CHAPTER 4 COLMATAGE FARMING IMPROVEMENT PROJECT IN KANDAL PROVINCE

4.1 Present Condition

4.1.1 Agriculture in Kandal Province

Kandal province has a land area of 3,663 km^2. The population of the area is 855,000 (1994), with a density ratio of 238 km^2, is the highest in the whole province. Most of the people engage in agriculture along the Mekong and Bassac rivers.

In the agricultural area, "Colmatage" farming is practiced. It is a traditional land reclamation and cultivation method allowing siltation on the land and recession of flooding. Provincial agriculture with colmatage farming is characterized as follows:

- Rice production is 210,200 ton (1994), about 10% of whole country. The yield is 3.18 ton per hectare, the highest in the province with an average of 1.49 ton per hectare. Dry season rice production is most active with favorable cropping conditions caused by colmatage canals.

- Maize is the largest production crop among field crops' cultivation in the whole province. Compared with the production volume of each province, Kandal province has the highest production, 22,900 tons, occupying 51% of the whole production.

- Vegetable production is also practiced on the higher terraced lands and on the slope of the natural levees behind the rivers. Cultivated area of 5,560 ha is the largest in the whole province. Its production volume is 34,490 ton (1994). The province has many advantages for vegetable production since it has a relatively good transportation system and is closed to the large market area of Phnom Penh

Taking account of the above conditions, Kandal is considered as the most important province having high agricultural productivity associated with periodic flooding of Mekong and Bassac rivers. The productivity, however, is stagnant at low levels after the civil war due to the worsening condition of the colmatage canals.

To attain the national goals of socio-economic development, agriculture development is the most important policy. For this end, recovering and increasing agricultural productivity in Kandal province is the basic and urgent approach. From this viewpoint, high priority should be given to the rehabilitation works of colmatage canals.

4.1.2 Backswamp Area

The Ministry of Environment expressed the Royal Government's intention to join the Ramsar Convention in 1994. After affiliation, the Ministry proposed the three (3) sites of Lake Chhma, Koah Kapik and associated areas and the Middle Reaches of the Mekong river, as the convention area. Besides these areas, the Ministry is also considering as environmental conservation area one site in the Bassac Marshes between the Mekong and Bassac rivers.

The Bassac Marshes is surrounded with natural levees at both rivers. The natural levee slopes

gently down to the inland, swamps, streams and lakes. Agricultural lands are distributed in the narrow band along the natural levees. Intensive farming is practiced in the areas. Upland crops and vegetable in the higher land, and rice in the lower land is planted with silt-bearing water supply through the colmatage canals.

Swamp is an important habitat for fishes that migrates from the Mekong river through colmatage canals and streams. The extension area is dependent on inflow amount from canals and streams. Storage water is released toward the Mekong river through same canals and streams, as inundation subsides. Water channel is also useful for fish migration. Present swamp areas are formed by linkage of the Mekong and Bassac rivers and colmatage canals.

The Department of Fisheries (DOFi) provides fishing lots in and around the swamp area to fishermen through auction. In Kandal province, a total of 19 fishing lots with an area of 178,907 ha, is counted.

4.1.3 Distribution of Colmatage Canals

Silt-bearing water intrudes into colmatage canals as water level of the Mekong and Bassac rivers rises more than the bottom of canal. Intake water with silt is flooded into farmland and backswamp behind the natural levees, improving the agro-ecosystem of land. Silt plays an essential role in maintaining the fertility of surface soil of land. In this flow of flooded water, colmatage canal serves as important factor for natural environment conservation and agricultural and fishing activities. Its functions are summarized as follows.

- Supply of silt-bearing water on the farmlands
- Water resources for recession rice cultivation
- Water supply into backswamp for conservation of inundated forest and fishing resources
- Conservation of fish habitat and mitigation route
- New land reclamation through siltation
- Maintenance of soil fertility through silting on and washing off farmlands

Colmatage farming has many advantages for conducting agriculture harmonized with natural ecosystem. It is considered as sustainable and environmentally conservative farming well balanced with annual flooding cycle.

Though colmatage canal plays important roles of providing many benefits for maintaining agro-ecosystem of cropland and swamp, its function has been deteriorating due to non-functional control gates, deposited sedimentation in the canal and soil erosion on the slope of canal.

If this situation would continue without any remedial measures, traditional colmatage farming and fishing production systems will be damaged by decrease of flow capacity, siltation on the land, water supply into backswamp, and blockade of fish migration routes.

The number of colmatage canals in the project area is 250. Koh Thom district has the largest number, 103 or 41% of total while Kean Svay has the smallest number, 22 or 9%. The scale of canals in each district is summarized in Table 4.1 while the distribution of the canals is shown in

Figure 4.1.

Considering water source, farm land, farming practice, dimension and density of the canals, the colmatage farming area is divided into five (5) zones (see Table 4.2 and 4.3, Figure 4.2).

4.1.4 Colmatage Farming

Considering regional statistics, the dry season cropping area occupies half of the total cropping area and the dry season paddy area is nearly three times of the dry season field crop's area. During the wet season, both areas for paddy and field crops are almost same. About five (5) % of the whole cropping area is used as orchard. The double cropping area represents seven (7) % of the whole cropping area and is mainly distributed in Saang and Koh Thom districts. Judging from the data and field survey, double cropping is practiced on the upland fields on river banks and its back slope areas around colmatage system during the dry season (see Table 4.4).

At present, the regions of the four districts are the most productive areas. The northern part of the region, namely Kean Svay and Saang districts, has a wide range of agriculture due to its geographical advantage; the presence of the capital suburbs. In particular, Saang is an important vegetable supply area for capital demands. Various kinds of vegetables, such as, leafy, tuberous and fruit, is planted both during wet and dry seasons. On the other hand, the southern part of the region, namely Koh Thom and Leuk Dek districts, are major wet season maize cropping area. Koh Thom has also large vegetable field, especially chili, during the dry season (see Table 4.5 and 4.6).

The present cropping patterns of the four districts are shown in Figure 4.3. This pattern is based on the results of interview of farmers conducted during the Rural Socio-economic Survey. The early dry season paddy that starts in October is predominantly seen in Kean Svay. The late dry season paddy that starts in December, January and February are common in the other three districts. Wet season paddy usually begins in May and June. The harvesting time of wet season paddy depends on the variety. To avoid climate risks due to erratic precipitation and flooding damage, many kinds of traditional varieties and some IR varieties are widely practiced. The dominant variety for dry season paddy is IR 66 but for the wet season paddy, most farmers mentioned only traditional varieties.

On the river banks and its back slope areas, field crops are widely practiced. During the wet season, farming for field crops starts in May simultaneous with the occurrence of rainfall. Harvesting ends before September or October when the flood covers the area. Maize represents more than 80% of all field crop's area in wet season. In dry season, the land that contains enough moisture for plant growing or is located near available irrigation water is cultivated. Some of the farmers use movable pumps from colmatage canal to irrigate upland field. Vegetables, beans (mungbean, peanut) and maize is the main crops in the dry season.

4.2 Agricultural Development Plan

4.2.1 Land Use Plan

The agricultural production in the region is expected to increase by the rehabilitation of colmatage system. If it is possible to control water level of colmatage by water control facility

such as gate, dry season cropping will increase. If more water can be retained in the colmatage canal during dry season, the farmers can irrigate and cultivate upland fields not used during the dry season. At present, half of upland fields are cultivated during the dry season. It represents 16% of the whole cropping area. The target is to increase upland cropping ratio during the dry season from 16 to 23% of the whole cropping area.

4.2.2 Agricultural Production Plan

Considering the proposed cropping pattern shown in Figure 4.4, the production data with/without projects are estimated as shown in Table 4.7. The present yields are obtained from statistical data and target yields are set based on the highest value obtained among the four districts.

4.2.3 Irrigation Development Plan

(1) Land Use Availability

According to inventory survey, the mean interval of colmatage canals is 0.9 km. The largest interval is 2.5 km, in Kean Svay while the narrowest is 0.6 km, in Kho Thom. On the other hand, the average width of cultivated area in each canal is estimated at 0.5 km. The space/area between the canals varies from 0.2 km to 1.0 km. It shows that some parts of the space/area still have a potential to be developed for upland crops.

Considering the environmental impact of developing backswamp area, land reclamation between the canals with construction of secondary canals that are perpendicular to the colmatage canal, is recommended to be given more emphasis for development.

(2) Water Resource

If gates are constructed or rehabilitated and canals are re-excavated to 1.5 m deeper, about 13.6 MCM of water can be stored in the canals at the end of wet season. Taking into account evaporation, percolation and domestic water use, etc., the volume of 50% (6.8 MCM) stored water can be used for irrigation purposes. It would cause the increase of more than 1,400 ha of upland crops in the dry season that is about 20% of the present cultivated area.

4.3 Colmatage Canal Rehabilitation Plan

4.3.1 Rehabilitation Priority Area

The canals are distributed widely. For rehabilitation purposes, grouping or zoning the area with canal is advantageous project implementation. The priority would be given by the grouped area/zone and ranking the priority is determined by socio-economic and infrastructure conditions of their zones. Some ranking indexes as shown in Table 4.8, are used to decide the priority. According to the study results, Kean Svay district was considered first priority for rehabilitation of facilities.

4.3.2 Types of Colmatage Canals

Considering the colmatage canal's inventory, construction/rehabilitation of the colmatage canal

is divided into five (5) types as shown below (see Figure 4.5).

In the planning, present canals are classified based on the types. As for the type-A, the scale of canal is so small that some parts of rehabilitation work can be conducted by farmers themselves. In the planning of water control gate, sluice and manual type will be applied.

Type	Bottom Width of Canal (m)	Water Control Facility
A	6.0 ≧ BW	Culvert
B	6.0 < BW ≦ 10.0	2 series gate
C	10.0< BW ≦ 15.0	3 series gate
D	15.0< BW ≦ 20.0	5 series gate
E	BW > 20.0	7 series gate

4.3.3 Rehabilitation Facilities Planning

(1) General

The basic idea for the rehabilitation of colmatage canal is to restore the original functions of the facilities. It does not include expansion of canal capacity. At present, to control flood water intrusion to wet season crops, about 20% of colmatage canals in the area are blocked by dikes embanked by farmers or gates operation. Considering environment impact caused by flowing out to the downstream area and farmer's capability to operate gate, the number of canals to be installed with gates is estimated.

(2) Plan of Rehabilitation

(a) Water control gate

A gate facility should be light weight and easy to operate for water control. Bank protection around the gate is also necessary. There are 33 canals equipped with gate, or 13% of total. Almost all of them are not functional. According to these conditions, (1) 33 (or 13%) of existing gates should be reconstructed and (2) 17 (or 7%) canals should be newly provided with gates.

(b) Bridge

According to the inventory, almost all the wooden bridges should be rehabilitated due to old and weak structure.

(c) Canal

To prevent silt sedimentation and to protect from erosion of slopes, design velocity of flow should be more than 0.6 m/sec and less than 1.5 m/sec. The slope required is 1:1.5. If the waste land between the canals is planned to be developed for upland crops, excavation of secondary canal of which route is perpendicular to the colmatage canal would be useful. Related to the canal of type-A, farmers should have responsibility of dredging or re-shaping

since its scale are small.

(3) Maintenance Road

The improvement of maintenance road consists of gravel pavement, banking and construction of related structures. According to the land holding conditions, the area from the crest of canal front slope to the top of the dike is a government property. However, the boundary between private and public lands is not clear. Before implementation of rehabilitation/construction of the maintenance road, GDIMH should have the responsibility to acquire the necessary area for maintenance road. Some appropriate foundation treatment should be considered due to distribution of soft soils.

4.3.4 Operation and Maintenance and Farmer's Organization

It is essential to establish a system to manage irrigation facilities properly. The beneficiaries of the canal system should manage the facilities, because the facilities will eventually be owned by them. Relevant government offices or any other capable organizations should help organize the beneficiaries into water users' association. The district hydrology office is basically responsible for organizing the beneficiaries. Extension workers or NGOs should also tap their assistance on the beneficiaries. It is also very important to make the beneficiaries feel a sense of ownership on the facilities. If they feel the ownership of the facilities, they will be willing to operate and maintain the facilities.

There are farmer's groups in Kandal province that can tap its activity into operation and maintenance of canals. However, the groups are very loosely organized. They belong to a commune and functions as an administrative organization. At present, main gates are being operated under the orders of the commune chief. The beneficiaries get together and undertake opening or closing gate, dredging and reshaping canal.

However, despite the present set-up, it is still necessary to reorganize and strengthen them to maintain and operate the facilities constructed in a more efficient and properly manner. The association can also be tapped to disseminate new agricultural techniques, new crops for diversification, higher productive varieties, etc. and to offer credit and other services to its members.

Installed gates will be operated based on the water level of the Mekong river and the cropping situation along the canal. Generally, gate can be opened to allow flood water intrusion about August when crops are almost harvested while the water level is rising. It can be closed at the end of flooding season when the intruded flood water is backing into the Mekong river. Opening and closing gates should be practiced based on the consent of farmers' association.

4.3.5 Project Cost and Implementation Program

(1) Project Cost

Project cost is estimated on the basis of the following conditions:

- The construction works will be carried out by contractor(s) selected through competitive bidding.

- The local unit prices are estimated based on the current market prices in October 1996. Cost data were obtained from similar works in and around the Study Area. Foreign currency portion is estimated on the basis of CIF at Phnom Penh.
- The project cost consists of construction cost, engineering service cost and administrative cost, etc.

The total project cost is estimated to be US$ 37.9 million. The summary of the cost in each zone is shown below (the detail is shown in Table 4.9).

Project Cost

Unit: 1,000 US$

Zone No.	Cost			
	Canal	Intake Gate	Bridge	Total
I	1,234	2,717	78	4,029
II	0	681	819	1,500
III	527	1,284	444	2,255
IV	9,875	3,622	2,071	15,568
V	9,744	2,168	2,647	14,559
Total	21,380	10,472	6,059	37,911

(2) Project Implementation Program

Considering the rehabilitation priority of the proposed zones and the quantity of construction works in each zone, implementation period is determined at five (5) years. The project consists of survey, detailed design and construction works in each zone. The implementation schedule of the project is shown in Figure 4.6.

4.4 Project Justification

4.4.1 Economic Evaluation

(1) Agricultural Benefits

Direct and indirect benefits will be generated with implementation of the project. The most tangible benefit in the colmatage beneficial areas is the agricultural benefits. Incremental agricultural benefit will be generated from (a) increase in crop yield, (b) increase in cropping intensity and (c) increase in planting areas (refer to Table 4.10).

(2) Project Cost

Project cost for the rehabilitation of the colmatage canal was estimated at 37.91 million US$ in financial price. Price escalation, taxes, subsidy and compensation costs were excluded in the estimation of the economic project cost, estimated at 34.12 million US$. Replacement cost necessary for gates was taken into account every 30 years.

(3) Project Justification

Economic project cost and incremental benefits were discounted by using definite discount rates to calculate present values for a 50 years' project life. Comparisons were made. Consequently, the EIRR (economic internal rate of return) was accounted at 12.3%, indicating that implementation of the project is economically feasible from national economic point of view. This is because the computed EIRR is higher than 10%, the assumed opportunity cost of capital in Cambodia.

4.4.2 Financial Analysis

Farm economy for typical farm with farm size of 0.6 ha, with and without project, was compared based on financial costs. When estimating household incomes, incomes from fishery and off-farm works were taken into account because these incomes are indispensable for farmers to maintain living standard. Farm economy will be improved and disposable income will be generated with the implementation of the project.

4.5 Environmental Impact

The Bassac Marshes Area, where part of the area is proposed as conservation area, has been maintained by periodic annual flood coming through colmatage canals. There are nine (9) fishing lots in the area. The surrounding area is used mainly for production of rice, maize, vegetable, etc. The colmatage canals play important role in agricultural and fishing production, and ecosystem preservation, since it carries silt bearing water on agricultural lands and swamps in the area. The activities of agriculture and fishery and the ecosystem in the area are controlled by flooding under the hydrological regime of the Mekong river. The present situation scarcely changes in the area, unless the Mekong river system is drastically altered in the future.

The rehabilitation project in the colmatage canals aims to recover the canal functions lost in the flow. After the canals blocked and/or silted with soil are improved with the project implementation, those canals will be able to convey flooding water smoothly to the farmlands, and to reserve irrigation water in the dry season. At the same time, improved water control gates will be able to control water flow for agricultural use, and to promote agricultural production activities. Since the project has no large scale rehabilitation plans and no new construction of canals, irrigation/drainage systems with the flooding water and ecological situation in the area should be maintained as its present condition.

Farming system in the area is traditional and based on the annual sedimentation. Agricultural inputs are minimized because silt bearing water provides rich natural fertilizer. The soil fertility is naturally maintained. After the project, the canals shall carry water rich in sediment and organism into the farmlands. However, if farming system would change with extensive chemical fertilizers and water bodies would become polluted, it might cause slight negative impact on the ecosystem in some parts of the swamp areas in the future. However, the influence is scarce at present due to enormous water flash in the flood season.

In the area, original ecosystem has almost been altered with the expansion of agricultural land.

Present forests and shrubs located around water bodies are still part of the fuel resources of the villagers. Actual condition of forest degradation is unclear because of the absence of detailed information. Since the project has no plans of expanding the farmlands, those forests and shrubs will not be touched. However, over-cutting firewood practicing in the area may eventually affect on the present forest system. The ecosystem including forest, therefore, should be properly maintained.

For conservation of the ecosystem around water bodies and swamps, without any influence of agricultural and fishery activities, land use idea on forest, agriculture and fishery should be actualized. Moreover, zoning for conservation of natural resources should be delineated politically and technically at the soonest time. Furthermore, it is important that environmental changes be monitored. Field survey should also be considered to understand the present situation on plants, birds and fish for the future.

A survey was conducted on the practice of using pesticide among 200 farmers picked up at random. About 100 farmers each in the Saang district along the left bank of the Bassac river and Kean Svay district along the right bank of the Mekong river were interviewed. According to the survey, 92% of farmers are using pesticide. The information on pesticide use has been also gathered from other farmers and from the market source of pesticide. Findings also show that about 34% of farmers were injured once by the pesticide. Most of the farmers want to know the proper application method for the use of pesticide. Folidol, DDT and Azodrin are the commonly used pesticides. Since these pesticides are highly hazardous, proper control and guidance is necessary.

The flooded forests in the area are still the main fuel resources for villagers. Some species of trees for firewood are found. Most of the species grown around water bodies is the popular one. Reang, in Khmer on Barringtonia micrantha, is mainly used as firewood. This tree grows easily and rapidly anywhere throughout the year. It was observed that Mimosa pigra, one of hazardous plants for farmland with its rapid growth, has been used. This tree has been exploited except at the central area. At least, however, the forests should be conserved for fishing ground and for maintenance of the ecosystem.

The lists of plants, birds and fish identified in the Study, are compiled. In the lists, plants include cover grass, tree and water plants. Birds comprise 31 species. Eight (8) of these species are easily located, while the 15 birds are difficult to locate at present. Thirty-five fish species were identified n the area. It is said that some large sized fish are already difficult to find.

The natural environment will not be affected with the rehabilitation of the colmatage canal, because the project will not disturb the present regime of the Mekong river. Since the area is closely located in the central area, social and economic impacts such as the rapid economic growth will likely occur in future.

4.6 Overall Evaluation

Agriculture in the backslopes of natural levees and natural condition of the Bassac marsh are maintained by periodic flood intrusion through colmatage canals. The canals have many

functions in the process of carrying silt-bearing water into agricultural land and backswamp.

The rehabilitation project aims to recover the deteriorated function of canals, which will bring further incentive to farming on the related farmers. Agriculture activities would become more active. Consequently, agriculture production would be expected to increase in the area along the canals. The project would also contribute to maintaining fishery resources in backswamp areas.

Therefore, project justification should be based both on the fields of agriculture development and environmental conservation involved in the preservation of the ecosystem in the swamp area. Economic evaluation is based on the quantitative benefit from increase of agriculture production. Environmental effect such as conservation of fish habitat and migration route is considered to be non-quantitative benefit. Considering the economic analysis, the project is considered as feasible from the viewpoint of quantitative agricultural increment benefit. The implementation of the project will not cause negative impact on the agriculture and swamp areas, according to the environment impact study. Therefore, the project is concluded to be workable and is recommended to be implement urgently.

This study is based on the comprehensive study for the area along the Mekong and the Bassac rivers. In implementing the rehabilitation of each canal, detailed survey including farmer's consent is required by each canal.

CHAPTER 5 THE PRIORITY PROJECTS AND AREAS

5.1 Significance of the Priority Projects in the Priority Areas

As mentioned in 3.7, two types projects of colmatage farming improvement project in Kandal province and 20 projects of agricultural development project harmonized with fisheries were proposed as the first approach for implementation of the development plans. Required development components cover various fields which have to be implemented keeping close cooperation with related institutions. On the other hand, financial and institutional capability for project implementation is limited. The implementation works will face with many technical and financial difficulties in the course of project implementation. Consequently, it is not practical to implement every development plan all over the Study Area

Considering the above situations, it is the more effective and practical approach that priority projects/areas are selected and development plans are materialized and implemented as the pilot projects.

5.2 Priority Projects

5.2.1 Basic Requirement of the Priority Projects

The priority project is considered as the pilot project for agricultural development in the flooded area. The outcomes of the priority projects have to be proceeded to the next development program and extended into the whole flooded area. The priority projects, therefore, has to include every development aspects of infrastructure improvement and non-infrastructural development as planned in 3.3, 3.4 and 3.5.

In the priority projects, proposed development plan such as rehabilitation of irrigation and drainage facilities, institutional capability strengthening, establishment of farmers' organization and improvement of farming practice should be implemented with related institutions and farmers.

5.2.2 Priority Projects

Based on the above considerations, the following two types projects are considered as the priority projects.

(1) Colmatage Farming Improvement Project

(2) Agricultural Development Project Harmonized with Fisheries

In the project (1), development plans such as rehabilitation of colmatage canals, improvement of farming practice for crop diversification and strengthening farmers' organization involved in water users' association through operation and maintenance activities of rehabilitated canals are implemented for demonstration.

In the project (2), development plans such as rehabilitation of irrigation facilities and swamps, construction of dikes and canals, introduction of small pumps, improvement of farming practice

harmonized with fishing activities and establishment of farmers' organization are implemented. The project also includes to demonstrate typical scheme of small scale rainfed agriculture development which is essential for medium and long term development target.

5.3 Priority Areas

5.3.1 Selection Criteria for Priority Project Areas

Priority project areas are selected from the areas of proposed projects as mentioned in 3.7. The areas play an important role as an initiator for development in the flooded area. For selecting areas, the following selection criteria is applied.

- The above mentioned development components are likely to be implemented easily as the pilot project.
- With the project implementation, quick development effect and higher economic return are expected. Farmers' participation is essential for smooth implementation of the projects. The project areas may be selected from the area in which present farming is active and farmers' intention for improvement of farming is strong.
- Access is easy for a demonstrative effect. The area is expected to be close to Phnom Penh. The outcomes of the project areas will be propagated to surrounding farmers and related institutions in the course of project implementation.
- Significant negative change may not cause on social harmony and natural environment in and around the areas. If the area is placed in comprehensive river basin in which the implementation may bring directly negative impacts, the wide scope of study and long study period are required covering various technical fields.
- The projects will be implemented in close cooperation with the institutions concerned. Then, GDIMH shall act as the implementing body. In the areas, development components anticipated will be suitable under the conditions of present financial limitation and implementing capability.

5.3.2 Selection of the Priority Project Areas

By applying the above criteria, priority project areas are selected as follows (see Figure 5.1).

(1) Colmatage Farming Improvement Project Area:

Area along the Mekong and Bassac rivers, Kean Svay and Saang districts. The number of canal is expected at from 10 to 15.

Rehabilitation priority is given into the order of Kean Svay, Saang, Leuk Dek and Kho Thom. The groups with canals were selected from Kean Svay and Saang districts based on the survey, considering agricultural and socio-economic activities along the rivers, and urgency in canal rehabilitation.

(2) Agricultural Development Project Harmonized with Fisheries:

Around swamps and lakes in Ksach Kandal, especially around the Phtea lake area, was selected.

In the selection process, Tamouk reservoir area was preliminarily selected. However, the selected one was decided to be developed under financial assistance of MRC, so that it was requested to change.

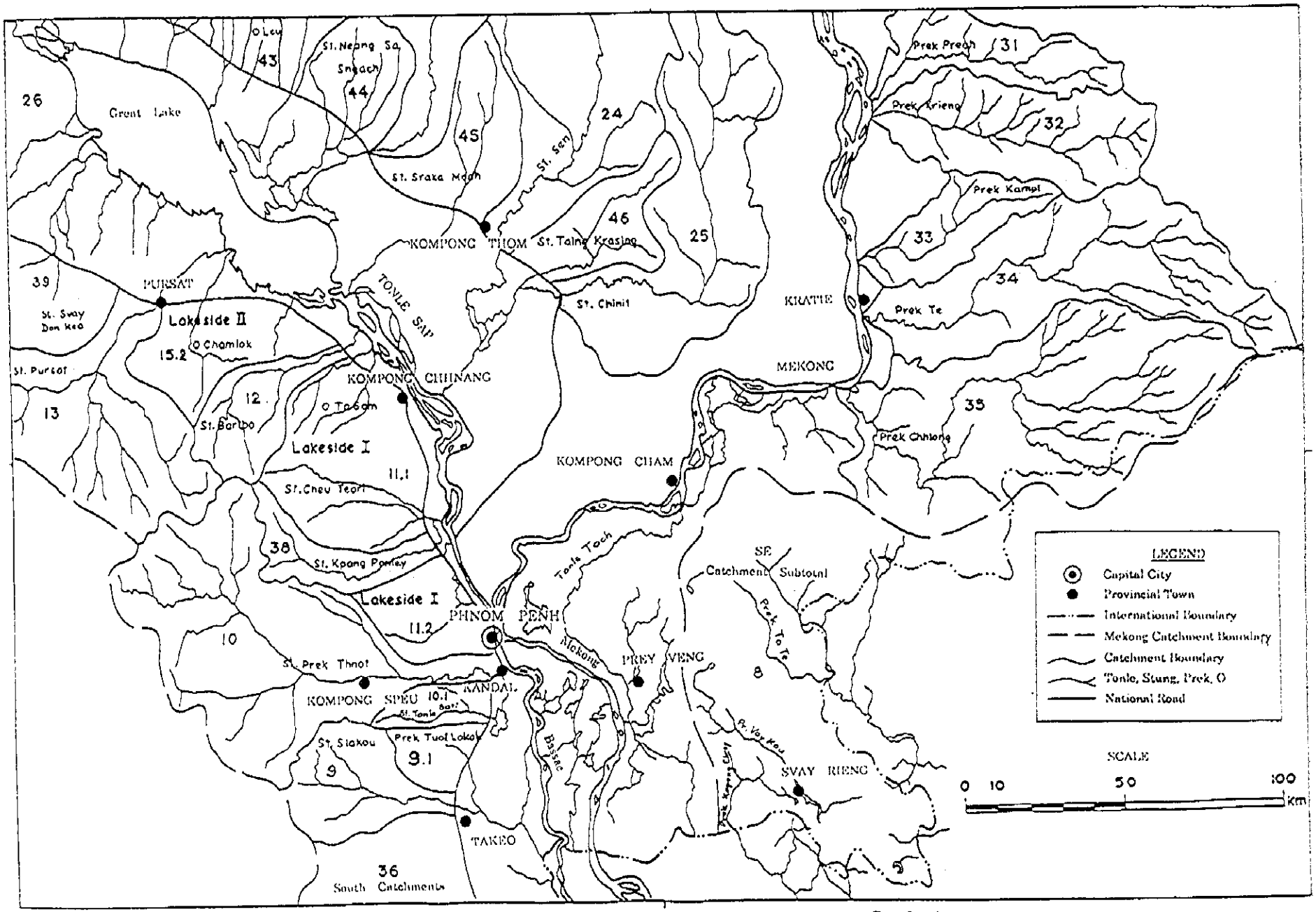
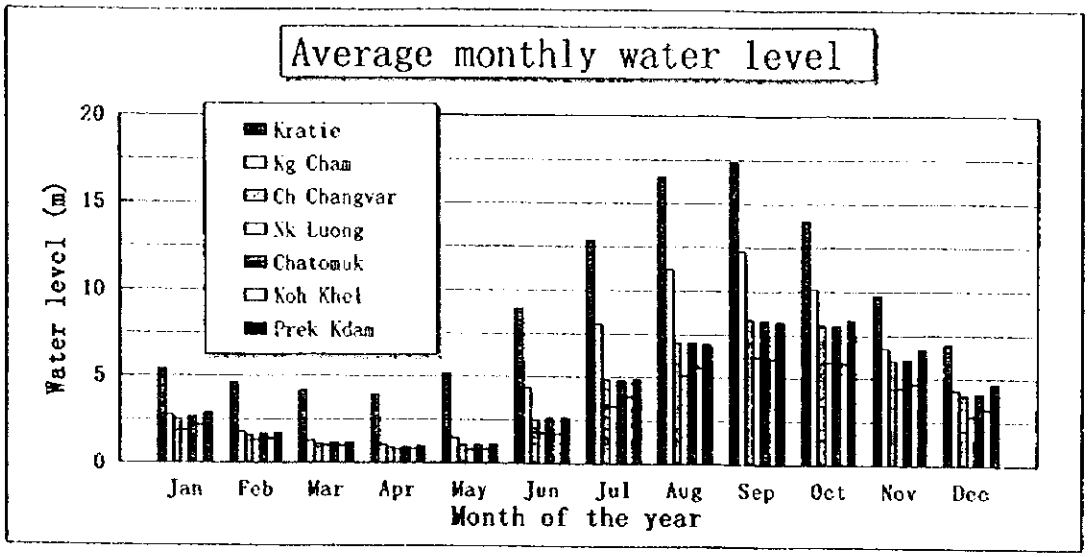


Figure 2.1 Catchment of Mainstreams and Tributaries in the Study Area

Average monthly water level

	Mekong river				Bassac river		Tonle sap river
	Kratie	Kompong Cham	Chrouy Changvar	Neak Luong	Chatomuk	Koh Khel	Prek Kdam
Jan	5.41	2.76	2.52	1.89	2.63	2.16	2.89
Feb	4.64	1.80	1.61	1.30	1.67	1.37	1.73
Mar	4.15	1.29	1.09	0.99	1.15	0.99	1.17
Apr	3.98	1.05	0.89	0.79	0.90	0.82	0.95
May	5.17	1.42	1.04	0.79	1.06	0.81	1.08
Jun	8.92	4.37	2.52	1.78	2.61	1.73	2.64
Jul	12.87	8.05	4.86	3.31	4.81	3.89	4.87
Aug	16.52	11.27	7.03	5.14	6.98	5.56	6.90
Sep	17.38	12.27	8.35	6.19	8.30	6.09	8.25
Oct	14.03	10.13	8.07	5.96	8.03	5.86	8.33
Nov	9.76	6.76	6.04	4.43	6.06	4.68	6.66
Dec	6.97	4.33	4.07	2.84	4.09	3.24	4.68



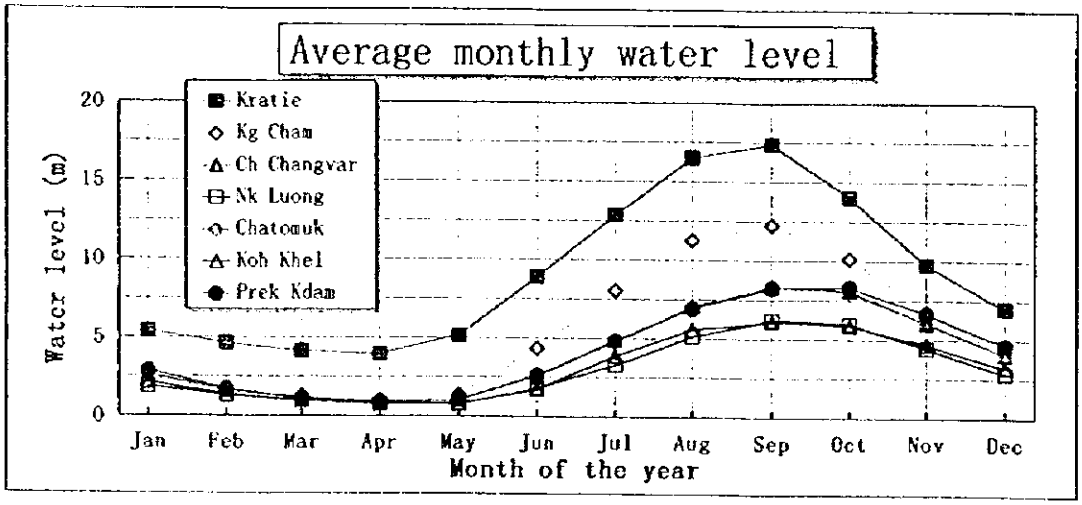


Figure 2.2 Average Flood Stage at the Gauging Stations in the Study Area

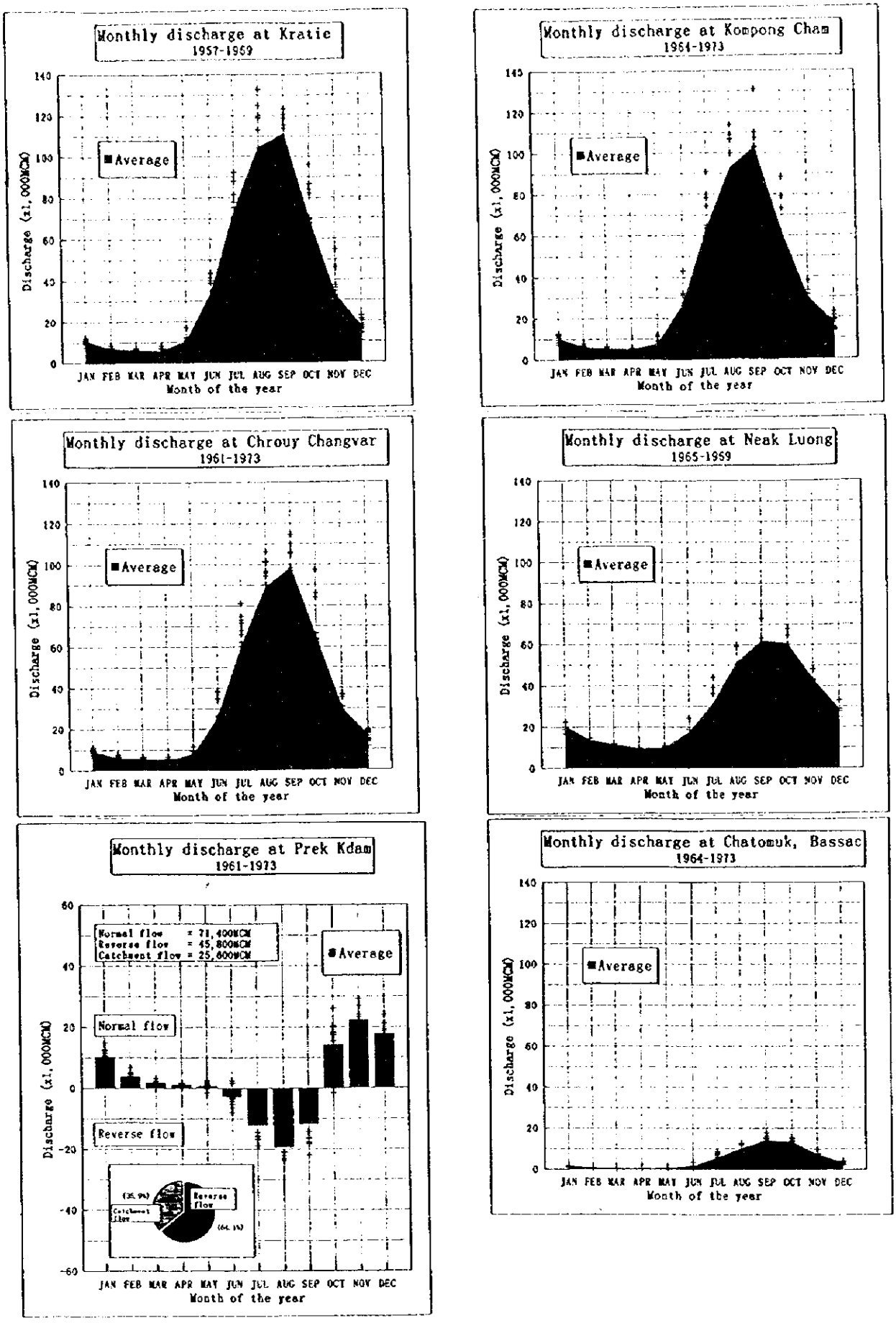


Figure 2.3 Average Monthly Discharge at the Gauging Stations

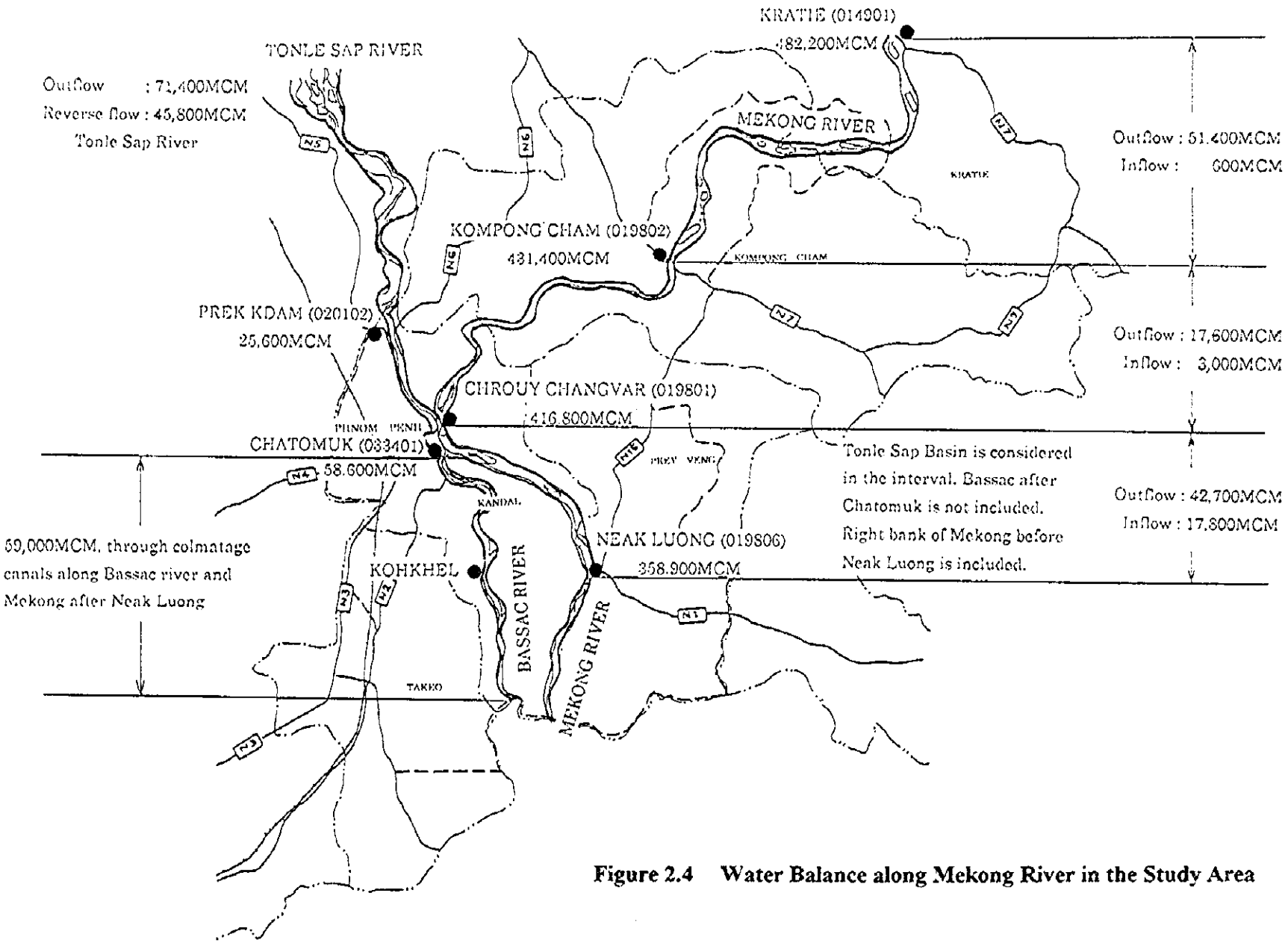
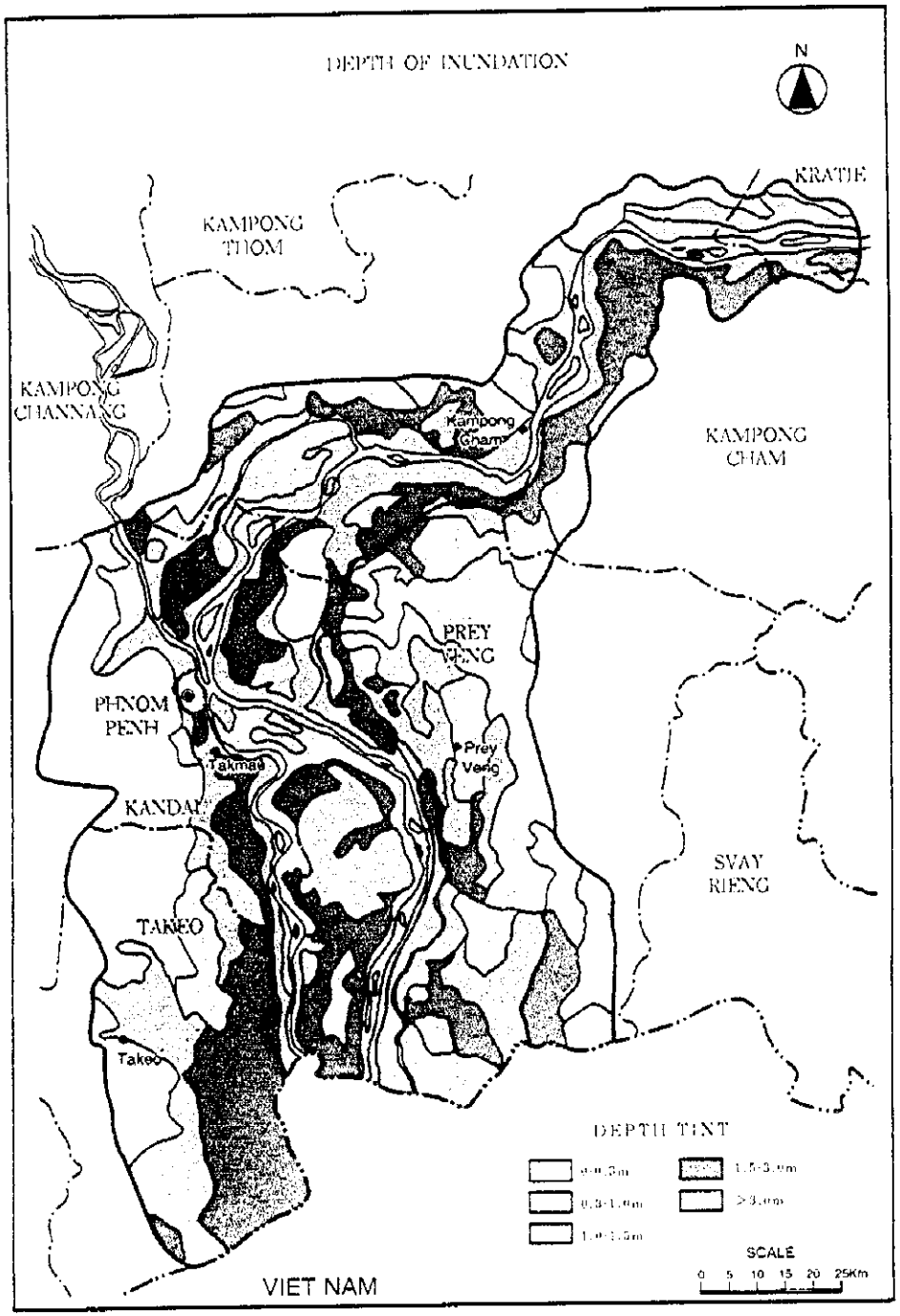


Figure 2.4 Water Balance along Mekong River in the Study Area



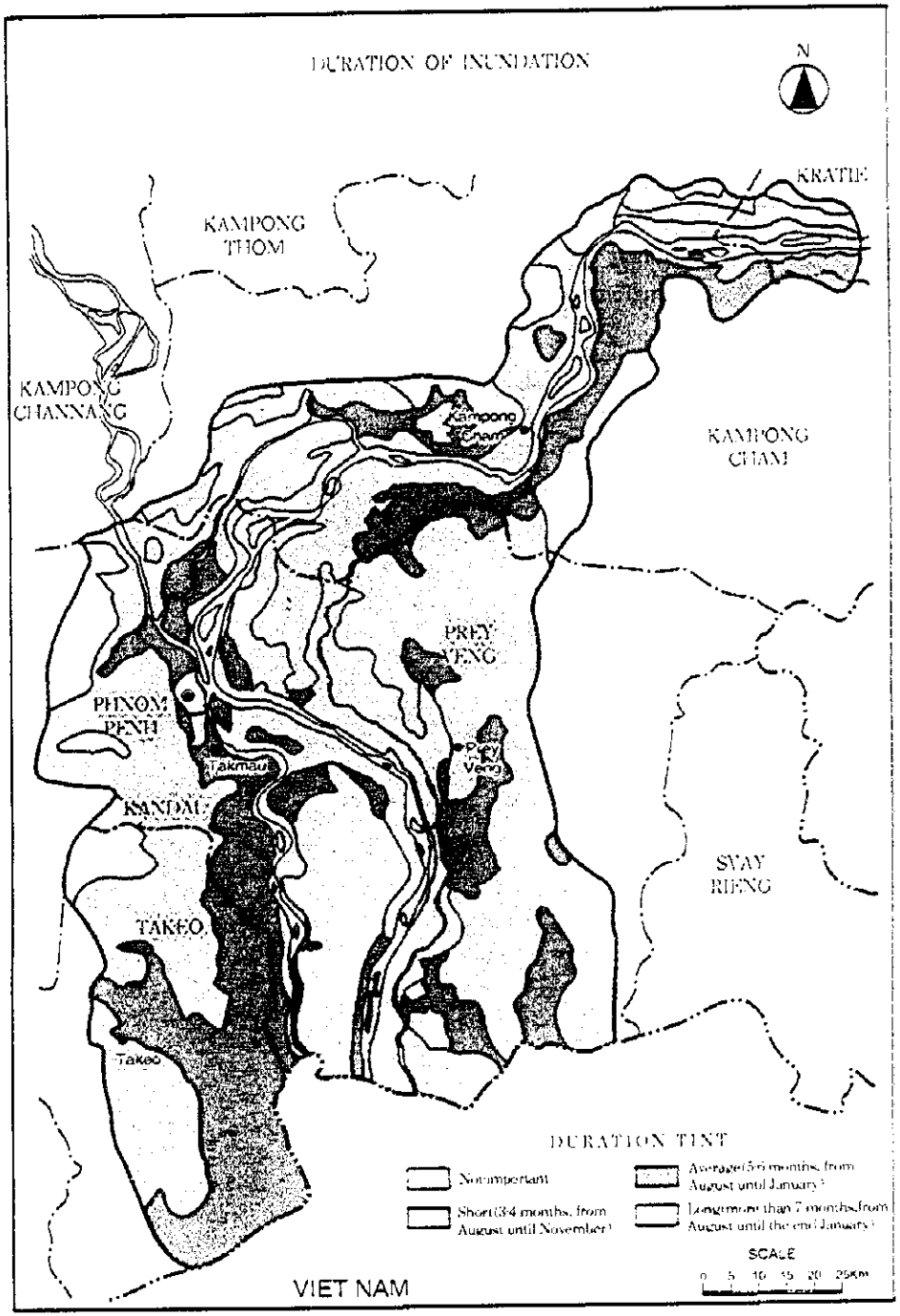


Figure 2.5 Depth and Duration of Inundation in the Study Area.

(adapted from DES AGRO-ECOSYSTEM DE LA REPUBLIQUE POPULAIRE DE KAMPUCHEA)

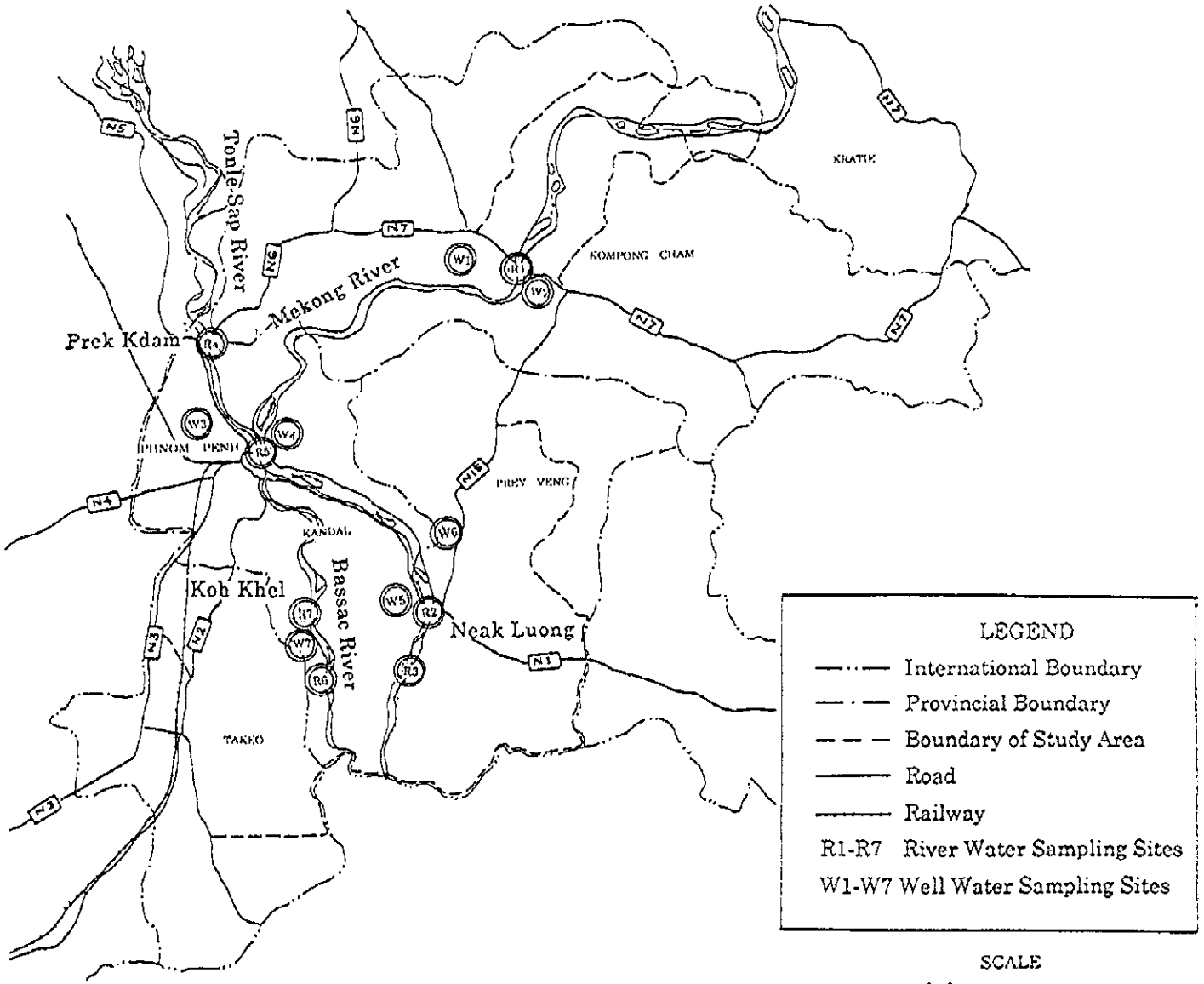
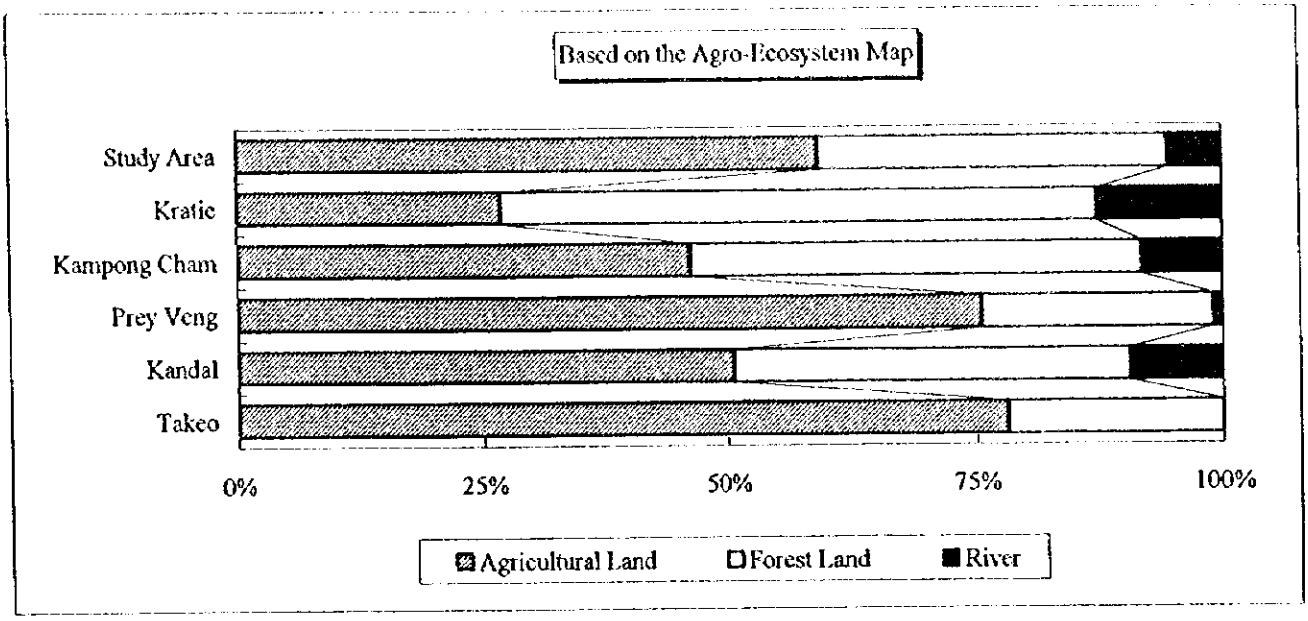
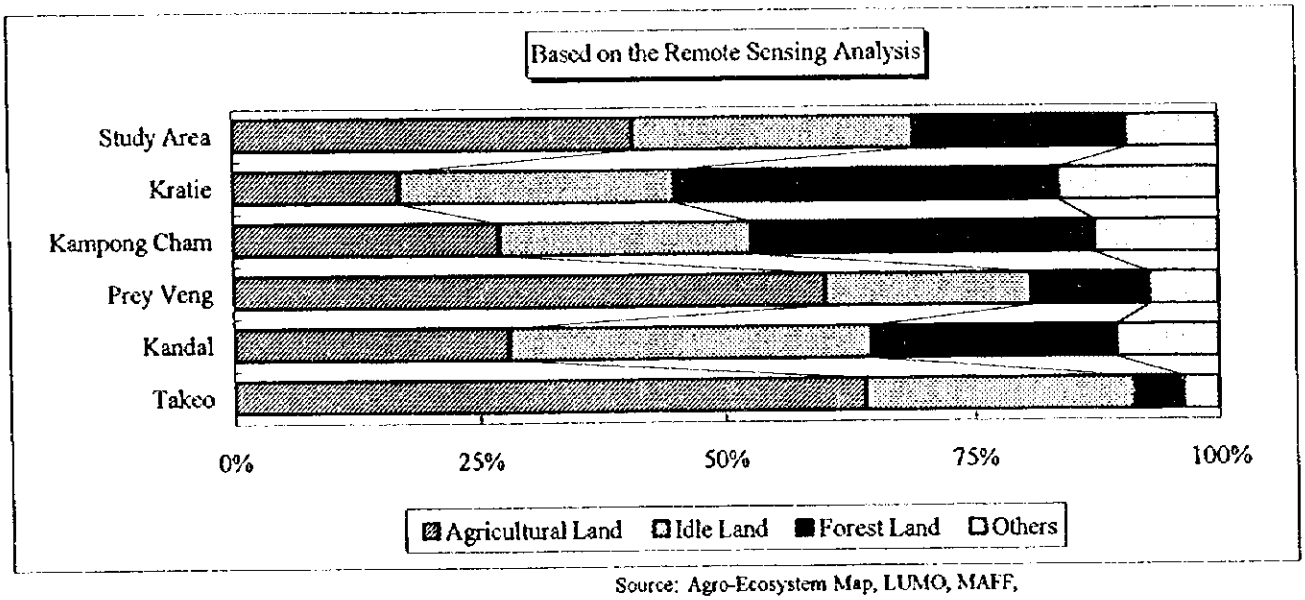


Figure 2.6 Location of Water Sampling Sites in the Study Area





Source: Agro-Ecosystem Map, LUMO, MAFF,
Remote Sensing Analysis Data, JICA Study Team
Note: Idle Land is consisted of waste land, grassland and swamp.

Figure 2.7 Land Use Distribution of the Study Area

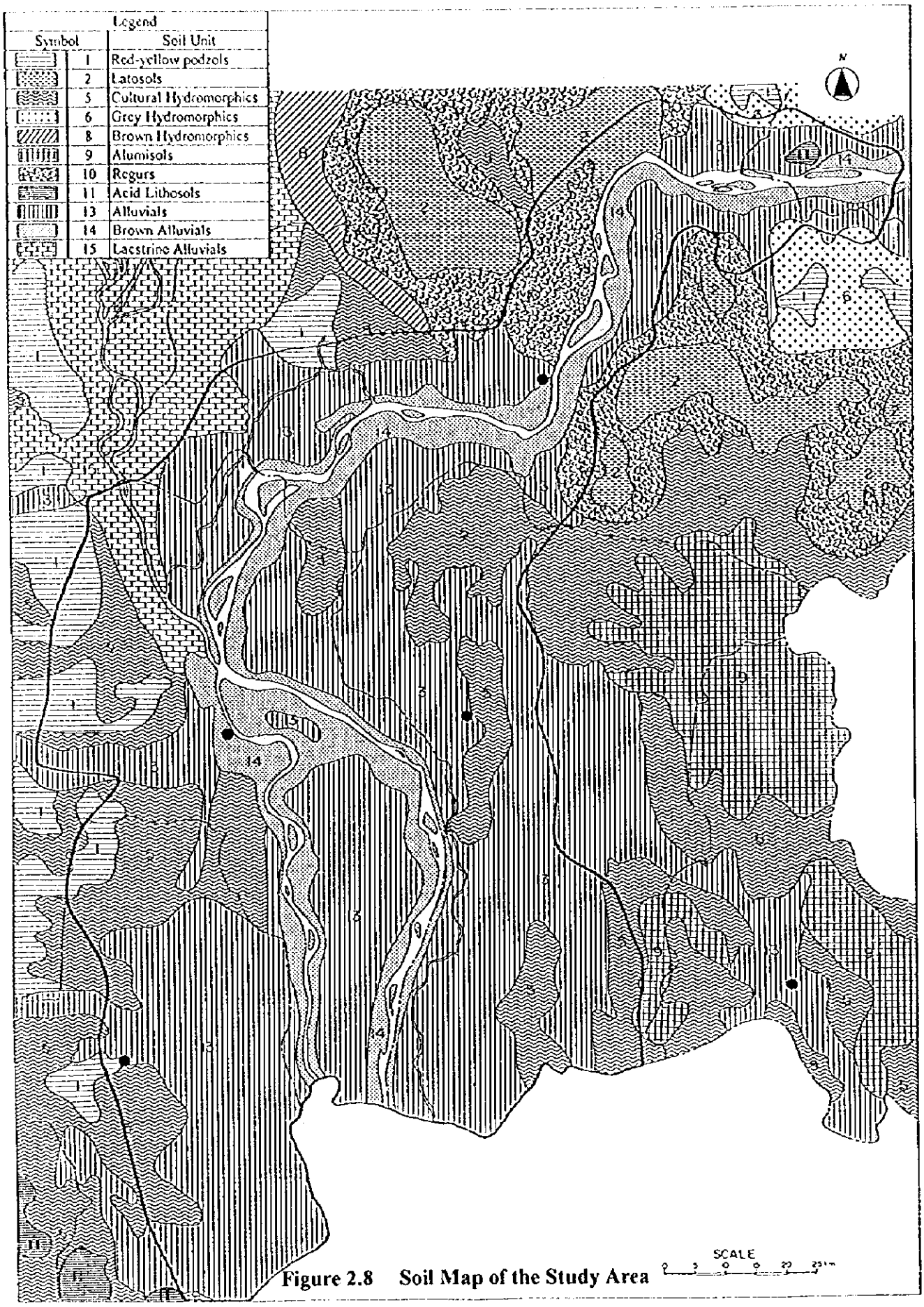
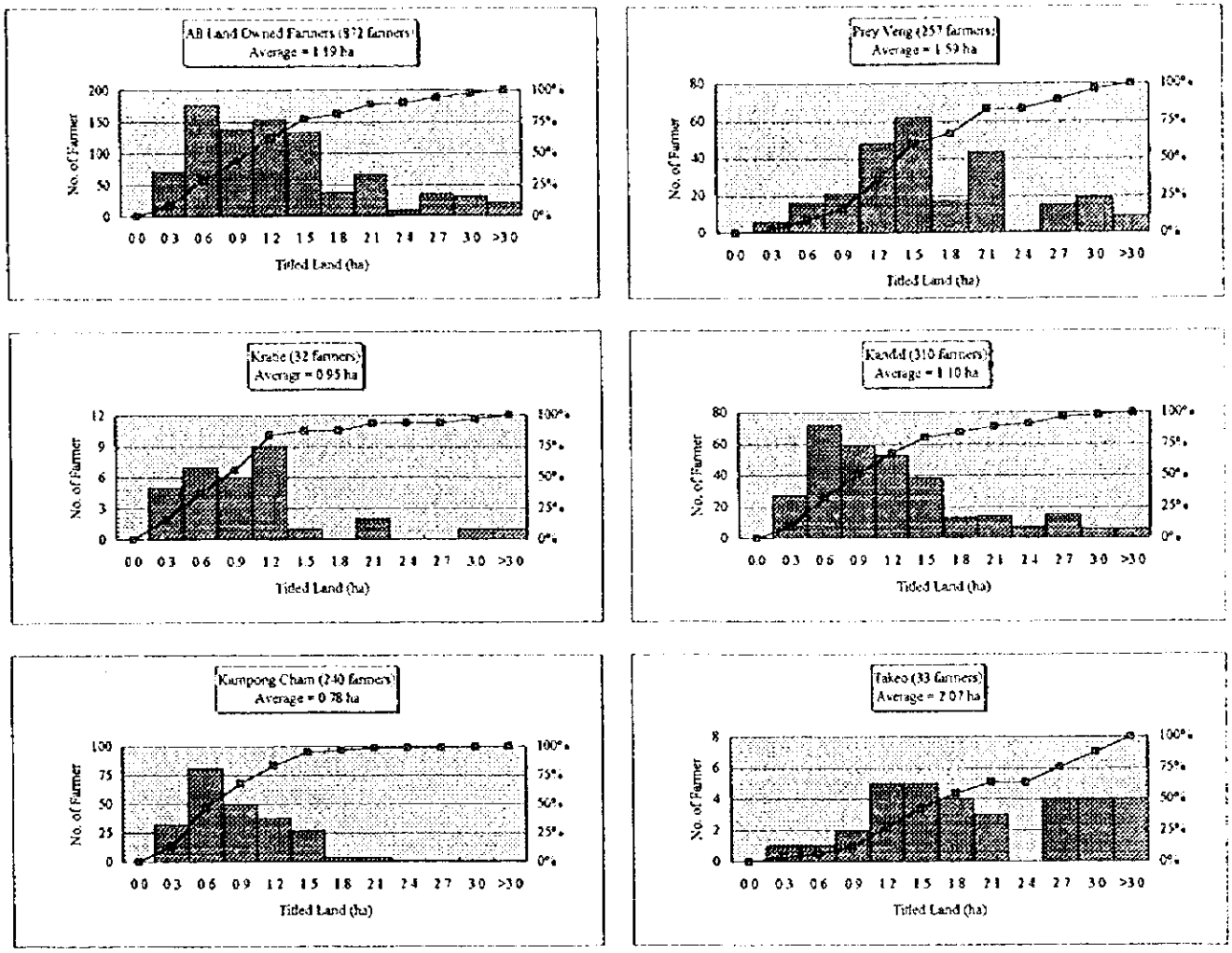
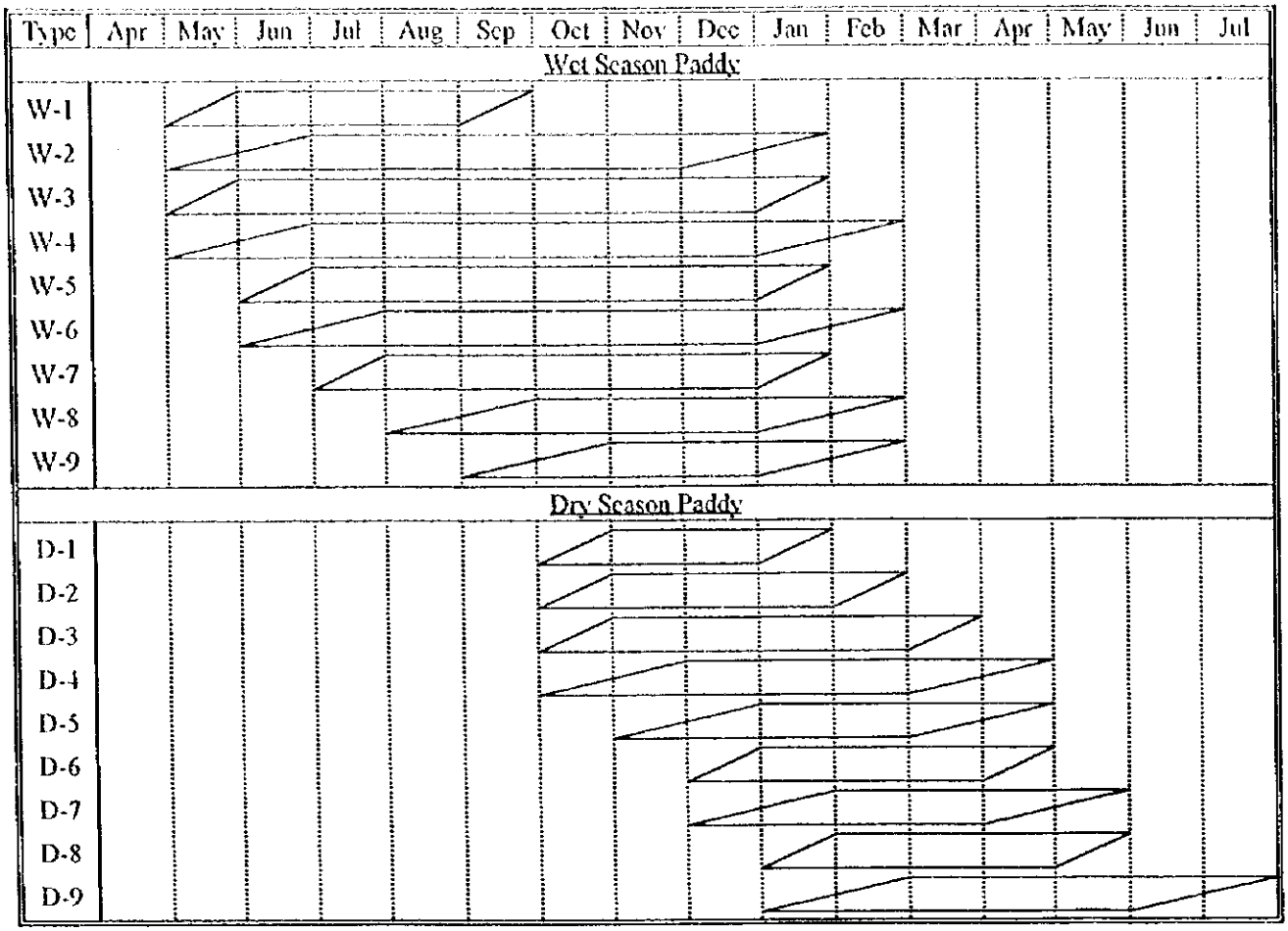


Figure 2.8 Soil Map of the Study Area



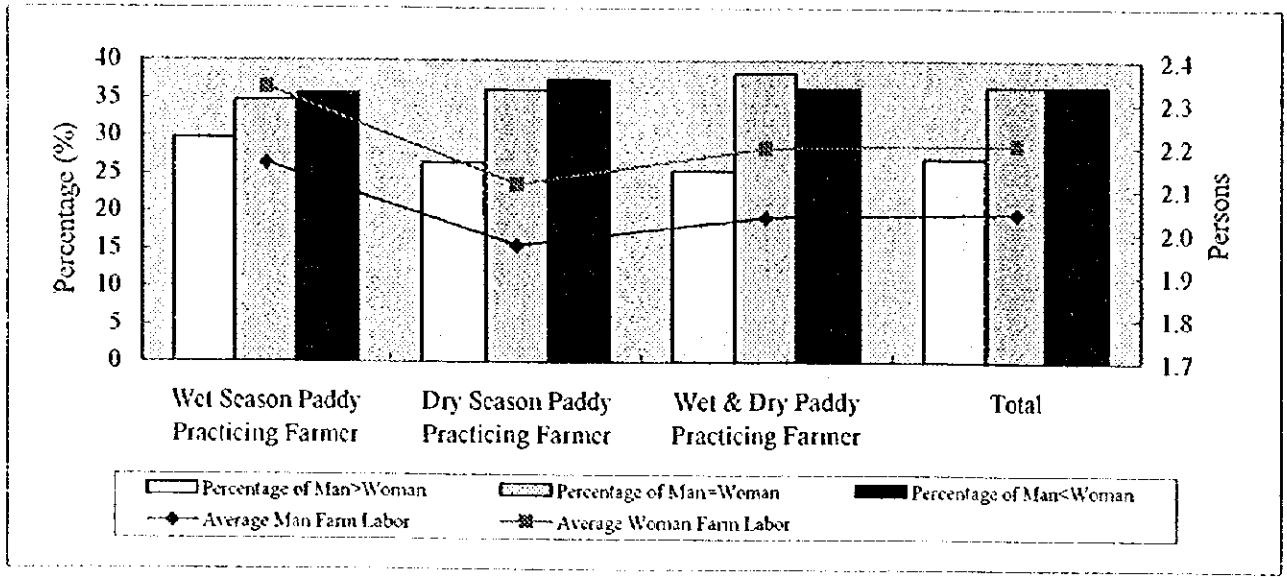
Source Rural Socio-Economic Survey, JICA Study Team

Figure 2.9 Histograms of Number of Farmers by Titled Land Area by Province



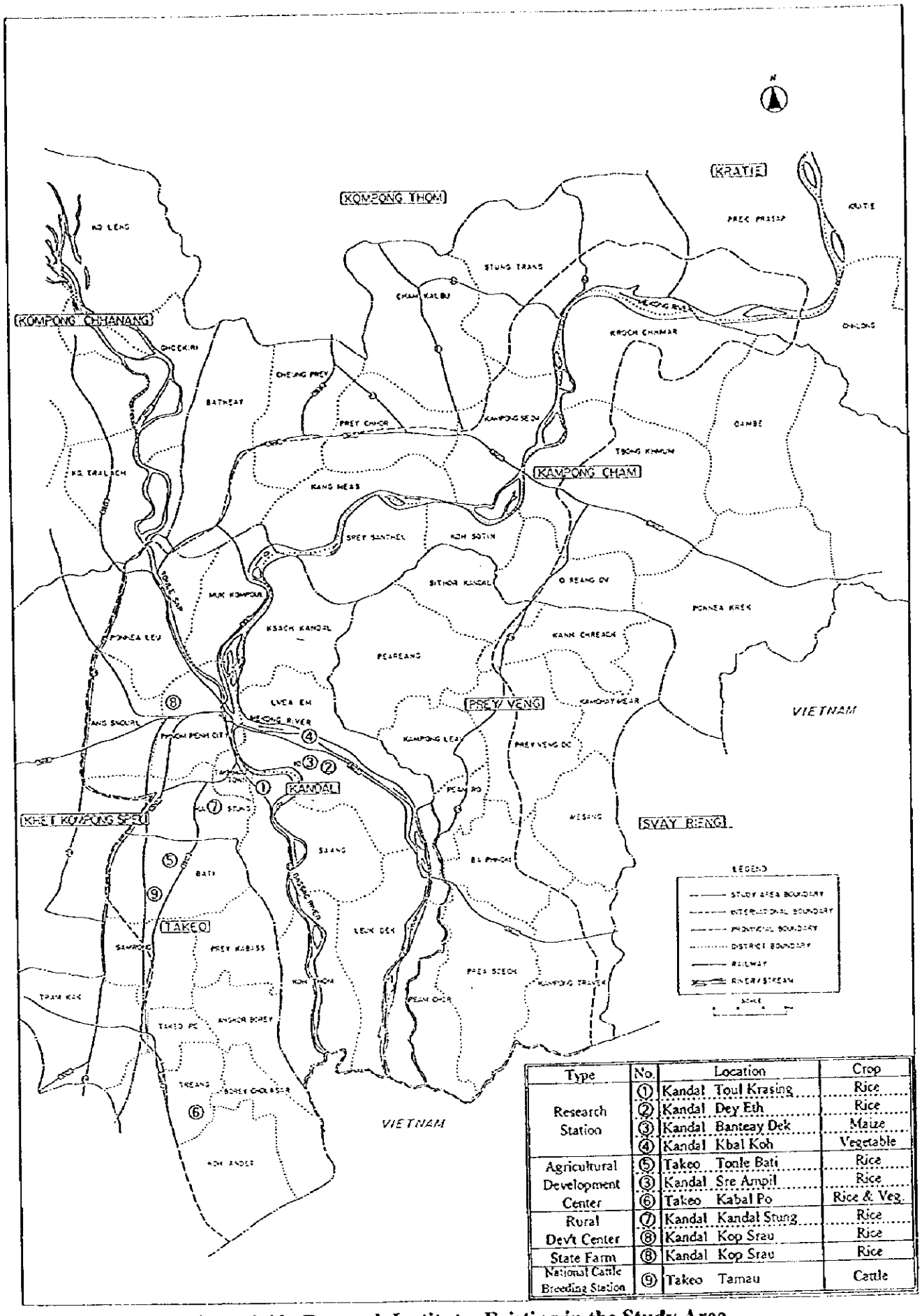
Source: Rural Socio-Economic Survey, JICA Study Team
Note: W-2,3,5 and 6 are dominant in wet season
D-3,5,6 and 8 are dominant in dry seasson

Figure 2.10 Cropping Patterns of Paddy in the Study Area



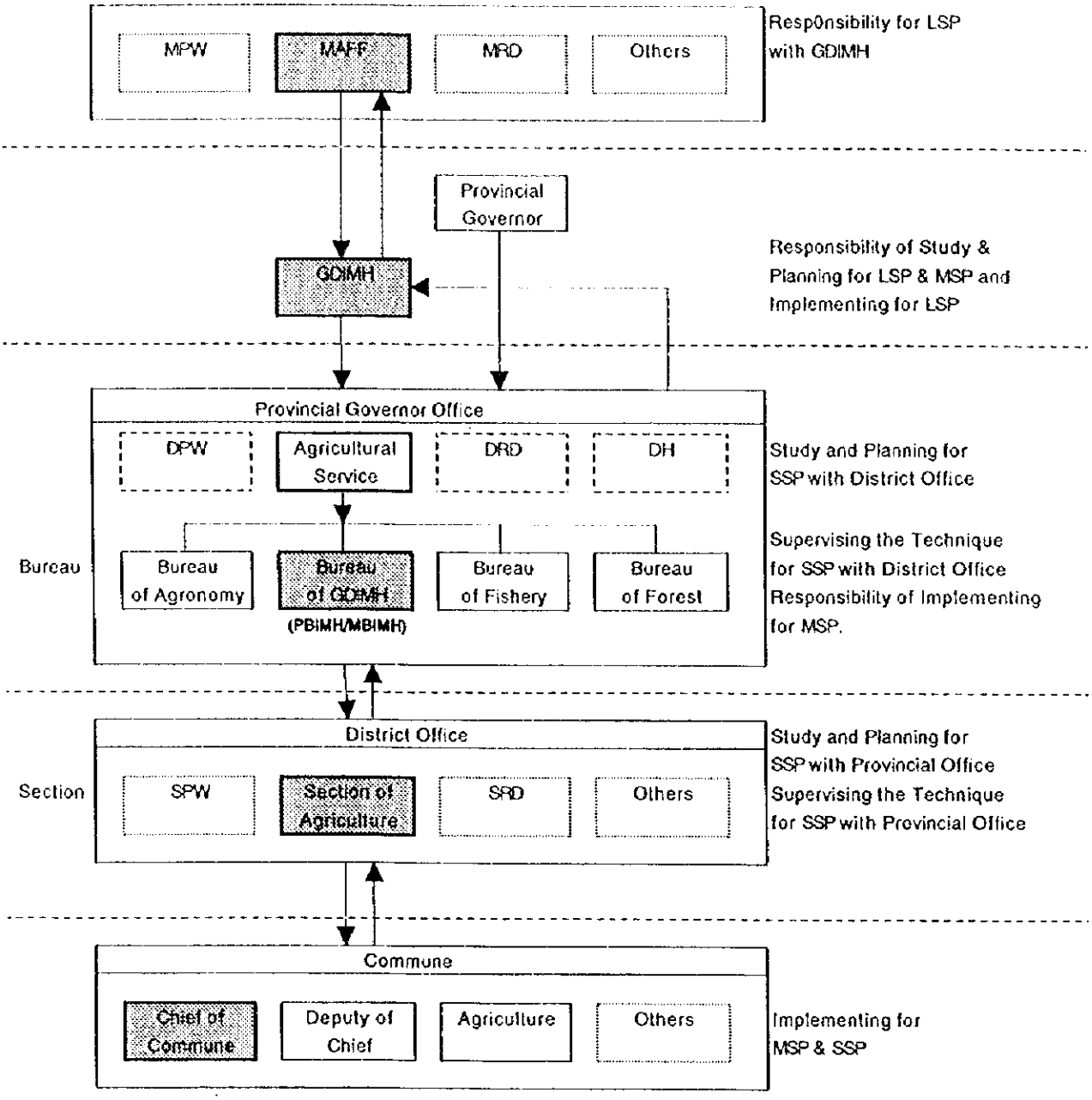
Source: Rural Socio-Economic Survey, JICA Study Team

Figure 2.11 Ratios of Farmers who Have More Man Labor than Woman Labor, Equal and More Woman than Man and Average Man and Woman Farm Labor per Farm by Paddy Cropping Type



Type	No.	Location	Crop
Research Station	①	Kandal Toul Krasing	Rice
	②	Kandal Dey Eth	Rice
	③	Kandal Banteay Dek	Maize
	④	Kandal Kbal Koh	Vegetable
Agricultural Development Center	⑤	Takeo Tonle Bati	Rice
	③	Kandal Sre Ampil	Rice
	⑥	Takeo Kabal Po	Rice & Veg.
Rural Devt Center	⑦	Kandal Kandal Stung	Rice
	⑧	Kandal Kop Srau	Rice
State Farm	⑧	Kandal Kop Srau	Rice
National Cattle Breeding Station	⑨	Takeo Tamau	Cattle

Figure 2.12 Research Institutes Existing in the Study Area



GDIMH : General Directorate of Irrigation, Meteorology and Hydrology
PBIMH : Provincial Bureau of Irrigation, Meteorology and Hydrology
MBIMH: Municipality Bureau of Irrigation, Meteorology and Hydrology
SSP: Small Scale Project<200ha, MSP: Medium Scale Project ≦200ha & <5,000ha
LSP: Large Scale Project 5,000ha≧

Figure 2.13 Flow Chart of Construction and Rehabilitation of Irrigation and Drainage Systems

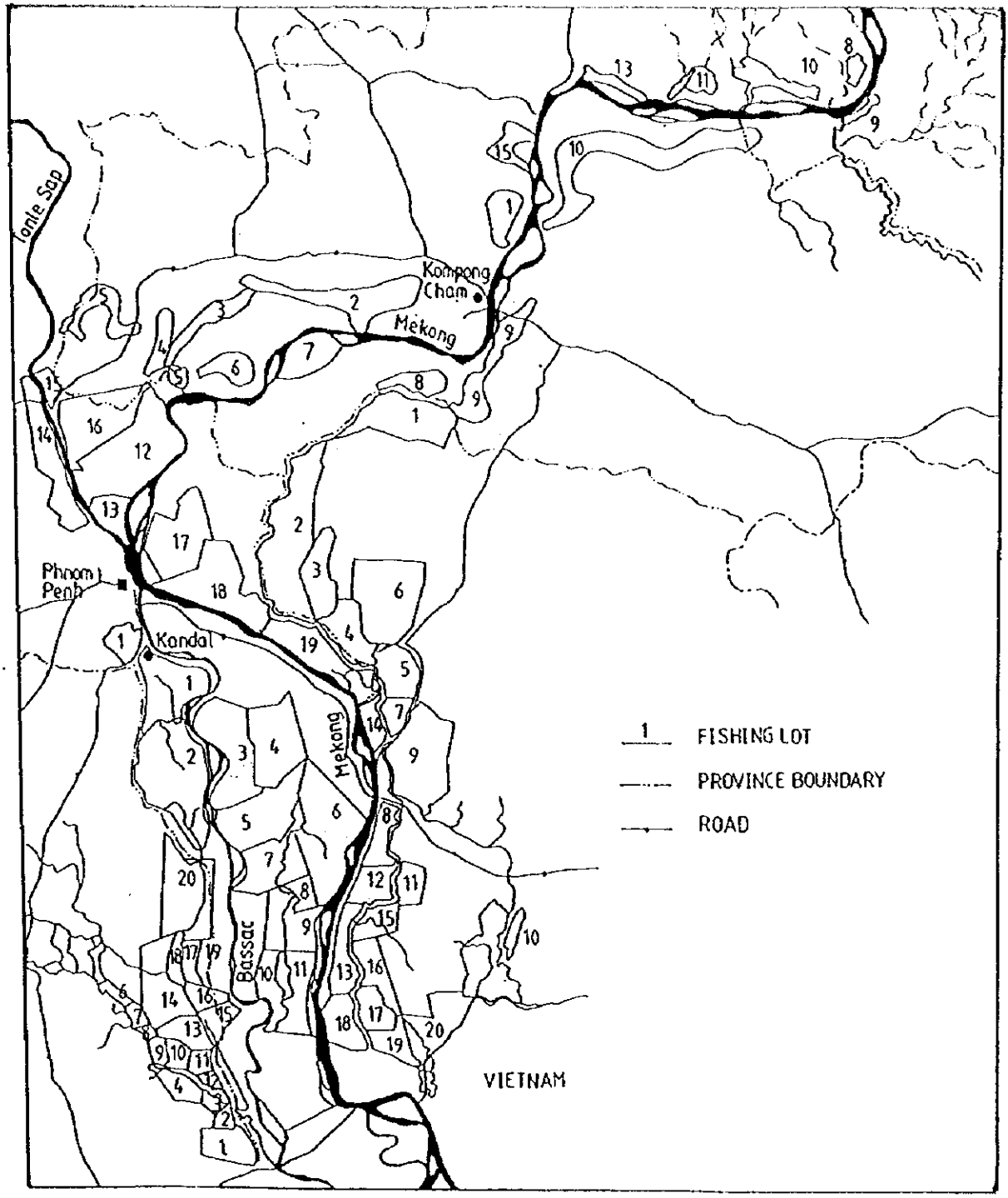


Figure 2.14 Locations of Fishing Lots in the Study Area

(Fisheries in the Lower Mekong Basin, 1992, Mekong Secretariat)

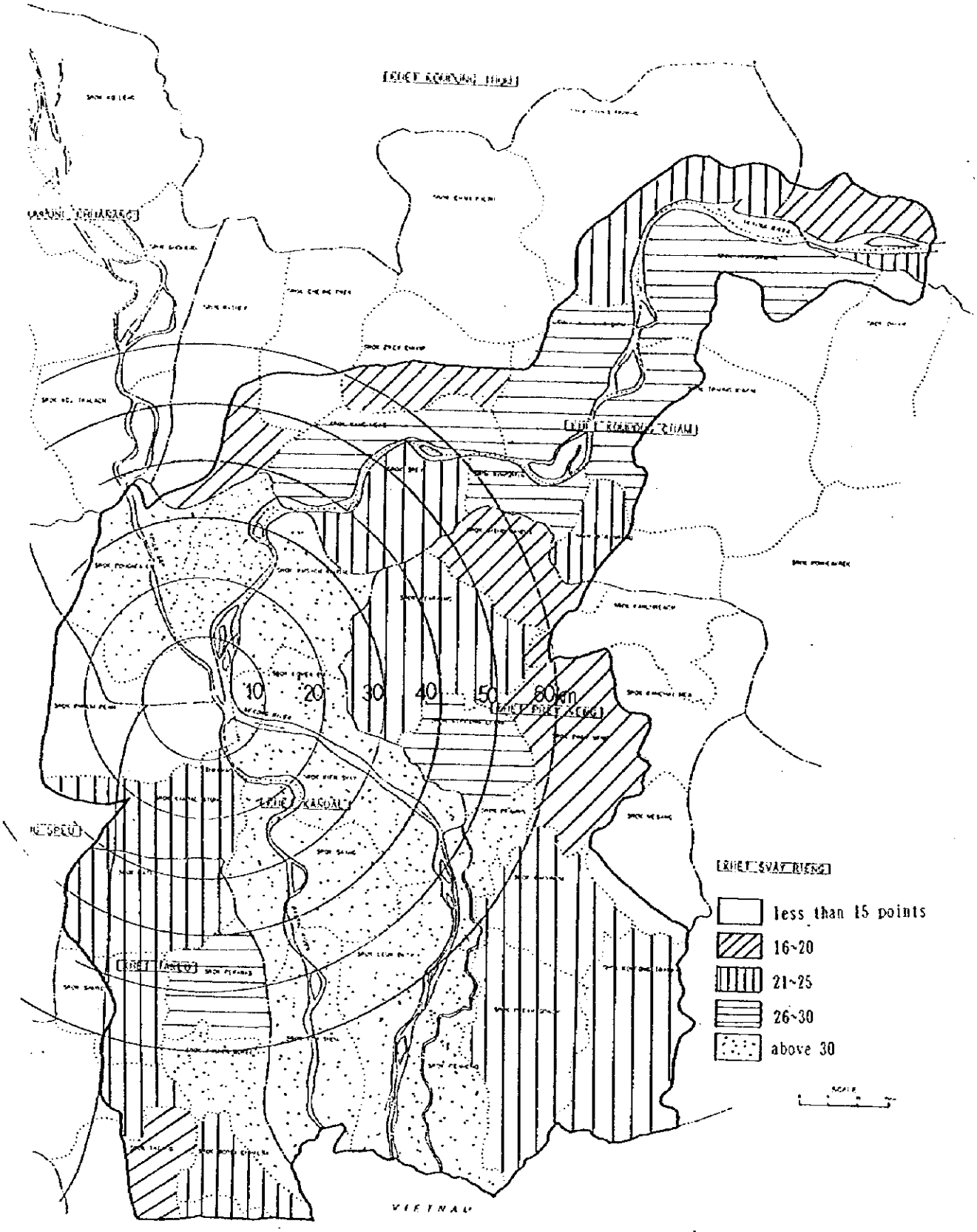


Figure 2.15 Comprehensive Evaluation of Districts

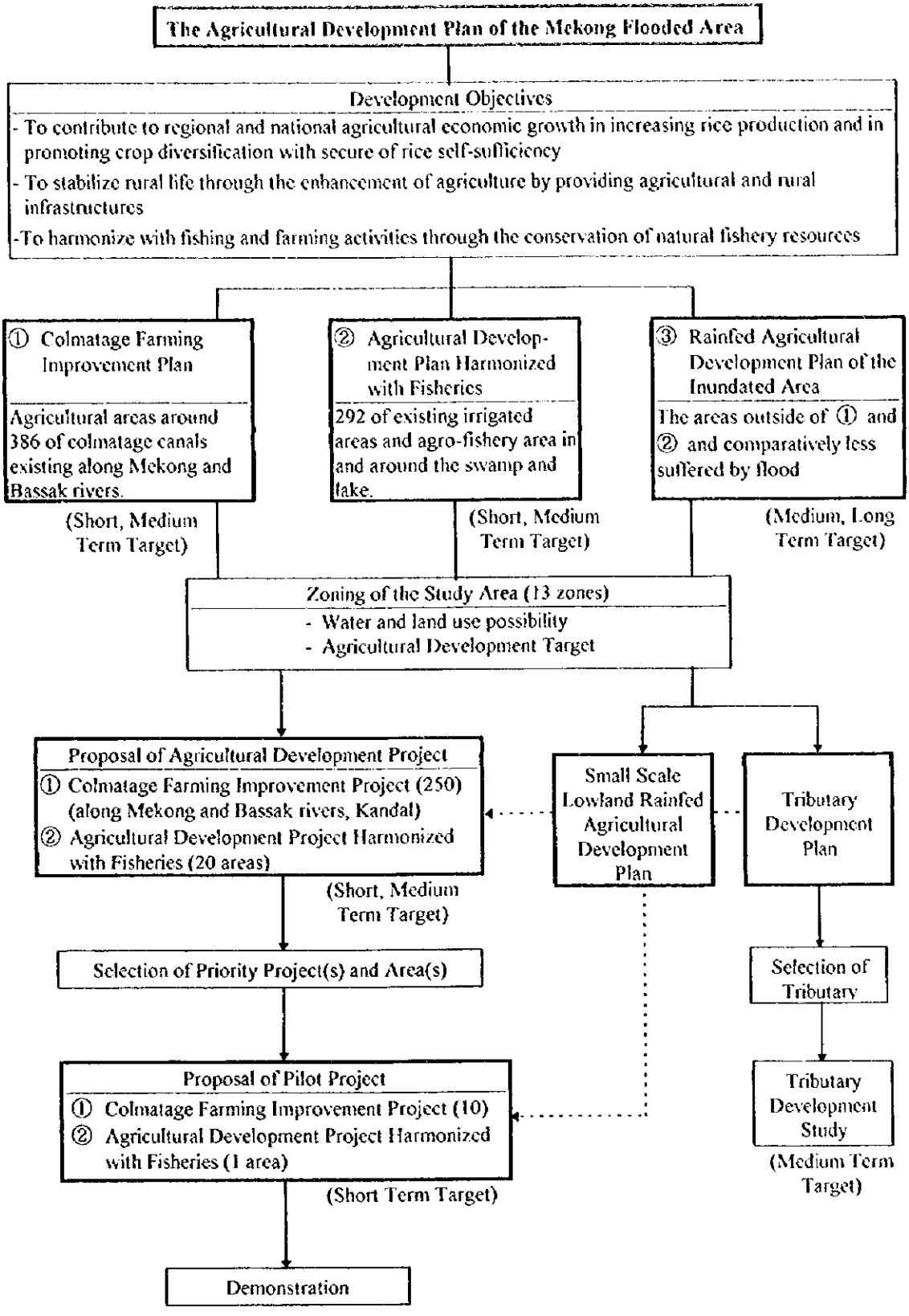
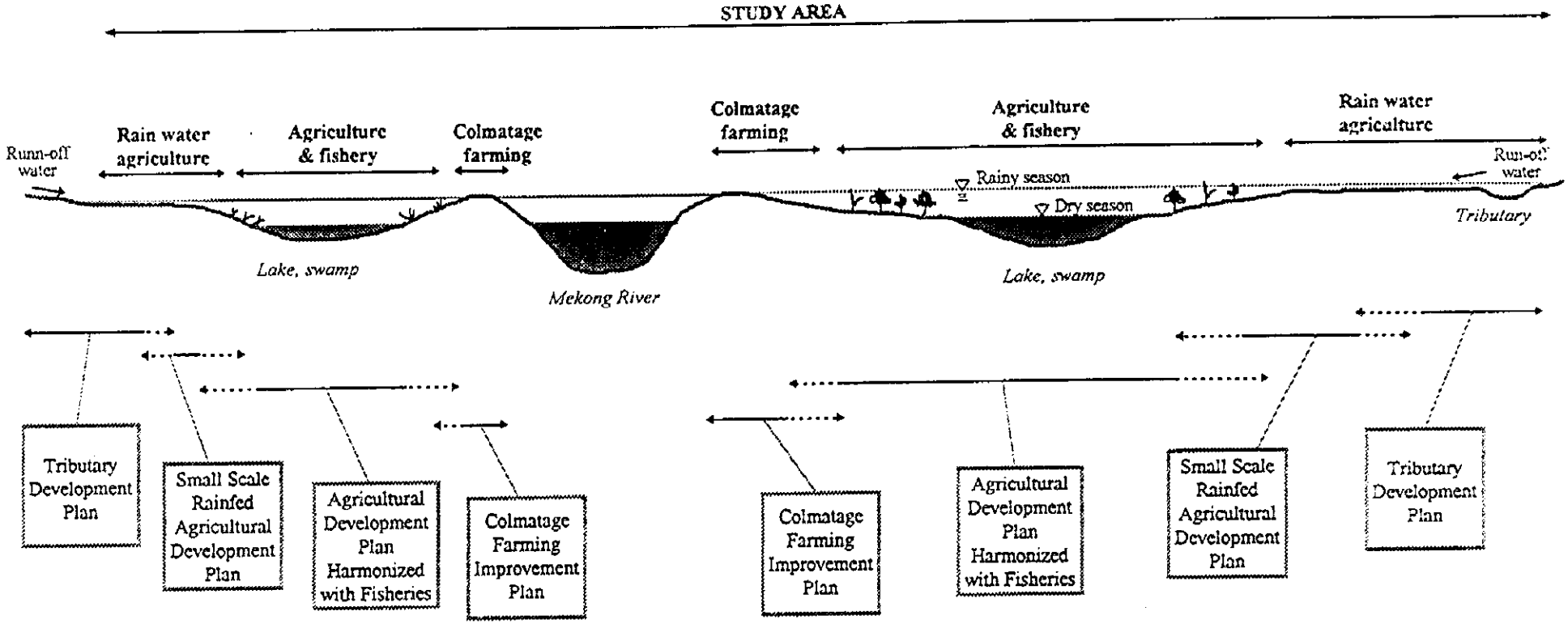


Figure 3.1 Basic Development Concept of Master Plan and Development Strategy



Development plan	Area	Main development purpose
Colmatage Farming Improvement Plan	Silting area around colmatage canals along Mekong and Bassac river (Flood is not severe).	- Crop diversification - Increase of crop yield
Agricultural Development Plan Harmonized with Fisheries	Agro-Fishery area around swamp and lake (Flood is severe).	- Increase of dry paddy area - Conservation of fishing resources
Rainfed Agricultural Development Plan	Area depending on rain water, far from swamp and lake (Flood is not severe).	- Increase of cropping area - Stabilization of wet paddy
Small Scale Rainfed Agricultural Development Plan	Around agro-fishery area, difficult to access to water resources.	
Tributary Development Plan	Along river system.	

Figure 3.2 Development Concept of the Study Area

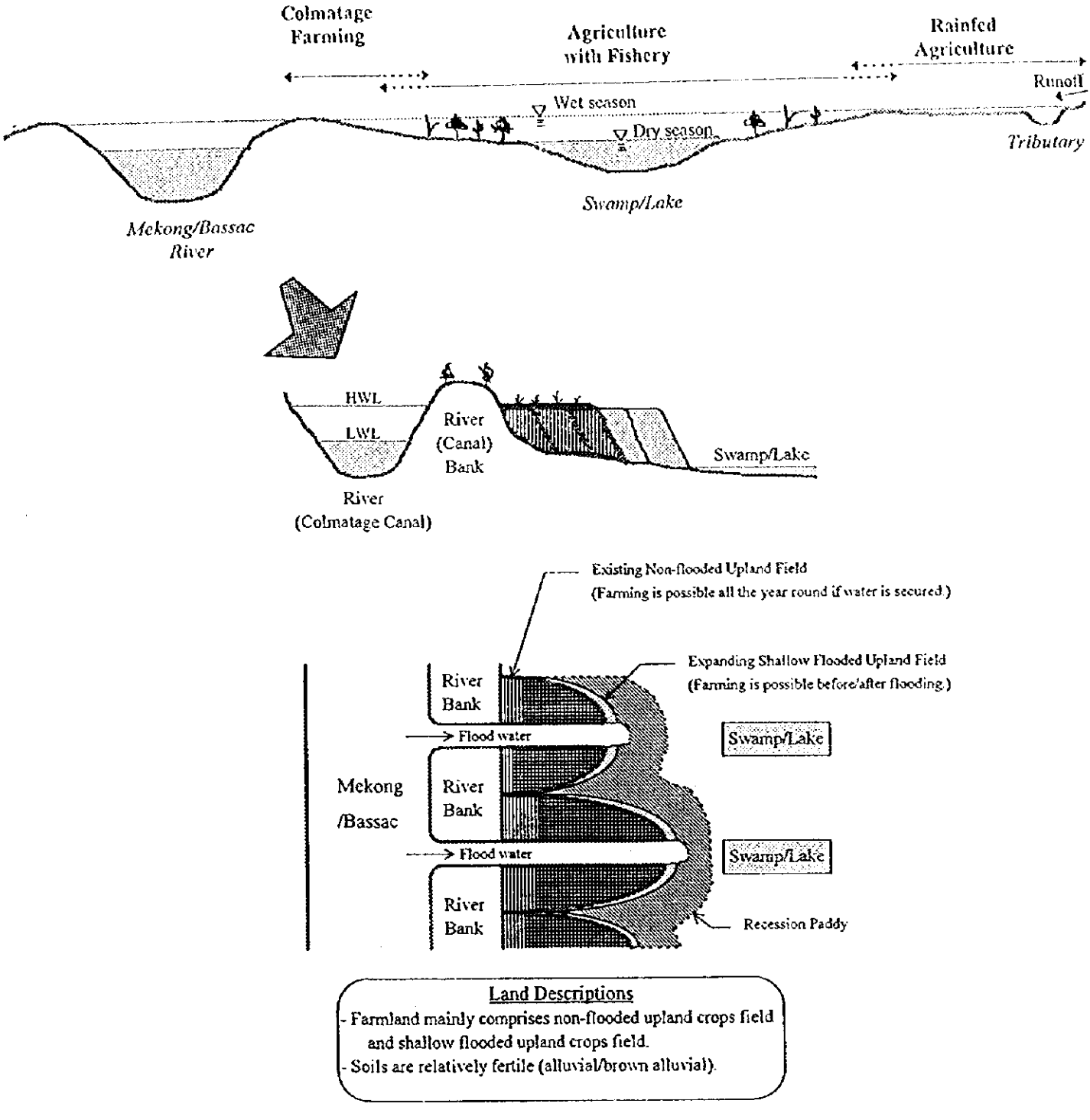


Figure 3.3 Outline of Land Use in Colmatage Farming Areas

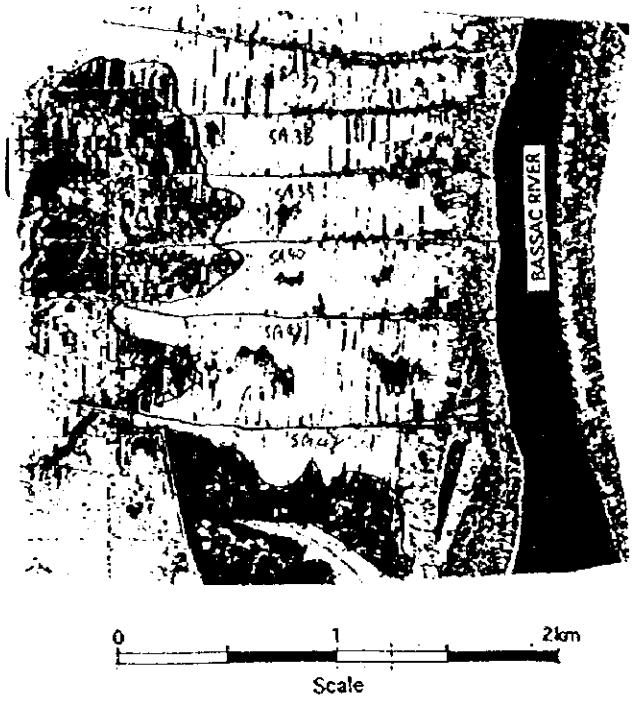


Figure 3.4 Typical Plane of Colmatage Canal Type I (Dec. '92)

Saang District, Kandal Province
Colmatage System No. SA61-SA69

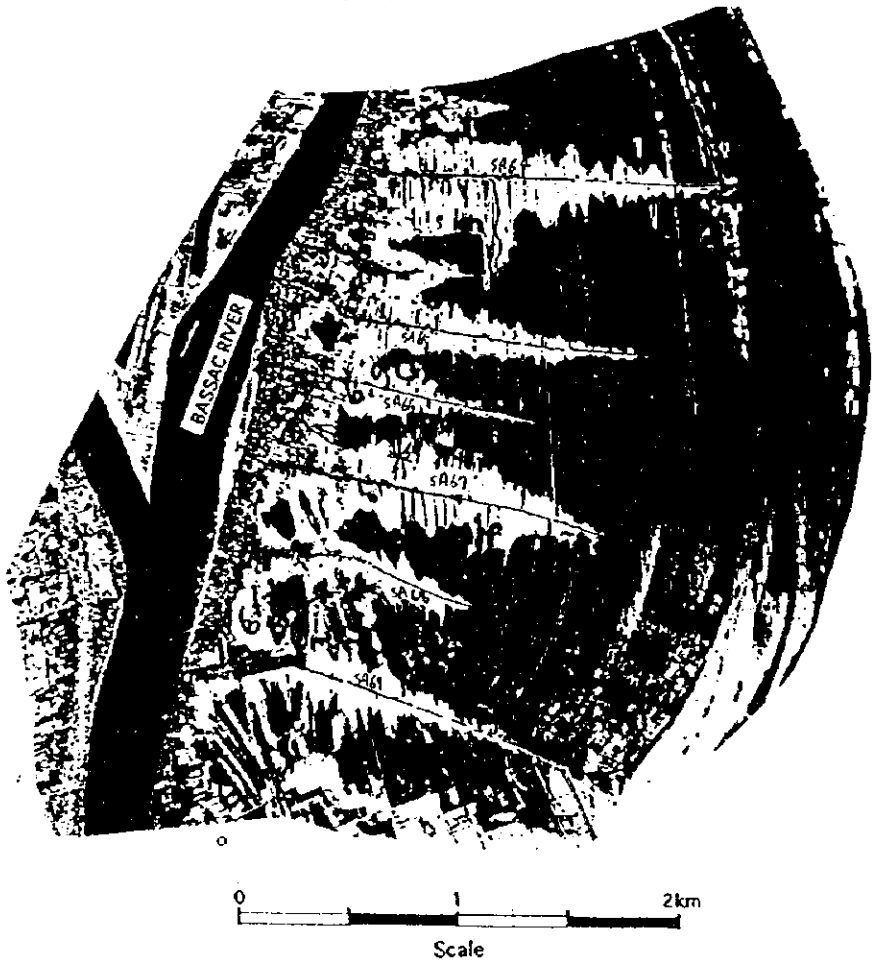
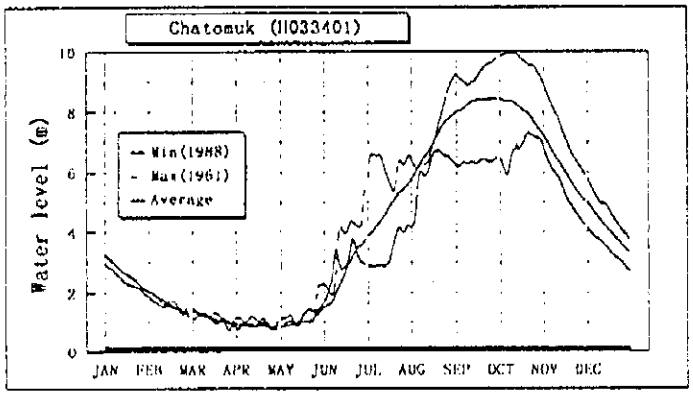
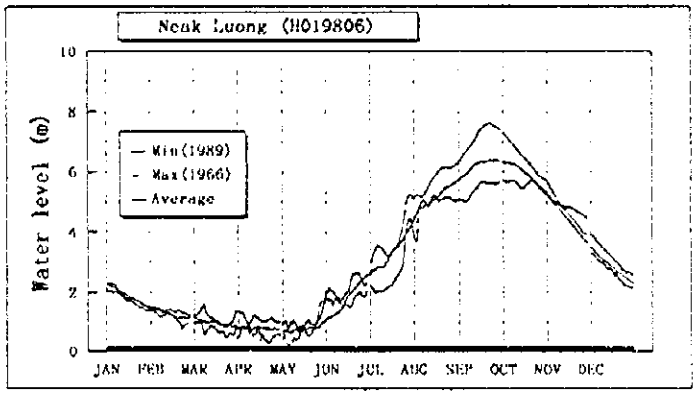


Figure 3.5 Typical Plane of Colmatage Canal Type II (Nov. '92)

Saang District, Kandal Province
Colmatage System No. SA37-SA42





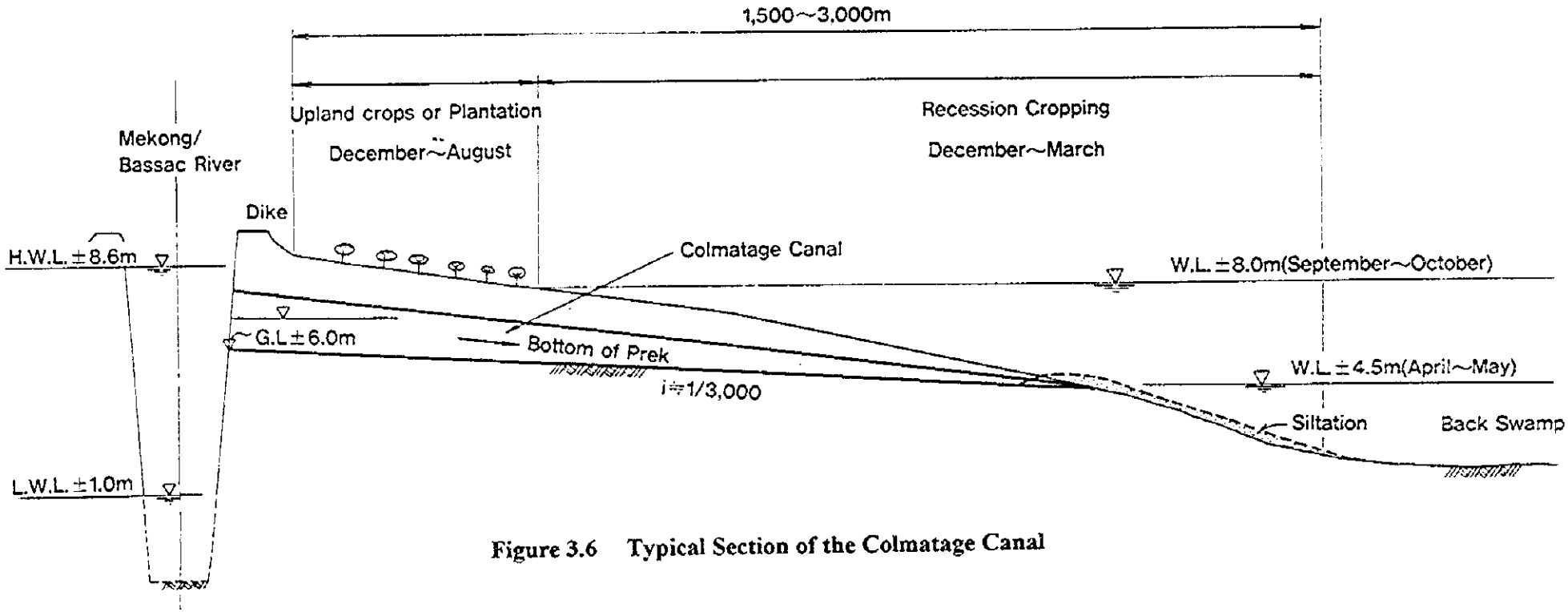
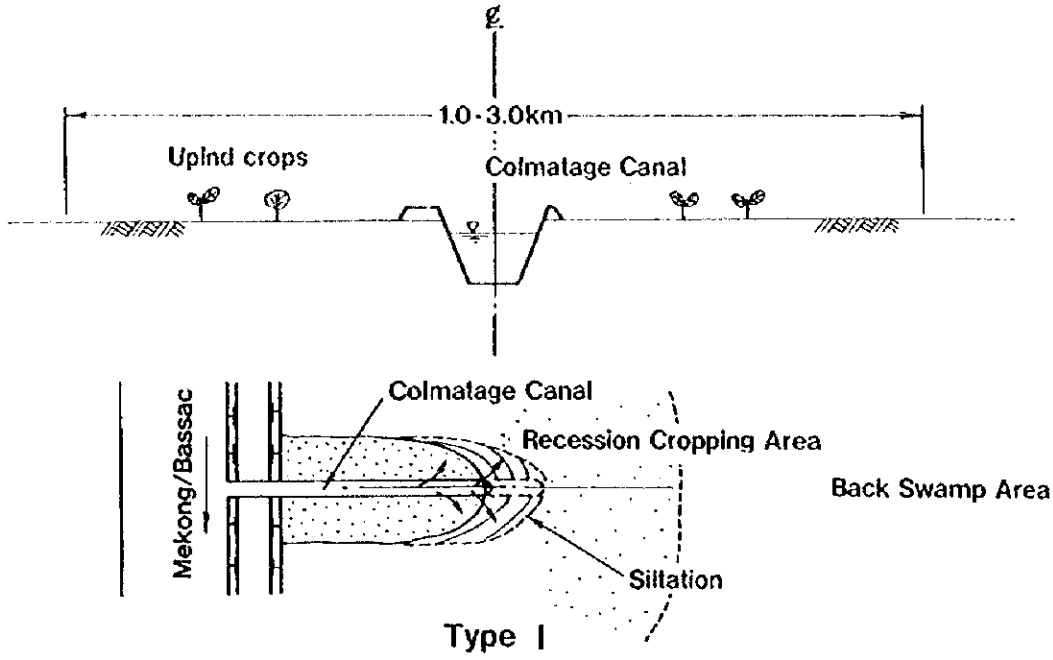
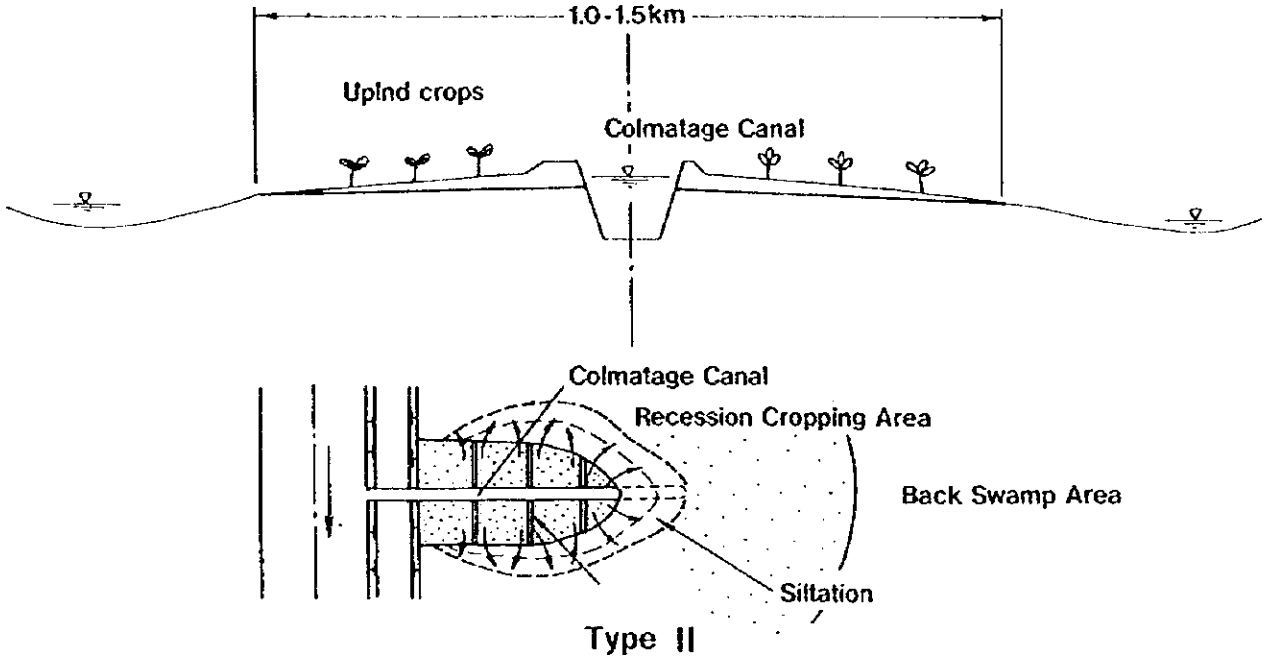


Figure 3.6 Typical Section of the Colmatage Canal



Type I

Note ; -Upland crops area is usually not inundated.
-velocity in canal is estimated at about 1.0m/sec.
-Siltation depth is about 2.5 cm/year



Type II

Note ; -Upland crops area is usually inundated after September.
-Velocity in canal is estimated at about 1.5m/sec.
-Siltation depth is about 5 cm/year.
-in order to expand an agricultural land, farmers make small ditches cross to the Colmatage canals to introduce the silty flood water.

Figure 3.7 Function of the Colmatage Canal

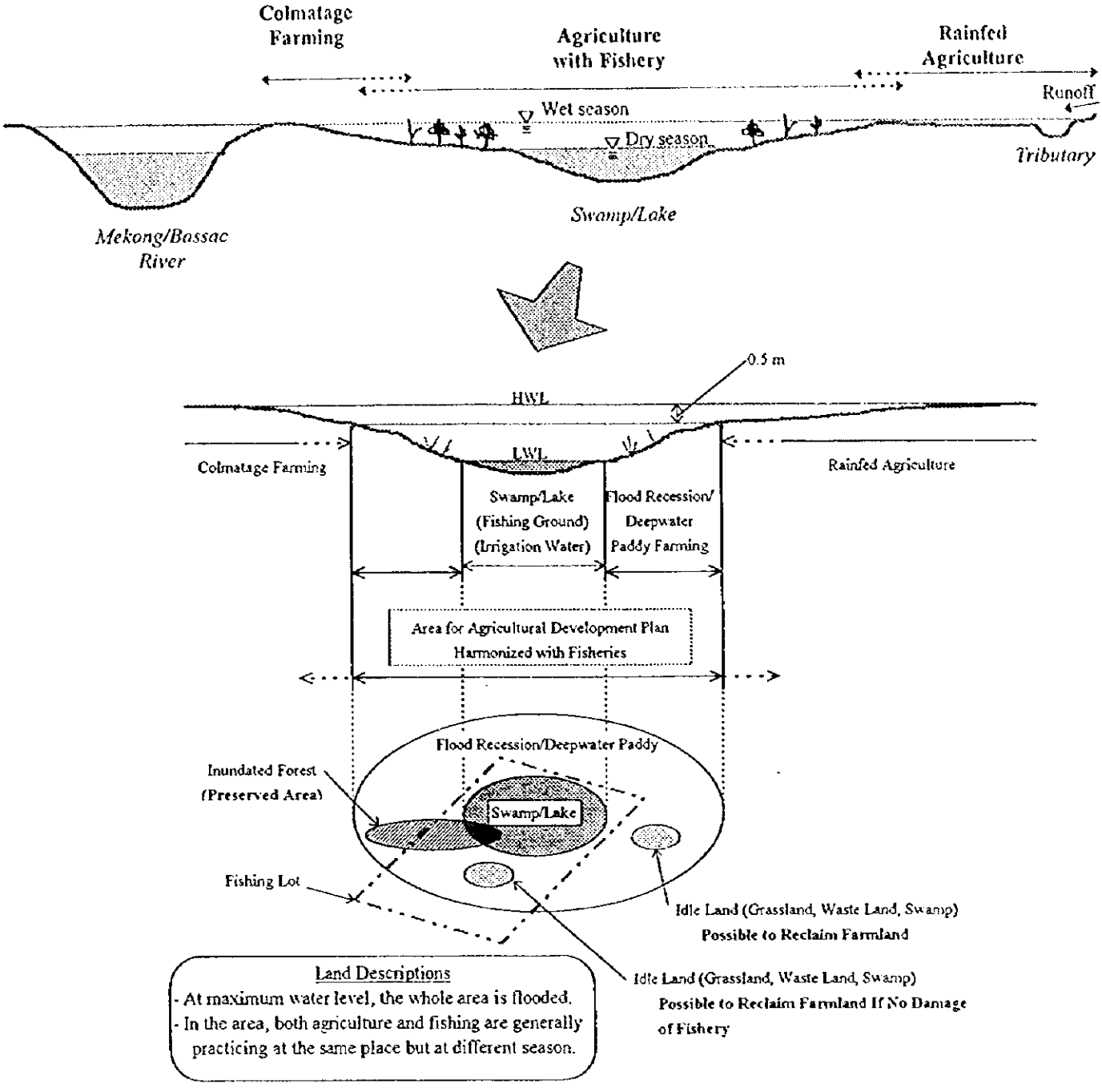


Figure 3.8 Outline of Land Use in the Areas for Agricultural Development Plan Harmonized with Fishery

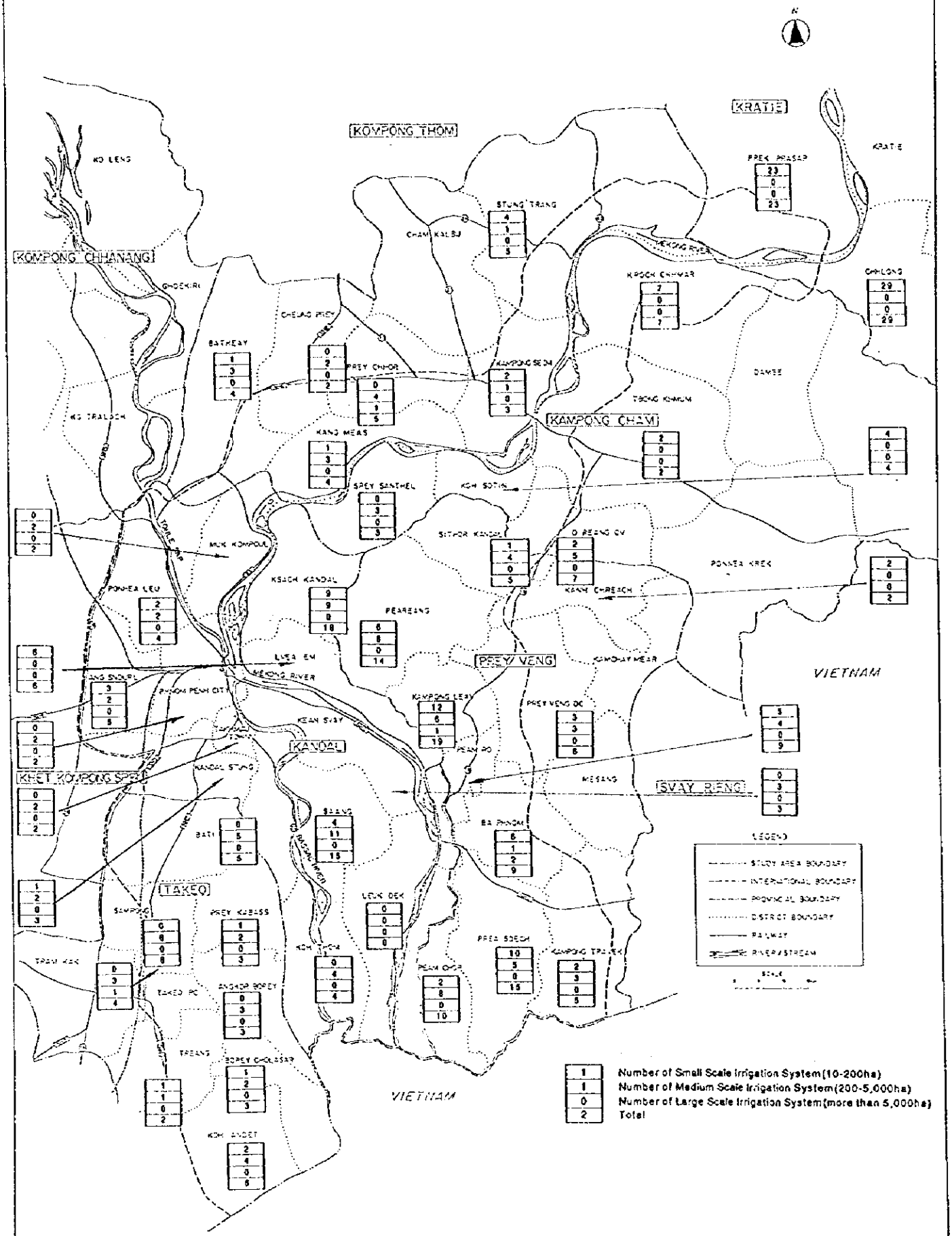
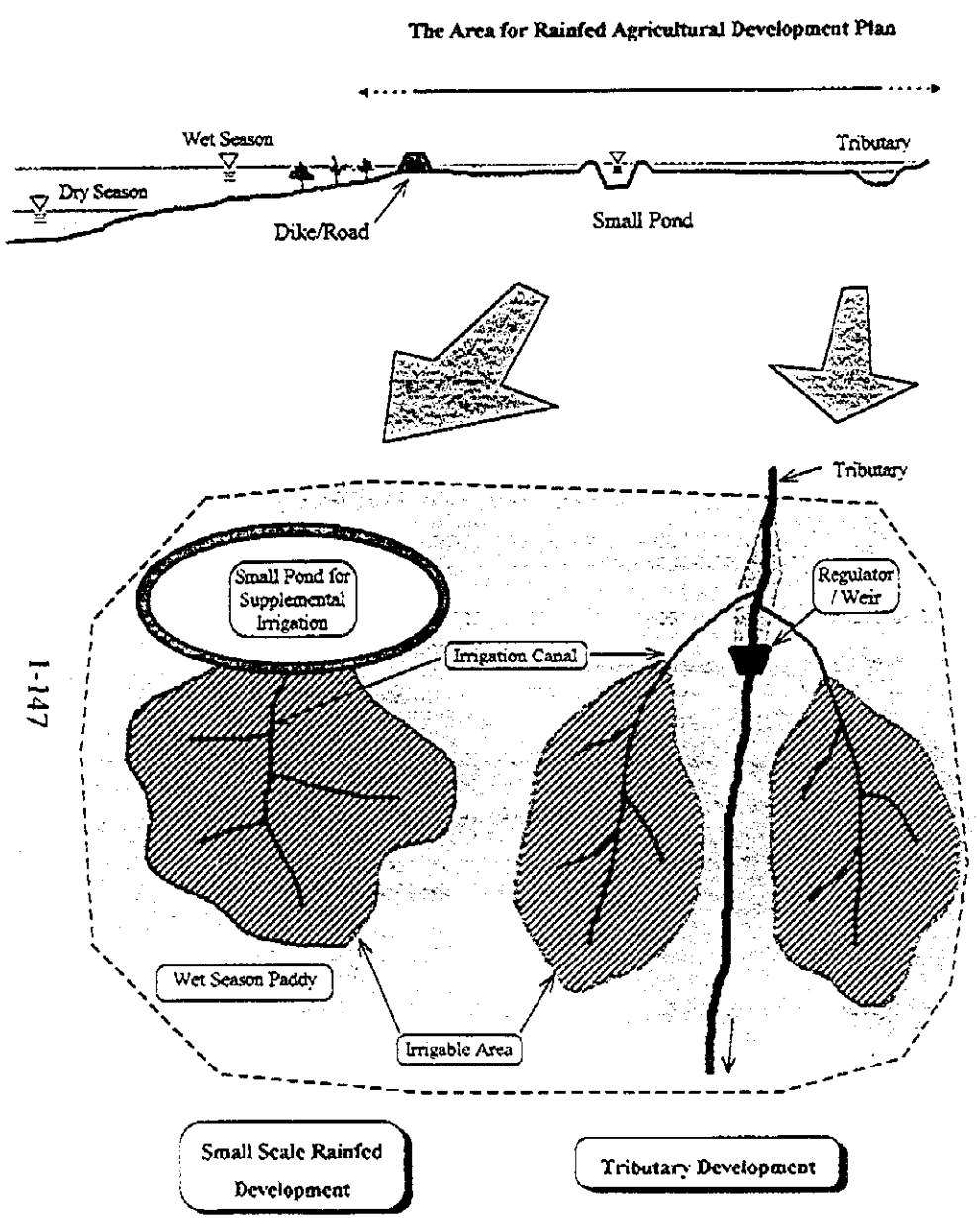
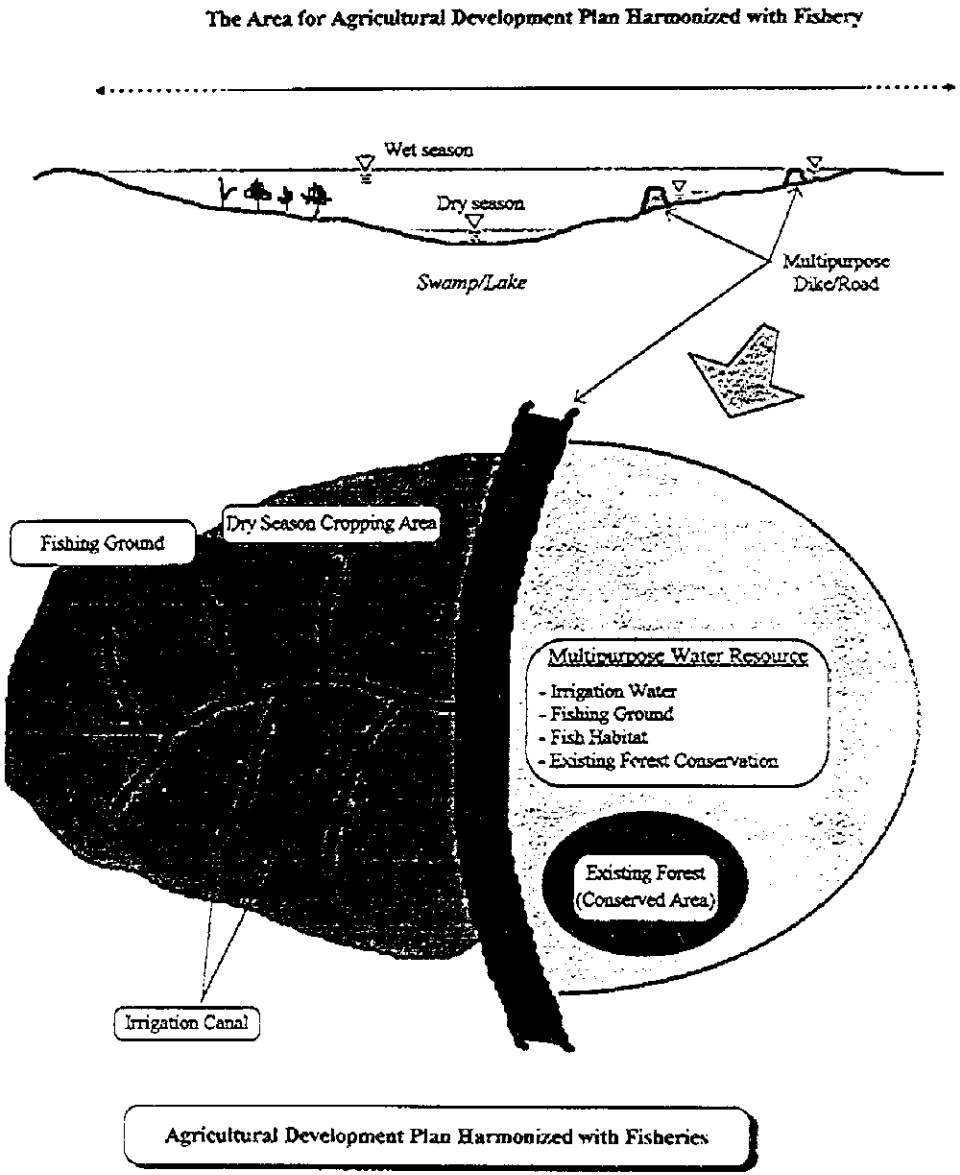


Figure 3.9 Distribution of Existing Lowland Irrigation System to be Rehabilitated



Outline of Rainfed Agricultural Development Plan



Outline of Agricultural Development Plan Harmonized with Fisheries

Figure 3.10 Basic Concept of Agricultural Development Plan Harmonized with Fisheries and Rainfed Agricultural Development Plan

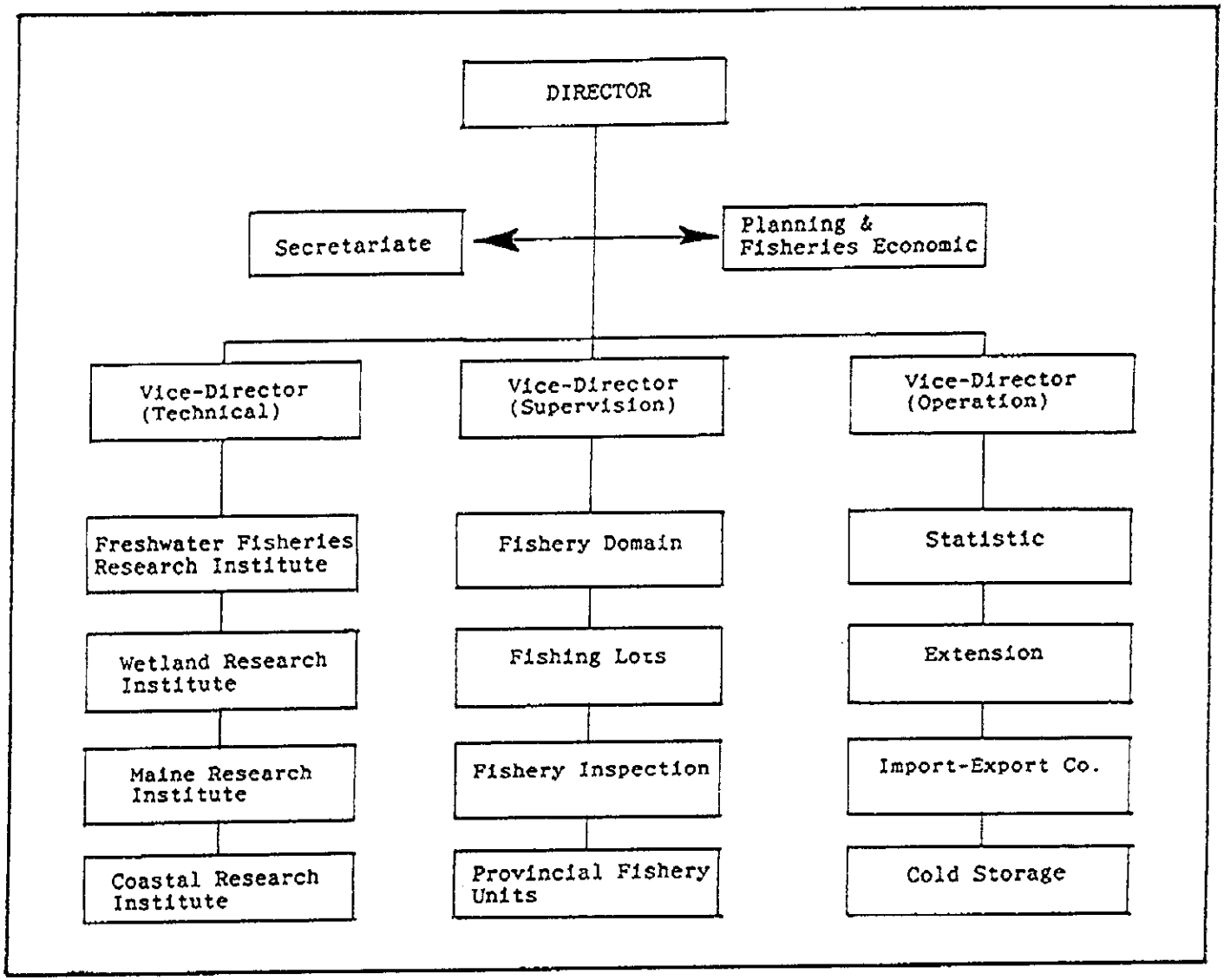


Figure 3.11 Proposal for New Arrangement of DOF

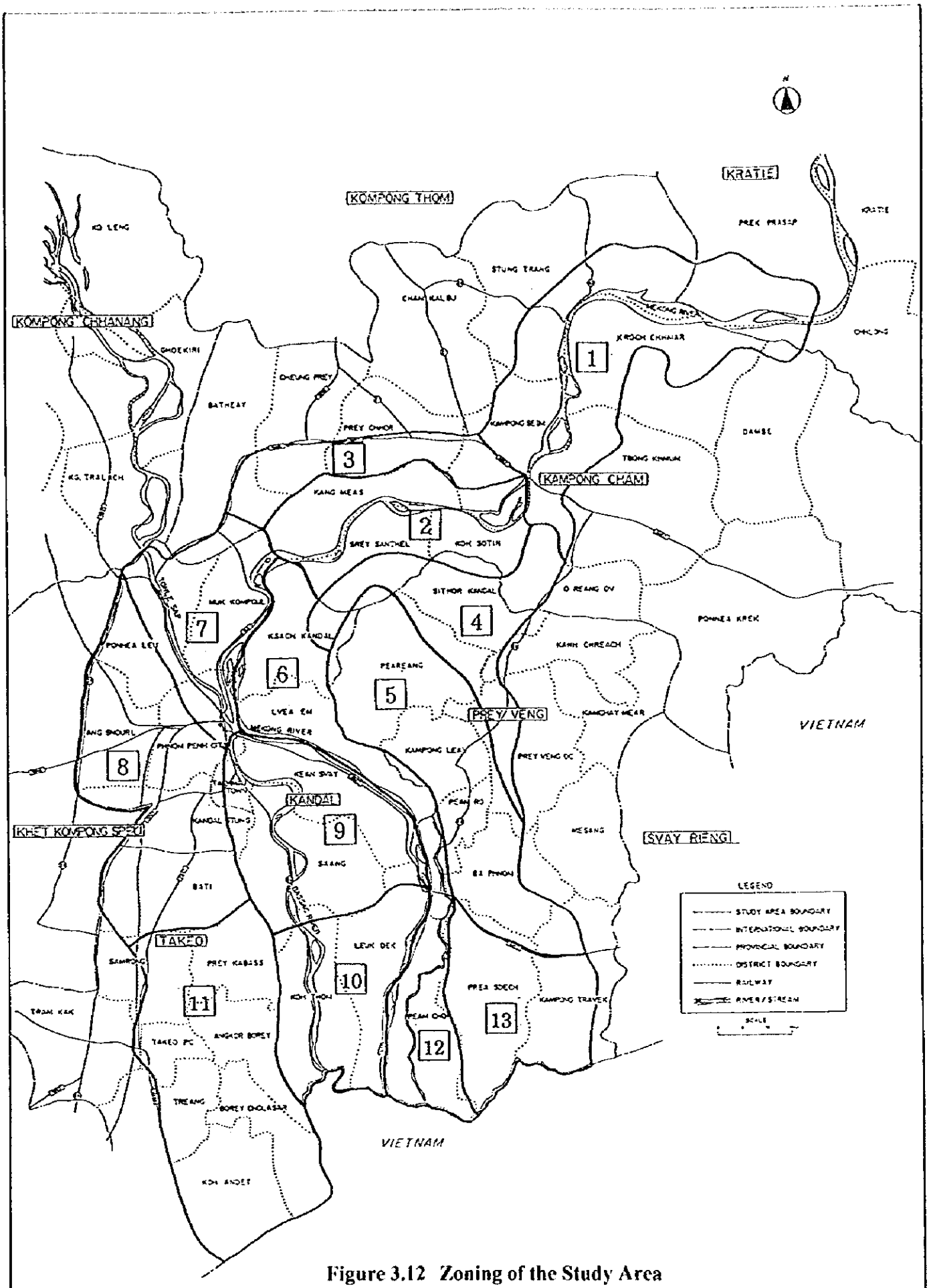


Figure 3.12 Zoning of the Study Area

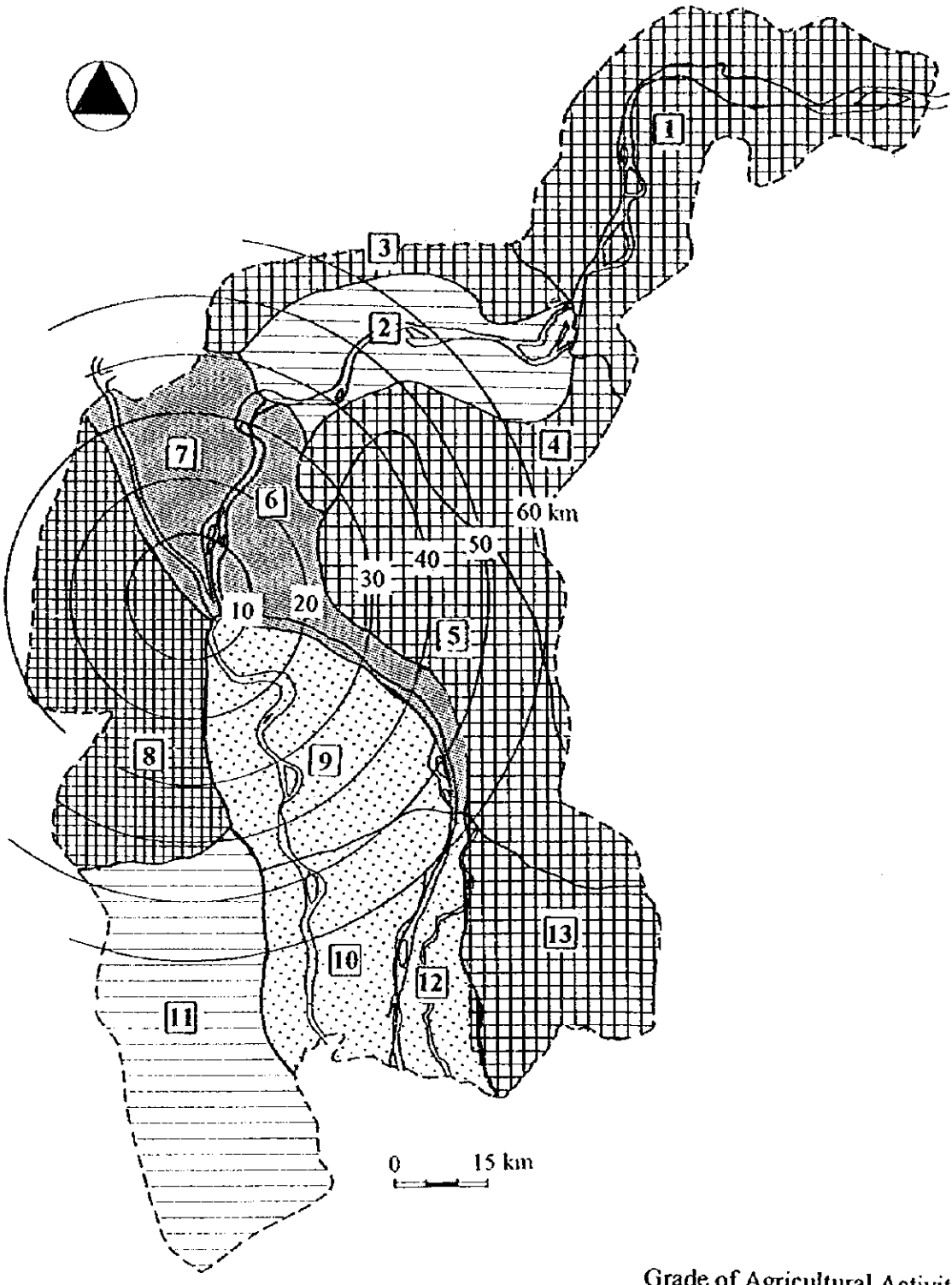
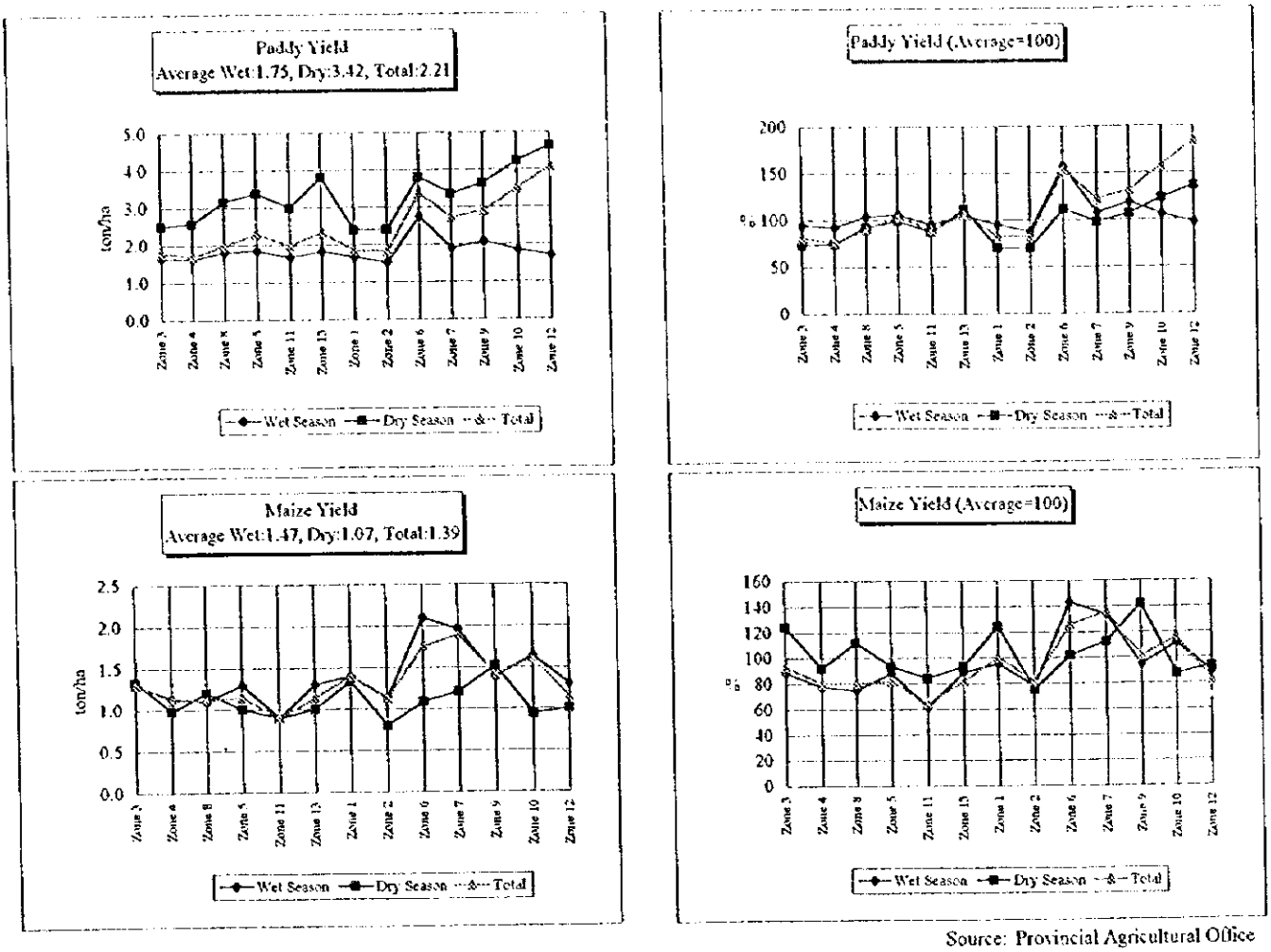
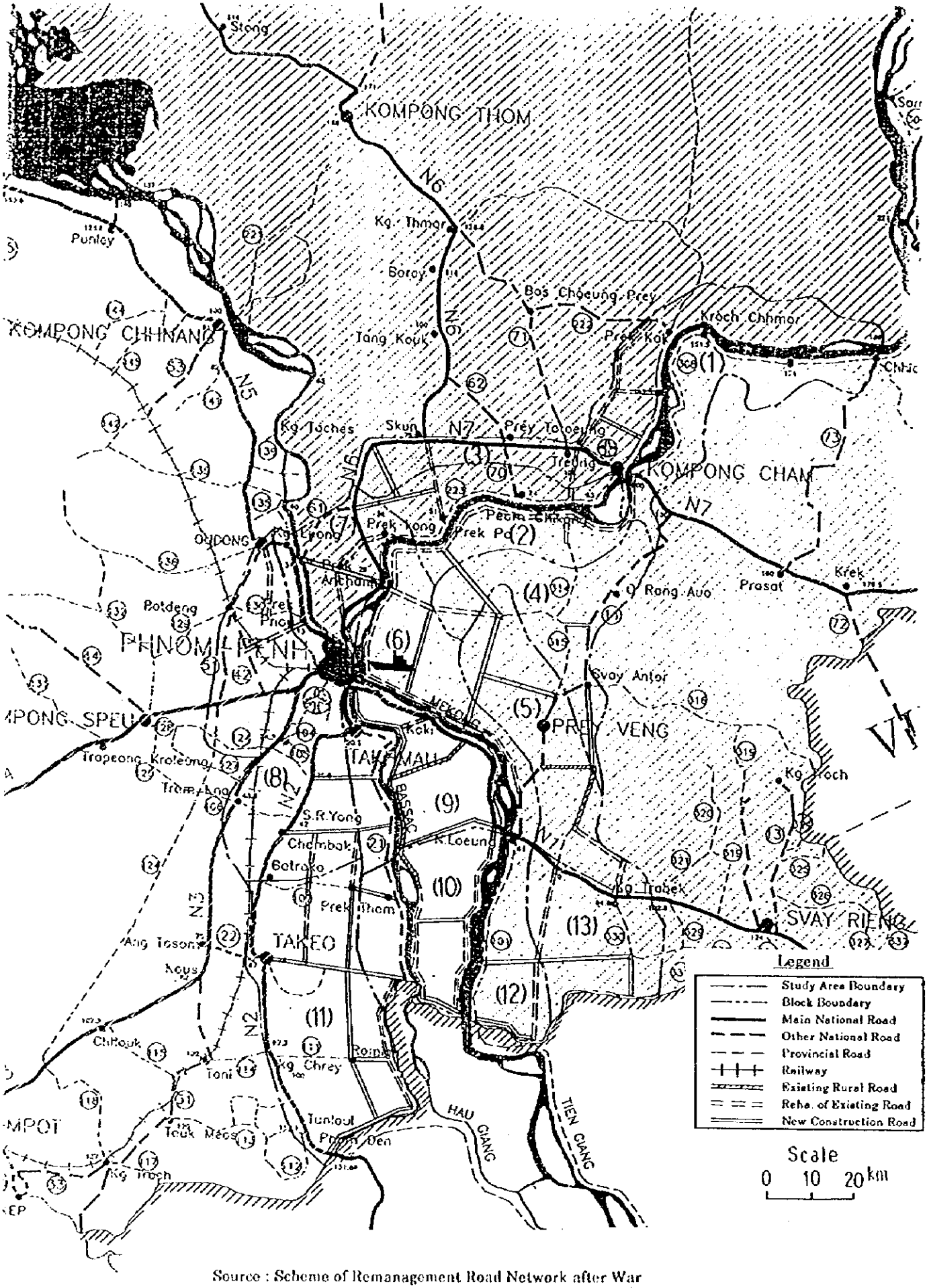


Figure 3.13 Comprehensive Evaluation of Each Zone



Source: Provincial Agricultural Office

Figure 3.14 Yield of Paddy and Maize by Each Zone



Source : Scheme of Remanagement Road Network after War

Figure 3.15 Location Map of Improvement Plan for Rural Road Networks