5.3 People's Irrigation Systems

(1) Introduction

Muang Fai, or People's Irrigation System (PIS), is the traditional gravity-fed irrigation system often found in the northern region of Thailand. PIS, known to have existed for hundreds of years, is developed communally by groups of farmers. This system has proved successful and efficient in management of water resources due to its long period of use and fair distribution of water at farm-level. The system utilises a weir, or a diversion dam, constructed across a river or a stream. This structure slows the water flow and raises the water level so that the water will flow into canals and farm ditches leading to paddy fields at lower elevations. Traditionally, farmers themselves build a weir, using locally available materials such as bamboo, wood and stones. The farmers' contribution also involves digging canals, repair and improvement of weir structures, dredging and cleaning canals as well as other related works. Each group has a *Kae Fai* (weir chief) or *Kae Muang* (canal chief), who is a respected and knowledgeable member of the community, selected by the group members to act as the leader. The chief's responsibilities include organising meetings and days of repair and cleaning, securing fair allocation of water to the members, resolving conflicts, etc. Each group has a set of effective laws and regulations known as *Sanya Muang Fai*, in which members' duties and responsibilities are clearly stated and which are agreed upon among the water user members. It also stipulates penalties, which are imposed on those who violate the agreements or cause damage to the irrigation system. The size of the irrigation area under the care of each *Kae Muang* is not very large. It averages around 50 rai, and does not normally exceed 10,000 rai[26].

The government's involvement in PIS began 65 years ago by passing the Act of Muang Fai and Phanang (earth dam) in 1934 and the People's Irrigation Act[27] in 1939. The latter became the guideline for the revised versions of People's Irrigation Act issued in 1980 and 1983. Under the People's Irrigation Act, PIS groups have to be certified by the district officer, though in reality this is not always the case. Many of the PIS groups still abide by the Sanya Muang Fai of their own group rather than regulations defined under the People's Irrigation Act. In recent years, government agencies, such as RID and ARD, have re-constructed some weirs and main canals using more durable materials, though in most cases the management of the system remains little changed. Therefore, in northern Thailand, PIS groups still play an important role in the rural life.

During the previous study stage, several PIS groups were identified in the area where the Kok-Ing diversion canal is proposed. Simultaneously, it was recognised that construction of the diversion canal could cause significant negative impacts on the existing PIS unless suitable mitigation measures are taken. The danger was clearly illustrated by sedimentation of canals and farm ditches and inundation of farmlands caused by the recent construction of DEDP irrigation canals, which are not yet completed, in the vicinity of Chiang Rai Weir. Impacts on the farmers whose land is directly affected and who need compensation have been already assessed by the TEAM/JV. However, the impacts on those PIS groups were not studied. A more detailed survey on the existing PIS groups was, therefore, included in this study stage.

The objectives of the study are to identify existing PIS groups along the Kok-Ing diversion canal with their organisation and problems, to analyse the impacts of the Project, and to propose mitigation measures.

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[26] Historical Development and Management of Irrigation Systems in Northern Thailand, Vanpen Surarerks, 1986.

[27] *People's Irrigation Act* is described in sub-section 4.6(3)(a).

(2) Methodology

The following steps were taken:

- Identification of water supply sources along the proposed Kok-Ing diversion canal route by field survey with location confirmed by GPS;
- Identification of existing PIS groups, referring to the surveyed water supply sources, by enquiry with different offices and the local population;
- Inventory survey of existing PIS groups through a discussion with each identified group;
- Impact assessment of the Project by a group discussion with each group;
- Formulation of mitigation measures by a group discussion with each group; and
- An in-depth case study of selected PIS groups.

(3) Existing PIS and Problems

(a) PIS Inventory Survey

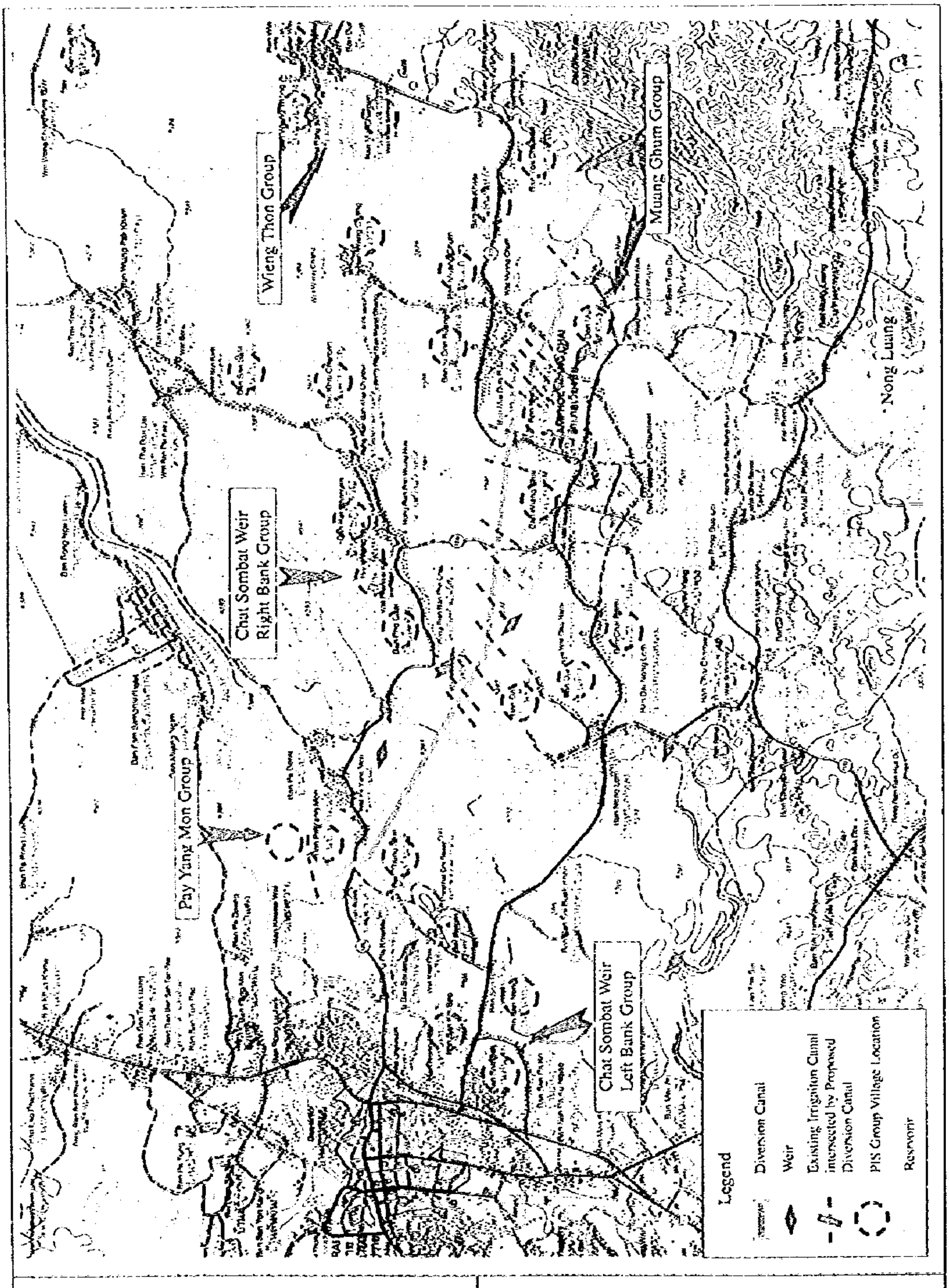
Fourteen PIS groups were identified along the Kok-Ing diversion canal route. The locations of PIS groups are shown in Figure 5.3.1 and the information gathered from each group as an inventory survey is tabulated in Table 5.3.1.

The identified PIS groups vary considerably in size, both in terms of cultivated land and the number of member households. For example, Pracha Asa Weir Group in Tambon Mai Ya has only 12 households as members and its cultivated land is 100 rai whereas Chai Sombat Weir Right Bank Group consists of around 2200 households of 15 villages and its cultivated land is 15,000 rai.

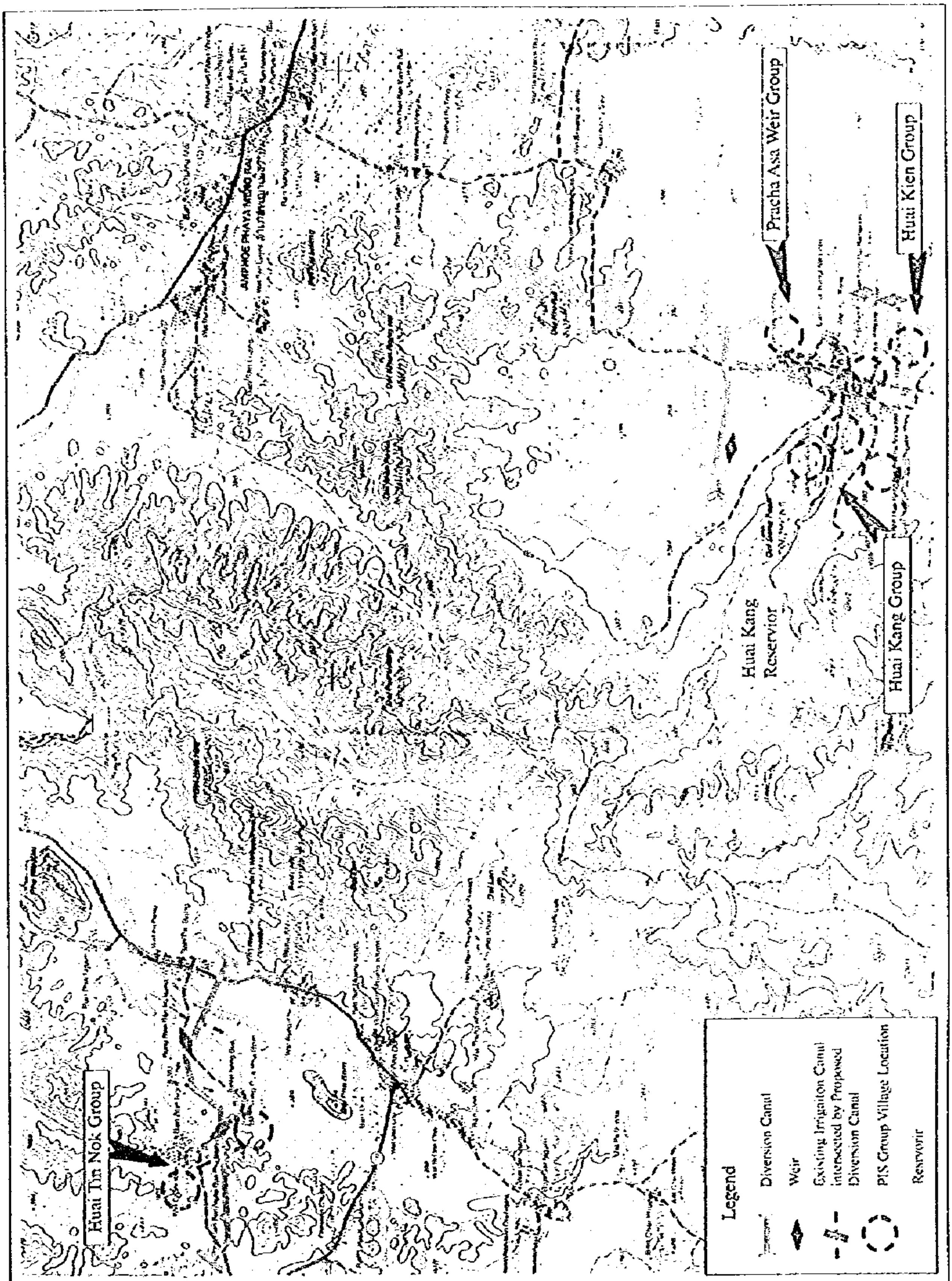
Most of the farmers in the 14 groups are engaged in small-scale, rain-fed rice cultivation in the rainy season. The irrigation water of most of the PIS groups is applied almost exclusively during the rainy season in order to supplement the rain. In general, very little farming is practised in the dry season due to the shortage of water. Ten groups cultivated less than 10 % of their wet-season farmland during the dry season. Twelve out of fourteen groups mentioned shortage of water in the dry season as a severe problem. Five of them noted shortages of water even in the rainy season. Water shortages in the rainy season may last one to four weeks between June and September and are due to rainfall variations during the rainy season. Water demand is highest in July for rice cultivation in these areas. Water shortage during this period is mainly due to competitive water use of farmers. Five groups (of which four are in the Kok Basin and one in the Ing Basin) mentioned flooding in the rainy season as one of their problems.

Out of the fourteen PIS groups identified, six are in the Kok Basin and eight are in the Ing Basin. Water supply sources of the PIS groups found in the Kok Basin are from rivers: i.e. Mae Korn, Mae Lao and Mae Sa Kuen, all of which are tributaries of the Kok River. Those in the Ing Basin are usually from constructed reservoirs on natural streams. Among the PIS groups studied, Thun Khan Chai Group in the Ing Basin is the only group using the pumping irrigation system. Although most of the surveyed PIS groups suffer from a shortage of water in the dry season, the PIS groups in the Ing Basin suffer more severely from the water shortage, even in the rainy season, due to the limited storage capacity of reservoirs (see Figure 5.3.2).

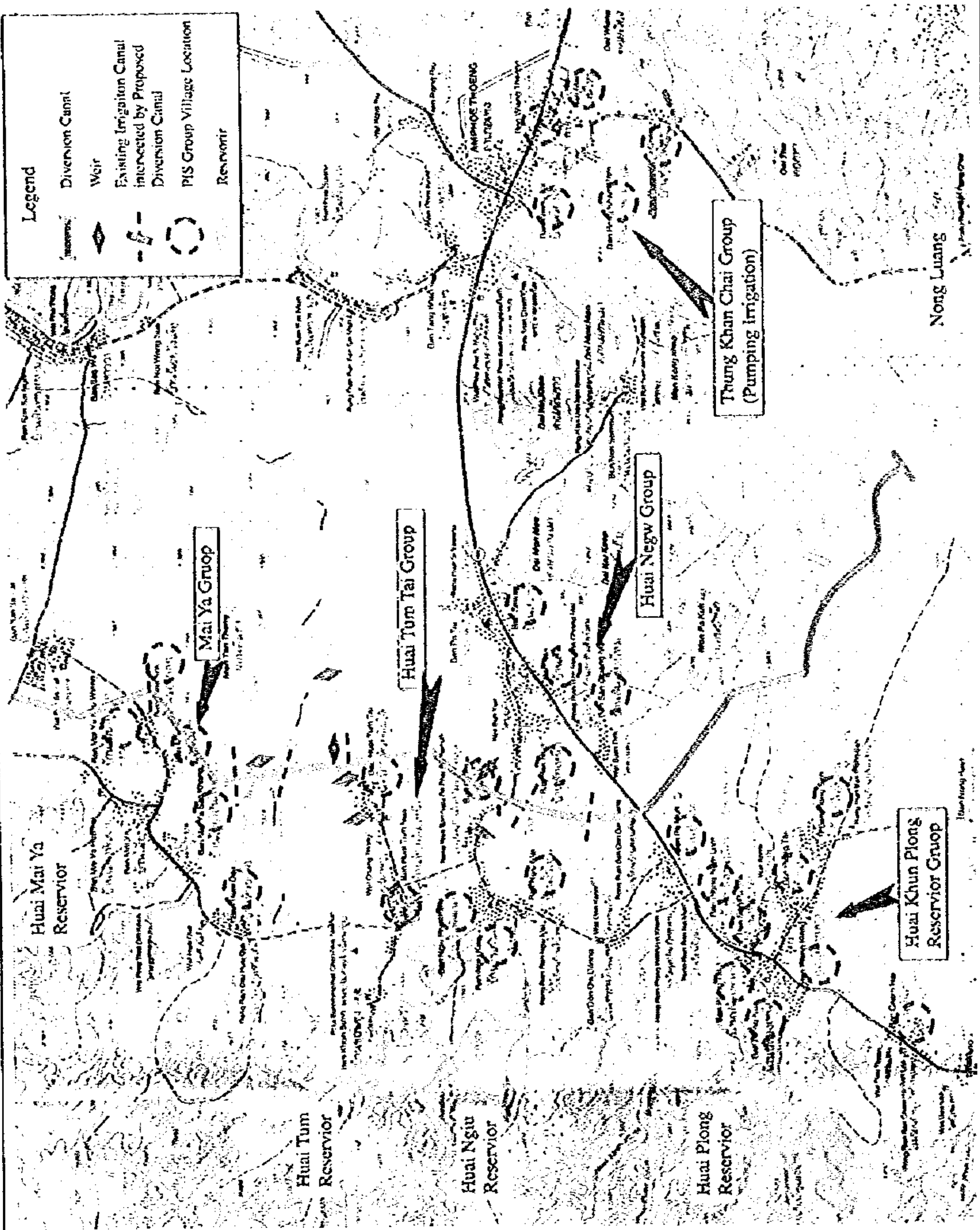
Most of the groups have a committee, which organises member meetings and an annual day, or days, for repair and cleaning of the canals. About half of the groups collect a "Water Fee" (in reality it is more like a membership fee) from each member, according to the size of his/her farm, while some groups collect a voluntary donation when necessary. Some groups also demand a penalty in the case of a member being absent from repair, cleaning or meetings.



ENVIRONMENTAL STUDY THE KOK-ING-NAN WATER DIVERSION PROJECT	**Figure 5.3.1. PIS Groups along K-I-N Diversion Canal**
JAPAN INTERNATIONAL COOPERATION AGENCY	



ENVIRONMENTAL STUDY THE KOK-ING-NAN WATER DIVERSION PROJECT	**Figure 5.3.1 (continued-1)** **PIS Groups along K-I-N Diversion Canal**
JAPAN INTERNATIONAL COOPERATION AGENCY	



ENVIRONMENTAL STUDY THE KOK-ING-NAN WATER DIVERSION PROJECT	**Figure 5.3.1 (continued-2)** **PIS Groups along K-I-N Diversion Canal**
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Table 5.3.1. Inventory Survey of PIS Groups
(page 1 of 4)

Mapping Number	1 (Case Study 1)	2	3 (Case Study 2)	4
Name of PIS Group	Pa Yang Mon Group	Chai Sombat Weir Left Bank Group	Chai Sombat Weir Right Bank Group	Muang Chum Group
Location:				
District	Chiang Rai, Muang District	Chiang Rai, Muang District	Chiang Rai, Wieng Chai District	Chiang Rai, Wieng Chai District
Sub-district	Rob Wiang	Wieng Sub-district and Rob Wieng Sub-district	Wieng Chai, Wieng Nua and Muang Chum Sub-district	Muang Chum Sub-district
Villages (number: names)	3 : Pa Yang Mon 1, Pa Yang Mon 2, Thung Mon	12 : San Pa Koe, San Sa Lee, San Nong, Pa San, Sai Moon, Nong Lom, Dai, Rim Korn, Pa Kluai, Pa Yang Mon, San Kee Bao, Nong Bua	15 : Pong Luang, Sri Wieng, Rong Bua Loi, Dai, Chai Narai, Klang Wieng, Chai Ya Pum, Mai Don Ruang, Wieng Nua, Phoe Chai, Rat Charoen, San Salid, Kai Charoen, Wieng Chai, Wieng Chum	4 : Don Moon, Yok Charoen, Wang Chang, Muang Chum
Member Households	138 (27 % of the community)	620 (50 % of the community)	2200	532 (80 % of the community)
Irrigated Area:				
Wet Season	1500 rai; Rice	4000 rai; rice (3000 rai), corn (1000 rai)	15,000 rai; sticky rice (10,500 rai), rice (4500 rai)	2000 rai; sticky rice (2/3), rice (1/3)
Dry Season (area; crop)	200 rai; second rice (150 rai), vegetables (50 rai)	1000 rai; corn (600 rai), vegetables (300 rai), longan and lychee (100 rai)	12,000 rai; rice (6000 rai), corn (1500 rai), vegetables, garlic, onion, etc. (4500 rai)	10 rai; vegetables, ground nut
Irrigation Period	June – November	June – September	All the year round	June - November
Source of Water	Mae Korn River, originated from Khun Korn Waterfall	Lao River	Lao River	Mae Sa Kuean flowing through Nong Luang Reservoir and finally flowing into Kok River
Weir	W10m X L8m X D4m, concrete About 30 years ago farmers themselves built the weir with 3 steel water-gates across the Mae Korn river.	W10m X L75 m X D2m, concrete In 1984 RID built the Chai Sombat Weir, costing 10 million Baht.	W10m X L5 m X D2m, concrete In early 60s the farmers built a weir across the Lao River. In 1984 RID built the new weir, costing 10 million Baht.	L50m X W40m X D3m, concrete, 2 steel water gates The reservoir has 3 water gates. The weir is across the Mae Sa Kuean river at Don Moon Village. The weir was built in 1993.
Canal	1 main canal and 3 laterals of around 1.7 - 2 km long	1 main canal of 10 km long, with 2 steel watergates with 5 laterals of 1-8 km long.	1 main earth canal and 5 laterals of 10-20 km long	1 main canal of 5 km long and 2 laterals of 1.5 and 4 km long.
History of the Group	They suffered from the flooding from Lao and Mae Korn Rivers in the rainy season and the drought in the dry season. The people formed a group long ago and built a bamboo weir across Mae Korn river in 1918. About 30 years ago, they built a concrete weir by themselves using the money donated by the people. Because it is located close to Chiang Rai city, the group might be eliminated due to urbanisation.	Around 30 years ago, the farmers formed the group following the Chai Sombat Weir Right Bank Group.	In 1962 the group was formed and they built the weir themselves. In 1984 RID built the new weir, costing 10 million Baht. 1997 the group got the budget from RID for repair. This group is the largest and most self-reliant PIS group in the area.	40 years ago the farmers built a bamboo weir. 20 years ago they formed a group and reconstructed the weir by themselves. 5 years ago the current weir was constructed.
Committee (number members; meeting)	11; 1/year, after harvest	12; 1/year in March	173; 12/year, once every month	17; 5/year, but depends on the situation
All Member Meeting	1/year, in December	1/year in March	1/year	1/year in February
Water Fee	20 Baht/rai for a fee paid to the weir's guard	20 Baht/rai	10 Baht/rai	15 Baht/rai
Penalty	25 Baht/rai if absent from repair and cleaning, 100 Baht per person if absent from the meeting.	150 Baht/person/day if absent from the cleaning and repair	100 Baht per person if absent from the meeting, 50 Baht per person if absent from the cleaning and repair, 1000 Baht if making obstruction in the waterway	100 Baht per person if absent from cleaning and repair
Repair	Once a year, repair of the weir (March or April)	The group do themselves	In 1997, they asked RID for the repair of the weir. It was the first repair since it was built in 1962.	Repair the weir by themselves. Twice for the past 5 years.
Cleaning	Once a year usually before rice plantation (April)	3 times a year but depends on the situation	Once a year by themselves	1/year in April by themselves or hire a machine
Problems of the Group	1. Lack of water in the dry season 2. Flooding from the water source (low land)	1. Damage of the earth dyke protecting against flood 2. Lack of water in the dry season (March-May) 3. Lack of water even in the rainy season 4. Flooding from the water source (Aug.-Sept) 5. Competitive water use at the peak season	1. Shallowness of the canals due to sedimentation 2. Damage of the weir	1. Lack of water in the dry season 2. Competitive water use during the peak period 3. Flooding from the water source (Aug., Sept.) 4. Damage of earth drop structures
Problems of the Community	1. Shortage of water 2. Lack of farm land 3. Lack of agricultural credit 4. Low price of agricultural products 5. Lack of marketing knowledge 6. Lack of appropriate technology and productive skills	1. Uncertainty of farm product prices 2. The lack of efficient marketing outlets 3. Plant diseases and pest 4. High cost of fertiliser and insecticide	1. Low farm product price 2. Lack of viable market outlets 3. Shortage and high cost of labour 4. Shortage of technology and employment opportunity	1. Shortage of water 2. High consumer goods prices 3. Low farm product prices determined by middleman 4. High cost of farm inputs 5. Inefficient use of water by the PIS group

Table 5.3.1. Inventory Survey of PIS Groups
(page 2 of 4)

Mapping Number	5	6	7 (Case Study 3)	8
Name of PIS Group	Huai Tin Nok Group	Wieng Thong Group	Mai Ya Group	Huai Kien Group
Location:				
District	Chiang Rai, Wieng Chai District	Chiang Rai, Wieng Chai District	Chiang Rai, Phaya Meng Rai District	Chiang Rai, Phaya Meng Rai District
Sub-district	Pha Ngam Sub-district	Muang Chum Sub-district	May Ya Sub-district	Mai Ya Sub-district
Villages (number: names)	2 : San Ngon Thai, Nong Bua Pha Bom	5 : Wieng Thong, Mai Muang Chum, Wieng Kaew, Huai Kien, Mai Charoen	4 : Mai Ya San Kong, Mai Ya Ku Wieng, Mai Ya Kao, Mai Ya Mai	2 : Huai Kang Na Lom, Huai Kang Rat
Member Households	115 (27 % of the community)	262 (38 % of the community)	155 (15 % of the community)	50 (17 % of the community)
Irrigated Area:				
Wet Season (area; crop)	1300 rai; sticky rice	2000 rai; sticky rice	800 rai; sticky rice	600 rai; sticky rice
Dry Season (area; crop)	5 rai; vegetables (domestic)	-	-	3-4 rai; vegetables (domestic)
Irrigation Period	June - November	June - September	May – October	May - August
Source of Water	Huai Tin Nok originating from the mountain	Mae Sa Kuean river flowing through Nong Luang Reservoir and finally flowing into Kok River	Huai Mai Ya Reservoir, a 70 rai reservoir with a steel water-gate built by ARD in 1985	Huai Kien stream
Weir	L12m X W12m XD1.5-2m 4 earth weirs were built by the farmers a long time ago and 3 concrete weirs were built in 1985, 1990 and 1995 with the budget from MOI.	W5m X L2m X D2.5m, concrete 1995 the weir was built by the Tambon Council	No weir	W6m X L20m X D4m, concrete The weir was built by ARD in 1972
Canal	Natural stream of 4 km has 7 main earth ditches with some drop structures	1 main canal (Lam Muang) separates from the Mae Sa Kuean, flows into Nong Na Phanang built by RID 3 years ago, and finally flows into Kok river.	2 concrete main canals of 3 km and 1.5 km long and 2-5 m wide built with farm ditches in 1985.	1 farm ditch separates at Huai Kien Weir on the Huai Kien stream
History of the Group	About 30 years ago the group was formed by the farmers themselves.	50 years ago the group was formed by the farmers themselves.	After building the reservoir and canals, ARD encouraged to form a water users' group. They sent some of the farmers to Lampang Province to learn about water users' group.	In 1996 the farmers formed a group themselves.
Committee (number members; meeting)	9 : 1/year	8 : 1/year in February	6; 1/year in April	4; 2/year
All Member Meeting	Every month	2/year in February and April	1/year in April	2-3/year
Water Fee	They collect a donation according to the needs	10-20 Baht/rai	Usually not collected. Ask for a donation if needed depending on the size of the land they own.	20-50 Baht/rai
Penalty	150 Baht/person/day if absent from cleaning and repair	100 Baht or more per person per day if absent from cleaning and repairing the ditch. They also have to work for the group as a compensation of the absence.	No	50 Baht/person if absent from the meeting; 100 Baht/person if absent from repairing and cleaning
Repair	Once a year in May, repair earth weirs by themselves	Once a year in April, repair of Lam Muang	Request to ARD, if necessary.	Themselves if necessary
Cleaning	Every year cleaning of ditches by themselves	Once a year in April, cleaning of Lam Muang	Once a year by the members (May or June).	Once a year in November before harvest by themselves
Problems of the Group	1. Lack of water in the dry season 2. Damage of weirs and ditches 3. Lack of water even in the rainy season 4. Competitive water use (July - Aug.)	1. Lack of water in the dry season. 2. Flooding from the water source.	1. Lack of water even in the rainy season 2. Dispute over water distribution among members 3. Competitive water use in the peak period 4. Theft of irrigation water (Aug., Sept.)	1. Lack of water in the dry season 2. Dispute over water distribution among members 3. Competitive water use in the peak period
Problems of the Community	1. Lack of viable PIS group 2. Lack of water 3. Insufficient agricultural farm credit 4. Lack of knowledge in new agricultural techniques 5. Lack of market outlets for farm products 6. Inactive women and youth groups	1. Lack of government support for agricultural techniques	1. Lack of water even during the rainy season 2. Poverty due to low income of farmers 3. Drug addiction among youth. 4. Weak cohesiveness of PIS group	1. Lack of water even in the rainy season 2. Low price of farm products 3. High cost of farm inputs 4. High labour cost 5. Farm product prices are determined by a middleman 6. Limited suitable agricultural credit sources

Table 5.3.1. Inventory Survey of PIS Groups
(page 3 of 4)

Mapping Number	9	10	11	12
Name of PIS Group	Pracha Asa Weir Group	Huai Kang "Group"	Huai Tum Tai Group	Huai Ngew Group
Location:				
District	Chiang Rai, Phaya Meng Rai District	Chiang Rai, Phaya Meng Rai District	Chiang Rai, Thoeng District	Chiang Rai, Thoeng District
Sub-district	Mai Ya Sub-district	Mai Ya Sub-district	Ngew Sub-district	Ngew Sub-district
Villages (number: names)	2 : Huai Kang, San Kong	2 : Huai Kang Rat, Sri Chum	1 : Huai Tum Tai	7 : Sak Nua, Pa Phai, San Chieng Mai, Sa Wan, Sak Tai, Pa Tiew, Sak Santirat
Member Households	12 (7 % of the community)	370 (90 % of the community)	350 (100 % of the community)	1510 (100 % of the community)
Irrigated Area:				
Wet Season (area; crop)	100 rai; sticky rice	4000 rai; sticky rice, vegetables (5,6 rai)	3500 rai; sticky rice (self consumption)	6200 rai; sticky rice
Dry Season (area; crop)	4 rai; vegetables (domestic)	21 rai; sweet tamarind (5 rai), longan (15 rai), vegetables (1 rai)	25 rai; garlic, onion, beans	5650 rai; vegetables (40 rai), onion (little), lychee (10 rai), straw mushroom (90% of rice field), longan (20 rai)
Irrigation Period	May – August	June – October	May – October	May – October
Source of Water	Huai Kien stream, down stream of Huai Kien weir	Huai Kang stream flows into Huai Kang reservoir built by ARD in 1984, and finally it flows into Huai Kien	Huai Khon Sung Reservoir, built by ARD in 1973	Huai Ngew stream which flows through Khun Huai Ngew reservoir, built by ARD in 1987
Weir	W4m X L10m X D4m, earth The farmers built the Pracha Asa weir themselves in 1986 and later 7 weirs across the Huai Kien river.	2 concrete weirs of W3m X L15m X L3m The weirs were built in 1996 by the Amphoe Council. (One concrete weir of W3m X L15m X L3m, built by the villagers 5 years ago, is now damaged and not in use)	4 concrete weirs of W3m X L4m X D3m The weirs were built by the villagers by themselves	No weir.
Canal	a natural stream of Huai Kien with small earth weirs	a natural canal of 3km, and an ARD built canal of 3.5 km, which is damaged	1 main canal with small weirs supplies water to the field directly	An earth canal of 3 km built by ARD in 1987 and an natural stream of 6 km with a lateral of 2 km and many inlets along the canal and stream.
History of the Group	In 1986 the group built the weir and separated from the Huai Kien Group.	The group was not yet formed, but they are using the water from the same source.	The villagers themselves established the group long time ago.	50 years ago the farmers formed the group by themselves, but the group is influenced by ARD and became dependent and less self-reliant.
Committee (number members; meeting)	2; 2/year	-; -	4; 2/year in May and in December	16; 12/year, every month
All Member Meeting	2-3/year	-	1/year in May	12/year, every month
Water Fee	20-50 Baht/rai	-	Not collected. Donation is collected, if needed.	Not collected.
Penalty	No	-	No	No
Repair	Once a year, repair the weir by themselves	-	Not often	They request the money from ARD for repair
Cleaning	No	Three times a year they clean the stream	Not often	Once a year in April by themselves
Problems of the Group	1. Lack of water in the dry season 2. Damage of the weirs 3. Lack of water even in the rainy season	1. Lack of water in the dry season 2. Dispute over water distribution among farmers 3. Competitive water use during the peak period 4. Theft of irrigation water	1. Lack of water in the dry season	1. Lack of water in the dry season
Problems of the Community	1. Low yield of farm products 2. High labour cost 3. Flooding	1. High competition of water use among farmers 2. No PIS group to manage water efficiently 3. Low price of farm product 4. High cost of agricultural input 5. Lack of stable market outlets 6. Lack of appropriate technology to improve farming	1. Lack of water all year round 2. Lack of off-farm employment opportunities 3. Lack of government support for community activities	1. Shortage of water even in the rainy season 2. Low price of farm products 3. High cost of agricultural inputs 4. Shortage and high cost of labour 5. Farm product prices are determined by a middleman 6. Lack of suitable agriculture credit

Table 5.3.1. Inventory Survey of PIS Groups
(page 4 of 4)

Mapping Number	13	14 (Case Study 4)
Name of PIS Group	Thung Khan Chai Group (DEDP Pumping Irrigation)	Huai Khun Plong Reservoir Group
Location:		
District	Chiang Rai, Thoeng District	Chiang Rai, Thoeng District
Sub-district	Wieng Sub-district	Plong Sub-district
Villages (number: names)	4 : Rong Khan Pom, Thung Khan Cahi, Mai, Wieng Tai	12 : Lao, Cham Hai, Plong Tai, Plong Nua, Plong Talad, Don Din Daeng, Plong Klang, Plong San, Pa Muan, San Pa Sak, Plong Nam Lon, Thung Charoen
Member Households	120 (17 % of the community)	2161 (93 % of the community)
Irrigated Area:		
Wet Season (area; crop)	3000 rai; rice	10,000 rai; sticky rice (80%), rice (20%)
Dry Season (area; crop)	1600 rai; maize (1000 rai), rice (500 rai), vegetables (100 rai)	1000 rai; ground nut (800 rai), vegetables (200 rai), vegetables and mushroom (little)
Irrigation Period	All year round	July – September
Source of Water	Lao River	Khun Plong Reservoir, built as a Royal Project in 1984
Weir	DEDP pumping station established in 1992	W15m XL10-15 m X D3-4 m, one concrete and 4 earth The villagers built the concrete weir about 30 years ago, and the earth weirs about 20-30 years ago.
Canal	2 cement canals of 2.2 km and 1.3 km long, 2.2 m wide, 0.6 m deep	1 concrete canal of 4 km long with a concrete lateral of 50 m long and 1 natural stream of 5 km long.
History of the Group	After DEDP established the pumping station and the canals, the agency recommended the formation of a water users' group. There was no group prior to the DEDP pumping station.	Due to the water use problems, RID recommended the organisation of a group in 1984. The chief is also a member of tambon administration.
Committee (number members; meeting)	10; 2/year in June and in December	70; 3/year in May, July and December
All Member Meeting	2/year in June and in December	1/year in each village
Water Fee	0.8 Baht/unit electricity (part of it is kept as fund)	Not collected
Penalty	100 Baht/person/day, if not attend the cleaning	No
Repair	The group repairs using their own fund	Budget from the Obotor
Cleaning	Once a year by themselves	Once a year by themselves (April, May)
Problems of the Group	1. Dispute over water use during the peak period (one water pump supplying the two canals) 2. Damage of the canal	1. Dispute over water distribution among members 2. Structure of the irrigation network is not practical 3. Lack of water in the dry season 4. Flooding from the water source
Problems of the Community	1. Low price of farm products 2. High cost of agricultural inputs 3. Strong power of middleman to set the price 4. Shortage of agricultural credit 5. Theft and robbery 6. Weak cohesiveness of PIS group	1. Lack of water for farming in the dry season 2. Migration of youth to cities, seeking for jobs 3. Shortage of water 4. Depleted soil condition 5. Low price of farm products 6. Forest destruction

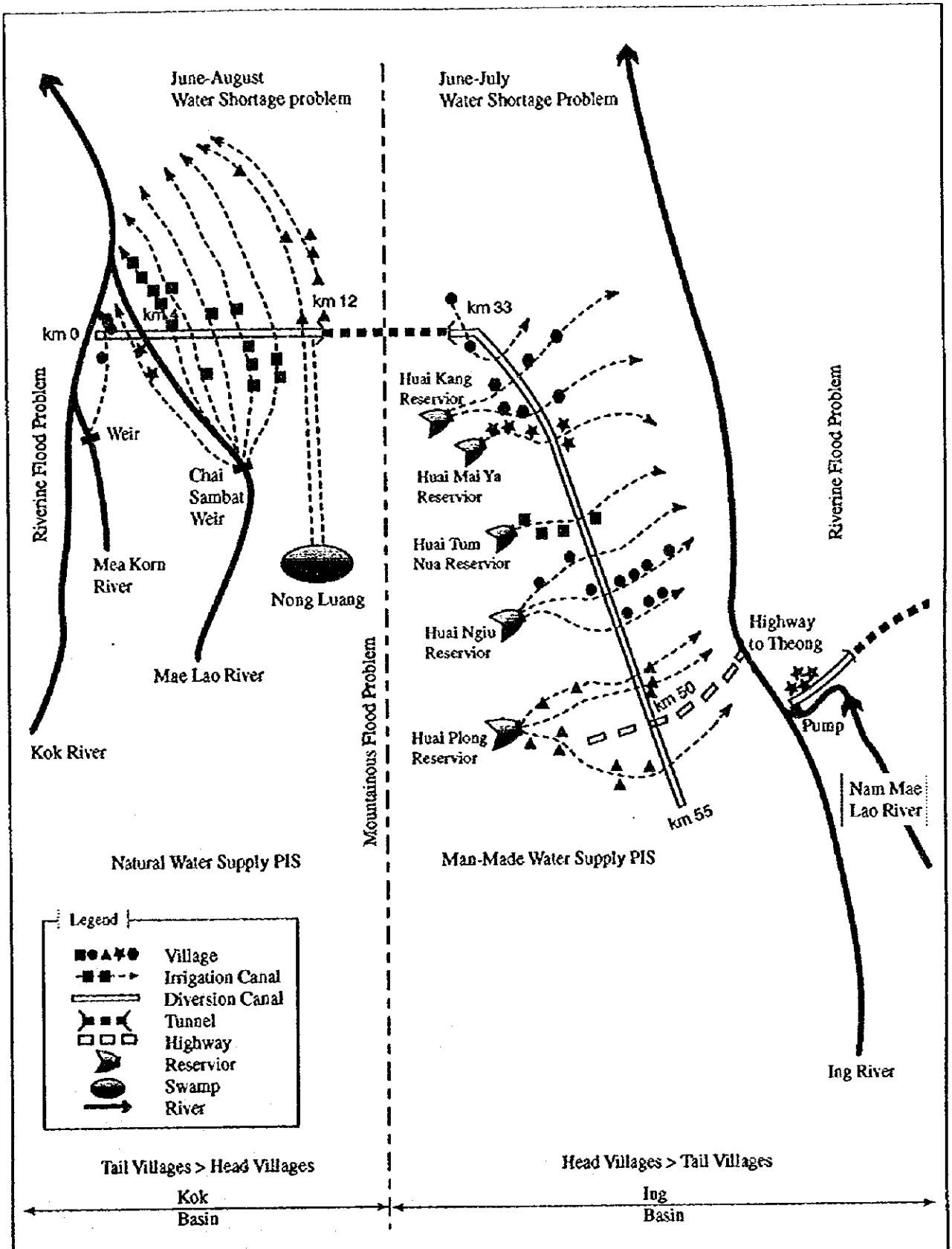

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Figure 5.3.2. Existing People's Irrigation System and Problems in Kok & Ing Basins

With respect to the groups' organisation, the Chai Sombat Weir Right Bank Group in the Kok Basin represents the most organised and self-reliant PIS group. As mentioned above, this group is the largest, consisting of 2200 member households from 15 villages, but it is well managed by the committee under the leadership of an energetic *Kae Fai* (Weir Chief). The committee members gather monthly and try to solve the problems they are facing. On the other hand, there are a number of less mature groups, which were recently formed due to an external influence, i.e. the intervention of government agencies in irrigation development. For example, Mai Ya Group was formed by the encouragement of ARD after the agency had constructed Huai Mai Ya Reservoir and main canals in 1985. Similarly, Huai Khun Plong Reservoir Group was established in 1984 on the recommendation of RID.

Although a shortage of water is found to be the most serious problem for the PIS groups surveyed, there are other factors which impede the development and which need to be addressed. The following are the problems most often expressed by the farmers during the discussions:

- Shortage of water in the dry season, or even in the rainy season in some cases;
- Low price of farm products, which is often determined by a middleman;
- High cost of farm inputs such as fertiliser, pesticide and herbicide;
- Lack of suitable marketing outlets or lack of marketing knowledge;
- Lack of adequate agricultural credit; and
- Shortage or high cost of farm labour.

(b) In-depth Case Studies

From the 14 PIS groups identified, the following four groups were selected for further in-depth case studies: Pa Yang Mon Group and Chai Sombat Weir Right Bank Group in the Kok Basin, and Mai Ya Group and Huai Khun Plong Reservoir Group in the Ing Basin. The topographical condition of the area, type of water source, group size and organisational structure of the group were considered for the selection, so that the selected groups would represent the different characteristics and problems of the existing PIS groups in the area.

The irrigation areas of the Pa Yang Mon Group and the Chai Sombat Weir Right Bank Group are located in the broader and lower river-valley or floodplain of the Mae Korn River and Lao River, respectively, at the same average height of 380-390 metres above sea level. There is no difficulty in allocating irrigation water to the farmland, particularly the rice fields, in the rainy season. However, both groups are faced with a regular problem of excess water in the rainy season due to the climatological conditions of the tropical monsoon. Heavy rain in the lowlands often results in flooding of farmland and the loss of crop production. In most years the crop damage is partial, but in some years the entire production is destroyed. For example, in 1957, 1979 and 1993-1994, flooding caused the loss of the entire rice production in the irrigation area of the Pa Yang Mon Group. In those years flooding reached a depth of 2-3 metres for more than one month during August and September and in some years till October. For the Chai Sombat Weir Right Bank Group, the damage caused by flooding is much less severe, usually about 10 % of the crop production. The Pa Yang Mon Group also suffers from regular shortages of water in the dry season for 4-5 months. The group can cultivate only 200 rai, or less than 15 % of the farmland, in the dry season. The Chai Sombat Weir Right Bank Group, with a more permanent irrigation structure and good co-operation with the RID regional office, is better equipped to face water shortage problems. The group can supply water in the dry season to 12,000 rai, or about 80 % of the farmlands, although only half of the area receives enough water to grow a second rice crop while the rest is used for the cultivation of vegetables and maize.

The Mai Ya Group and the Huai Khun Plong Reservoir Group in the Ing Basin are located in the higher and drier areas at a height of 410-420 metres and 390-400 metres above sea level, respectively. They have no water source except small streams originating from relatively small reservoirs. Therefore, water shortage is the most severe problem that these groups face. The Mai Ya Group faces shortages of water almost the whole year. Even in the rainy season, the water source can only supply water to 800 rai of farmland, leaving the surrounding 16,000 rai of farmland fallow all through the year. In the dry season, no farming is possible at all. The Huai Khun Plong Reservoir Group also has a severe problem of water shortage during the dry season. There is no second rice cultivation in the area and only 1,000 rai, or 10 % of the farmland, is used for the cultivation of groundnuts and vegetable in the dry season. Many of the villagers in these two groups seek non-farm employment (mainly in the construction sector) in the city during the dry season, and often in a foreign country for periods of several years.

(4) Impacts and Mitigation Measures

The expected impacts of the Project on the PIS groups are classified into physical and social aspects. In relation to the physical barrier created by the construction of the diversion canal, a PIS group will be divided into the "head" and the "tail" sections of the group as shown in Figure 5.3.2.

Typical impacts expected by the PIS groups are periodical flooding in the head section, shortage of water in the tail section and the subsequent social segregation of the group.

Flooding: The farmers in the head section of the groups expressed concern about flooding of their land. This arises from a fear that the diversion canal might block the flow of water of PIS irrigation canals. This flood impact is expected to be more significant in the head sections of the group in the Kok Basin, due to the pre-existing frequency of riverine flooding in the area.

Shortage of Water: The farmers in the tail section of the groups were concerned about possible water shortages when the diversion canal blocks the water flow to the downstream section of their irrigation canals. This water shortage impact will be more significant for the groups in the Ing Basin, because of the limited water supply source available from the reservoirs in the area.

Clogging of Siphon Structure: A number of farmers expressed concern about the siphon structures, if used at the cross section of a PIS canal with the diversion canal. Clogging of a siphon by siltation will restrict the water flow or block the siphon completely.

Division of the Group: Impacts of dividing the area by the diversion canal are assessed significant unless suitable physical connections are provided. The social impact on the group, due to the physical barrier of the diversion canal, is thought to be minor by many of the groups. However, it may lead to a re-organisation, or even the disintegration, of the PIS group, if the two sections of the group have little common interest in terms of water utilisation.

The following mitigation measures have to be considered in order to minimise the negative impacts on the existing PIS groups along the Kok-Ing diversion canal:

- **Drainage**
  It is necessary to provide an appropriate drainage system to mitigate the flood impact in the head sections. It was suggested by several PIS groups that the drainage ditch of the maintenance road along the diversion canal needs to be enlarged to become a drainage canal, so that floodwaters can be drained to nearby waterways.

- **Siphon or Overshoot**
  It is necessary to provide a structure that will allow the water of a existing stream or a PIS canal to flow naturally towards the downstream. In practice, a siphon is usually placed in such a position. In case of a siphon structure, it is suggested that a large siphon block culvert be used, so that the PIS members could use manholes to enter the siphon, in order to dig out such clogged sand and silt, as necessary. The alternative solution is the provision of an overshoot, which will allow the water to flow without obstruction. Considering the width of the diversion canal that the overshoot has to cross, provision of several supports will be necessary. Such supports should withstand the velocity of the current in the diversion canal. A way of cleaning and maintenance of the structure has to be simple enough for the PIS group to manage. For small systems it may not be cost effective to link the "head" and "tail" sections. In some cases a possibility of supplying the water to the "tail" section directly from the diversion canal should be considered, provided the group opts for this alternative.

- **Bridge**
  It is necessary to provide physical connections, including bridge crossovers, which will link existing access routes between the "head" and the "tail" sections of the group.

(5) Remarks and Recommendations

Most of the PIS groups along the Kok-Ing diversion canal suffer from water shortages in the dry season. Some of the groups are also faced with water shortages in the rainy season. In the eyes of those farmers, the Project's claim of 2,000 MCM of rainy season "surplus water" in the Kok and Ing Basins has no validity. Unless the people in the Donor Basins are supplied with sufficient water all year round, the concept of "surplus water" might be regarded as theoretical. Appropriate measures for providing water to farmers in this area need to be planned and implemented prior to the Project.

Many farmers along the Kok-Ing diversion canal will lose substantial areas of their farmland due to the construction of the canal.[28] Fair compensation for the land as well as the appropriate method and the timing of payment should be addressed and agreed. Further, in order to compensate for the loss of land, which is the most important factor in agricultural production, it is recommended that the government should try to assist the farmers in the area in improving their agricultural practices. For example, implementation of small-scale irrigation projects to secure year-round water supply to the farmland, agricultural extension works on crop diversification and integrated farming and the introduction of small-scale agro-industry will all help promote sustainable agricultural development, and will also improve the life of the farmers in the area.

It is inevitable for any social structure to undergo change as a result of the socio-economic evolution of the society. The PIS is of no exception and the system is already undergoing some changes due to such factors as the introduction of modern farming and irrigation facilities, urbanisation of the community, a shift from subsistence farming to commercial farming, migration of young people to the city, etc. Recent government interventions have also influenced the structure of PIS groups to a certain extent. However, the PIS has functioned efficiently as a small-scale, self-reliant irrigation system for hundreds of years in the northern region and it still plays a significant role in farming communities. It is, therefore, important that the main principles of organisation and management system should be respected and supported when mitigation measures are planned and implemented. Most of the groups have expressed their willingness to co-operate, if the government approves the project, provided fair compensation and all the necessary mitigation measures are arranged. They also expect to benefit from the project by receiving additional irrigation water to their irrigation systems.

[28] According to the draft report produced by TEAM/JV the land loss along the Kok-Ing diversion canal is estimated at around 4,000 rai.

Considering the time lag between the current study stage and the implementation of the Project, it is predictable that the PIS in the area will change according to the social and economic evolution of the area. Small PIS groups in proximity of Amphoe Muang and Wiang Chai might be eliminated by urbanisation in the next two decades. New irrigation projects such as DEDP Chiang Rai Weir Irrigation Project will also alter the current organisation of PIS groups in the area. It is therefore necessary to study the conditions of the PIS groups and re-assess the impacts on the groups at a later stage.

5.4 Fisheries, Aquatic Ecology and Freshwater Biodiversity

(1) Introduction

This section presents a study of fisheries, aquatic ecology and freshwater biodiversity in general, given the nutritional and economic importance of fisheries to the donor area population and the potential significance of the project for aquatic ecosystems and freshwater biodiversity. Many development projects impact freshwater biodiversity and ecosystems through flow regulation, pollution, siltation, eutrophication, and changes in vegetation cover, and many of Thailand's poorest people depend on freshwater ecosystems for their protein needs.

Nationally, Thailand has recorded over 690 species of freshwater fish,[29] a significant ecological resource and the fourth highest number of fish species recorded in any one country in Asia. The threats faced by freshwater biodiversity in Asia as a whole are manifold and pervasive. There are cumulative and synergistic effects, and tolerance to one factor may be lowered by a stress resulting from the presence of another factor. A major problem in managing freshwater ecosystems in the region is the lack of knowledge of how the various induced human changes affect aquatic life. What is known and is beyond doubt, however, is that environmental degradation may result in significant ecological change.

The cyclic rise and fall of water levels in Thailand's rivers and lakes are of particular significance. Inundated flood plains are the main or sometimes exclusive spawning and nursery grounds for many fish species. The cycle also signals and stimulates the breeding and movement of many freshwater species, and any changes in timing and flow rates due to flow impoundment may have adverse effects. A period of zero flow during or following dam construction will clearly be devastating to aquatic communities downstream. However, the deleterious effects of flow regulation and water diversion may be more subtle than other effects and are often difficult to distinguish from other associated impacts. Other negative impacts of flow regulation measures and water diversion include habitat destruction and modification, alteration of flood regimes, creation of sterile habitats and of barriers to migration. Canals, and water transfer schemes, by connecting different river basins, may allow the entry of exotic species and pathogens.

Reservoir construction may result in the destruction of aquatic communities in the reservoir area itself, as well as downstream. Nature conservation areas are often established around reservoirs to prevent siltation in the basin and to increase the life of a reservoir. This may benefit terrestrial ecological communities, but has few benefits for aquatic communities, the very part of the biosphere most seriously impacted by reservoir creation. Sontirat[30] reports a sharp decline in fish biodiversity in two reservoirs in Thailand constructed for hydropower generation.

In the first years after completion of a reservoir some fish species may become more abundant. However, local fishermen are often unprepared for this and unfamiliar with techniques to catch fish in the new reservoir environment. Outsiders rather than locals may have more experience with such conditions and eclipse local fishermen, thus reducing their food supply. In addition the prospect of profitable economic activity may attract outsiders to the reservoir area, thereby increasing the fishing pressure and other impacts (pollution, deforestation, siltation, etc.). An example of this may be observed at Sirikit reservoir where the floating fishing village, Pak Nai, causes localised deterioration in water quality from organic pollution.[31]

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[29] *Freshwater Biodiversity in Asia – With Special Reference to Fish*, M Kottelat and T Whitten, World Bank Technical Paper 343, (1996).

[30] Studies on the Effects of Some Hydro-electric Dams on Fish Species Composition in Thailand, S Sontirat (1991)

[31] Personal Communication, EGAT (1998)

The implications of the Kok-Ing-Nan project for fisheries aquatic ecology and freshwater biodiversity are therefore potentially very significant. This is because of the nature and scale of the project, the socio-economic and ecological importance of such aquatic ecosystems, and also because of the sensitivity of such systems to change. In addition, potential impacts will prove difficult to predict and evaluate because of the lack of detailed knowledge and understanding of the nature and status of freshwater fisheries and aquatic ecology in Thailand. Supplementary studies have therefore been undertaken to attempt to address some of these issues in more detail.

(2) Assessment of Existing Fisheries and Aquaculture Production

Human communities depend on freshwater ecosystems and biodiversity for a number of reasons. However, fish are often identified as the most significant because of their overwhelming economic importance, primarily as a food source, but also for fertiliser, medicine or use merely for pleasure in aquaria. An assessment was therefore undertaken of the existing fisheries and aquaculture present in the project area.

Very little work has been undertaken in Thailand on the true economic value of freshwater fisheries. The few available data are mainly fisheries statistics that are of limited value for three main reasons. Firstly most statistics do not discriminate between aquaculture and capture fisheries. Secondly, statistics are often unreliable because of their method of collection and the difficulty in collecting accurate information - it is not uncommon to see statistics for areas where data is rarely collected, and it is often advantageous for fishermen to underestimate catches. The third and most significant point is that fisheries statistics, in the main, represent only catches that are commercially sold in markets and completely overlook subsistence fisheries, which represent a much larger biomass.

Commercial fisheries are usually exclusively represented in official statistics. However, these are probably not the most crucial resource for the majority of the population, especially the impoverished. Almost everywhere along rivers in the project area people catch fish; larger fish are sold at markets or to middlemen, and smaller fish are eaten locally. This is probably the main source of animal protein in the project area, and is reported to be the preferred source of animal protein in Thailand,[32] and yet is virtually ignored in official statistics.

The underestimation may be considerable as household consumption studies in North-east Thailand suggest actual fish consumption to represent 32,200 tonnes, a figure 5.5 times higher than the reported quantity of fish caught and cultured.[33] Official statistics for the fisheries catch and aquaculture production in the lower Mekong basin for Laos, Thailand, Cambodia and Vietnam in 1992 estimated the catch at 360,000 tonnes. However, the Mekong River Commission suggests that the total fisheries catch and aquaculture production may be as high as 1 million tonnes. A field assessment of the situation in the project area was therefore deemed desirable.

(a) Fisheries in Natural Waters

In the provinces of the project area, most of the fishing grounds are natural waters such as rivers, natural swamps and lakes. The total area of fishing grounds recorded is 167,660 rai for Chiang Rai, 61,921 rai for Phayao, and 19,700 rai for Nan.

An interview survey was conducted along the Ing, Kok, Lao and Lao Kao Rivers with a sample of fishermen and villagers using a questionnaire on the 20 and 22-23 November 1998. One informal interview sample was taken from each sampling station. The sampling stations

[32] *Personal Communication* - Village Head, Ing Basin (1998)

[33] *Summary Report on Analysis of Freshwater Fish Consumption and Marine Product Marketing in North-east Thailand* - P. Prapertchob (1989) Northeast Fisheries Project Report No. 9 DOF/CIDA

are illustrated on Figure 5.4.1. The aims of the survey on fisheries activities along the rivers were:

- to examine the seasonal migration of fish from the Mekong River to inland fishery sources and to qualitatively assess the relative abundance of the different species encountered in the Ing, Kok, Lao and Lao Kao Rivers in Chiang Rai; and

- to observe the existing fishery activities along the Ing, Kok, Lao and Lao Kao Rivers.

The results from the survey are summarised below:

- Existing Fisheries along the Kok River

  The results from the survey, although strictly limited in nature, indicate that fisheries activity along the Kok River is mainly for catching fish for domestic consumption and not for commercial sale. Some commercial fisheries are found at Chiang Rai Weir, situated in Amphoe Muang Chiang Rai, where it is common to see several fishermen.

  At the weir, commercial fishermen mainly use fishing methods such as rod and line with some netting, and generally fishing lasts for a duration of around 4 to 5 hours a day. Fishermen fishing for domestic consumption rather than commercial sale usually utilise nets, including seine nets and gill nets, or use rod and line. Fishing on such an *ad hoc* basis lasts for a duration of anywhere between 1 and 8 hours a day.

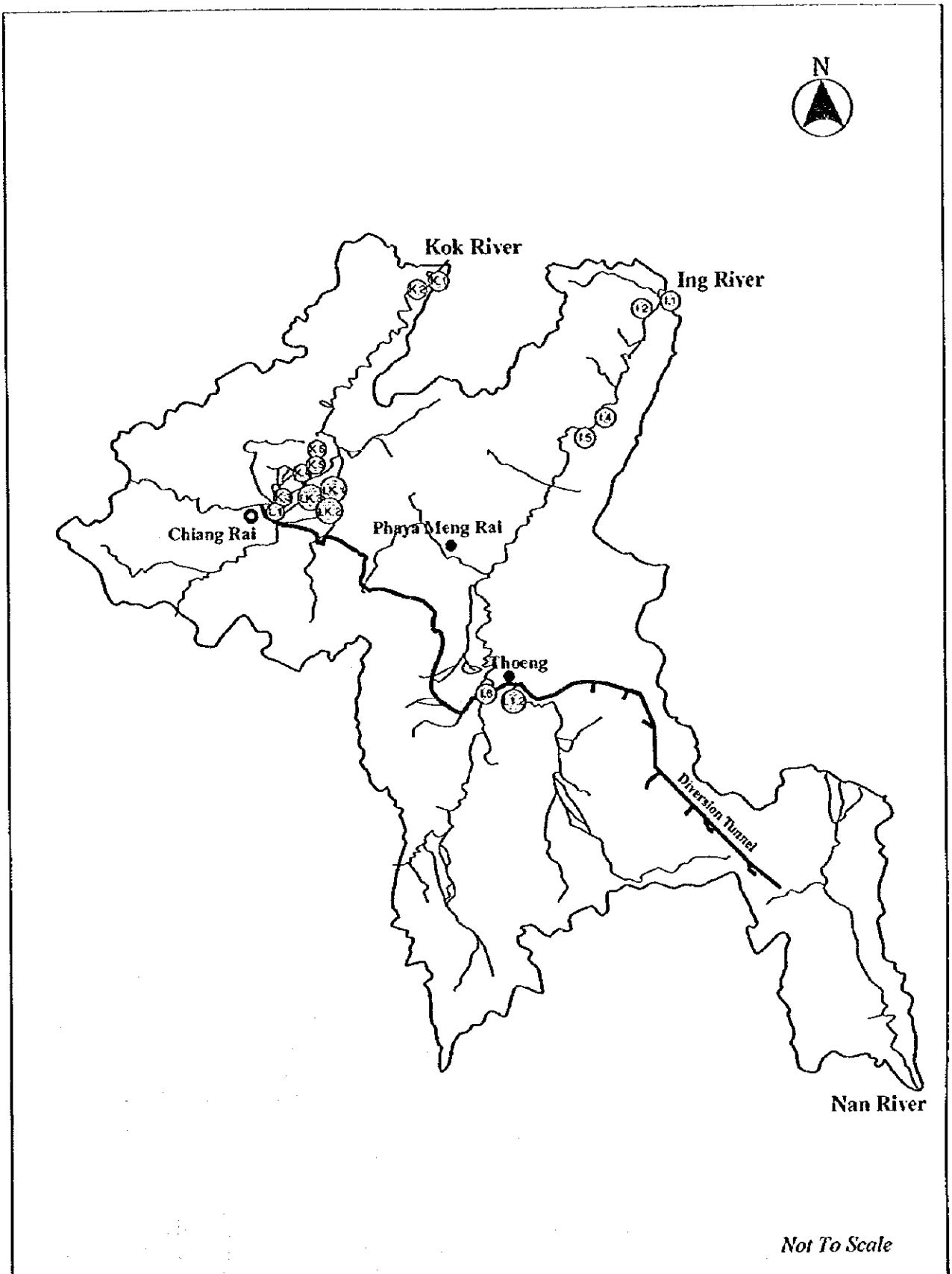
  From additional survey work carried out on the Kok River it is apparent that fish traps are common along the riparian margins. In addition, some local people reported other illegal methods such as poisoning, explosives or electro-fishing, which was reported to be particularly successful.[34] The impacts of such illegal methods have not been quantified and their effects on overall fish populations are not known.

  In the interview survey, fishermen indicated that the main fish species found in the Kok River, which are also known to be common in the Mekong River and may migrate between the two rivers, included:

  - Jullien's Mud Carp (*Pla Sroi Khaw*)***;
  - Yellow Mystus (*Pla Kod Luang*)***;
  - Great Black Shark (*Pla Ka* or *Pla Plie*)**;
  - Great White Sheatfish (Pla Kao)**;
  - Giant Bagarius (*Pla Kae*)**; and
  - Bleeker (*Pla Kang*)**.

  (*** indicates very abundant and ** indicates abundant)

[34] *Personal Communication* - Village Head, Kok Basin (1998)



ENVIRONMENTAL STUDY THE KOK-ING-NAN WATER DIVERSION PROJECT	Figure 5.4.1. Locations of Fisheries Survey Stations in the Project Area
JAPAN INTERNATIONAL COOPERATION AGENCY	

The Mekong Catfish (*Pla Buak*) was reported to be caught occasionally at Nam Lua Watergate, a small-scale irrigation project implemented by RID, situated at Ban Santhad (Tambon Yo Nok, Amphoe Chiang Saen) and specimens caught here were reported to weigh in the region of 50-60 kg. Fishermen generally indicated that fish catches were highest in the wet season.

For domestic consumption, fish catches were reported to be approximately 0.5-5 kg per day in the dry season and 5-6 kg in the wet season. For commercial fishermen, fish catches were reported to be approximately 2-6 kg per day in the dry season and up to about 20-30 kg in the wet season, reaching a maximum of up to 100-200 kg per day in September. The average fish catch during the year was reported to be approximately 5-6 kg per day.

The market prices for fish are dependent on size and, as a rule of thumb, are higher per unit weight the larger the fish. The fishermen's incomes were reported to be approximately 100-200 Baht per day in the dry season and average about 200-300 Baht per day over the full year. Market prices reported for the different species of fish commonly caught and sold are listed in Table 5.4.1.

Table 5.4.1. Market Prices (Baht per kg) for Different Fish Species in the Kok, Ing, Lao and Lao Kao Basins.

Species	Kok Basin	Ing Basin	Lao Basin	Lao Kao Basin
Great Black Shark	50-80	30-150	50-80	NR
Jullien's Mud Carp	30-40	20-50	30-40	40-50
Yellow Mystus	60-100	60-150	60-100	80
Great White Sheatfish	100-150	100-150	100-150	100
Giant Bagarius	100-150	150	100-150	-
Bleeker	70-120	120-150	70-120	-
Mekong Catfish	-	600	-	-

NR = Not reported because of the infrequency of catches, - = fish not caught in this basin.

- Existing Fisheries along the Ing River

The results from the survey, although strictly limited in nature, again indicate that fisheries activity along the Ing River is mainly for catching fish for domestic consumption and not for commercial sale. A limited number of commercial fisheries are found at Ban Pak Ing Tai, a village situated near the Mekong-Ing confluence, in Tambon Sri Donchai, Amphoe Chiang Khong. This area is managed as a conservation zone during the spawning season in June and July and fishing activity is suspended during this time. In addition, some reaches of the Ing River at Tambon Boon Ruang, Amphoe Chiang Khong, are also managed as conservation zones, with the objective of conserving the fish populations so that they may reproduce and replenish stocks in other river reaches.

Fishermen who fish mainly for domestic consumption utilise simple fishing methods such as netting with seine nets and rod and line and spend approximately 3-6 hours a day fishing. Some use gear like gill nets and spend approximately 12-24 hours per day fishing. Commercial fishermen also use nets such as gill nets and seine nets, and spend between 12 and 24 hours a day fishing. In addition, it was reported that at Ban Pak Ing Tai some fishermen have been using illegal methods such as electro-fishing and explosives.

In the interview survey, fishermen indicated that that the main fish species found in the Ing River, that are also common in Mekong River and may migrate between the two rivers, included:

- Greater Black Shark***;
- Jullien's Mud Carp***;
- Yellow Mystus***; and
- Great White Sheatfish***.

(*** indicates very abundant and ** indicates abundant)

Giant Bagarius, Bleeker and Mekong Catfish were reported to be much less abundant and are caught only at Ban Pak Ing Tai. Specimens of Mekong Catfish caught in this area weigh approximately 150-300 kg.

During the survey, fishermen indicated that fish are abundant in July and very abundant during August and September. Fish catches decline in October and are very low during the rest of the year. However, at Ban Pak Ing Tai, fish were reported to be abundant until December and, at Ban Sri Donchai in Amphoe Chiang Khong, the Greater Black Shark and Jullien's Mud Carp are common all year round.

During the wet season, especially in August and September, fish catches are higher and the average size of the fish is larger. Fish catches for domestic consumption average approximately 0.5-3 kg per day in the dry season and 3-5 kg per day in the wet season. For commercial fishermen, the average fish catch was reported to be approximately 5-6 kg per day in the dry season, rising to a maximum of 30-50 kg per day in the wet season.

The market prices for fish are dependent on size and, as a rule of thumb, are higher per unit weight the larger the fish. The fishermen's incomes were reported to be approximately 100-200 Baht per day in the dry season, and up to a maximum of 2000 Baht per day in the wet season. Market prices reported for the different species of fish commonly caught and sold are listed in Table 5.4.1.

- Existing Fisheries along the Lao River

The results from the survey, although strictly limited in nature, once again indicate that fisheries activity along the Ing River is mainly for catching fish for domestic consumption and not for commercial sale. A limited number of commercial fisheries are found at Ban Thung Khan Chai (Tambon Wieng, Amphoe Thoeng) where the river is managed as a conservation zone during the spawning season in June and July and fishing activity is suspended.

Fishermen who fish only for domestic consumption simply use netting and gill-netting for approximately 2-3 hours a day. Commercial fishermen use more sophisticated methods such as long lines that are placed in the river for approximately 6 hours a day, and gill nets which are left in the river for up to 12 hours a day.

In Amphoe Muang, one domestic fisherman reported that fish including the Greater Black Shark, Jullien's Mud Carp, Yellow Mystus and Giant Bagarius are all common. Another fisherman at Ban Thung Khan Chai, Amphoe Thoeng, reported that the Great Black Shark, Jullien's Mud Carp and Yellow Mystus were all abundant but that Giant Bagarius are less common. The fishermen reported that fish are abundant in July and

even more abundant in the months of August, September and October, after which catches diminish to very low levels for the remainder of the year.

Fish catches for domestic consumption average approximately 1-2 kg per day during the dry season and about 3-4 kg a day in the wet season. Commercial catches were reported to be approximately 2-6 kg per day in the dry season, rising to a maximum of 10 kg per day in the wet season.

The market prices for fish are dependent on size and, as a rule of thumb, are higher per unit weight the larger the fish. The fishermen's incomes were reported to be approximately 50-200 Baht per day in the dry season and up to a maximum of 500 Baht per day in the wet season. Market prices reported for the different species of fish commonly caught and sold are listed in Table 5.4.1.

- Existing Fisheries along the Lao Kao River

In addition to the surveys conducted along the Ing, Kok and Lao Rivers, a survey was also conducted on the Lao Kao River and the results indicate that the majority of fishing along the river is for domestic consumption. The fishermen usually use nets, such as seine nets and gill nets, and generally fish for approximately 4-5 hours a day.

Great White Sheatfish, Jullien's Mud Carp and Yellow Mystus were all reported to be common species in the basin. The Greater Black Shark, that was reported to be abundant and very abundant along the Ing, Kok and Lao Rivers, is rarely caught in this basin. It was reported that fish are abundant in July, and very abundant in August and September, becoming scarcer after October although catches are still reasonable until about April. Fish catches average approximately 0.2-3 kg a day in the dry season and about 2-3 kg in the wet season.

Market prices for fish are dependent on size and, as a rule of thumb, are higher per unit weight the larger the fish. Market prices reported for the different species of fish commonly caught and sold are listed in Table 5.4.1.

(b) Fish Consumption

In the provinces of the project area, fish and fish products are of great importance in the local diet as a source of protein. The current demand for fish in the project area has not been assessed. However, the national target of per capita consumption of fish has been set at 20 kg since 1980 and remains unchanged. In the project area total fish production has been consistently increasing from 3,163 tonnes in 1990 to 7,545 tonnes in 1994, the last year for which official data are available The data are summarised in Table 5.4.2.

Given the population of the three provinces in the project area was approximately 2.1 million in 1994, the per capita freshwater fish consumption was about 3.6 kg. However, as previously described, the Mekong River Commission has suggested that the estimation of freshwater fish production in the Mekong riparian countries may be 3.5 times less than the actual catch. There is therefore some justification in assuming that per capita freshwater fish consumption in the project area may be around 10 kg per person per year.

Table 5.4.2. Freshwater Fish Production (tonnes/year), including Aquaculture, in the Project Area (Source: Department of Fisheries).

Province	1990	1991	1992	1993	1994
Chiang Rai	1,637	2,049	2,087	1,205	2,217
Phayao	567	2,377	2,368	3,323	3,665
Nan	959	1,151	1,126	1,403	1,663
Total	3,163	5,577	5,581	5,931	7,545
Total Northern	40,512	50,301	59,602	74,308	80,053
Total as % of Total Northern	7.8	11.1	9.4	8	9.4

(c) Economic Significance of Fisheries in the Project Area

Despite the relatively modest size of the fisheries in the project area, the contribution to the local economy is significant. In 1994 total freshwater fish production in the project area was 7,545 tonnes of which 2,217 tonnes, 3,665 tonnes, and 1,663 tonnes was produced in the respective provinces of Chiang Rai, Phayao and Nan. If the theory of underestimation of fish production is once again considered, and an underestimation of a factor of 3.5 is taken into consideration, the freshwater fish production would be 7,800 tonnes, 12,800 tonnes and 5,800 tonnes for the three provinces respectively. This is estimated to have a value of approximately 160 million Baht, 260 million Baht and 120 million Baht for Chiang Rai, Phayao and Nan, respectively. Thus, fisheries contribute about 3%, 9% and 4.5 % of the agricultural production of the respective provinces (Table 5.4.3).

Table 5.4.3. Economic Status of the Project Area (Million Baht). (Source: Ministry of Interior)

Provinces	Gross Provincial Product (Thousand Baht)	Per Capita Income (Baht)	Agriculture (Thousand Baht)	Fisheries (Thousand Baht)
Chiang Rai	31,516,217	28,521	5,565,912	155,200*
Phayao	12,869,527	25,719	2,917,658	256,600*
Nan	11,489,532	26,232	2,518,521	116,400*

*consultant's estimation

(d) Aquaculture in the Project Area

Currently aquaculture in the project area contributes significantly to total fish production. In 1994 total production from the provinces in the project area was 1,129 tonnes of which 536.2 tonnes were produced in Chiang Rai, 418.8 tonnes in Phayao and 173.7 tonnes were from Nan. Based upon these figures aquaculture contributes about 14.4 % of the total fish production in the project area. Fish production in the project area by provinces is shown in Table 5.4.4.

In terms of socio-economics, fish culture is quite well distributed across the project area, except a few particularly large commercial aquaculture ventures in Chiang Rai. The total number of fish-farmers in the project area is 9,374 of which 3,652, 3,487 and 2,195 are located in Chiang Rai, Phayao and Nan respectively. The distribution of aquaculture in area is on average approximately 1 rai/farm; in Chiang Rai it is higher at 1.47 rai/farm, lower in Phayao at about 0.82 rai/farm and significantly lower in Nan at 0.5 rai/farm These figures are illustrated in Table 5.4.5. The number of fish farmers and cultivated area by Amphoe in Chiang Rai, Phayao and Nan are detailed in Tables 5.4.6. to 5.4.8., respectively.

Table 5.4.4. Fish Production from Aquaculture (tonnes) in the Project Area 1994 (Source : Department of Fisheries).

Province/Type	Pond	Paddy Field	Ditch	Cage	Total	Value (M. Baht)
Chiang Rai	499.7	36	0.5	0	536.2	15.8
Phayao	318.8	1	7	0	418.8	10.9
Nan	164.7	0	0	9	173.7	4.7
Total	983	37	7.5	9	1,129	31.4
Total Northern	28,247	143	131	796	29,317	684
Total as % of Total Northern	3.5	25.9	5.7	1.1	3.9	4.6

Table 5.4.5. Number of Fish Farms and Culture Area (rai) in the Project Area (1994) (Source: Department of Fisheries).

Culture Type	Pond		Paddy Field		Ditch		Cage		Total	
Province	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Chiang Rai	3,607	4,623	72	779	13	8	0	0	3,692	5,410
Phayao	3,441	2,771	13	74	33	33	0	0	3,487	2,878
Nan	2,169	1,123	0	0	0	0	26	1	2,195	1,124
Total	9,217	8,517	85	853	46	41	26	1	9,374	9,412

Table 5.4.6. Number of Fish Farmers, Culture Area and Production by Amphoe in Chiang Rai Province (1997) (Source: Chiang Rai Provincial Fisheries Office).

District	No. of fish farmers	Area (rai)	Production (tonne/year)
Muang	2,175	1,888	N.A.
Mae Chan	1,914	2,727	N.A.
Mae Sai	763	1,316	N.A.

N.A. - no data available

Table 5.4.7. Number of Fish Farmers, Culture Area and Production by Amphoe in Phayao Province (1995) (Source: Phayao Provincial Fisheries Office).

District	No. of fish farmers	Area (rai)	Production (tonne/year)
Pong	457	201	65,154
Maechai	204	252	20,160
Total	5,312	4,409.60	451,114

Table 5.4.8. Number of Fish Farmers, Culture Area and Production by Amphoe in Nan Province (1996) (Source: Nan Provincial Fisheries Office).

District	No. of fish farmers	Area (rai)	Production (tonne/year)
Muang	517	299	N.A.
Wieng Sa	1,256	617	N.A.
Na Noi	418	126	N.A.

A survey of aquaculture in the Kok and Ing Basins was carried out in December 1998 using a questionnaire survey. One sample interview was taken from each of the following districts (*amphoes*) as shown in Figure 5.4.2.

Kok Basin	
K.1	Ban Tha Bundai (Moo 1), Tambon Wiang Nua, Amphoe Wiang Chai;
K.2	Ban Tha Kao Pluak (Moo 7), Tambon Tha Kao Pluak, Amphoe Mae Chan; and
K.3	Ban Mai Klang (Moo 7), Tambon Nong Pla Kho, King Amphoe Doi Luang.
Ing Basin	
I.1	Ban Thung Khan Chai (Moo 10), Tambon Wiang, Amphoe Thoeng;
I.2	Ban Nong Hed, Tambon Nong Hed, Amphoe Thoeng;
I.3	Ban Wiang Wai (Moo 8), Tambon Meng Rai, Amphoe Phaya Meng Rai; and
I.4	Ban Kan (Moo 13), Tambon Huai So, Amphoe Chiang Khong.

The results of the survey indicate that the majority of aquacultural activities operating in the Kok and Ing Basins are not dependent on water from the Kok and Ing Rivers, due to the high costs incurred for pumping water from the rivers. The rivers often have very low water levels in the dry season representing a high head and correspondingly high pumping costs. Only one farm was identified that utilised water from the Ing River for aquaculture. Details of water sources for the different fish-farms surveyed are given in Table 5.4.9.

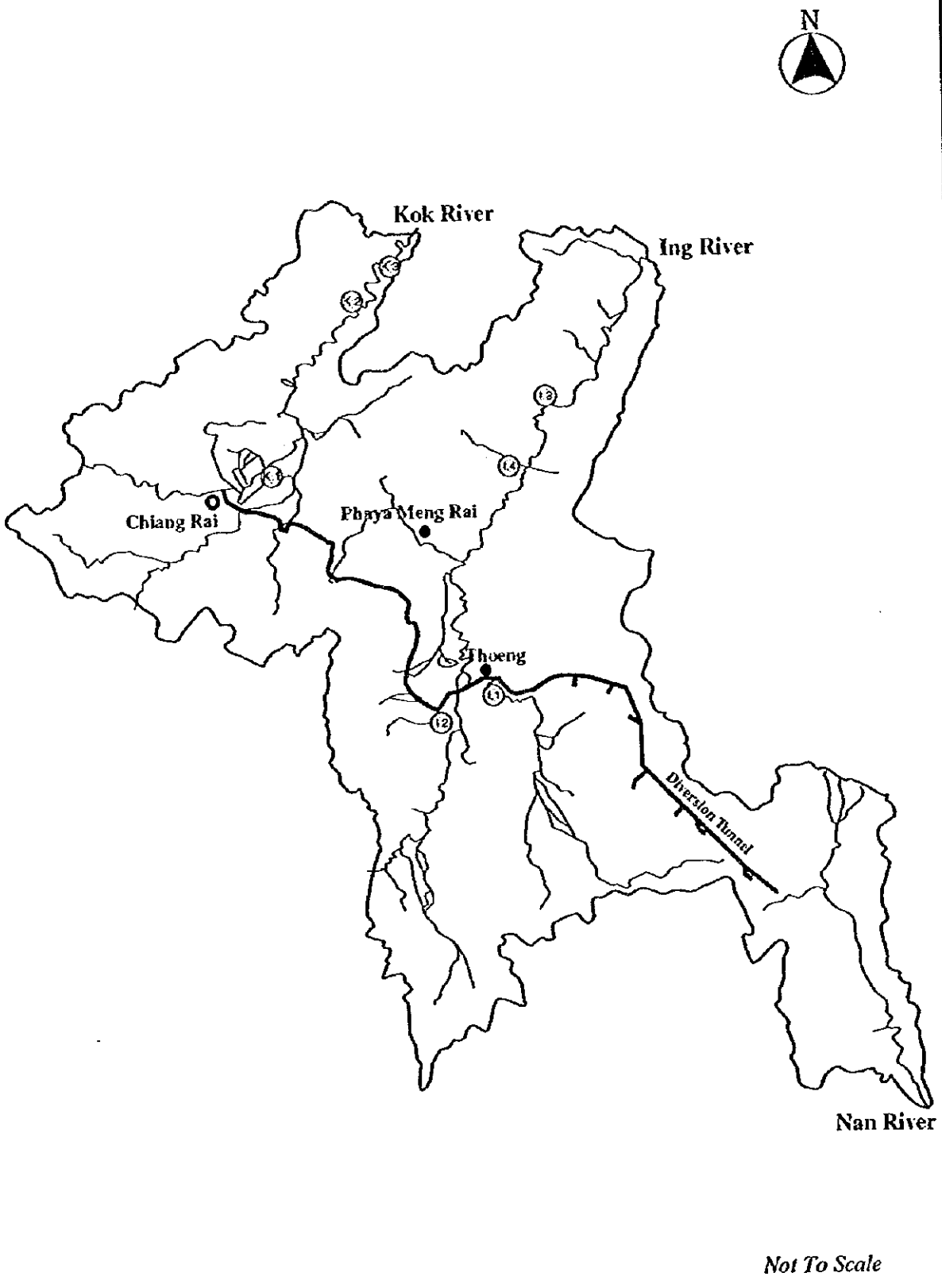
Table 5.4.9. Water Use in Aquaculture in Areas Adjacent to the Kok and Ing Rivers.

Amphoe/King Amphoe	Source of water for aquaculture	Average distance from the river (km)	Number of farms interviewed during the survey
Kok Basin			
1. Amphoe Wieng Chai	rain-water	0.5	2
2. King Amphoe Wieng Chiengrung	rain-water	5.0	-
3. Amphoe Mae Chan	rain-water	1.0	2
4. King Amphoe Doi Luang	rain-water	1.0	1
5. Amphoe Chieng San	rain-water	5.0	-
Ing Basin			
1. Upstream area of Nam Ing Weir* in Amphoe Thoeng	Ing and Lao Rivers	0.5	2
2. Amphoe Thoeng	rain-water	2.0	-
3. Amphoe Phaya Meng Rai	rain-water	less than 0.5	-
4. Amphoe Chiang Khong	rain-water	2.0	5
	Ing River**	0.4	1

Remarks: The survey was carried out on farms within 1.5 km of the main river channel.
The vicinity of Nam Ing Weir is not part of the study area.

* The area was included because one farm operated using water from the Ing River, and another uses water from the Lao River.

** Only one farm was identified that utilised water from the Ing River.



ENVIRONMENTAL STUDY THE KOK-ING-NAN WATER DIVERSION PROJECT	Figure 5.4.2. Sampling Stations for the Aquaculture Survey
JAPAN INTERNATIONAL COOPERATION AGENCY	

- Aquaculture along the Kok River

The interview survey was carried out at 5 farms in Amphoe Wiang Chai, Amphoe Mae Chan and King Amphoe Doi Luang. The survey revealed that there are no co-operative groups in the area and the aquaculture here is operated both as a primary and supplementary occupation. Only one farm is operated just to produce fish for domestic consumption and having no commercial interests. From the survey results the average farm size was determined as approximately 9 rai, with average annual fish production of approximately 2,550 kg/rai and total income of around 45,000 Baht/year. The main problems encountered by the farmers included diseases in fry, high cost of fish food, water shortages in the dry season and financial difficulties.

Fish species cultured include Nile Tilapia (*Pla Nile*) which is by far the dominant species, Common Silver Barb (*Pla Tapien*), Batrachian Walking Catfish (*Pla Dook*), Common Carp (*Pla Nai*) and Striped Catfish (*Pla Sawai*).

- Aquaculture along the Ing River

The interview survey downstream of the proposed Ing Diversion Weir was carried out at 6 farms operating in the area near the Ing River in Amphoe Phaya Meng Rai and Amphoe Chiang Khong. The survey results indicate that fish farming in this area is mainly undertaken as a supplementary occupation, with no organised co-operatives operational in the area. The average farm size in the area is quite small in Amphoe Phaya Meng Rai, averaging about 2.2 rai. By contrast, in Amphoe Chiang Khong, the average size of a farm is around 20 rai, with fish production of around 600 kg/rai, giving an income of around 4000 Baht per rai per year. Two farms are operated merely for domestic consumption having no commercial interests. Fish species cultured are mainly Nile Tilapia, Common Carp, Common Silver Barb, Batrachian Walking Catfish and Striped Snake-Head Fish (*Pla Chon*). About half of the farmers who were interviewed reported difficulties including high costs of water pumping and diseases in fry.

The interview survey upstream of the Nam Ing Weir was carried out on two farms located about 2 km upstream of the weir, in Amphoe Thoeng. One covers an area of approximately 80 rai, and utilises water pumped from the Ing River. The farm cultures the Giant Freshwater Prawn and achieves production levels of approximately 50 kg/rai. In addition the farm also cultures fish including Nile Tilapia, Common Carp, Great White Sheatfish and Mekong Catfish, which achieve production levels of approximately 2,000 kg/rai. The total income generated at this farm was estimated at 10 million Baht per year. The second farm also cultures Giant Freshwater Prawn, covers an area of approximately 9 rai and utilises water pumped from the Lao River. The farm also has a production level of around 50 kg/rai and generates income of approximately 600,000 Baht per year.

(3) Fisheries Legislation and Its Implications for the Project

The following section represents a review of the legislation pertinent to implementation of the project. The project requires close consultation with the Department of Fisheries throughout its development.

The legislation is described in more detail below.

The *Fisheries Act* B.E. 2490 (1947), as amended by the *Fisheries Act (No. 2)* B.E. 2496 (1953) and the *Fisheries Act (No. 3)* B.E. 2528 (1985), includes a number of relevant provisions, most of which require obtaining permission from the "competent official":

Section 4. In this Act:

(1) "Aquatic animals" means animals that inhabit or have one part of their life cycle in water, or inhabit inundated areas, such as fish, shrimps, crabs, horseshoe crabs, molluscs, tortoises, turtles, snapping turtles, crocodiles including their eggs, mammals, sea-cucumbers, sponges, coral, coralline and marine algae, as well as their carcasses or any part of them and includes water plants as specified by a Royal Decree.

(5) "Fisheries" means land with still or running water such as sea, river, canal, swamp, marsh, pond and beach, which are domaine public of State, including forest and ground which are inundated during flood season, not withstanding that it be domaine public of State or the land owned by any person, and being within territorial waters, or any other waters in which Thailand exercises or may be entitled to exercise its fishery rights, as such waters publicly appear to be delimited by local or international law or usage, by treaty or in any other way.

(16) "Competent official" means provincial governor, district officer, fishery officer or other person who is appointed by the Minister to carry out this Act.

Section 17. - No person shall erect anything in preservation fisheries, leasable fisheries, reserved fisheries which are not owned by a person, and in public waters, [...] unless permission has been obtained from the competent official.[35]

Section 19. - No person shall pour, throw away, drain or lay in the fisheries such poisonous substance as determined by the notification of the Minister in the Government Gazette, or do any act that stupefies the aquatic animals, or pour, throw away, drain or lay in the fisheries any substance in the manner that it is dangerous to aquatic animals or causes pollution therein [...].

Section 21. - No person shall make any alteration to the fisheries not lying within the land owned by a person affecting its former condition, unless permission has been obtained from the competent official. The licensee must comply with the conditions imposed by the competent official.

Section 22. - No person shall erect, set up or build a dike, dam, screen, fence, fishing nets or other fishing implement in fisheries obstructing the passage of aquatic animals, unless permission has been obtained from the competent official or if it is for the agricultural purposes in the land owned by the person. The licensee must comply with the conditions imposed by the competent official such as those in relation to fish-ladders or other implements enabling aquatic animals to swim up and down.

Section 55. - No person shall introduce in any fisheries any kind of aquatic animals as specified by a Royal Decree, unless permission has been obtained from the competent official.

Section 55 might be relevant if an exotic species of fish (listed in a relevant Royal Decree) were already present in the Kok or Ing Rivers, but not in the Nan River, and construction of the diversion canal were to result in its introduction to the Nan River.

[35] [...] indicates text included in the original has been omitted for the sake of brevity.

The *Wild Animals Preservation and Protection Act* B.E. 2535 (1992) lists preserved and protected species.

Section 6 of the *Enhancement and Conservation of National Environmental Quality Act* B.E. 2535 (1992) accords a number of rights including

> *(2) To be remedied or compensated by the State in case damage or injury is sustained as a consequence of dangers arisen from contamination by pollutants or spread of pollution, and such incident is caused by any activity or project initiated, supported or undertaken by government agency or state enterprise.*

Thus, if the project were to cause water pollution, RID might be liable for prosecution.

The Ministerial Regulation No. 9 (1966), under the 1942 Royal Irrigation Act, restricts use of particular fishing gear in class I irrigation water bodies (used for irrigation purposes only) and class II irrigation water bodies (used for navigation and irrigation purposes).

A number of legislative acts prohibit the pollution of, or dumping of material in, water bodies, and activities that could result in damage to fisheries, including:

- Civil and Commercial Code,
- Penal Code,
- Maintenance of Canals Act B.E. 2446 (1903),
- Royal Thai Irrigation Act B.E. 2485 (1942) as subsequently amended,
- National Parks Act B.E. 2504 (1961) or subsequent revision,
- Minerals Act B.E 2510 (1965) as subsequently amended,
- Navigation in Thai Waterways Act B.E. 2535 (1992).

In particular, the project requires attention with respect to Section 22 of the Fisheries Act. The section relates to the design of any fish passes or ladders required by the project which must allow the free passage of aquatic fauna upstream and downstream of any structure. Issues relating to fish movement and migration are discussed in more detail in the subsequent section.

(4) Potential Impacts of Hydraulic Structures on Fish Movement and Migration

One well-understood impact on fish species composition and biodiversity is the creation of a barrier to fish movement across a river, since it will alter the longitudinal migration pattern of fishes. Fish movement upstream and to a lesser extent, downstream is obstructed by such facilities. Such a restriction in fish movement may impact species diversity, community structure and population size. Any impact on such a significant ecological and socio-economic resource must be avoided; there is no successful way to mitigate destruction of a formerly productive and diverse ecosystem.

There is an existing structure on the Kok River at Chiang Rai, Chiang Rai weir, which currently prevents free passage of aquatic fauna upstream and restricts the movement of aquatic fauna downstream. This structure is believed to impact fish populations upstream of the weir, a theory that is supported by markedly poorer fish catches in the river[36] upstream of the weir. The impact of the weir is so significant that little effort is expended by local fishermen upstream of the weir, in contrast to the productive subsistence and artisanal fisheries that are present downstream of the weir.

The legal requirement of the project to allow free passage of aquatic fauna upstream and downstream of structures dictated that fish passes or ladders are incorporated into the designs of all permanent river structures. In considering the design and purpose of such structures the issue of

[36] *Personal Communication*, Chiang Rai fishermen, October 1998.

Chiang Rai weir and its impedance on fish movement was highlighted, and as a consequence, the project has incorporated the design and construction of a fish pass or ladder for the weir.

Effective fish passage through a fish pass or fish ladder is essential in order to prevent significant loss of habitat and isolation of fish stocks from historic habitat that may lead to lowered productivity, decreased biodiversity, and conversion of preferred fisheries to those with less desirable and less marketable species.

As previously described, Thailand's fish fauna is extremely diverse, and if there are a number of different species migrating through the project area, each species may require different criteria for passage making an effective fish pass scheme difficult to design and operate. Design and operation of successful fish passes in south-east Asia is not well documented or proven, and many examples exist of structures that do not work satisfactorily such as those at Pak Mun Dam in North-east Thailand and at Phayao Lake.

The design and construction of existing fish passes in Asia has largely followed models from temperate countries where they are designed primarily for sport and game fish such as trout and salmon. Transposed to Asian rivers with fish communities which include a larger number of migrating species or species that have the requirement to move around extensively within the river basin, the structures constructed to date have largely failed to allow the normal movement of fish and other aquatic organisms. A large proportion of the migratory fish are bottom dwelling fish that are unable to "jump" and therefore unable to utilise existing fish passes or ladders. Some have adapted their behaviour and breed in habitats to which they are newly confined, however many others have simply failed to breed at all.

There is therefore an urgent need to investigate the feasibility of effective fish ladders, fish passes, lifts or swimways that are suitably adapted to the needs of indigenous fish species. However, for many species there is currently insufficient knowledge of their biological requirements to enable adequate measures to be taken.

An additional problem is that fish often have difficulty finding the entrance of the fish passes or fish ladders and it must be borne in mind that if fish migrate in one direction they, or their offspring, need to return downstream again, and not via a turbine or spillway. Villagers downstream of the Pak Mun dam have reported incidences of headless fish downstream of the dam that have been macerated as they pass through the dams turbines or through the partially-opened flood gates, the only route available to migrating to fish to pass downstream again[37]. Newspaper reports have attributed the Pak Mun dam, completed in 1994, with the destruction of 90% of the Mun River's once productive fisheries. The issue of fish passage upstream and downstream of any hydraulic structures is therefore particularly important, and design of a successful structure is likely to require a substantial amount of research and development.

(5) Potential Impacts on Flood Fisheries in the Kok and Ing Basin

As previously discussed, seasonal flooding of the flood plain areas of the river basins is extremely significant for fisheries ecology. Floods are crucial events for many riverine fisheries as during flooding many fish invade the inundated land where food is abundant for the adults and the fry; most fish spawn during floods or immediately before or after[38]. The adult fish and fry then return to the main channel as the floodwaters recede.

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[37] *Watershed*, Vol. 1, No. 3, March – June 1996, 'Pak Mun: The Lessons are Clear, But is Anyone Listening?' A Wangpattana

[38] *An Analytical Study of the Fish Fauna of the Mekong Basin as a Biological Production System in Nature* – Y Taki (1978) Research Institute of Evolutionary biology – Special Publication.

The numerous small lakes found in floodplain areas are also included in this category. Some function as buffers, filling with water during the high water levels experienced during flood events and then releasing it as water levels recede. These are very ephemeral episodes in the life of a large river, however they are crucial to maintaining biodiversity.

The potential impact on flood fisheries on the Kok and Ing Rivers is primarily related to the reduction of the spatial extents of flooded riverside areas caused by reducing the volumes of water discharged downstream of the Kok and Ing weirs during periods of high flows or flood flows. The volume of water to be diverted by the project, or the so-called "surplus" water constitutes up to 25% of the Kok River's annual run-off and 45% of Ing River's annual run-off.

The diversion of these volumes of water will obviously reduce the extent of downstream areas flooded during the rainy season. The most significant inundation areas in the project area are shown in Figure 5.4.3, and it is clear that the extent of some of these areas will be significantly reduced by the implementation of the project.

The impact of the reduction in size of these inundated areas and the reduction in frequency of inundation cannot be quantified with the available information on fisheries populations and community structure and therefore any assessment of the potential impacts is merely conjecture. It is imperative that an accurate assessment is made, not only because of the potential impacts on fisheries in the Kok and Ing basins but also for fisheries in the Mekong basin as a whole.

(6) Potential Impacts of Trans-basin Transfer of Water on Aquatic Ecology and Fisheries

The transfer of aquatic species from one river basin to another may seriously impact the aquatic biodiversity and fisheries of the basin to which they are transferred and in some cases may be comparable to the effects of introduced species. Threats posed by introduced species to freshwater biodiversity have been described as 'immense' and in the long-term may prove to be more damaging than habitat degradation and reduction because successful colonisation by introduced species is practically irreversible.

There are some well documented bio-geographical relationships between the, Mekong and Chao Phraya basins and hence their tributaries. Very similar habitats exist in the two basins including rivers, swamps, flood plains and estuaries, and with such similar conditions it might be expected that similar ecological assemblages exist. The evolutionary relationship between the two basins is well documented. Studies by Taki[39] [40]on the bio-geography of the Mekong, Chao Phraya and Greater Suda Islands fisheries have been reviewed and it has been concluded that almost all fish *genera* were originally shared between the Mekong and Chao Phraya basins. Rainboth (1996)[41] concluded in parallel with Taki that fish species assemblages of the middle Mekong River resemble those from the lower reaches of the Chao Phraya in central Thailand very closely.

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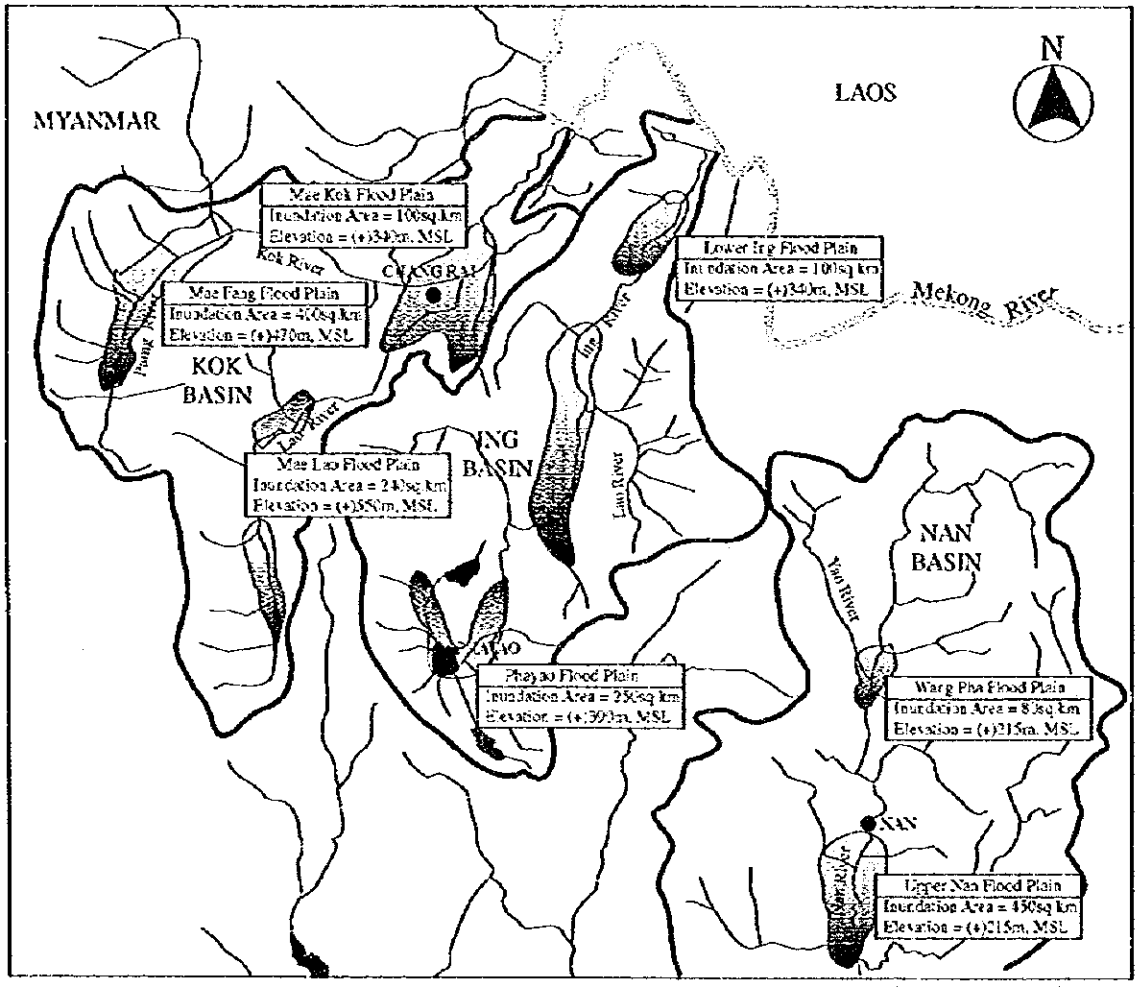
[39] *An Analytical Study of the Fish Fauna of the Mekong Basin as a Biological Production System in Nature* – Y Taki (1978) Research Institute of Evolutionary biology – Special Publication.

[40] *Fisheries of the Laos Mekong Basin* – Y Taki (1974) USAID Mission to Laos, Agricultural Development, Vientiane.

[41] *Fishes of the Cambodian Mekong* - W J Rainboth (1996) FAO Species Identification - Field Guide for Fishery Purposes. FAO. Rome



Not To Scale

ENVIRONMENTAL STUDY THE KOK-ING-NAN WATER DIVERSION PROJECT	**Figure 5.4.3. Kok-Ing-Nan River System and Inundation Areas**
JAPAN INTERNATIONAL COOPERATION AGENCY	

To establish the potential explanation for the similarities in species distribution between the two basins, the recent work of many geologists who reconstructed the geomorphology and drainage of previous river basins of Southeast Asia is relevant. From this information it is clear that the drainage patterns in the *Cenozoic* Era were very different from the drainage patterns present today. It is likely that over geological time tectonic activity and movements of the earth's crust have substantially changed river morphology and hydrology. It is possible that at one time, when river basin drainage patterns were different, that fish were able to migrate easily between the Mekong and Chao Phraya basins, hence the similarities.

The similar evolutionary history between the basins suggests that ecologically, the aquatic flora and fauna should be similar. It might therefore be tentatively concluded that trans-basin fish movement between Mekong and Chao Phraya basins, may have no adverse impact on species diversity, and may actually enhance species richness. However, as previously discussed, the ecological status of the fisheries and aquatic ecology in the Kok, Ing and Nan basins is not well understood, and the survey data collected by RID is not thought to be fully representative of the actual situation present in the basins. Until the status of the fisheries and aquatic ecology is more fully understood, and a more accurate assessment of status established, it would be unwise to make predictions regarding the potential impacts of trans-basin water transfers merely on the basis of evolutionary history.

In addition to the trans-basin transfer of species which may alter established natural communities, there is also a risk of transfer of pest species such as the Golden Apple Snail, a major rice pest which may cause significant damage in paddy fields, especially during the transplanting period. Although the Golden Apple Snail is widespread in Thailand, there is little information available as to its relative abundance across the Kok, Ing and Nan river basins. In 1997, the snail caused significant damage to rice in Chiang Rai province. If the snail is more common in one part of the project area than another the water transfer may assist its distribution by spreading the aquatic larval stages to new habitats. Further information on the distribution and occurrence of pest species, such as the Golden Apple Snail needs to be collected and assessed before detailed predictions of the implications of the water-transfer may be accurately assessed.

The impact of trans-basin water transfer on Sirikit reservoir also needs to be considered. Sirikit is a productive fishery in its own right and supports several fishing communities, including the floating fishing village of Pak Nai. The transfer of pest species or algal species to Sirikit may represent the major causes of concern, as Sirikit's fisheries are known to be far from natural and are stocked in what appears to be a somewhat *ad hoc* fashion. For example, the Mekong catfish has been stocked in the reservoir in the past and is reported to flourish in this environment.

Approximately 52 kilometres of tunnel link the Ing and Nan basins in the proposed project. During transport through the tunnel water may be subject to oxygen depletion due to lack of re-aeration in the tunnel and the oxygen demand exerted by decomposition of organic materials in the tunnel environment. However, Biochemical Oxygen Demand (BOD) measured in water samples from the Kok and Ing indicate that BOD is generally below 1.5 mg/l and with a residence time in the tunnel of less than six hours the impact on levels of dissolved oxygen is unlikely to be significant.

In addition to the potential impacts associated with oxygen depletion during the passage of water through the tunnel, it is possible that there will be a change in water temperature. This will be dependent on the ambient temperature in the tunnel, the flow rate and the volume of water flowing through the tunnel. The potential significance of temperature changes in the water in the tunnel are unlikely to be significant and are likely to be less than seasonal and diurnal temperature changes. This assumption is based on the design assumption that there is no thermal activity in geological strata through which the tunnels are to be constructed. Should thermal activity be encountered during tunnel construction the impact of temperature on water transport through the tunnels will have to be re-assessed.

(7) The Potential Impacts of Yao River Training on Fisheries and Aquatic Ecology

The impacts of the Yao River training works are potentially very significant permanent impacts. The average discharge of the Yao River at its confluence with the Nan River is 12 m^3/s and the maximum recorded discharge is 380 m^3/s[42]. The river training works will modify the morphology of the channel so that it is able to accommodate a design discharge of 265 m^3/s under normal conditions and 460 m^3/s under flood conditions[43]. The difference between these sets of figures gives an indication of the magnitude and significance of the channel modifications required; during diversion of water, the "normal flow" in the modified river channel will be in excess of twenty times the existing mean flow.

The existing river channel will be irreversibly modified with a loss of virtually all habitat and landscape features. The natural riffle and pool habitat will be completely lost from this stretch of the river with significant implications for fisheries habitat and invertebrate fauna. Such physical modifications to the river channel are likely to significantly change the nature and composition of existing ecological communities.

The natural flow regime will be completely altered and it is not known what the impact of such significant changes will be on fisheries and aquatic ecology. Flow velocities and water volume in the river channel are known to be cues for breeding in some fish species in south-east Asia, and such a radical change in the natural flow regime may have significant impacts on fish reproduction. The change in flow regime will also impact invertebrate species and. it is likely that the nature and composition of existing ecological communities will be significantly changed.

The socio-economic significance of the Yao River to local inhabitants is high. The river provides productive fisheries, water resources for domestic use and for irrigation, fertile riparian land cultivated as the floodwaters subside and a recreational and aesthetic resource that is central to the lives of the riparian communities.

The communities in this part of the project area have developed natural resource management practices to ensure the sustainability of their livelihoods. Such initiatives include management of community forests where tree cutting is prohibited and offenders may be fined up to 5,000 Baht. In addition local villagers have developed fisheries conservation zones where fishing is prohibited and offenders may be fined up to 2,500 Baht. Examples of fisheries conservation zones include the 700 m of the Yao River near the village of Na Nhun, where the fisheries conservation efforts are reported to have been particularly productive[44]. Other fishery conservation zones on the river also appear to have been very successful and have been verified during the field assessment period.

Although efforts have been made to accommodate mitigating measures into the design of the river training works, these measures are not adequate to do more than mitigate some of the most basic impacts such as loss of river access. River uses such as bathing and washing (as directly observed during field assessments) may become impossible, impractical, or may have to be significantly modified. A typical section of the Yao River is shown in Figure 5.4.4, and an artist's impression of the river after the river training works have been completed is shown in Figure 5.4.5.

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[42] *The Study on the Kok-Ing-Nan Water Diversion Project in the Kingdom of Thailand – Conceptual Planning Study (Main Report)*, Sanyu Consultants Inc. & Nippon Koei Co. Ltd. report to JICA, March 1997.

[43] *The Study on the Kok-Ing-Nan Water Diversion Project in the Kingdom of Thailand – Progress Report (2)*, Sanyu Consultants Inc. & Nippon Koei Co. Ltd. report to JICA, March 1999.

[44] *Watershed*, Vol. 4, No. 2, November 1998 – February 1999, Report of an Interview with Mr Boonchcrd Baiya, Village Head, Na Nhum.

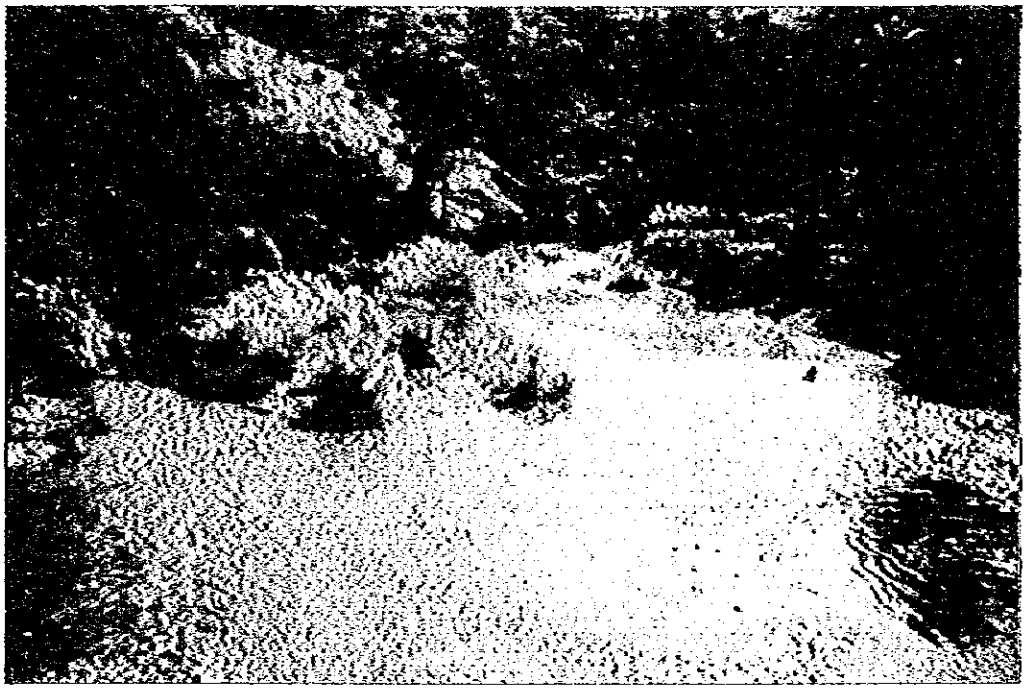

Figure 5.4.4

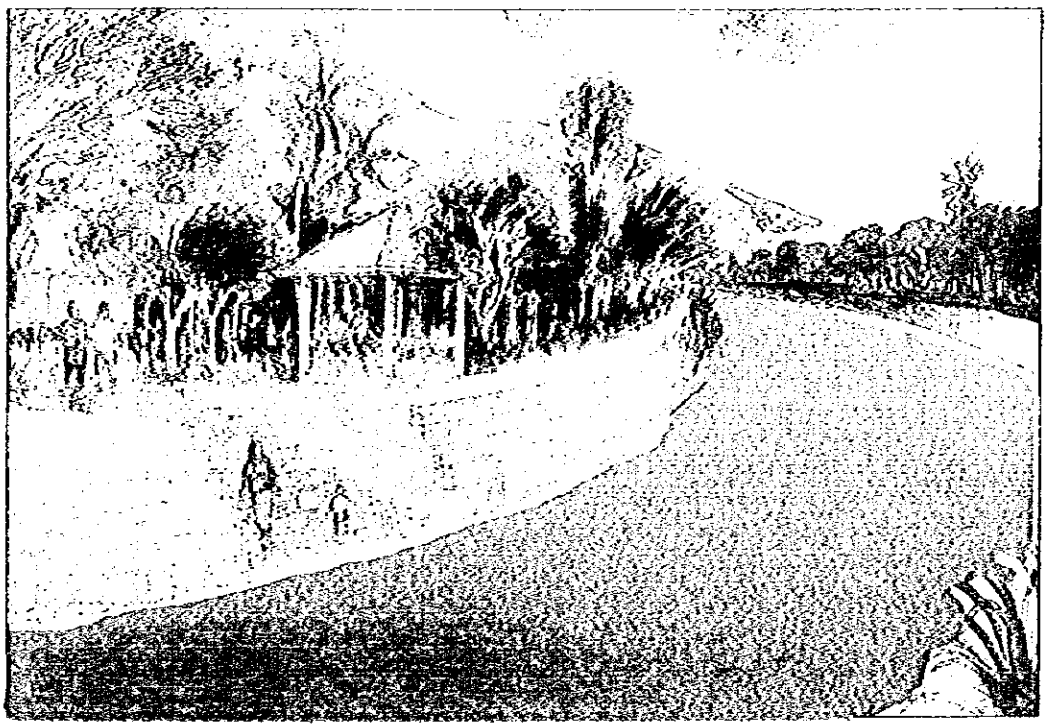

Figure 5.4.5

ENVIRONMENTAL STUDY THE KOK-ING-NAN WATER DIVERSION PROJECT	Figure 5.4.4. A Typical Section of the Yao River Figure 5.4.5. Artist's Impression of the Yao River with River Training Works
JAPAN INTERNATIONAL COOPERATION AGENCY	

In order to more effectively address issues such as habitat loss and the issue of very high flows, velocities and sediments, the design would have to be significantly modified and the land take for the river training works would need to be significantly increased. The size and scale of the resultant river training works, and the net benefits from the design of more effective mitigation measures may be outweighed by the significant increase in land take and severance. In summary, the social, socio-economic and ecological impacts the river training works are likely to be highly significant and practical mitigation of such impacts is likely to be very difficult to achieve.

(8) International Issues Relating to the Mekong River Fishery

The fisheries and freshwater biodiversity of the Mekong River are of international significance. The Mekong Basin is estimated to have the most diverse freshwater biodiversity of all the river basins in Asia with an estimated 400 fish species[45]. A number of 'hot spots' or areas of particular significance for freshwater biodiversity in Asia have been identified. The Mekong Basin has been identified as arguably the most important of these 'hot spots' because of its size and the potential and imminent threats to its integrity.

There is little useful data for assessment of the fisheries resources for the basin as a whole. The river's biodiversity is among one of the richest in the world. However, habitat loss and excessive harvesting of fauna and flora have impacted the river, and exploitation in recent years has led to a sharp reduction in fish populations and species diversity.

The implications of implementation of the project on the Mekong Basin are potentially significant, not only because of their potential nature and scale, but because the Mekong Basin is a resource that is shared internationally, and actions in one country may impact in another country. For example fish introduced in the Mekong basin in China are now appearing in Thailand[46].

The Mekong River Commission, in its 'Agreement on the Co-operation for the Sustainable Development of the Mekong River Basin' of April 1995, recognises '*...that the Mekong River Basin and the related natural resources and environment are natural assets of immense value to all the riparian countries for the economic and social well-being and living standards of their peoples.*'

It may be argued that impacts of individual projects such as the Kok-Ing-Nan may not be significant, however when considering the Mekong Basin as a whole, the cumulative impacts of water resource and hydropower development on fisheries are significant. The potential impacts of the project therefore need to be considered strategically and in the context of water resource and hydropower development on a basin-wide scale.

(9) Considerations for Further Study as Part of the Environmental Assessment of the Project.

The issues relating to prediction of the potential impacts of the project on fisheries, aquatic ecology and freshwater biodiversity in general are bedevilled with problems associated with an inadequate understanding of the existing conditions in the basins. This problem is further exacerbated by the generally poor understanding of aquatic ecology and freshwater biodiversity in south-east Asia generally.

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[45] *Freshwater Biodiversity in Asia – With Special Reference to Fish*, M Kottelat and T Whitten, World Bank Technical Paper 343, 1996.

[46] *First Records of Abottina rivularis from the Mekong Basin*, C Vidthayanon and M Kottelat, Japanese Journal of Ichthyology, 1995.

It is therefore recommended that a more intense survey is conducted and the implications of the project's implementation re-assessed in light of the findings of this study. In design of the future study the following should be taken into consideration:

- The initial step in the study programme should be to undertake a survey and mapping exercise of all the major aquatic systems present in the project area. The project area should include all of the three major river basins that may be affected by the project and should also reference the Mekong Basin as a whole (at some appropriate scale). The mapping should then be used to organise subsequent sampling and assessment of ecological distribution and abundance with particular reference to fish species. Sampling should be undertaken at regular intervals (minimum of once per month where conditions allow) and continue for a minimum duration of one year. In the case of the Kok-Ing-Nan project it would not be unreasonable to continue the sampling exercise until commencement of construction and adapt it to fit in with monitoring of impacts and post-construction evaluations. Sampling on each occasion should continue until repeated efforts result in no additional species. The sampling methods selected should be appropriate for the size and nature of the water body to be sampled and should be documented in detail. Smaller mesh size nets may be required, in addition to standard size nets, in order to sample the significant smaller species as well as the young of larger species. The studies should involve both local and international experts, whose area of expertise is freshwater ecology and freshwater biodiversity as distinct from fisheries *per se*.

- A comprehensive survey and monitoring of the socio-economic status of fisheries in the project area is required from family level (subsistence) through medium-scale (artisanal) to large-scale (commercial) activities. This study would also supplement the ecological and biodiversity studies described above. This study may include assessment of fishermen's catches and market stalls if the location of the catches can be verified and as long as not too much confidence is placed in local names, particularly of the smaller less significant species. An assessment should be made of the fishing effort expended and the size of the catch, as this will give an indication of the social and economic significance of the resource that may be put at risk by development of the project. Consideration should be given to the fact that the current catch is not necessarily a reflection of the capability or potential of any fishery.

Once the data has been collected and collated it should once again be assessed. The prediction and quantification of the impacts must take into consideration the complexity of inter-relationships in aquatic systems, and some important considerations include:

- Riparian trees and vegetation provide shade, moderate temperature and reduce the amount of sediment washed into any river channel. They also provide organic material and insects that assist in the productivity of systems with low primary productivity.

- Consideration should be given to the requirements of the significant species within an aquatic system throughout the whole life-cycle – breeding, spawning, larval stages, migration, feeding and shelter from predators. An adverse impact on just one of these requirements may negate the best efforts to protect the others.

- When considering concentrations of pollutants or flow requirements, assessments should be made not just on existing river characteristics, but on predicted floods, potential low flows and both with and without project scenarios.

- Consideration should be given to the impacts of the whole project, not just in the area immediately adjacent to the project but on important downstream resources also. Interactions with the project and other existing and planned activities elsewhere in the basin may combine to produce significant impacts.

After completion of the surveys and consideration of other relevant factors a suitable mitigation and monitoring plan should be developed. Mitigation activities should include avoidance, modification or abandonment of particularly damaging project components as well as site rehabilitation and restoration. All unnecessary clearance of vegetation should be avoided, and replacement of trees along river banks should be encouraged even if the project has not been responsible for their loss. Opportunities for enhancements should be encouraged wherever possible.

Monitoring should serve two purposes; firstly to provide a measure of the effectiveness of the mitigation and management programme, and secondly to provide advanced warning of any unpredicted impacts. Project monitoring should be linked to the baseline studies previously carried out and have a sound statistical base.