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Description of PAPUSSA field sites in Southeast Asia

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1 Introduction

This report describes in detail the field sites covered in the PAPUSSA (Production in Aquatic Peri-Urban Systems in Southeast Asia) project. Figure 1 shows the different countries and cities of mainland Southeast Asia. The main characteristics of each site, especially with respect to their production systems, are summarised in succeeding tables and figures. Financial support for PAPUSSA came from the European Union through its International Scientific Cooperation Projects (1998-2002) (INCO, Contract number: ICA4-CT-2002-10020). This project runs from January 2003 to June 2006. The specific objectives of PAPUSSA are:

- Undertake a multidisciplinary situation appraisal of AFPS at 4 sites in 3 Southeast Asian countries, raise awareness of their role and benefits and conduct an institutional assessment;
- Risk assessment of existing AFPS and opportunities for enhanced management to reduce risks assessed in stakeholder consultation;
- Describe the role of AFPS in primary stakeholder livelihoods, assess vulnerability context and workshop outcomes;
- Assess social characteristics of AFPS and relate to spatial features, identify environmental tensions/conflicts, describe marketing and consumption patterns and policy implications of trajectories of change;
- Verification of occupational and consumer health hazards at 2 pilot sites identified in consultation with stakeholders, monitoring of interventions to reduce such risks and revised health risk assessment for modified Aquatic Food Production Systems (AFPS);
- Enhanced management strategies tested at pilot sites and preliminary assessment of livelihoods impacts made, identification of high potential strategies and appropriate dissemination pathways identified;
- PRA¹ undertaken at 2 representative pilot sites, case-studies for individual households and AFPS, in-depth analysis of local and national policy context and description and mapping of production, marketing and consumption sequence; and,
- To inform and stimulate interaction amongst stakeholders, ensure the integration of outputs, feed stakeholder perceptions into the research process, disseminate outcomes widely in appropriate formats and raise awareness among stakeholders.

¹ In the course of the project, what was PRA became PCA to reflect the fact that we are not dealing with a rural space but an urban one. As such, the project produced 15 PCAs from 4 cities (i.e., 4, Hanoi; 4, HCMC; 4, Phnom Penh; and 3, Bangkok).

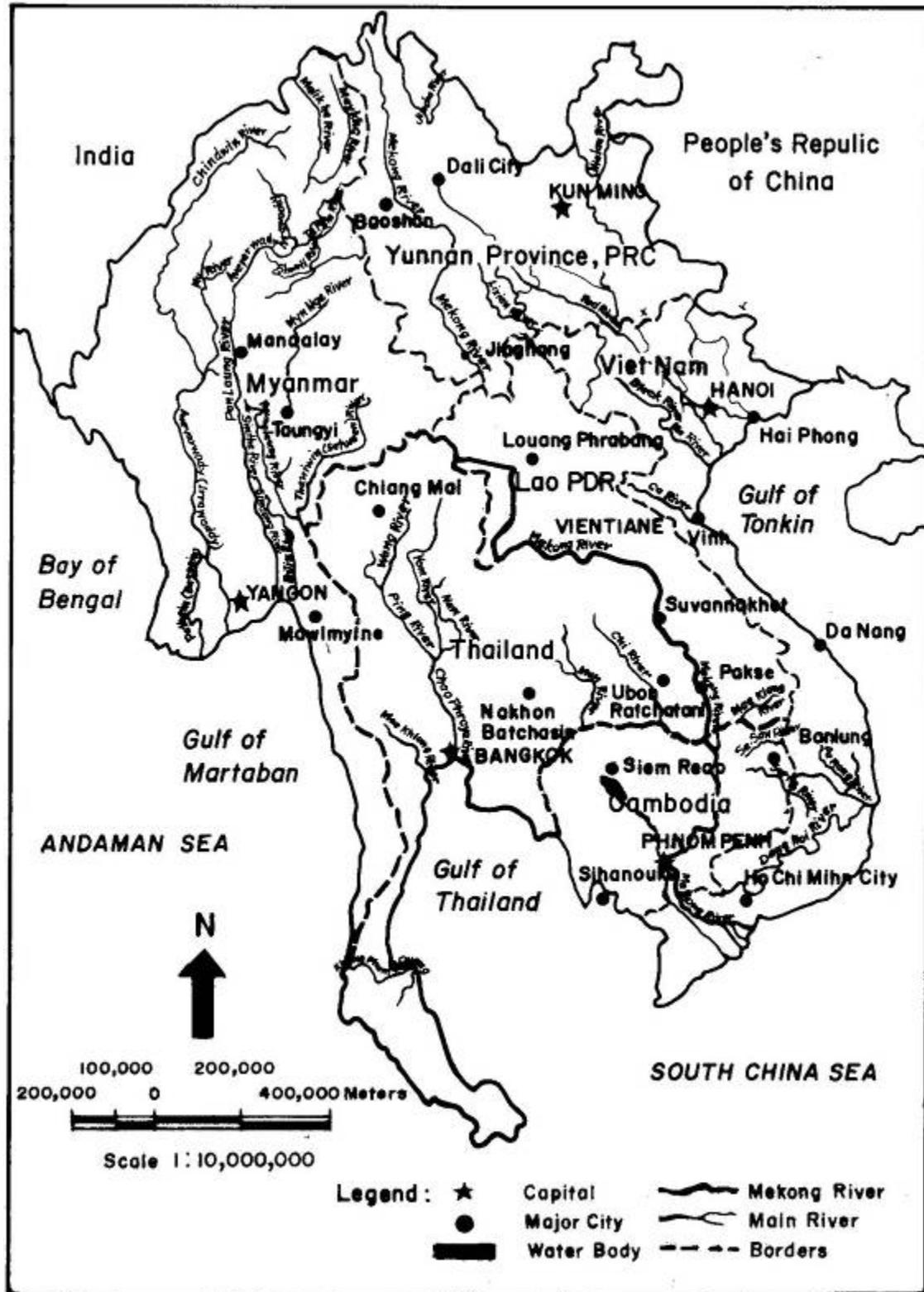


Figure 1 Map of Southeast Asia

2 Bangkok

The two provinces covered in Bangkok were Nonthaburi and Pathumthani. Both are inner provinces and part of the wider Extended Bangkok Metropolitan Region² and are located immediately north of the capital. Figure 2 shows these provinces and the location in relation to the city of Bangkok. Table 1 describes the main characteristics of the field sites in each province.

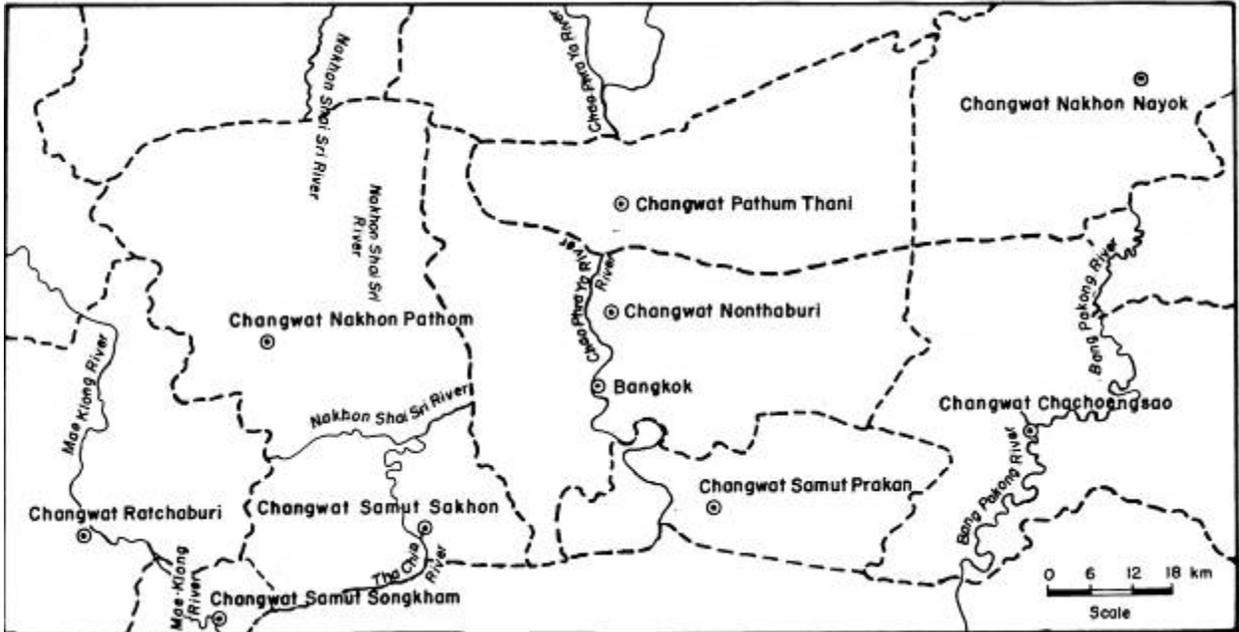


Figure 2 Map showing the provinces (changwat) of Pathumthani and Nonthaburi in relation to the city of Bangkok

Province	District	Village	Type of water body	Nature of water body and distance from city	Production System	Type of water used (WW=waste water; NWW=non wastewater)	Invol-ved HH
Pathum Thani Province	Lamlukka	Lumsai	Lamlukka Canal	55km from Bangkok	Hybrid catfish pond	NWW	80
					Non-hybrid catfish pond	NWW	20
Nonthaburi Province	Sainoi	Nong phrao-ngai	Tathom Canal	20km from Bangkok	Morning Glory	NWW	50
Pathum Thani Province	Muang	Suanprixthai	Chiangrak Canal	10km from Bangkok	Mimosa	WW (Seasonal WW)	50

Table 1 Field sites and production systems in Bangkok

² The Bangkok Metropolitan Region is composed of the Bangkok Metropolitan Administration and the five inner changwats or provinces of Samut Prakarn, Pathum Thani, Nakhon Pathom, Samut Sakhon, and Nonthaburi. The city of Bangkok is within the Bangkok Metropolitan Administration.

2.1 Nong Prao Ngai in Nonthaburi

Before the emergence of Bangkok's extended metropolitan area, rice, fruit and vegetable-growing were the dominant activities in Nonthaburi. The province was known for its orchards and home gardening. From the beginning of the Rattanakosin³ era (1782 AD up to present), Nonthaburi enjoyed a reputation as producing the best Thai fruits (Gajasen and Gajasen 1999:4). These included jack fruit (*Artocarpus heterophyllus* Lamk), Burmese grape (*Baccaurea spinda* Muell.), plum mango (*Bouea macrophylla* Griff.), durian (*Durio zibethinus* L.), Java apple (*Eugenia javanica* Lamk.), Malay apple (*Eugenia malaccensis* L.), mangosteen (*Garcinia mangstana* L.), and yellow santol (*Sandoricum koetjape* Merr.). However the integration of Thailand into the global economy, the accompanying economic boom and the improvement in the purchasing capacity of households coupled with its proximity to Bangkok and progressive improvements in the road network have all contributed to marked changes in land uses in the province. Askew (2003:287) describes a transformation in the economic base and the physical landscape of the province which is nothing less than radical. While rice, fruits and vegetables are still grown, the amount of land devoted to their culture has declined and their contribution to household income and gross provincial product has declined even more markedly. In their place has appeared a new mosaic of land use, where remnant agricultural activities are interspersed among housing estates (muban chasan) and industrial activities. Even the agricultural landscape has been transformed as new crops and cropping patterns are introduced. Housing estates spread across the western part of the province from the early 1990s (Askew 2003:287). In place of rice and fruit, Nonthaburi became a well-known supplier of fresh morning glory and water mimosa for the major wholesale and retail markets of Bangkok. Large areas of land are covered with morning glory and water mimosa production alongside remaining ricelands, housing estates and roads. The lands these aquatic vegetables occupy were formerly ricelands.

In 2005, the population of Nonthaburi was 973,821 in a land area of 622,303 km², giving the province a population density of 1,564.87 people per km² (Department of Provincial Administration-Thailand).

Administratively, Nonthaburi has 6 districts (amphoe), which are in turn made up of 52 sub-districts (tambon) and 309 villages (mubaan). These districts are Mueang Nonthaburi, Bang Kruai, Bang Yai, Bang Bua Thong, Sai Noi, and Pak Kret. Sai Noi, the district where a field site for this study was selected, is composed of seven sub-districts: Sai Noi, Khun Si, Rat Niyom, Khlong Khwang, Nong Phrao-ngai, Watthana, and Sai Yai (ThaiTambon).

Nong Phrao-ngai (NPN) is a sub-district of Sai Noi District. NPN covers an area of 17,170 rai (2,747 ha) and comprises of 12 villages (ThaiTambon Website). It has a total population of 5,892. NPN has 16 canals providing irrigation and is primarily an agricultural area with rice, land vegetables, aquatic vegetables, and orchards among the major crops. There are also fish farms in the area which produce tilapia, silver barb and giant gourami for household consumption. Rice is cropped three times a year while morning glory is harvested all year round and cropped every four months. The vegetables produced in NPN are sold at Pak Klong-Talaad and Bang Yai wholesale markets. Ta-Thom and Kij Sang Kom canals are the

³ The Rattanakosin era covers the period from 1782 AD to the present during which Bangkok was founded (Wyatt 1984:145-166).

main irrigation canals supplying water mainly for agricultural purposes as they have been since the early settlement of the village. Farming of morning glory was introduced after major floods in 1993 and 1995. Its commercial production was intensified through the efforts of the government in 1999. In 2000, financial support from the Japanese Government, through the Miyasawa Fund, enabled the establishment of several farmer groups (e.g., rice paddy group, morning glory group, vegetable plantation group and aquaculture group) which have become the vehicles for the further intensification of their respective production systems. Factory expansion in the area also dates from the 1990s; in 2001, more factories were built in the village (Yoonpundh *et al.* 2003b:8, 12).

2.2 Pathumthani

There are seven districts (amphoe) in Pathumthani province: Mueang Pathumthani, Klong Luang, Thanyaburi, Nong Suea, Lat Lum Kaeo, Lam Luk Ka, and Sam Khok. These districts are subdivided into 60 sub-districts or tambon and they, in turn, into 529 villages or mubaan (Wikipedia). The province of Pathumthani, located 27 km from Bangkok, had a population of 769,998 in 2004 and a land area of 1,525 km² or a density of 504.92 people per km² (Department of Provincial Administration-Thailand).

Two sites were chosen for the Papussa project in Pathumthani Province: Tambon Suan Prix Thai in Muang District and Tambon Lumsai in Lumlukka District.

2.2.1 Tambon Suan Prix Thai

Suan Prix Thai had a population of 5,570 in 2004 in seven villages (ThaiTambon). Moo 1 and Moo 7 are the study sites sampled for catfish and water mimosa production, respectively. A rough estimate based on key informant interviews showed that villagers in Tambon Suan Prix Thai as a whole are distributed in the following occupations: water mimosa production (15%), fish polyculture (30%), hired labour (25%), trading (20%), and factory work (10%). In a wealth ranking exercise carried out as part of a PCA, 43% of village members are considered wealthy, with being wealthy defined by the key informants as those households with surplus income. Moderately wealthy households, defined as those that are neither in deficit nor in surplus ('getting by'), account for 21% of households. Households with income deficits were considered poor households and accounted for 36% of the village (Yoonpundh *et al.* 2003c:14).

Due to problems with disaggregating population figures in terms of the villages within the tambon, it is estimated that for Moo 1 and Moo 7 combined there are 94 households involved in fish farming, water mimosa cultivation, hired labour, trading and factory work. Fish farming and wage labouring are the most prominent occupations among the households of the two villages. In terms of agriculture, ethnic Chinese (Sino-Thais) dominate fish farming, especially hybrid catfish and pangasius while Muslim households tend to be water mimosa growers. There is therefore a clear, but not absolute, division of occupation by ethnic/religious group. This is understandable as the Chinese fish farmers integrate their fish farming with their piggeries so that wastes from pigs serve as additional nutrients for the fish. Cultural norms/prohibitions therefore underpin and explain occupational patterns, in this regard at least. Fish farmers in the village tend to be richer than water mimosa growers and other occupations (Yoonpundh *et al.* 2003c:8). What we see, therefore,

is a link between production systems and religion/ethnicity which is then translated into a link with income/productivity.

Figure 3 presents the historical timeline of Suan Prix Thai illustrating the major developments in the Tambon. There is a significant number of Muslim Thais in the area compared to other adjoining sub-districts. These Muslim settlers were relocated from Pattani, in the south of Thailand, many generations ago during the 19th century. They live alongside the Sino-Thais. 'Suan Prix Thai' means 'pepper garden' after the pepper seedlings that were distributed to farmers in the area during the reign of King Rama V for farmers to plant on their allocated lands. The village was founded, however, rather earlier during the reign of King Rama IV (Yoonpundh *et al.* 2003c: 11).

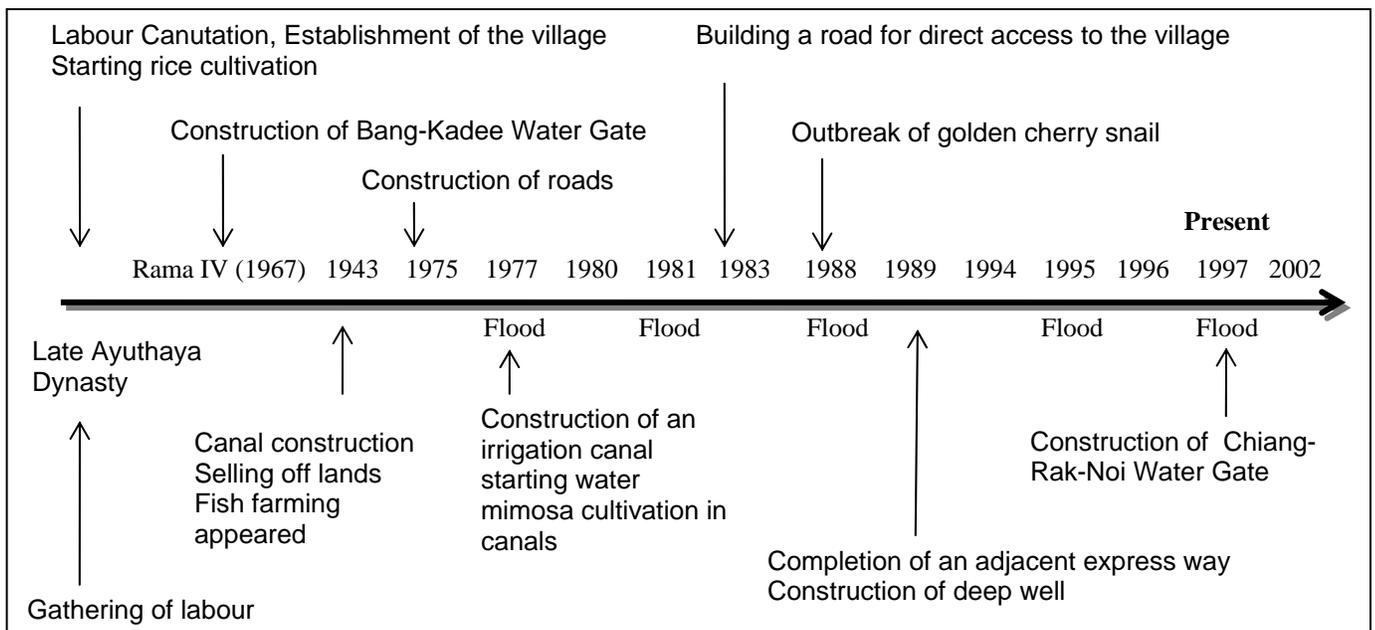


Figure 3 Historical development of Suan Prix Thai Village (Adapted from Yoonpundh *et al.* 2003c:12)

The construction of the Bang Kadee Water Gate in 1943 benefited the rice farmers who had already settled in the area. Before 1975, the canal was the main transport route in and out of the village. The construction of a road link began in 1975 and was completed in 1977; this fundamentally changed the transport geography of the village as villagers shifted from using canals in favour of road transport. The advent of the road system led some villagers to sell their lands to Sino-Thais for fish farming as the area became more accessible and therefore could meet the commercial needs of fish farming including the provision and transportation of inputs (feeds, implements) and outputs (fish). The area is also conducive to fish farming because of the availability of a regular water supply from the canals. Also in 1975, the construction of the Chiang Rak Noi irrigation canal commenced, but which was not finally completed until the early 1980s. This canal provided Muslim villagers with the opportunity to grow water mimosa. The major

floods of 1981 and 1983 affected water mimosa production and flooding remains a major problem in the sub-district as it affects both household and village production levels. The construction of a water gate on the Chiang Ran Noi Canal does not seem to have resolved this problem. At the same time, the dry season brings water shortages to the area, presenting a rather different set of production constraints. Aside from these fluctuations in water supply, another environmental problem faced by villagers in the sub-district is the presence in the canal of pollutants and waste discharged from upstream factories and housing estates. During October each year, the canal expels a strong odour, which villagers blame on the factories and industries nearby (Yoonpundh *et al.* 2003c: 13).

2.2.2 Tambon Lumsai

With a population of 3,458 in 14 villages (ThaiTambon Website), Lumsai is located about 55 km from Bangkok. It occupies an area of 29.7 km² (18,562 rai) giving a density of 116.43 people per hectare. Several canals provide irrigation water to the village. These canals are Klong 11, Klong 12, Kang Canals and two other irrigation canals connected with Klong 11 and Klong 12. Most of the households interviewed in Lumsai came from Moo 6 with some originating from Moo 8. Moo 6 has 675 residents composed of 335 males and 340 females. The main livelihoods in the area are: hybrid catfish farming, shrimp farming, wage labouring, working in the golf club, cultivating ornamental plants, and local trading. Farming catfish appears to be the most important productive activity in the village. Catfish are in huge demand in Bangkok and Lumsai is one of the major suppliers. Most catfish farmers were found to be relatively wealthy judging from the nature of their dwelling units, car ownership, and the general view of other villagers. Poor villagers earn their income from working as wage labourers, including as gardeners or caddies in Lum Luk Ka Golf and Country Club (Yoonpundh *et al.* 2003a: 8-9).

According to oral history, Lumsai was founded after King Rama V⁴ visited Pathumthani Province during his reign from 1868 to 1910 and provided funding for the construction of the Rangsit irrigation scheme. Around the same time, the Catholic Church established a mission in Pathumthani Province, which attracted more people to the area leading to the founding of the sub-district. The new settlers in the area were largely Catholic and were rice farmers. Rice farming in the sub-district became more mechanized after the floods of 1957 (Yoonpundh *et al.* 2003a: 12).

In 1990, Rungsiya Real Estate Company bought these lands from the Catholic Church and later converted some 3,000 rai in the sub-district into a golf and country club. The club boasts two state of the art 18-hole golf courses⁵. Lands that had been set aside for future expansion of the golf club stand idle. All farming in the sub-district is done on lands rented from Rungsiya ever since (Yoonpundh *et al.* 2003a: 12). Villagers were given residential lands if they rent out other lands from Rungsiya for their production systems (Interviews, Appendix 1).

⁴ Also known as King Chulalongkorn (Wyatt 1984: 313).

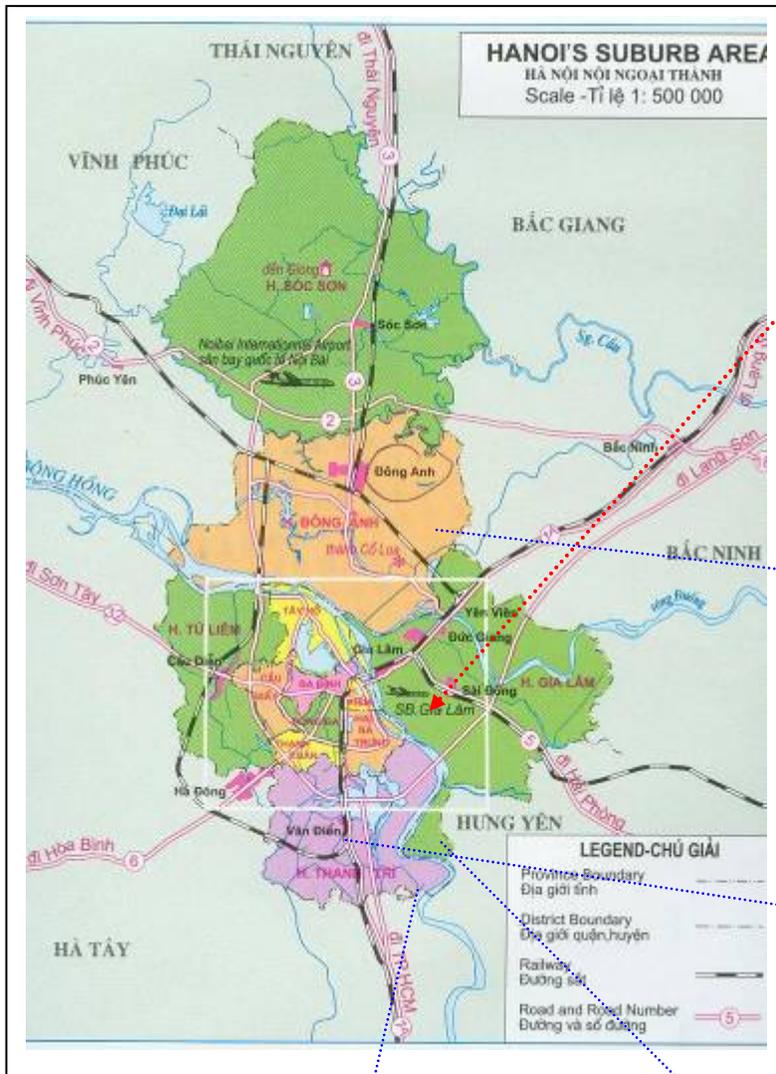
⁵ This golf course is designed by Roger Packard and is described as "pleasant modern course, typical of the former paddy field courses around Bangkok, with lots of water, wide fairways and big greens" (from <http://www.ash-golf.com/golfcourse/county/bangkok/lumlukka.html>).

3 Hanoi

The field sites and production systems studied in Hanoi are shown in Table 2. Three districts are covered in Hanoi – Thanh Tri, Hoang Mai, and Dong Anh Districts (See Figure 4). These districts are considered suburbs of Hanoi. However, three of the four sites are located in Thanh Tri District, the major freshwater aquaculture area in the city.

District	Commune	Village	Type of water body	Nature of water body and distance from city	Production System	Type of water used (WW=waste water; NWW=non wastewater)	Invol-ved HH
Thanh Tri	Khuyen Luong, Tran Phu	So Do Village	Swamp 1	City effluent - 5km from city, traditional, large swamp	Lake Fish Polyculture	WW	25
					Morning glory	WW	33
Hoang Mai	Hoang Liet	Bang B		Wastewater system	Morning glory	WW	23
Thanh Tri	Dong My	Thon 5	Pond	10-15km from city, Modern system	VAC	NWW	66
			Pond	>20km from city, Modern system future development potential			
Dong Anh	Duc Tu	Bien Commune		25 km from city centre	VAC	NWW	60

Table 2 Field sites and production systems in Hanoi



Hanoi Map



South East Asia map



1. Duc Tu: fish in non-ww, 25 km from Hanoi



2. Bang B: aquatic plants, 5 km from Hanoi



4. Dong My: fish in dilute wastewater, 25 km from Hanoi



Hanoi

3. Tran Phu: fish, aquatic plants in wastewater, 20 km from Hanoi

Figure 4 Location of project sites in Hanoi (Taken from Nguyen Thi Dieu Phuong et al. 2006:12)

The total area occupied for aquaculture in Hanoi has decreased slightly from 3,400 hectares in 2000 to 3,300 hectares in 2003. This area is considerably smaller when compared with other well-known aquaculture areas in the country, such as the provinces in the Mekong Delta, which had a total aquaculture area of 621,200 hectares in 2003 (General Statistics Office 2005:231). Perhaps more important is the trend indicated by these figures. Compared with Hanoi, Ho Chi Minh City has an expanding area under aquaculture, with land devoted to such activities increasing from 4,200 hectares in 2000 to 7,700 hectares in 2003. On this basis, it is tempting to see aquaculture in Hanoi's peri-urban stagnating and, possibly, even declining. As highlighted in other reports in this project (see Huynh Pham Viet Huy and Le Thanh Hung 2006, Nguyen Thi Dieu Phuong *et al.* 2006, Rigg and Salamanca 2006a, 2006b, 2006c), areas devoted to agriculture, in general, and aquaculture, in particular, have decreased considerably due to rapid urbanisation and the subsequent land use changes that privilege industrial, manufacturing and non-agricultural uses. This has prompted Edwards (2005) to speculate that the demise of wastewater aquaculture in Hanoi is likely to occur in the years to come. Although Hanoi's aquaculture areas may have decreased, it does not follow that its supply of fish and aquatic plants may have also decreased as other surrounding areas have been opened up for aquaculture production, such as Ha Tay and Hai Duong Provinces. These provinces are located less than 50 kms from Hanoi and have good transport links with the city. As such, the shortfall resulting from land use changes may easily be replaced by other sources. In comparison with other sites we surveyed, such as the provinces of Nonthaburi and Pathumthani in Bangkok, which are located around 30-40 kms from the city core, the peri-urban zone in Hanoi is shifting and radiating outwards. In the near future, if not already in the present, existing rural areas and their associated aquaculture production could soon be classified as peri-urban. Similarly, like their counterparts who used to or are still farming fish in Than Tri District, existing agriculturalists in these surrounding provinces in Hanoi are mostly entering aquaculture with no previous experience or family history in the activity and likewise converting rice paddy fields to fish ponds (Leschen, pers comm.).

Major socio-economic parameters	2000		2001 (Preliminary)	
	Thanh Tri*	Dong Anh	Thanh Tri*	Dong Anh
Number of communes and precincts (unit)				
- Xa – commune	24	24	24	24
- Thi Tran – town	1	1	1	1
Land area (km ²)	98.2	182.3	98.3	182.3
Average population	228,286	262,433	234,717	269,738
Density (person/km ²)	2,324.7	1,439.6	2,390.2	1,479.6
Planted area of paddy (ha)				
- spring paddy	2,931	7,268	2,930	7,205
- winter paddy	2,580	7,469	2,025	6,920
Gross output of paddy (ton)				
- spring paddy	14,069	34,160	13,522	29,685
- winter paddy	10,604	31,034	7,088	24,471
Gross output of fishery (ton)				
- exploitation	16.5	283	17.1	297
- culture	3,601	620	4,386	651
Industrial output value at				

current prices (million dong)				
- state owned enterprises	-	577,704	-	956,869
- non state enterprises	98,570	223,526	105,796	243,497
- foreign invested sector	-	516,461	-	555,371
*During these years, Hoang Mai was not yet created from Thanh Tri so these data includes Hoang Mai.				

Table 3 Socio-economic background of Thanh Tri and Dong Anh Districts (Source: Tran Hoang Kim 2002:47-9)

Table 3 shows the major socio-economic characteristics of Thanh Tri and Dong Anh Districts. This table excludes Hoang Mai because it was not yet established as a separate district at the time the data were collected, but was still part of Thanh Tri District. Hoang Mai was created from Thanh Tri in the late 1990s. As shown in the table, Dong Anh has higher industrial and agricultural outputs than Thanh Tri, although the latter has higher fisheries output. In terms of land area, Thanh Tri is half the size Dong Anh. While Hanoi city's natural population increase was reported at 10.48% in 2002, Thanh Tri District and Dong Anh District registered rates of 11.54% and 11.96% respectively. Considering their suburban locations and their status as areas of in-migration we suspect that the true rate of increase may be more rapid still. It is also likely that there is considerable population turbulence in the area as migrants, both temporary and permanent, colonise the area. Unfortunately, reliable data on population mobility is not available. The treatment of migration in this study is explored in relation to livelihood uptake and, to a certain extent, changes in land ownership and village histories. Migration is not, however, treated as a major research component and therefore this gap in our understanding must remain largely unfilled.

In 2002, the number of agricultural households in Thanh Tri District was reported at 22,925 while Dong Anh District had 39,840 (Hanoi Statistical Office 2003:162).

3.1 Thanh Tri District

In Hanoi, Thanh Tri District is considered an agriculture district with 95% of the population classified as engaged in agriculture (Table 4) based on the estimates made by JICA in their feasibility study for the construction of the Thanh Tri Bridge (Pacific Consultants International 1998).

Sector	Total Households	Workers	%
Agriculture	29,767	122,046	94.5
Fishery	477	1,907	1.5
Others	2,581	5,236	4.1
TOTAL	32,825	129,189	100

Table 4 Labour structure of Thanh Tri District in 1997 (Pacific Consultants International 1998)

3.1.1 Tran Phu Commune

Tran Phu is located 13 km from the city centre and consists of two villages: Khuyen Luong and Nam Du Ha. These villages are close to the Red River so that some agricultural lands are affected by flooding during June and August every year. Due to its low lying relief, the commune is also affected by floodwaters issuing from the inner city. In 1990, Linh Nam pumping station was built to drain floodwater out to the Red River. The commune has a total land area of 3.78 km² of which land devoted to agriculture is 2.21 km² and 0.96 km² allocated to aquaculture (Research Institute for Aquaculture 1 2005a).

Agriculture is the main source of income in the commune. Tran Phu is one of the communes in the district with a high level of fish production totalling over 300 tonnes per year. In 1987, each adult person received a total of 814 m² of agricultural land as part of the Hire 10 policy - usually composed of several parcels of land for different types of production system such as rice production, rice-fish production or aquaculture. Aside from the parcels of land they received as part of the Hire 10 policy, some individuals are able to access additional plots of land through concluding a contract with the commune (Research Institute for Aquaculture 1 2005a).

Aside from working in agriculture, younger members of the commune also work as teachers, mechanics, builders, textile workers, security guards, workers in the service sector, traders, and office workers (Research Institute for Aquaculture 1 2005a).

3.1.2 Dong My Commune

Among the five villages in Dong My Commune, Thon 5 was selected as the field site. Dong My, a commune within Thanh Tri district, is a lowland commune located about 15 km southeast of the city centre. It has a population of 6,000 people in just over 1,500 households. Despite being part of Thanh Tri where some of the major industries in the city are located, the commune itself accommodates relatively few industries. The commune's major economic activities are still related to agriculture including rice farming, fish farming, gardening land vegetables, livestock raising, and farming aquatic vegetables. Sixty-three percent (63%) of the commune's labour force are engaged in farming activities. Rice and vegetable production in this commune are mainly carried out by women while men are predominantly involved in aquaculture, but this activity accounts for only 5% of the total labour force. Others especially the men (about 37%) are involved in skilled work such as carpentry, business, office work, and trading, and unskilled work such as construction work. Limitations in their agricultural livelihoods have led many farmers, especially those who are young and middle-aged, to be involved in both farming and factory work, straddling the farm and non-farm sectors. Prior to 2001, most of the land area of Dong My was used for rice farming, but the pumping of urban waste water from the Kim Nguu River led to their conversion into fish farming areas. While producing food fish (e.g., tilapia, mud carp, silver carp, *Colossoma*, grass carp and common carp) for the urban market is a major aquaculture activity in the commune, there are other households involved in fingerling production and integrated systems such as fish and rice or fish and aquatic plants. These systems are semi-intensive with two or three harvests a year (Nguyen Thi Hanh Tien *et al.* 2005).

3.2 Hoang Liet Commune, Hoang Mai District

Five villages compose Hoang Liet Commune, one of the field sites in Hanoi located about 10 km south of the city centre. These villages are Bang A, Bang B, Tu Ky, Phap Van, and Linh Dam. Most of the work connected with this study was done in Bang B. Bang B is a well-known area for the production of aquatic vegetables and has 364 households. Two major waste water channels surround the village: Kim Nguu and To Lich Rivers (Nguyen Thi Dieu Phuong 2004: 1). Villagers draw water from these rivers through government provided pumping stations. These rivers in turn receive wastewater from the city, which by virtue of the water's nutrient rich quality enables the production of aquatic plants.

Rice farming was the mainstay of the large majority of villagers prior to 1970. Only a few households were involved at that time in producing floating morning glory and water mimosa in the To Lich River, which was not yet badly affected by the chemicals used by aquatic plant growers. Life in the village began to change after 1970 when electricity was available, a new wastewater pumping station was constructed, and canals and the main road were built linking the village with the city and surrounding areas. With the worsening water quality of the To Lich River due to inorganic pollution from the city and the impact of aquatic plant cultivation on the flow of the river, the production of aquatic plants in the river ceased in 1995 and shifted to ponds in areas that had previously been used for land vegetables. Water from the rivers was then supplied through pumping stations and purpose built concrete feeder canals. The pumping service was provided by the local agriculture cooperative. When farmers learned that aquatic plants could be produced profitably in this way, more and more converted their fields to this form of agriculture. Aside from morning glory and water mimosa, farmers are now (since 2000) also growing water dropwort and watercress which provide an attractive return. Water mimosa is largely grown in summer while watercress and water dropwort are cultivated during the winter months. Morning glory is grown throughout the year (Nguyen Thi Dieu Phuong 2004: 1-2).

Around 50% of households in Bang B are involved in aquatic plant production and the production system has made a very significant contribution to the income of the households in the village (Nguyen Thi Dieu Phuong 2004: 1-2).

3.3 Duc Tu Commune, Dong Anh District

Duc Tu is located 17 km north of the city centre. The commune is bounded by Viet Hung commune in the north, Chau Khe to the east, Co Loa to the west, and Mai Lam to the south. It has a total land area of 848 ha of which agricultural land amounts to 571 ha. Duc Tu is also a low lying area which is suitable for aquaculture. Aquaculture covers 96.5 ha. The Ngu Kien Khe River pumps water from the Red River into Duc Tu for use in aquaculture through 11 pumping stations. It is a peri-urban commune which supports food production for the inner city. Rapid urbanisation has affected agriculture and aquaculture in the area. Rapid development of infrastructure such as roads, the construction of factories and other buildings have reduced the area of agricultural land. Their presence in the surrounding area has also affected the water and environmental quality of the commune through an increase in pollution (Research Institute for Aquaculture 1 2005b).

Duc Tu has a population of 14,240 of which 6,906 are male (48.5% of total population) and 7,254 female (51.5% of total population). Agriculture is one of the most important occupations in the commune with 6,860 people or 79.2% of the labour force working in agriculture. However livelihoods have diversified and while in the past agriculture was the sole occupation of people in Duc Tu, today many people are also involved in handicrafts and in various service industry occupations, such as working as drivers. Current estimate of the total value of agriculture in the commune is 66 million VND/hectare/year (Research Institute for Aquaculture 1 2005b).

It is projected that handicraft making and service sector work will become even more important occupations in the commune. At present, there are 1,800 people working in handicrafts and the service sector, accounting for 21.8% of the total labor force in the commune. The two industries provide a total income of 19,480 million VND/year (Research Institute for Aquaculture 1 2005b).

4 Ho Chi Minh City

The field sites for the baseline and monitoring surveys in HCMC come from five districts and comprise of six locations. These locations are summarised in Table 5 and illustrated in Figure 5.

Table 5 Field sites and production systems in HCMC

District	Commune	Village	Type of water body	Nature of water body and distance from city	Production System	Type of water used (WW=waste water; NWW=non wastewater)	Invol-ved HH
Thu Duc	Tam Phu	Village 5	Pond	Wastewater – upstream of Sai Gon river/ 13 km	Morning glory	WW	48
					Fish-morning glory combination	WW	
District 9	Tang Nhon Phu	N/A	Pond	Non-wastewater system from upstream of Sai Gon river/ 15km	Fish mono and polyculture systems	NWW	10
Binh Chanh	Phong Phu	Village 5	Pond	Wastewater from down stream of Sai Gon river/ 17 km	Fish mono and polyculture	WW	55
	Da Phuoc	Village 5	Pond	Waste and non-wastewater/ 20 km	Fish polyculture		25
District 12	Thanh Xuan	N/A	Pond	Wastewater from Sai Gon river/15km	Water mimosa	WW	43
Hoc Mon	Dong Thanh	Village 5	Pond	Non-wastewater/ 20km	Fish monoculture	NWW	16

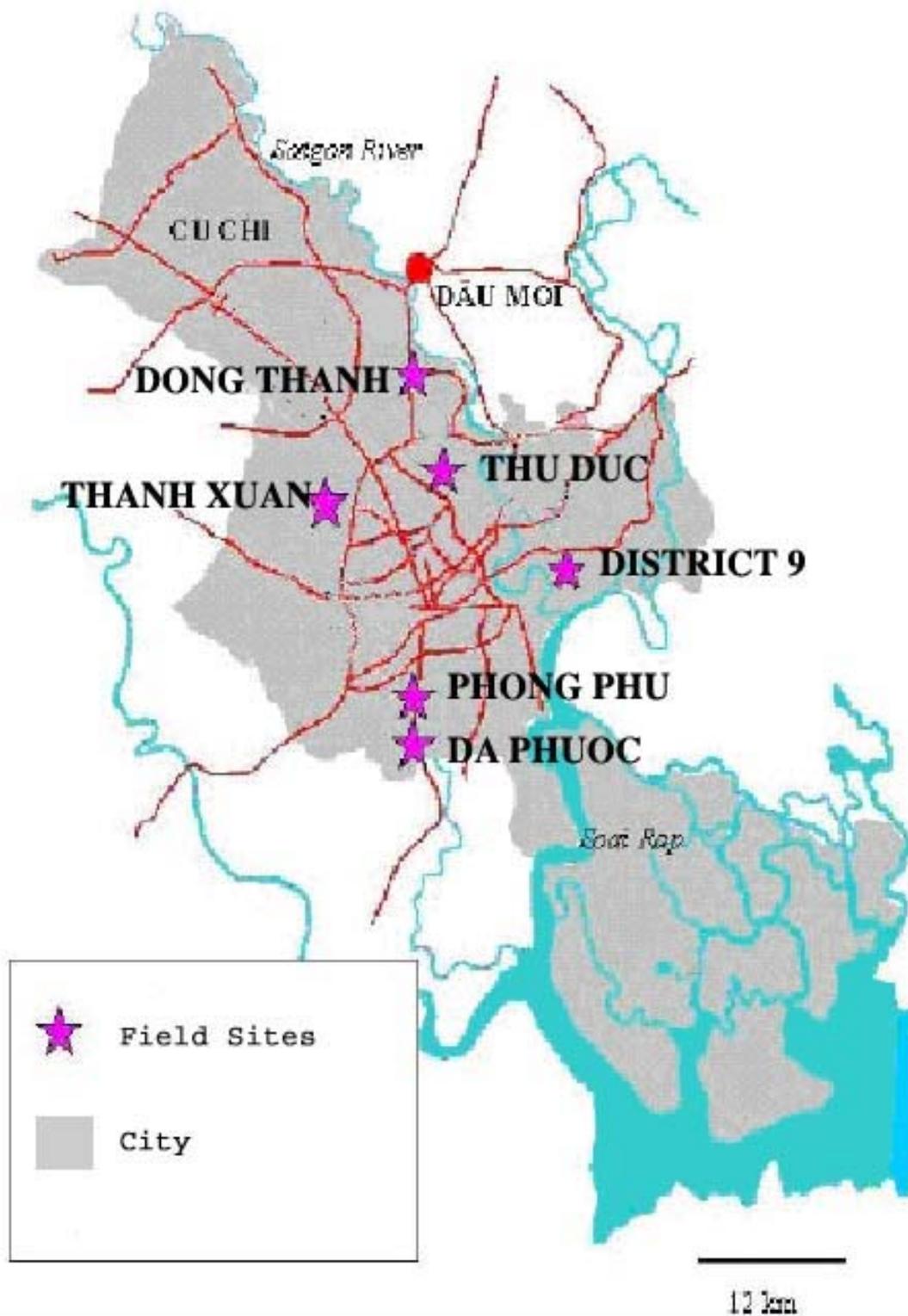


Figure 5 Field sites in HCMC (Taken from Huynh Pham Viet Huy and Le Thanh Hung 2006: 10)

4.1 Da Phuoc commune, Binh Chanh district

Da Phuoc commune is located in the southern part of Binh Chanh District, about 20 km from Ho Chi Minh City centre. It lies along Provincial Road No.50 and is adjacent to Can Giuoc River, which is the people's main source of water supply for agriculture. The village where most of the fieldwork was undertaken was Village 5, which is composed of 565 households and 2,975 individuals (Le Thanh Hung *et al.* 2003a: 7).

A dike was constructed in the village in 1979 to prevent flooding which in turn ushered in the onset of fish culture. During 1991, the villagers started culturing freshwater prawns and crabs, stimulated by high prices and a buoyant market, but stopped in 1995 when their water source became polluted from a factory nearby. In 1998, villagers began culturing walking catfish and tilapia which they considered more suited to the polluted water. The pollution in their water source diminished when the factory believed to have caused the pollution relocated in 2002-2003. Rice and vegetable culture showed strong development during 2000-2002 but the areas inside the dike were abandoned as rice yield was low. In 2003, fish culture commenced with even greater intensity than before as villagers increasingly saw this as the most profitable agricultural activity open to them. Other species such as red tilapia were cultured. However, their farming system is still small scale as water is seasonally unavailable, there is lack of capital, and water pollution is still a problem (Le Thanh Hung *et al.* 2003a: 10).

Almost all households inside the dike culture fish. Most of their ponds are average to small in size ranging from 500 to 5000 m². Fish pond sizes vary amongst the households depending on the conditions and status of each household. Fish are cultured on a household scale. There are rice-fish culture models or garden-pond-cage systems. Besides agricultural activities, people also knit sedge mats, make barbed wire and are working in different types of factories (Le Thanh Hung *et al.* 2003a: 8,11).

4.2 Phong Phu commune, Binh Chanh district

Village 5 in Phnom Phu Commune was chosen as the field site based on the recommendation of the Chairman of the Commune's Farmers Association which is also in accordance with the requirements of PAPUSSA. The commune is also located in the southern part of Binh Chanh district and is closer to the city than Da Phuoc Commune. It is about 17 km away from city centre with most of the households in the village located along Provincial Road No. 50. A salt water prevention dike divides the village so that some parts are located inside the dike while others are outside it. The inside area is used for rice cultivation producing two crops per year while the outside area is used for tilapia culture and seed production. Since the district to which the village belongs is an identified priority area for urbanisation, the land use here is very dynamic resulting in, among other things, the squeezing out of aquaculture. Residential areas have been encroaching upon and displacing agriculture/aquaculture areas. There is even a fear the aquaculture will disappear completely in the area (Le Thanh Hung *et al.* 2003b: 7-8).

There are 555 households in village 5 with a total population of 3,181. It has a land area of 507 ha of which 397 ha is agricultural land (Le Thanh Hung *et al.* 2003b:5).

Fifty-one of 555 households are migrants from other provinces. Another 106 households have moved from other districts in the city. Thus, 157 households (28%) comprised of 680 individuals can be considered migrants. Most of them do not own agricultural land. They have only acquired land to build their dwellings. They work as factory workers, mototaxi drivers or operate small grocery stalls (Le Thanh Hung *et al.* 2003b:8). To put it another way, it is not just that the occupations of established families are changing, but the make-up of the population itself and thus, the occupational profile of the village is being transformed.

About 40-50% of permanent households in the village are involved in aquaculture. Aquaculture here comes in a variety of forms: rice-fish, lotus production, water mimosa production, fish production, and seed production. Other villagers are involved in small business activities, motorbike repair services and other informal sector jobs. About 205 are considered to have these kinds of occupations with running a small business among the most popular (Le Thanh Hung *et al.* 2003b:8).

In 1975-1985, the main income earning activities of village members were related to rice and morning glory production. Water quality was good then. Pollution was first noticed in 1985 when insecticides and herbicides were increasingly being used in rice and morning glory fields by which time they started farming fish, fruit trees, and lotus. The VAC system was introduced in the village in 1986 and water mimosa cultivation began ten years later. When flooding became a serious problem in rice farming in 1999-2003, fish farming became a lucrative alternative option at which time tilapia became the species of choice.

4.3 Tam Phu commune, Thu Duc district

Tam Phu commune specializes in morning glory cultivation which covers about 600 ha of agricultural land in the district. The commune is located in the northwest part of the city, which is an elevated area. This commune is about 13 km from the city centre. Morning glory cultivation is largely undertaken by native farmers who have converted from rice culture since the 1980's.

4.4 Dong Thanh commune, Hoc Mon District

Dong Thanh commune is located in the middle west of the city, bordering Cu Chi and Binh Chanh districts, and District 12. It also borders Long An and Binh Duong Provinces. It is about 20 km from the centre of the city and is the nearest commune of those studied in this project to the centre of the city. Access and transportation are very good. Despite being in close proximity to the city centre, among the study sites it is the least affected by urban sprawl, because it has been reserved for agricultural use. Given the pace of urban growth, however, one wonders how long it will be insulated from changes in the wider area.

Village 1 dominates aquaculture in the commune. There are 413 households in the village. According to the Head of the Farmers Association, there are no migrants in the commune. There are about 25-30 households who carry out aquaculture in a village with a total area of 4 ha according to the Head of the

village's information centre. However the area for agriculture gets priority with an estimated area of more than 127 ha. Farmers culture fish on a household scale basis using both monoculture and polyculture systems. Species such as giant gourami are cultured in monoculture (highly intensive), while species of whitefish (e.g. silver carp, silver barb, common carp, etc.) are cultured in a polyculture model which aims to reuse natural food. Unlike the systems around Hanoi, however, fish culture is not integrated with rice farming. Agriculture is the main income earning activity of older men and women in the village, whilst the youth become workers in factories producing leather, shoes or textiles.

Thanh Xuan commune in District 12 is very close to Dong Thanh commune and even closer to Ho Chi Minh City, just 15 km away from the city. Due to its location, transportation and accessibility are very good. While this commune is rapidly becoming incorporated within the wider urban area it still supports a comparatively large area for water mimosa cultivation. Water mimosa cultivation here is a specialized system activity and the majority of water mimosa farmers are migrants, mainly from the North.

4.5 Tang Nhon Phu ward, District 9

Located in the north of the city, Tang Nhon Phu commune is about 15 km from the centre of the city. Though aquaculture is not the major activity in the community, a significant number of households are involved in fish culture and in some cases it is their main income source.

5 Phnom Penh

Compared to the other cities studied as part of this project, the sites in Phnom Penh are generally closer to the city core due to the smaller relative size of the city itself (See Figure 6). It is thus more compact and is not as built up as Hanoi or Bangkok. Table 6 summarizes the different sites in Phnom Penh. Nearly 70% of the sample in Phnom Penh came from the Boeung Cheung Ek (BCE) area (Table 6), located south of the city, while the remainder were taken from Boueng Kak, another lake in the city, and the surrounding province of Kandal. BCE is a sewage fed lake located on the south-eastern edge of the city.

Administrative Jurisdiction	Sangkat	Khan	Village	Water body	Nature of water body and distance from city	Production System	Type of water used (WW=waste water; NWW=non wastewater)	Invol-ved HH
Phnom Penh	Boeung Tompon	Mean Chey	Kba Tomnub	Boeung Cheung Ek	5-7 km from city centre	Morning glory, water mimosa, lotus grown in the lake	WW	73
Phnom Penh	Boeung Tompon	Mean Chey	Thnout Chrum	Boeung Cheung Ek	5-7 km from city centre	Morning glory, water mimosa, lotus grown in the lake	WW	60
Phnom Penh	Srash Chork	Daun Penh	Muoy	Boeung Kok	Within the city	Pangasius pen culture	WW	14
Kandal	Prek Phnauv	Porgnei Leu	Doung	Prek Phauv (near Phnom Penh)	About 17 km from the city centre	Snakehead, walking catfish, pangasius pond culture	NWW	28
Phnom Penh	Chraing Chamresh	Russey Koev	Buon	Prek Phauv (near Phnom Penh)	About 7 km from the city centre	Snakehead, walking catfish, pangasius etc pond culture	NWW	25

Table 6 Field sites and production systems in Phnom Penh

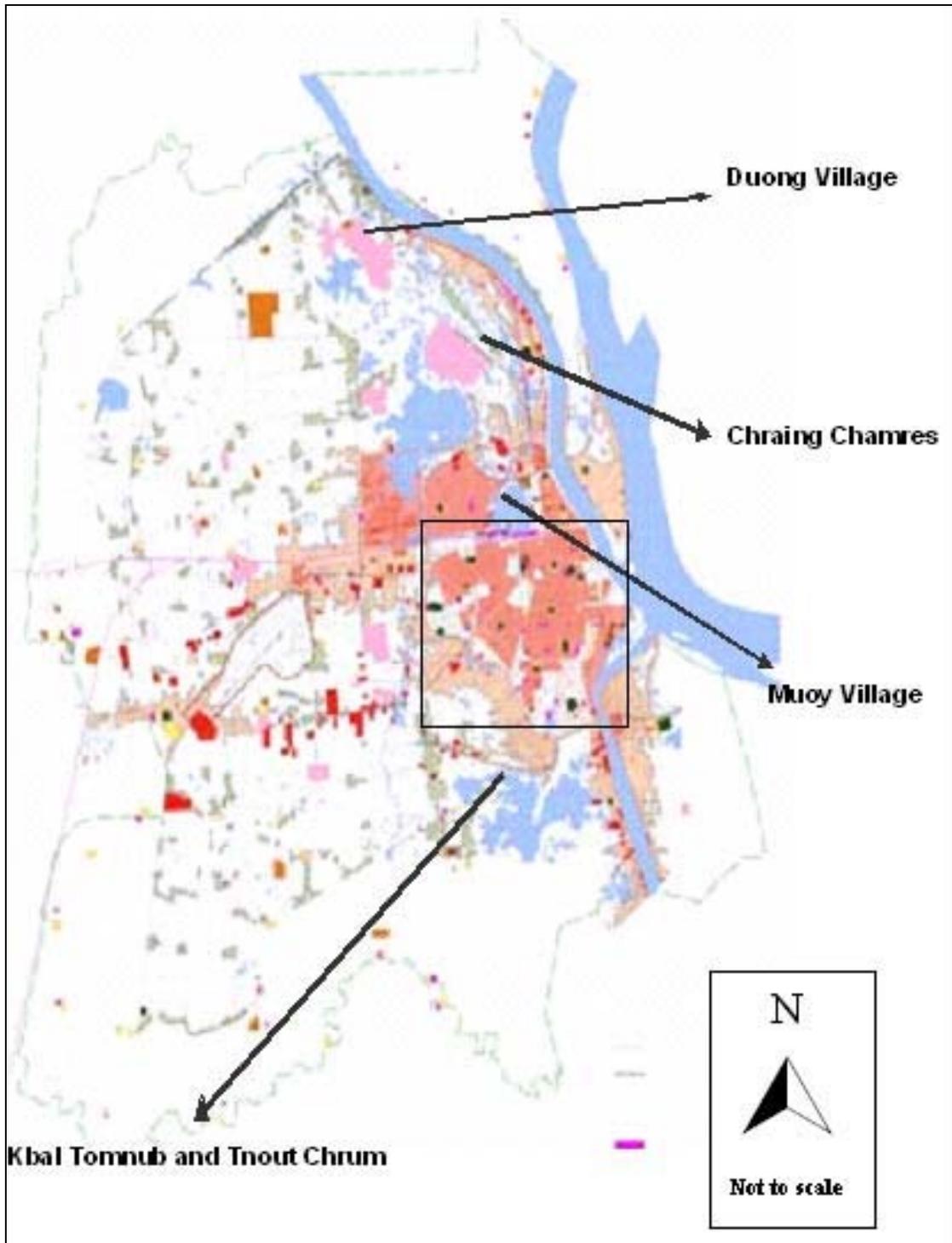


Figure 6 Relative locations of field sites in Phnom Penh (City centre in box. Boundaries are only illustrative) (Taken from Kuong, Little, and Leschen 2006: 6)

5.1 Kba Tumnob and Thnout Chrum in Boeung Cheung Ek

BCE is an important storage basin for the wastewater and stormwater flowing out of Phnom Penh before it is flushed out to the Bassac River. During the summer months when the water is low a huge swathe of the floodplain dries up, small depressions form into small lakes which the locals call by many different names. Some maps show these small depressions. However sedimentation and the gradual retreat of the flooded area due to land filling and housing developments has led to the gradual disappearance of the smaller lakes or a reduction in their size. The original Boeung Cheung Ek was located in Kandal Province, but it has been slowly incorporated into Phnom Penh as the city has expanded its boundaries, geographically and demographically. BCE is connected to two other lagoons: Boeung Tompun and Boeung Trabek. A small river also leads into BCE, discharging water drained from the Pochentong Airport area. It also receives wastes coming from abattoirs, piggeries, restaurants, and textile and tanning factories – as well as households – in the surrounding area. During the rainy season, usually June to November, water from the Mekong, Tonle Sap and Bassac Rivers inundates the lake causing the water level to rise. It then recedes again as the dry season sets in (Balmissé and Maisonhaute 2005: 37).

In dry months, the surface of the lake has an area of 1,300 ha but this expands to 2,000 ha during the monsoon season. However, the BCE region itself comprising the lake and the dry areas covers an area of 3,293 ha and had a population of 46,857 people in 1998 (Balmissé and Maisonhaute 2005: 36). Technically, it has a density of about 14 people/ha but this is an underestimate because so much of the area comprises the surface area of the lake. There is no accurate estimate of the dry area as this changes according to the season. However, field observations show that a lot of the housing settlements in the lake are clustered in patches of land that are not too deeply flooded during the rainy season.

A dramatic increase in population was noted when the roads on the Tompun dike and Takhmao were built (Balmissé and Maisonhaute 2005: 38). At least 400 houses, composed of several hundred households, are found on the lake itself (Kuong Kuov, pers comm.). The lake is covered with plant growth, but the most prominent of these are those being harvested for food such as *Ipomoea aquatica*, *Oldenlendra fraterna*, *Mentha arvensis*, *Latuca sativa*, and *Nelumbo nucifera*. BCE receives wastewater from two catchment areas: Boeung Trabek and Boeung Tompun (Balmissé and Maisonhaute 2005: 36).

Both Kba Tumnob and Thnout Chrum are located in Beung Tompun quarter, Mean Chey District not more than 5 kilometres from the centre of the city. These villages are located right on Tompun Dike, which is an outer ring dike that protects the city core from flooding, then expands outwards towards the middle of the lake so that houses are built on stilts in the lake itself. Aquatic production systems therefore co-mingle with human settlements in the lake. The dike starts from the junction with St 271 and runs for 4.4 km² until it meets National Road 303. There are two major pumping stations located on the Tompun Dike area: Trabek Pumping Station and Tompun Pumping Station. Both these pumping stations release water into BCE Lake, which is the de facto retention and purification pond for the city's sewage. The lake has a storage volume of 520,000 m³, but this is believed to be decreasing due to sedimentation, landfilling and the increasing growth of human settlements. The Trabek Pumping Station is responsible for removing stormwater from 40% of the city core area, which is equal to a catchment area of 10.63 km²,

while the Tompun Pumping Station covers a catchment area of 17.47 km². These pumping stations were originally built in the 1960s and have been part of the city's flood defences since then. The wastewater pumped out of these stations into BCE is untreated before outfalls. Considering that only a tiny amount of households in the city are connected to the sewerage network, these outfalls are rich in nutrients but are likely to also contain pollutants and parasites (CTI Engineering Co Ltd and Nippon Koei Co Ltd 1998:68-69, 101).

5.2 Phum Mouy in Boeung Kak

With Khan Reusey Keov village on the north, Phum Pi on the south, Phum Mpey on the east, and the railway on Khan Toul Kok on the west, Phum Muoy is located on Boeung Kak and lies about one km west of the centre of Phnom Penh. Boeung Kak (BK) is another lake found on the northern part of Phnom Penh. It is considerably smaller than BCE but more densely populated. BK covers a surface area of 190.9 ha and had a population of 14,000 in 1998 (Balmissse and Maisonhaute 2005: 34). Housing settlements, factories, warehouses, and other buildings are built on the edges of the lake leading to competition in the use of the space.

There are 186 families in Phum Mouy. A large number of villagers are involved in, among other activities, fish farming, livestock raising, the operation of motorbike taxis, and vegetable picking. Fish culture is carried out in the lake through netted fish pens or enclosures near or under the houses. Popular cultured species include *Pangasius hypophthalmus* and *Pangasius lanaudii*. Their popularity is linked to high market demand. Aside from fish farming, other members of the village harvest water hyacinth, morning glory, water lily and water mimosa in the lake. Others also supplement their food with fish catches from the lake. Two of the villagers are Vietnamese, according to the village head (Chhouk Borin, Chhim Rumuny *et al.* 2005: 1).

Information gathered through the PCA showed that the village was previously a military camp called Phum Tik La-ork until 1979 when it was renamed Phum Muoy. A few years back, the village had abundant natural resources and had fewer houses. Anecdotally, villagers would say that in the past, using simple gear, they could catch 4-5 kg of fish/day. Fishing and vegetable gardening then were the main occupations. However, bicycle taxi driving became a major occupation among some village members in 1979. In 1986, the Ministry of Culture built a resort in the lake. The advent of this resort brought problems to the local fishermen as chemicals were used to clean the lake of aquatic plants affecting their livelihoods. However, the resort was closed by 1989. Fish culture and pig-raising in the village started in 1993, when three households were involved in fish culture. Soon, the number of households involved in this livelihood increased while the resources they depended on were slowly declining. By 1995-96, there were 8-10 households involved in fish culture. Electricity was also provided to villagers through a private company. Landfilling of some lands in the village began in 1997-99. Roads were also constructed around this time. By 2003, more than 20 households were actively engaged in fish farming in the lake. People interviewed in the village noted a noticeable decline in the quality of the water of the lake as the number of people residing in the lake and human settlements have increased (Chhouk Borin, Chhim Rumuny *et al.* 2005:10-11).

5.3 Doung Village in Kandal Province

Doung Village is a village located about 17 km north of Phnom Penh and belongs to the jurisdiction of Prek Phnauv Commune, Por Gneiloieu District, Kandal Province. The village is close to the Tonle Sap River which villagers depend on for their aquaculture production. There are 451 households in the village of which 177 households are Chaams, an ethnic group that is predominantly Muslim. The Khmers account for 173 households while there are 101 Vietnamese households. The Vietnamese are largely fish farmers. Although a large number of villagers are involved in fish farming, many are also involved in factory work, growing vegetables, and construction work (Chhouk Borin, Thak Kuntheang *et al.* 2005: 1).

During the Khmer Rouge regime in 1975-79, people from the village were driven out to Battambang, Kompong Cham, and Pursat provinces while soldiers of the regime constructed dais (bagnet fisheries) in the village. The villagers returned when the regime was deposed. It was at this time that the Vietnamese started migrating to and settling in the village. During the period of the State of Cambodia (1989-92), schools and pagodas were built which improved education in the village. A wealth ranking exercise held in the village in 2003 showed that only 10% of the village members are considered rich. The rest have the following ranks: 20% average, 50% poor, and 20% very poor. The wealth ranking categories are set out in Table 7 (Chhouk Borin, Thak Kuntheang *et al.* 2005: 11, 14).

Criteria	Ranking			
	Rich	Average	Poor	Very poor
House	A row of two houses, ground brick houses (big) with zinc and tile roof and plywood wall	Wooden houses with zinc roof and small plywood or leaf wall	Thatched house with leaf and bamboo wall	Cortege with leaf roof or rent from other people (no land)
Land for home	(10x50) m ²	(4x6) m ² or (4x8) m ²	(4x6) m ²	(4x6) m ² (rent land from other people)
Animal culture	More than 10,000 fish stocked (pangasius, walking snakehead, and tilapia) and 20-30 pigs	1 pig and 3-4 chickens	1 pig (exchange with other people) and 4-5 chickens	None
Pond	Have own ponds and rent out to other people	(10x50) m ² (small amount of people have own ponds and most of them rent from others)	None	None
Occupation	Fish sauce shop, fishing lot, fish landing site, building construction, and houses for rent, animal culture, lending money	Small scale fish culture, master of construction workers, fishermen, good and fish sellers, factory workers (smaller one)	Small scale fishermen, working in rice field, motorbike taxi, construction workers, and very small business owner	Very small scale subsistence fishermen, workers, motorbike taxis, beggars
Properties	Cars, motorbikes, and TV (modern) and	Cars, motors, and TV (second	Motors (old), bicycles and	Old bicycles, small boats

	bicycles	hand or not modern and bicycles and boat with engine	boats without engine	without engine
Investment in business	Big investment	Small investment, when they take business need to go to get loan from ACLEDA bank and their neighbours	Smaller investment than average when they take a business need to get loan from ACLEDA bank and their neighbours but a small amount	No investment
Educational level of children	Grade 10 (Senior secondary school)	Grade 7- 8 (Junior secondary school)	Grade 4-5 (Primary school)	Grade 1- 3 (Primary school)
Income	High income	Medium income	A small amount of income	Smallest amount of income
Percentage of village	10 %	20%	50%	20%

Table 7 Wealth Ranking and criteria used in Duong Village (Chhouk Borin, Thak Kuntheang *et al.* 2005:14)

5.4 Chraing Chamresh

Chraing Chamresh is one of Phnom Penh's many villages located on the northern side of the city along Road Number 5. It is situated in Reusey Keo district near Prek Phnouv, about 9 km north of the city. This village has a sizeable presence of Chaam, or Muslim Cambodians. Several mosques line Road Number 5, a testament to the enduring presence of this group within a predominantly Buddhist country. Although the village is situated close to the river, the pond fish culture here depends on waste water discharged from the city and accessed through canals. Pangasius catfish is the main species grown in the villages, although some species such as tilapia, silver barb and carp are farmed in polyculture systems. Fish farming, fishing, selling fish and factory work are among the important occupations among households.

In the sub-village, Buon village, where the fieldwork was conducted, there are 346 household of which 22 are female headed households. The population is 1,925. All of households in the village only have access to water supply and electricity from state enterprises in 2003 and 2004.

Most of the land in the village is used for housing while some is used as backyard ponds and for paddy production. However, areas used for paddy and aquaculture production has been decreasing due to land use changes brought about by urban development.

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8 Appendix

Bangkok	Place	Date
Government		
1. Dr Douglas Webster	Team Leader Planning for Sustainable Urbanization Project Office of the National Economic and Social Development Board Krung Kasem Road, Pomprab	22 July 2003
Farmers		
1. Mr Manuwan Mohamad	Suanprixthai, Pathumthani	22 April 2005
2. Mrs Teemu Jaewae	Suanprixthai, Pathumthani	23 April 2005
3. Mr Yong Tanom Suk	Suanprixthai, Pathumthani	26 April 2005
4. Mrs Samran Buakanthong	Suanprixthai, Pathumthani	26 April 2005
5. Mr Pon Kongdun	Nongpraongai, Nonthaburi	27 April 2005
6. Mrs Pew ThaiKet	Nongpraongai, Nonthaburi	02 May 2005
7. Mrs Penpan Chewnawin/Mrs Yean Suthichai	Lumsai, Pathumthani	03 May 2005
8. Mr Vichai Suthikongka	Lumsai, Pathumthani	03 May 2005
9. Mrs Ravee Pethin	Lumsai, Pathumthani	03 May 2005

Appendix 1 List of individuals interviewed in the qualitative interviews in Bangkok