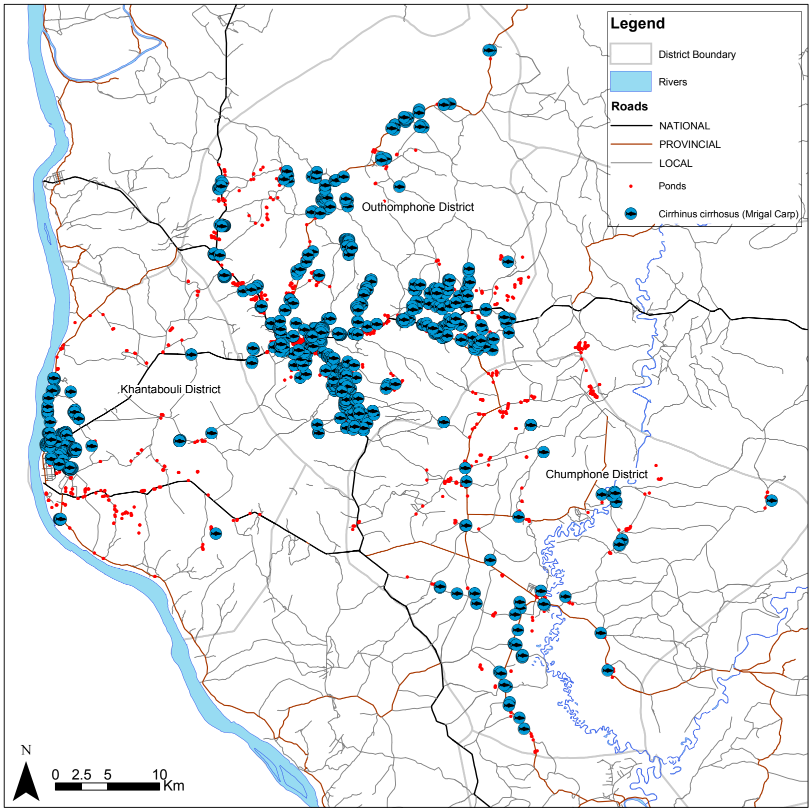

Figure 4-8 Distribution of *Cirrhinus cirrhosus* (Mrigal Carp, exotic species)

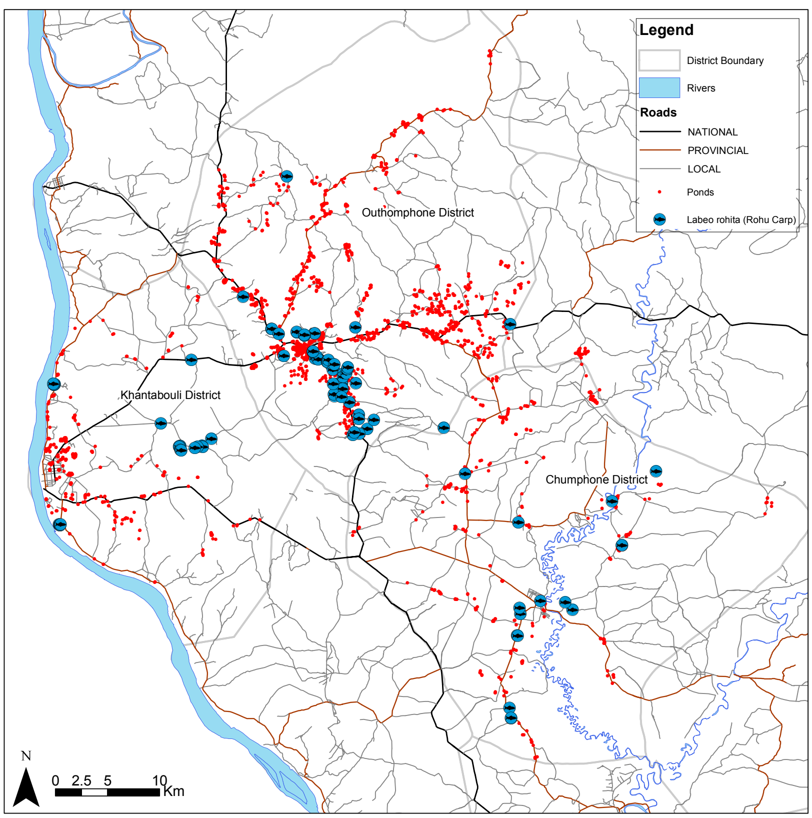

Figure 4-9 Distribution of *Labeo rohita* (Rohu Carp, exotic species)

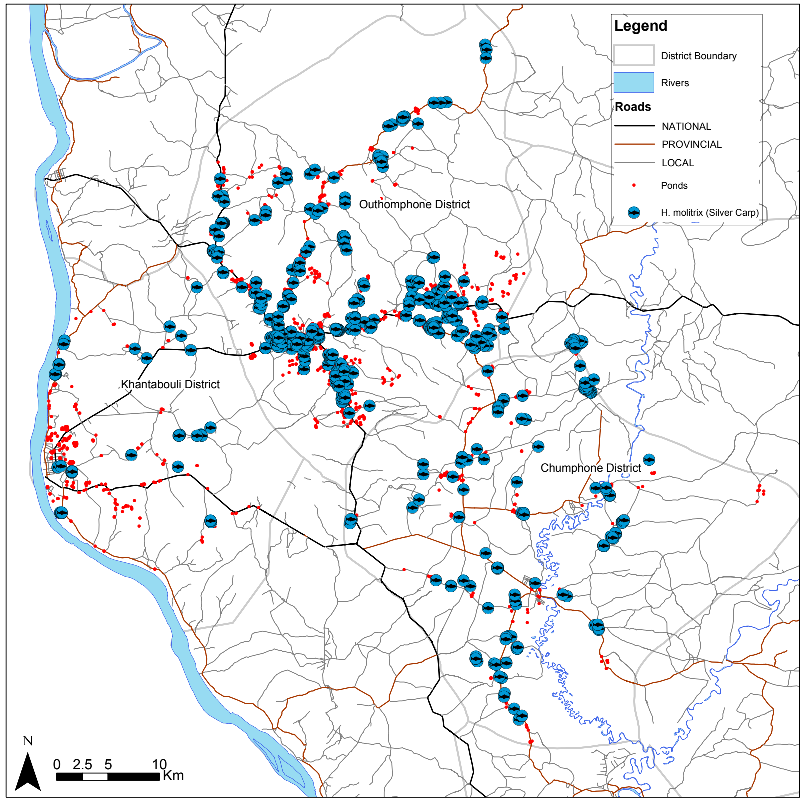

Figure 4-10 Distribution of *Hypohthalmichthys molitrix* (Silver Carp, exotic species)

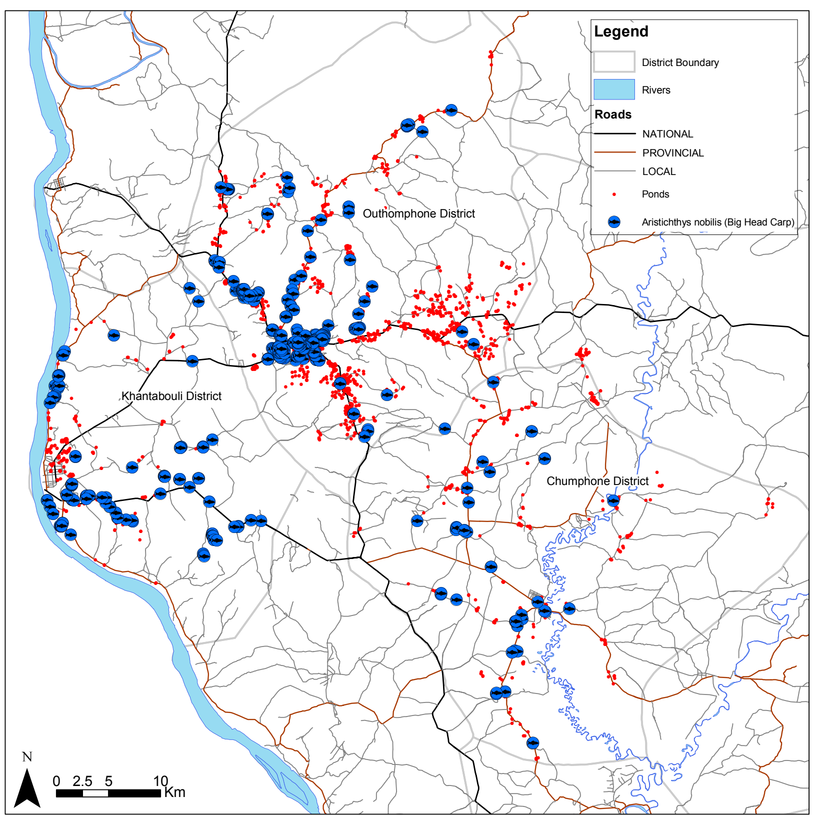

Figure 4-11 Distrbution of *Aristichthys nobilis* (Big Head Carp, exotic species)

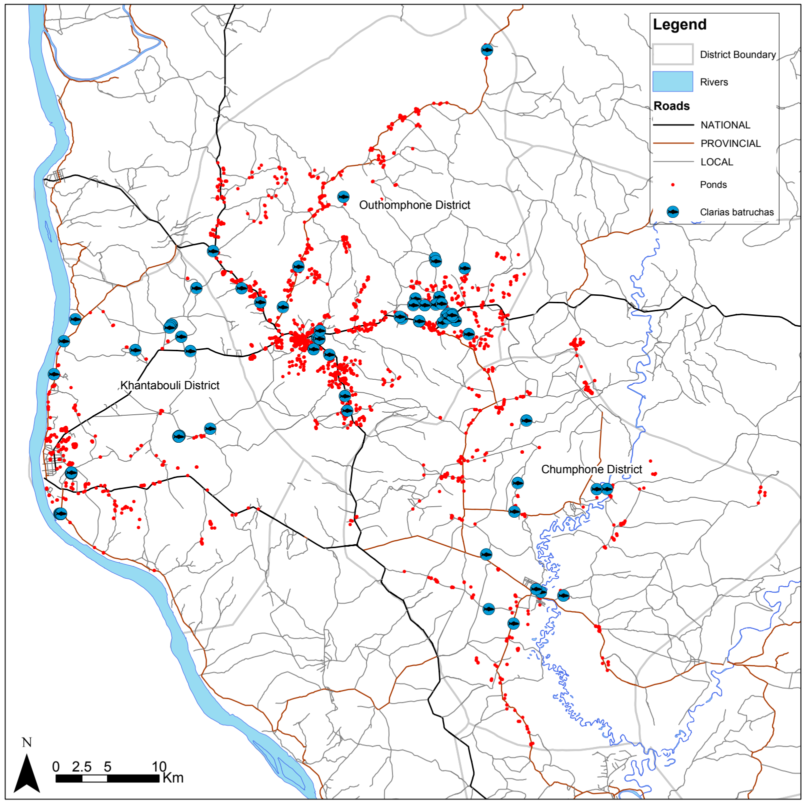

Figure 4-12 Distrbution of *Clarius batrachus* (African Walking Catfish, exotic species)

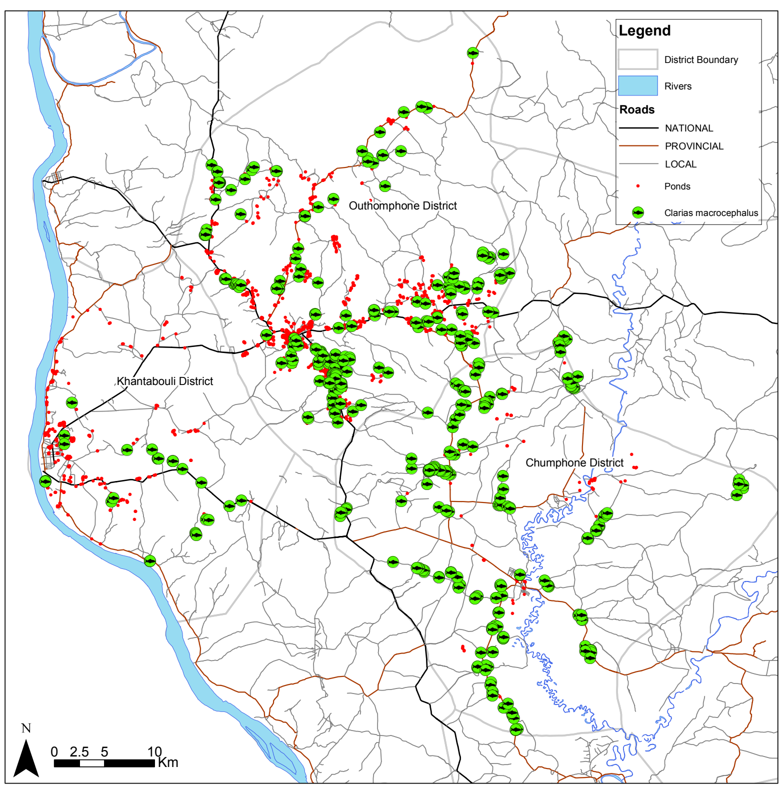

Figure 4-13 Distribution of *Clarius macrocephalus* (Walking Catfish, native species)

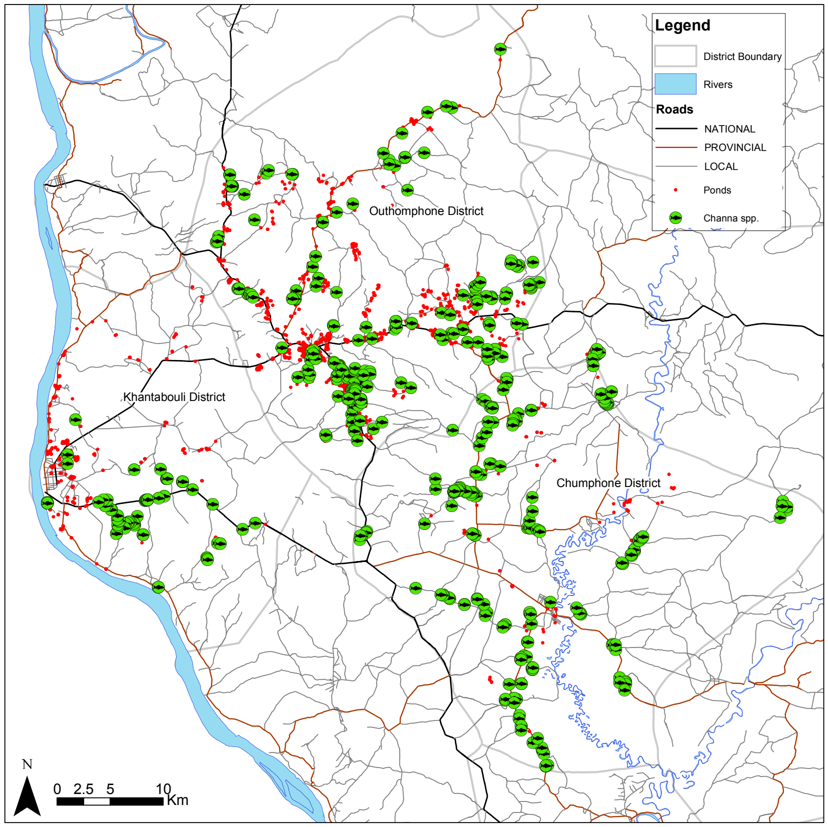

Figure 4-14 Distribution of *Channa striata* (Snakehead, native species)

4.4.3 Stocking rate and density

Stocking densities range from an average of 2.2 fingerlings/m^2 to 5.1 fingerlings/m^2 (Table 4-1).[15] The stocking density in Outhomphone is lower than that found by Funge-Smith (1999). However, stocking densities for Khantabouli and Chumphone are well above the national average of 2.2 fingerlings/m^2 (ibid.). These higher stocking rates may indicate a greater investment since Funge-Smith's survey in 1997, or alternatively may indicate a larger pond size. The stocking density of ponds stocked exclusively with

[15] Stocking density is calculated from the area and number of fish stocked in the pond. AIT spawning network farmers said bags of *P. gonoitus* and *T. nilotica* and both Indian and Chinese Carp contain between 150-400 fingerlings. For the purpose of the following study it is assumed that 250 fingerlings per bag is the average. *C. macrocephalus* were sold in bags containing 150 fingerlings/bag as these fish are sold at a larger size, as also reflected in their higher price. Stocking density was therefore calculated on these two average number of fingerlings per bag. The stocking proportion of the two species groups (Major Carps/*P. gonoitus*/*T. nilotica* and *C. macrocephalus*) was calculated as a percentage of the total number of species stocked. This was then multiplied by the number of bags stocked in each pond. The stocking density (per m^2) was then calculated from this adjusted figure of fingerlings per pond.

exotic species is very similar to ponds stocked with native species at 3.4 fingerlings/m^2 (S.D 5.6) and 3.3 fingerlings/m^2 (S.D. 6.8) respectively.

The spatial distribution of stocking rates is shown in Figure 4-15. In Outhomphone there is a concentrated mix of stocking rates. Around Seno there is a concentration of ponds with one, two or three bags stocked. This area has a number of ponds with higher stocking rates of up to 10 bags. The diversity of stocking rates may indicate the various uses of fish ponds in the water poor area of Outhomphone. In Khantabouli there appears to be higher stocking rates of between 4 and 10 bags in the urban centre and north along the Mekong River. This indicates the relative wealth of these areas and the proximity to fingerlings from Thailand. In Chumphone high stocking rates appear to be found across the district. This may reflect the prevalence of large natural perennial water bodies in Chumphone which are able to be stocked with less risk of desiccation.

Table 4-4. Stocking densities by district (fingerlings/m^2)

	Chumphone	Khantabouli	Outhomphone	All Ponds
Number of Ponds	363	383	1601	2347
Mean stocking density	4.1	5.1	2.2	3.0
Std. Deviation	9.5	7.4	3.1	5.6
Maximum	75	59.5	83.3	83.3

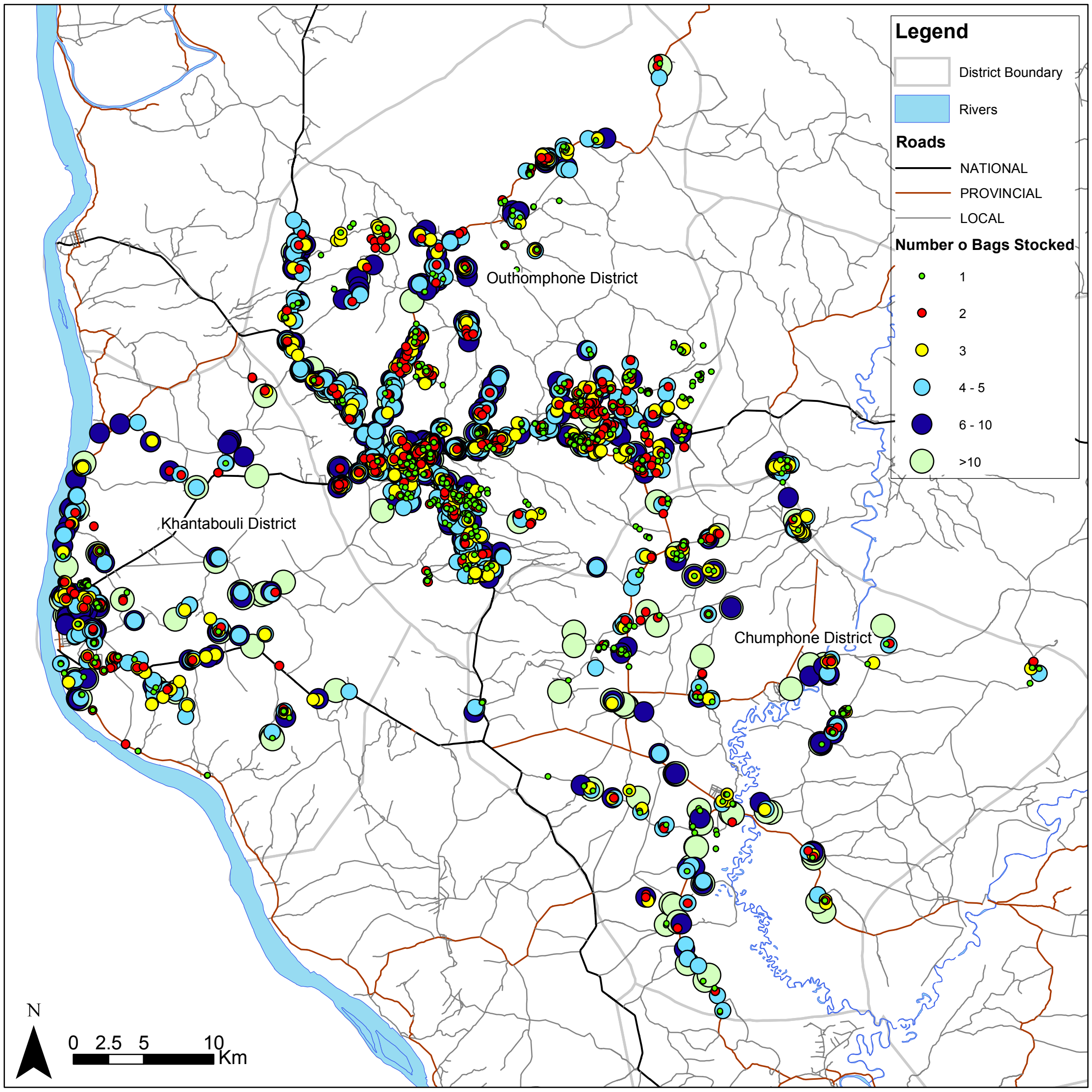

Figure 4-15 Distribution of bags stocked

Map projection: WGS 1984, UTM zone 48 north

(Source: Administrative boundaries roads from WHO, Rivers from MRC)

4.4.4 Feed

In Lao PDR feed is considered a major constraint to the intensification of aquaculture (Choulamany 2002). Feed production in Lao PDR is undeveloped, especially outside of Vientiane (Edwards and Allan 2001). In rural areas feed is mainly comprised of agricultural by-products such as rice bran and buffalo manure. The survey found that the most common feed is rice bran, found in 59% of all ponds. The second most common feed are termites, found in 12.1% of all ponds. Termites are protein rich and of greater nutritional value than the alternatives, however they are seasonal and restricted to forest areas. Processed feed, produced either commercially or locally from a combination of materials, is found in just over 1% of all ponds. Interestingly, up to 27% of ponds that are stocked have no form of feed. This may indicate that fish farmers have inadequate knowledge of even the most basic pond fertilisation techniques as argued by Guttman and Funge-Smith (Guttman and Funge-Smith 2000). Alternatively it may indicate that feeding is prohibitively expensive.

The spatial distribution of feed highlights the influence of the local environment (Figure 4-16). Processed feed, for example, is found in ponds along the Mekong River and in Savannakhet town where it is easily imported from Thailand. Rice bran is found across open areas of wet rice cultivation, especially north of Seno as well as across much of Khantabouli. As is expected, termites are found in ponds located near to forested areas. Interestingly there is a concentration of ponds with no feed input east of Seno. This is reflected in the concentration of low stocking rates in this same area as shown in Figure 4-15.

4.4.5 Source of water

Ready access to water is important for successful aquaculture. A lack of consistent water is considered one of the main constraints to aquaculture in Laos, particularly in upland and non-irrigated areas (Guttman and Funge-Smith 2000). The long dry season means that without a constant supply of water ponds dry up for 2-3 months per year. Aquaculture ponds in both Khantabouli and Chumphone have exploited groundwater, reservoirs or local stream irrigation systems for domestic and agricultural needs. However, relatively little investment in water procurement has been made for aquaculture. Instead, over 90% of ponds in these two districts are rain-fed. This is compared to Outhomphone, where 100% of ponds were reported as rain-fed, and a strong reflection of the lack of water sources in that district. Instead of being a consumer of water in the seasonally dry environment, fish ponds are used as a dry season reservoir. This indicates that the decision to invest in a pond is based on investing in a range of uses beyond aquaculture.

4.4.6 Summary

It appears that fish ponds are directly influenced by their immediate surrounding environment. The survey results indicate that there are a variety of stocking strategies which reflect the lack or abundance of water resources and native fish. In Chumphone, for example, it appears that a large number of ponds are important for capture fisheries as trap ponds. In Outhomphone, the converse is true: the lack of aquatic resources means that greater importance is placed on fish culture. Feed is also locally contingent. The location of a pond determines the immediate availability of feeds from either agriculture or forest areas. It therefore appears that fish ponds are not dug in locations that maximise their potential for fish production alone. Instead, it appears that farmers adapt their strategies for the multipurpose use of ponds based on the surrounding environment.

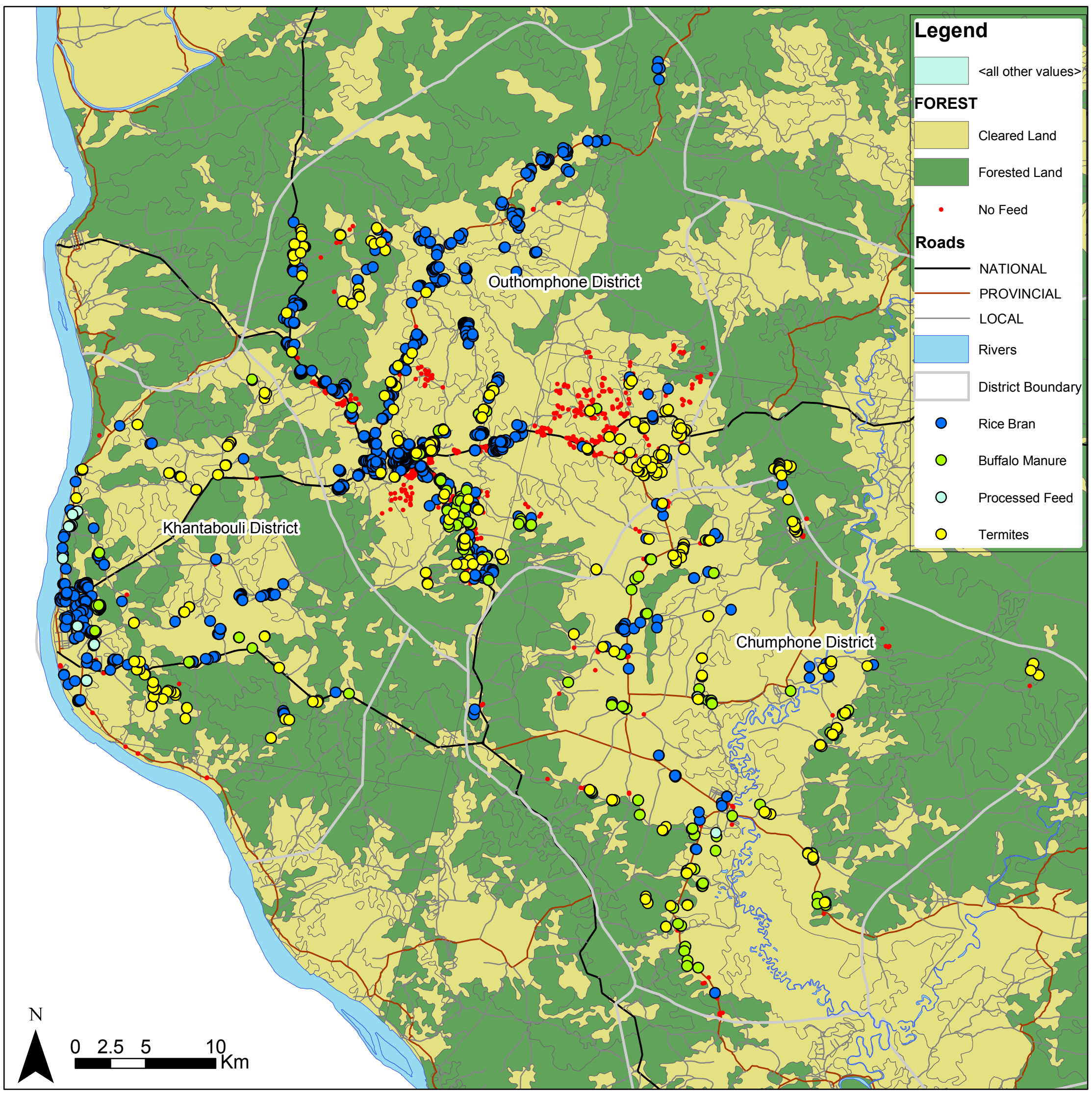

Figure 4-16 Distribution of feed

4.5 Fish pond investment

There is a lack of general information on aquaculture and fisheries in Lao PDR. Assessments of aquaculture by government agencies have been predominantly based on anecdotal evidence. The following provides a systematic analysis of the level of investment in fish ponds across the three districts. Economic evaluation of ponds has not been possible due to a lack of time and the inherent inaccuracy of economic surveys in semi-subsistence communities. Instead three indicators are used: feed, stocking and water source. Feed and stocking in particular are cited as a major constraint to the development of aquaculture in Laos. No commercial feed is produced in Laos, and farmers have been noted as having little knowledge of feeding strategies beyond the most basic pond fertilisation techniques (Funge-Smith 2001; Edwards and Allan 2001). Knowledge of correct stocking levels is also limited in Laos and the provision of fingerlings is a key priority of fishery development in the country (see Chapter 7). The following outlines the rationale for formulating the investment groups.

4.5.1 Feed

Different feeds are classified as different levels of investment (see Table 4-5). Rice bran and buffalo manure are considered low investment feeds as they are agricultural by products, requiring little effort. Termites are considered low cost opportunistic feeds sourced from surrounding forested areas. However, as they are found in only 20% of ponds that used feed in the last year it is considered a feeding strategy requiring considerable effort to collect. As such, termites are classified as a high investment feed. Finally, processed feed requires the highest capital investment, through either purchasing premixed feed from Thailand or local production from a combination of other feeds.

Table 4-5. Feed index

Group	Feed	Cost
Low	Buffalo Manure	Free, low effort
	Rice Bran	Free/low cost, Low effort
	Other Feeds (manures and waste)	Free, low effort
High	Termites	Free, High effort
	Processed Feed	Expensive, High effort
None	No feed	

4.5.2 Stocking

Stocking rates were collected for the previous season only. The number of bags per pond ranged from 0-50 with a mean of 4.5. Three investment categories were created. The first, low investment, was assigned to those ponds with 1-3 bags in them at an average cost of 12500 kip per bag. Ponds with four or more bags are classified as high investment. The final category was no investment, which is comprised of farmers who did not stock ponds in 2001. It is acknowledged, however, that these ponds may have a residual number of fish from the previous season. There are very few of these ponds and their inclusion does not affect the outcome of the following analysis.

4.5.3 Water source

As outlined above four sources of water are identified by the survey: irrigation, groundwater, rain-fed and small streams. Rain-fed ponds require no effort, however, they dry out at the end of the dry season which means that they are limited to one growing season. Stream water requires investment in pumping or irrigating and access may require consultation with village committees. Bore water requires the effort of irrigating, drilling or pumping the water into the pond. Irrigation requires the largest investment. The level of investment in water sources reflects the level of effort and potential costs (see Table 4-6). A score of one is given to any investment in water. Correspondingly, no score is given to an absence of investment.

Table 4-6. Water sources index

Group	Water source	Effort	Cost
Investment	Stream	Medium	Low (pump, irrigation)
	Irrigation	High	High
	Bore	Low	Low (pump, drilling)
No investment	Rain	Nil	Nil

4.5.4 Final investment groups

The rationale for the final grouping was based on stocking and feed. These two indicators were added to produce a combined grouping. When stocking is high and feed was high then the final investment group would also be high. If, however, stocking is high and feed low then investment in a pond is classified as medium. Water is a supplementary indicator. If a pond has an investment in water then it can be raised an investment group. However, the lack of investment cannot move a pond down an investment group (see Appendix A for a summary of the classification combinations).

The size of final classification groups is shown in Figure 4-17. The low investment group is the largest making up 46% of all ponds surveyed. The high investment group comprises 7% and medium investment ponds make up 34%. Ponds with no investment make up 12.5%. This last category corresponds with those ponds that have stocked before the previous 12 months but have kept feeding or alternatively stocked but do not feed.

A comparison of investment groups by district highlights the geographic variation in aquaculture and capture fishery strategies (see Figure 4-18). Chumphone has the highest proportion of high investment ponds while Outhomphone has the lowest. This is an unexpected finding. The large extent of water in Chumphone should discourage the investment in aquaculture because of the abundance of native species. However, the larger proportion of high investment ponds indicates the availability of a year round supply of water. Likewise, the lack of investment in Outhomphone reflects the lack of water available and the variability of water from season to season.

The dry upland environment should be more suitable for high investment in aquaculture as argued by Funge-Smith (1999) and Pravongviengkham (1998). The relatively large proportion of low investment ponds in Outhomphone indicates that the variability of water between seasons is a deterrent to invest in aquaculture. Variability is particularly important as it contributes to the environmental insecurity of farmers, which directly influences their confidence in investing in a single activity such as aquaculture (see Ellis 2000; Scoones 1998). Instead farmers in such environments are more likely to diversify their production activities. This point is discussed in detail in Chapter 6. Both Chumphone and Khantabouli have a smaller proportion of low investment ponds than Outhomphone. The size of their low and medium investment groups is similar. Khantabouli in particular has the largest combined proportion of ponds in the medium and high investment groups which also indicates a stable environment, supported by the close proximity to a large urban centre. This again indicates greater willingness to invest in aquaculture where there is less seasonal or environment variation.

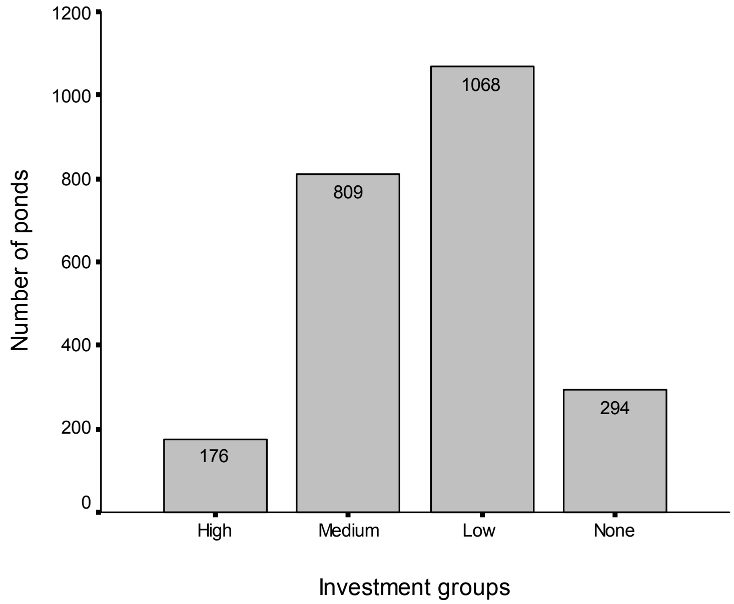

Figure 4-17. Distribution of ponds between investment groups

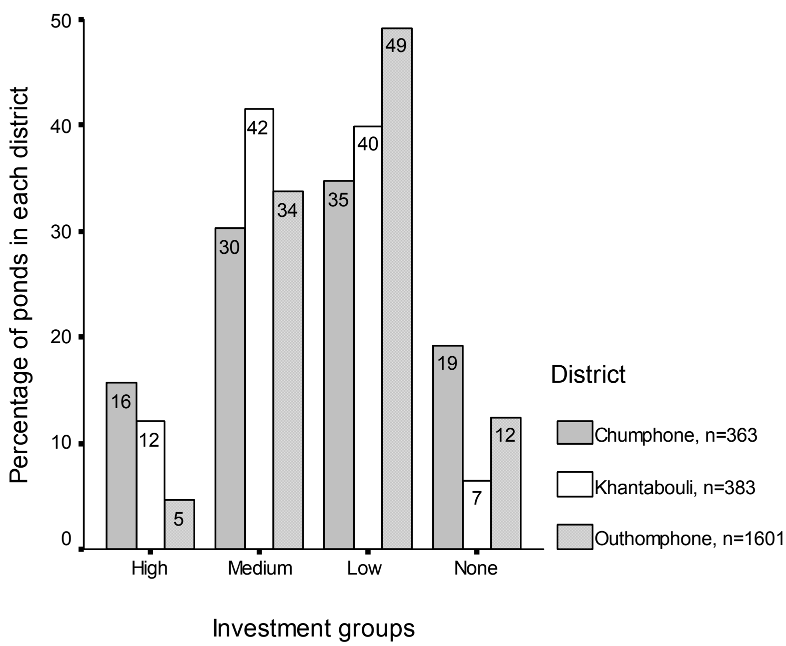

Figure 4-18. Comparison of investment groups by district

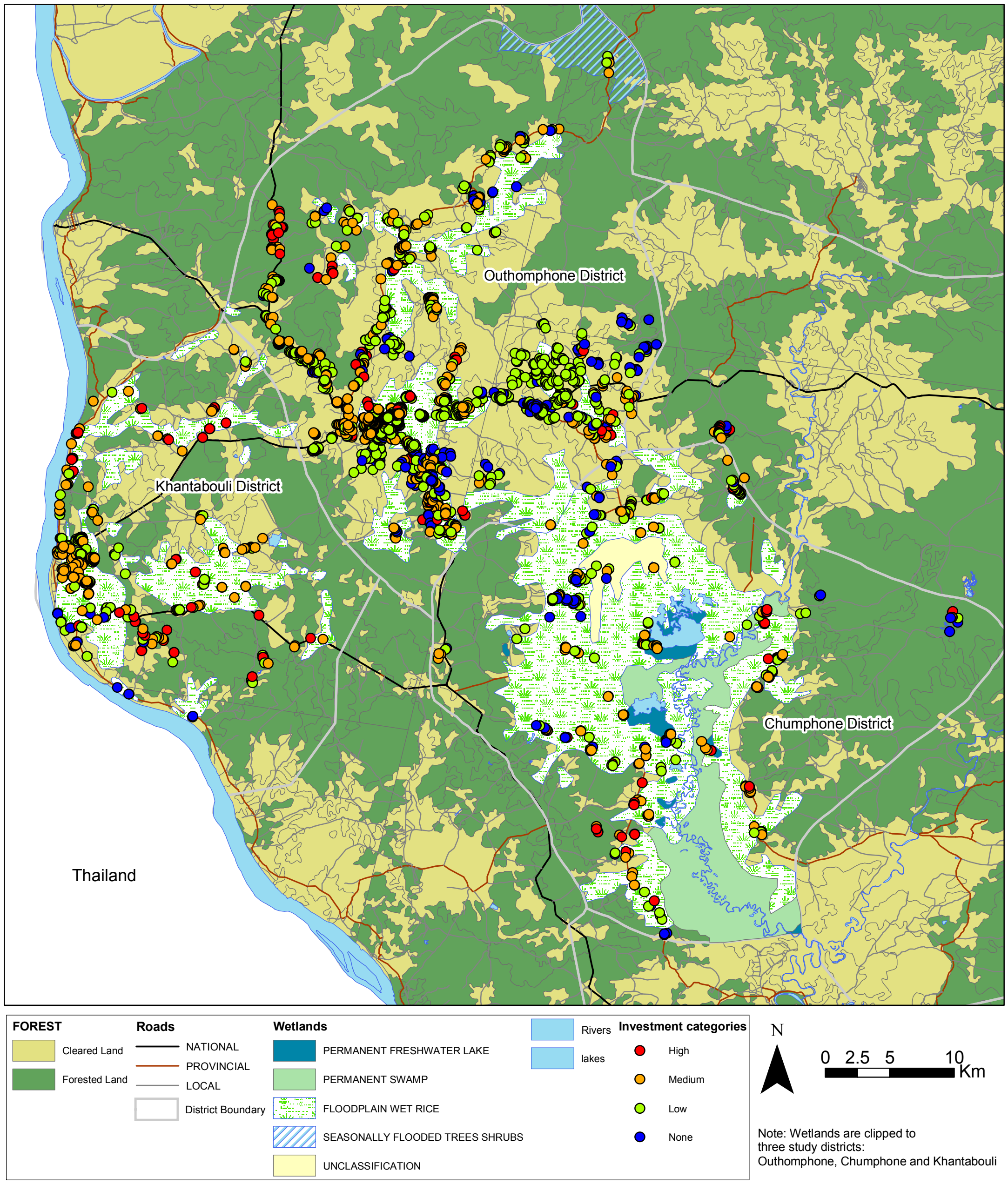

Figure 4-19 Distribution of final investment categories

A spatial analysis of investment is shown in Figure 4-19. No strong patterns emerge. However there is some indication that the low investment ponds, and ponds with no investment are concentrated to the east and south of Seno. There is also some indication that the medium and high investment ponds are located along Route 13 north of Seno. Khantabouli also appears to have a high concentration of medium investment ponds in Savannakhet town. High investment ponds are located along the Mekong as well as east of Savannakhet town. No clear pattern emerges from Chumphone. There appears to be higher investment along the road south to Sonbouli and a concentration of low and no investment ponds east of Ang Souie. This shows that there is a local variation not only at the district level but also within districts. Pond investment is therefore contingent on local environmental factors.

4.5.5 Summary

Investment in aquaculture is linked to the location of the pond and the stability of the environment. The relatively lower variation between investment groups in Chumphone shows that ponds are used for a variety of different purposes, ranging from high input aquaculture to trap ponds. Despite this there is a much lower number of ponds in Chumphone indicating an overall lack of investment in fish ponds. Conversely, in Outhomphone where there are six times more ponds, there is a greater proportion of low investment ponds. This indicates that despite having an immediate need for aquaculture due to a lack of natural aquatic resources, environmental security prohibits greater investment.

4.6 Environmental determinants of investment

Location is an important factor in determining the investment made in a fish pond. A number of studies have attempted to classify the suitable land for aquaculture extension (e.g. Nath *et al.* 2000; Kapetsky *et al.* 1987; Aguilar-Manjarrez and Ross 1995; Simms 2002; McLeod *et al.* 2002; Kapetsky *et al.* 1990; Kapetsky 1994; Kapetsky and Nath 1997). These studies are the basis of aquaculture planning and extension ranging from continental to national scales. However, there have been no studies that examine how environmental factors influence existing levels of investment. Using GIS data layers from the Lao government and MRC this section examines whether and how investment is influenced by these environmental factors. Analysis is divided into analysis of ponds in all districts and then ponds within each of the three districts.

The environmental factors are divided into land attributes, aquatic resource attributes and infrastructure attributes. They include the following data layers:

- *Land attributes*
    - land use
    - soil type

        - slope
- *Aquatic resource attributes*
    - Distance to irrigation areas
    - Distance to rivers
    - Distance to reservoirs
- *Infrastructure/Accessibility attributes*
    - Road type
    - Distance to roads

Each environmental attribute was reduced to nominal categories (see Appendix B) and the Chi Squared test was used to determine statistical significant difference between investment groups.

4.6.1 Environmental influence across all districts

Overall, the level of investment is influenced by the extent of aquatic resources and infrastructure. Distance to irrigation, rivers and reservoirs was significantly different between investment groups ($p<0.05$). Distance to roads was also significantly different ($p<0.05$). Of the land attributes, however, only landuse was significantly different between groups ($p<0.05$). Both topography and soil type have little to no influence over the level of investment made in fish ponds.

The majority of ponds across all investment groups are located in agricultural lands. This is an expected finding. There is some indication, however, that medium and low investment ponds are more likely to be found in agricultural land than high investment ponds (Figure 4-20). This is supported by Kapetsky and Nath (1997) who argue that agricultural land is more suitable location because of the readily available feed. This is especially reflected by the low and medium level investment ponds. Both these groups are more reliant on agricultural products.

As outlined above access to water is very important for successful aquaculture. Few ponds, however, are located in irrigated areas (Figure 4-21). There is some indication that high investment ponds are found closer to irrigated land. This reflects the reluctance of farmers to turn their rice fields over to aquaculture once an investment in rice production has been made. A steady flow of running water becomes a major advantage to aquaculture. The results also show that the majority of ponds are situated between 50 and 500 metres from waterways and relatively few are situated within 50 metres (Figure 4-22). Those ponds more than 50 m away may avoid flood events yet are in close enough proximity to obtain water.

As indicated in section 4.4.1, fish pond development is influenced by road development. The majority of ponds in Savannakhet are situated within 500 metres of roads at an average distance of 239 m. Approximately one quarter of all ponds are dug near national roads which require major earthworks. As a by-product of construction ponds are often left as artefacts. The majority of ponds, however, are found near local roads which require less construction. Kapetsky and Nath (1997) argue that sealed roads are key to increasing access to markets. Although there is some indication that increased production may be linked to major road access the lack of sealed roads found in Savannakhet (and the rest of the country) does not support their assertion. The implications of fish pond geography and market access are discussed further in the following chapter.

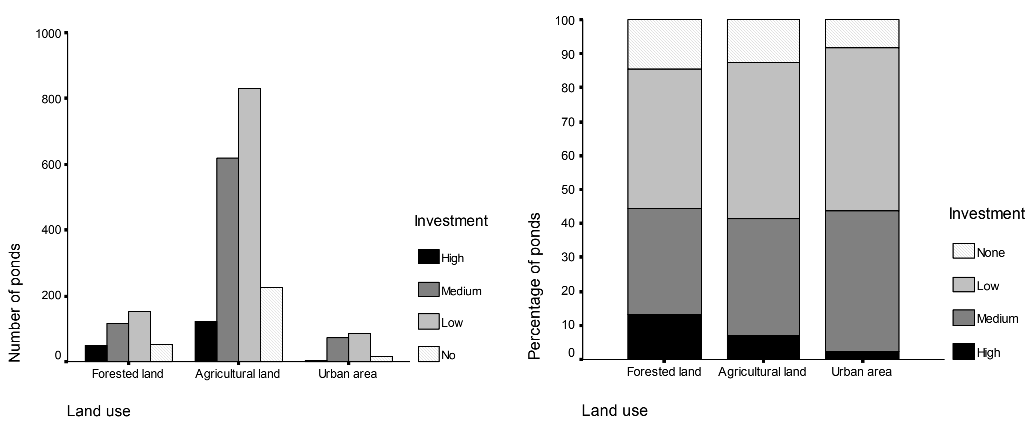

Figure 4-20 Land use by investment groups

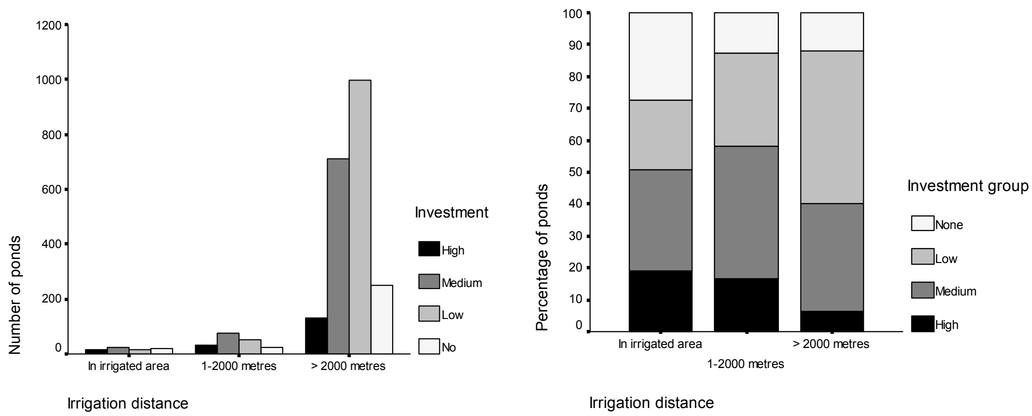

Figure 4-21 Irrigation by investment groups

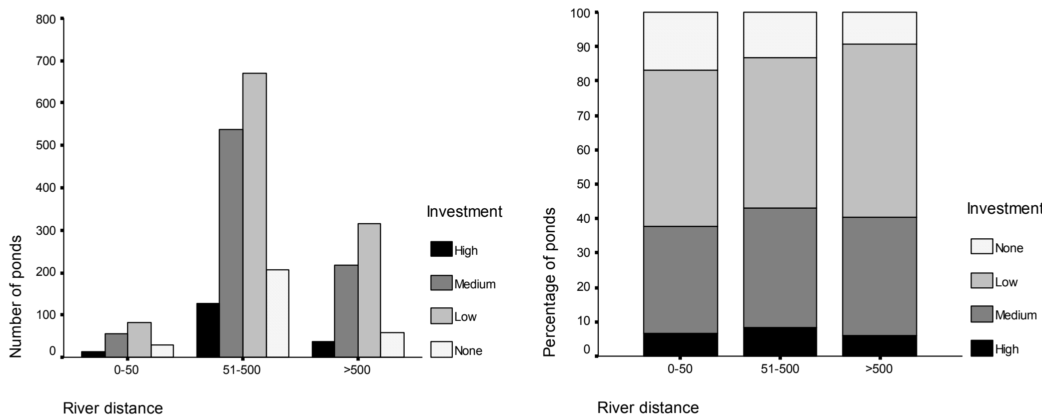

Figure 4-22 River distance by investment groups

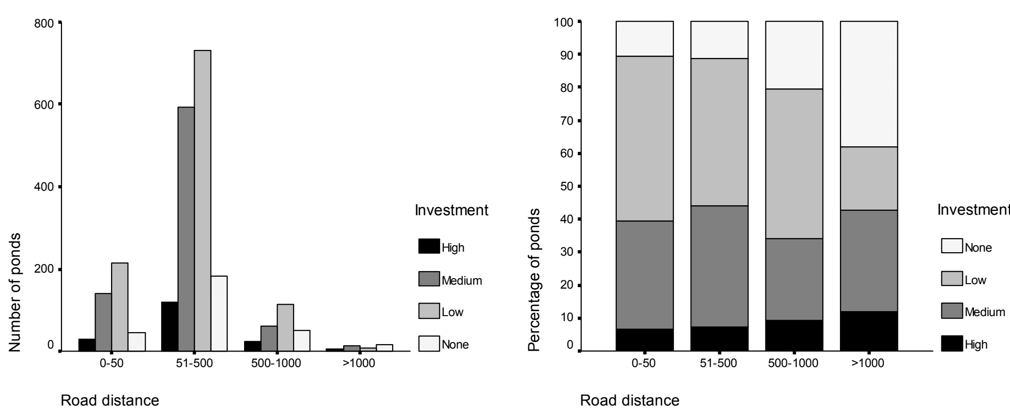

Figure 4-23 Road distance by investment groups

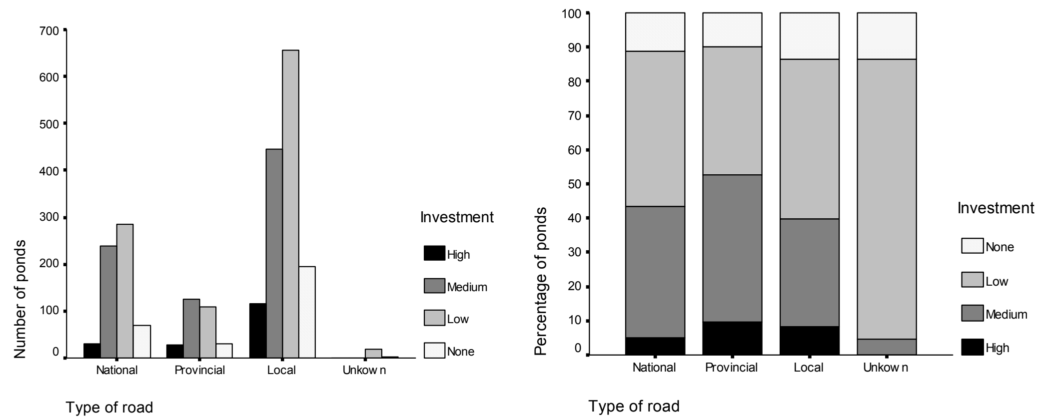

Figure 4-24 Road type by investment group

4.6.2 Environmental influence within districts

The development patterns and level of investment in fish ponds in each district has distinct patterns for landuse, distance to aquatic resources and road infrastructure. There is a significant difference between the different land use patterns in each of the districts ($p<0.05$). In Khantabouli district 47% of all ponds are in urban areas. This indicates the potential importance of aquaculture to fish supply in feeding the large centralised population. Within this area there are very few high investment ponds, mostly they are medium and low investment ponds. Khantabouli also has a high proportion of medium investment ponds in agricultural areas. Both Chumphone and Outhomphone show a relatively similar proportion of ponds in agricultural and forested lands. Chumphone, however, has a relatively high proportion of ponds in forest areas at 23 %. This indicates both the prevalence of forest in that district and the greater investment in irrigated rice. However, no strong pattern of development emerges.

The prevalence of water resources directly influences the level of investment. The results show that there is a significant difference between investment groups, with respect to distance to rivers and streams in Outhomphone and Khantabouli ($p<0.05$), whereas there is no significant difference in Chumphone. This indicates the abundance of rives and streams in Chumphone available between all investment groups. In Khantabouli and Outhomphone water scarcity means that investment is limited. However, this is not the case with irrigated areas. In Chumphone the majority of ponds are located more than two kilometres from irrigated rice, and there is no significant difference between investment groups. As also found by Funge-Smith (Funge-Smith

2000), this indicates the reluctance of farmers to turn their rice paddy over to other activities. Interestingly, however, 34% of ponds found in irrigated areas have no investment which reflects the importance of trap ponds for native species.

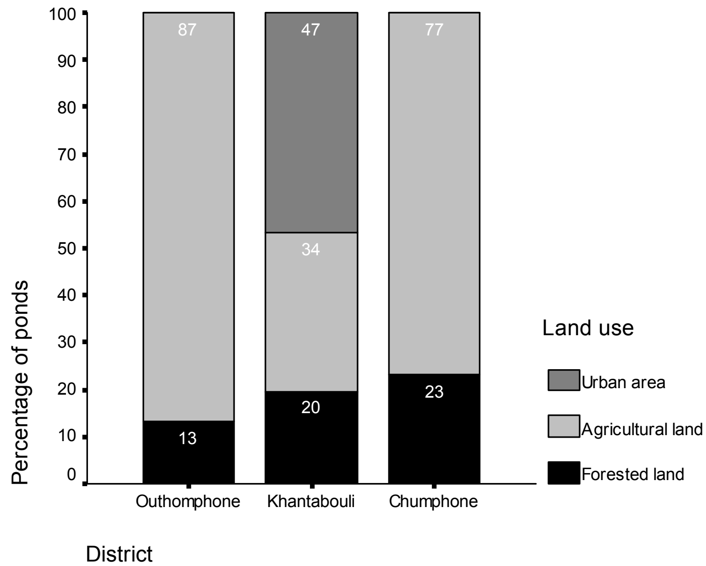

Figure 4-25 Proportion of ponds by land use in each district

The influence of road infrastructure is also different across each of the districts. In Outhomphone for instance, there is a significant difference between pond investment and road type ($p<0.05$). This could be related to the larger extent of national roads that have been constructed over the last ten years, which has influenced the rapid rate of pond construction in the area (see Figure 4-2). In Outhomphone there are more high investment ponds near local roads than national roads. By comparison, in both Chumphone and Khantabouli pond construction and investment is independent of road type, with no significant difference between investment groups. This may be a result of the overall access of these two districts to markets and fingerling traders, however, the difference between the districts indicates that increased access will not necessarily increase investment.

There is also a significant difference between investment groups when comparing the distance of ponds to roads in Khantabouli and Outhomphone. Proportionally twice as many ponds are found within 500m of national roads in Outhomphone as there are in

Khantabouli. However, in Khantabouli 40% of those ponds are high investment compared to 10% in Outhomphone. This indicates the wider extent of road construction in Khantabouli, especially in Savannakhet town, facilitating better access to fingerlings and feed.

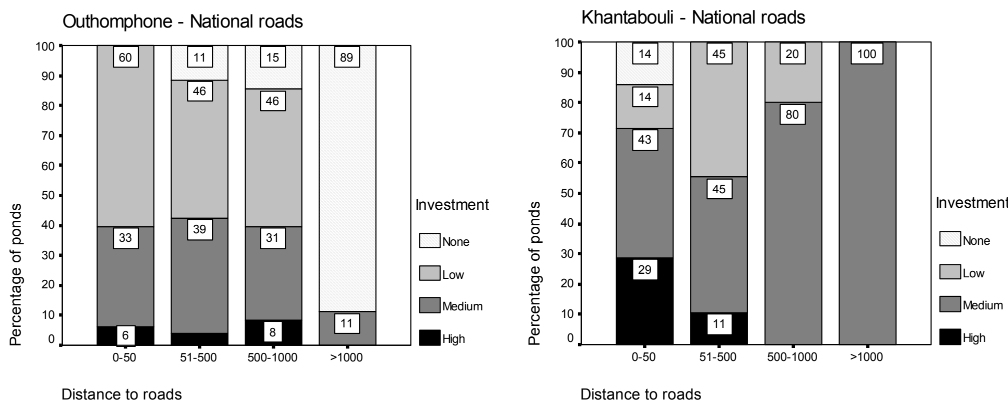

Figure 4-26 Comparison of road distance and investment in Khantabouli and Outhomphone

4.6.3 Summary

Environmental factors play an important role in determining investment in fish ponds. The decision to adopt and invest in aquaculture is therefore locally contingent. The result is a range of investment levels in fish ponds reflecting the diversity of landscapes. Analysis across all three districts shows that differences exist between water abundant and water poor areas and also between areas with and without infrastructure development. The results show that investment is reliant on variable combinations of environmental factors. Aquaculture development and extension policy is based on generalisations that do not reflect this variation and complexity. Policy may advocate the benefits of aquaculture to national poverty alleviation and food security however does not take into consideration local conditions of aquatic resource exploitation.

4.7 Discussion

The results of the survey show that there is a range of strategies for stocking and feeding both exotic and native species. Fish ponds represent a complex aquatic resource used for multiple activities along the aquaculture-capture fisheries continuum outlined in Chapter

1. This supports the finding of Shoemaker *et al.* (2001) in Khamouane province in Laos who argued that the presence of man made ponds used as trap ponds (*Nong Sa*) should not be mistaken for aquaculture. The misrepresentation of fish ponds as aquaculture has meant that existing complex systems have been simplified into models such as outlined by Setboonsarng (1993). She argued that there are observable stages in fish production systems up a sequential ‘ladder of intensification’ (see Chapter 3). In addition the model outlines a progression from trap ponds to intensive livestock/fish integrated systems based on a step-wise intensification of labour and capital inputs. The model highlights the progressive exclusion of native fish production with the progression of capital intensive culture of exotic species. Such thinking is implicit in the green revolution ideology that outlines progressive levels of sophistication in agricultural production, and a move away from natural resource systems.

The results of the survey refute any notion of a ladder of intensification. Instead, a variety of activities were found involving both exotic and native fish. The complex combination would exist at the fulcrum of Guttman’s Aquaculture-capture fisheries continuum outlined in Chapter 1. Instead of a dichotomous system of aquaculture and capture fisheries, there is instead a range of hybrid systems. This is expressed graphically in Figure 4-27, an adaptation of Guttman’s continuum that stresses the influence of location of investment. This finding supports the argument of Gregory and Guttman (1996), who stress the importance of local contingency in determining the level of investment that communities and individuals place in living aquatic resources. The level of investment in a fish pond is locally contingent, based on a range of social and environmental factors. By using complex and diverse strategies farmers adapt the use of a fish pond and the required level of investment to their specific needs.

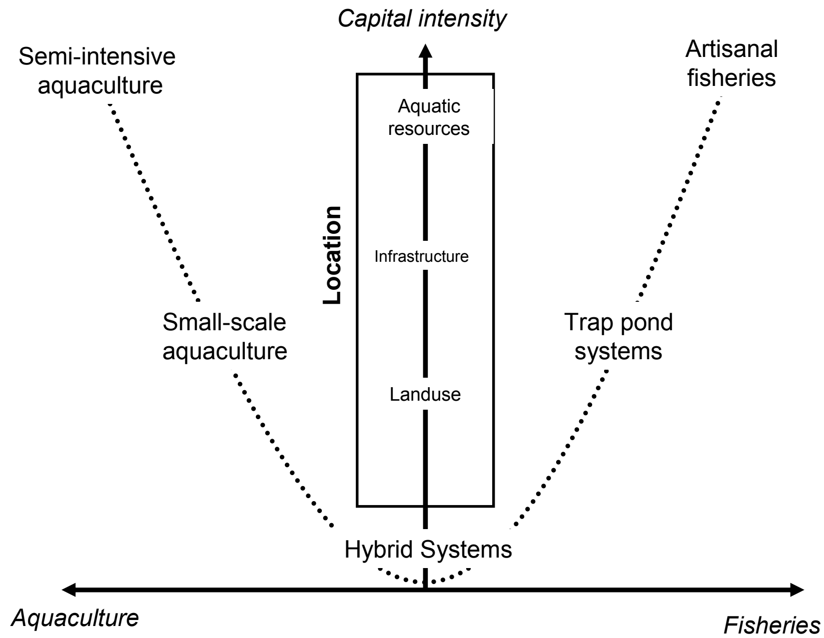

Figure 4-27 Rural aquaculture-fisheries continuum

In addition, the level of investment in a fish pond is also dependent on its location. This is also represented by Figure 4-27. This complexity cannot be simplified into policy statements. Many extension models assume that aquaculture extension is based on capital and access to water, fingerlings and feed. This is evident in intensive cage culture systems in Laos. Hambry (2002), for example, outlines that intensive aquaculture in Laos can be profitable because the cost of production is low and flexible. In rural semi-subsistence systems, however, successful aquaculture is dependent on local abundance and access to local resources (Edwards and Allan 2001). In Laos the main constraints have been identified as a lack of water, fingerlings and locally sourced feed. Although these may constrain the level of production, they do not appear to prohibit the adoption of aquaculture *per se*. It may be more expedient to frame aquaculture in terms of how it is adapted to local conditions. This is especially important considering that the location of a pond, in most cases, is the major factor leading to the level investment in a pond.

The importance and influence of pond location is most pronounced at the scale of a village or household. As shown in the next chapter, site selection of a pond is limited to the extent of their land holding. Land is not widely traded at the village level, especially to develop a new activity such as aquaculture with a high level of risk involved. Pond owners are limited by the local environment of the pond, whether it is located near a road, in a rice field, near to running water or in an area that floods. Contrary to Setboonsarng's linear model, the adoption and subsequent investment in aquaculture is a complex combination of decisions made by farmers based on the location of the pond. The use of fish ponds therefore comprises adaptive strategies along the aquaculture-capture fisheries continuum ranging from stocking of exotic species to trap pond system.

4.8 Conclusion

This chapter describes the first systematic survey of rural aquaculture in Lao PDR. The results conclude that fish ponds are a complex and diverse aquatic resource with a range of stocking strategies involving both exotic and native species. Furthermore, new patterns of fish pond development emerge that highlight the diverse range of pond use. The analysis shows that aquaculture may not be an equally accessible activity to communities across different environments. Instead development and investment in aquaculture is contingent on a range of environmental influences. In Outhomphone the large number of low investment ponds reflects the need for water storage, while in Chumphone and Khantabouli there are extensive wetland areas and fish ponds have a high incidence of native species.

In each district there are different levels of investment in fish ponds, which reflect the local environment. Investment in ponds is contingent on the surrounding environment and the location of ponds is contingent on land use and ownership. Development orthodoxies for living aquatic resources do not reflect this diversity and complexity, especially with reference to poverty alleviation and rural development. If the decision to adopt aquaculture is based on pond location then households with unsuitable land are put at an immediate disadvantage. Adoption and investment in fish ponds is therefore not a linear progression from trap ponds to intensive aquaculture, but rather is a complex combination of simultaneously occurring strategies along the aquaculture-capture fisheries continuum.

The results of this chapter provide a detailed empirical record of the variety of ways in which fish ponds are used in Lao PDR. The results refute the notion of a universal orthodoxy of aquaculture development. Managers need to base decisions on more than cursory observations of ponds, taking their presence as an indication of successful aquaculture adoption and investment. Instead managers need to pay more attention to the locally contingent nature of fish pond development and use. Such attention is necessary to further an understanding of the contingent nature of aquaculture and its position within the wider portfolio of living aquatic resources in rural Lao communities.