*SECTOR III*

# *LAND USE*

# SECTOR III: LAND USE

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# 1. INTRODUCTION

## 1.1 Background

Flood mitigation in the Chao Phraya River basin is the goal of the Study and land use is one of important aspects to be analyzed. In land use analysis, the current and past land use conditions in the Study Area are investigated and probable as well as possible future changes in land use are analyzed.

A land use condition is one of key parameters to determine flood conditions, so that it cannot be ignored in formulating any flood mitigation measures. For example, a coefficient of discharge is closely related to a land use condition, and if a forest area where the coefficient of discharge is very low is converted into an urban area, the flood conditions around that area would get considerably worse.

Ad hoc development without plan and control usually leads to unfavorable and disorderly land use by which environment is deteriorated and flood conditions worsen. Structural measures, such as construction of dikes, drainage systems and diversion channels, do not have a mighty power to prevent floods completely. Or even if they could, it would cost extravagantly and at the same time a flood damage potential would skyrocket. They should go along with other measures, namely, non-structural measures. One of promising non-structural measures in the Study is to control and/or guide land use by rules and regulations.

## 1.2 Objectives of the Study on Land Use

The objectives to conduct the study on land use are described as follows:

(1) to provide useful information on land use to formulate non-structural measures as well as structural measures for flood mitigation, and

(2) to formulate non-structural measures by way of land use control and guidance for flood mitigation.

## 1.3 Procedure of the Study

Firstly, all those available data concerning land use are to be collected as many as possible. Especially the emphasis is on the data in the flood-prone area because the goal of the Study is to mitigate flood damage in the floodplain.

Secondly, the present land use conditions are investigated. Based on the data collected as well as interviews and field survey, the present and past land use conditions are depicted. To know the past land use conditions is important to understand historical consequences based on which a future land use can be projected.

As for agricultural land use, special attention is paid to paddy fields due to its scale dominance and its high retarding function of flood water. For example, floating rice can elongate at 4 to 5 m height so that its vulnerability to floods is very low while HYV can grow only up to 50 cm to 1m height and it is highly vulnerable to floods. Hence, the land use for paddy fields needs to be more scrutinized than other land use types.

It can be said that impacts of urban land use, except those of land use in Bangkok Metropolis, on overall flood conditions in the basin are negligibly small because of its relatively small size. There are many urban areas in the flood-prone area most of which have their own urban development plans and flood protection plans. In terms of land use, however, there is not much difference in what they are planning to do for development and flood protection. Therefore, no detailed analysis is made in any particular urban area. Rather all those urban areas can be basically regarded as sets of homogenous areas.

Also it is assumed in the Study that almost all major cities in the Study Area will be protected well by ring dikes planned and implemented mainly by PWD. With this assumption, urban land use can be put aside in the study on land use and can be considered as issues more related to urban drainage as well as institutions and organizations.

Thirdly, projection of future land use is undertaken. For urban land use projection, the urban development plans by DTCP and PWD are basically utilized with some supporting information from on-going development projects and planning reports available from government agencies. The method of projection applied is simple because the Study Area is too large to adopt any detailed and/or sophisticated method under constraints of limited time and resources in the Study.

The future agricultural land use projection is made by referring to the on-going JICA study of "the Kok-Ing-Nan Water Diversion Project" with the report named "Chao Phraya Basin Water Management Strategy," prepared by Binnie & Partners (Overseas) Ltd. in October, 1997, in which agricultural land use projections are made in the Chao Phyara delta and the basin, respectively.

In these projections, however, only the shares of land use types are projected and described in percentage in tables. There is no two-dimensional future land use information, so-called, a land use map. Preparing a two-dimensional future land use map is really a challenging task to complete. The Study Team understands that the accuracy on projecting future land use is very low and that it is too reckless to describe a projected future land use as a map in the Study report. For analyzing future flood conditions by flood simulation, however, it is necessary to have two-dimensional land use data. Only for this reason, a future land use map is prepared in this study. The future land use map shown in this report should be considered as one of possible scenarios of the future and being prepared for convenience for the computer simulation analysis.

Finally and the most important of all, non-structural measures of land use control and guidance are formulated. To do this, three different types of flood risk maps are prepared. The first type is historical flood maps. The second is a hydrological-hydraulic flood map. And the third is present and future flood damage maps. With these maps in hand, land use control and guidance can be analyzed.

Detailed discussion on rules and regulations, however, is not done here. Only the areas that need land use control and guidance are analyzed and proposed, and the purposes on land use control and guidance on those areas are indicated. Instead, detailed discussion on rules and regulations are given in the chapter of Institutions and Organizations.

# 2. PRESENT CONDITIONS OF LAND USE

## 2.1 Available Land Use Maps

There are four major types of land use maps that have been prepared or collected by the Study Team. Based on these maps and other information, the present conditions of land use in the Study Area can be analyzed. These four are discussed below:

(1) Satellite Photographs

The Study Team has collected the necessary satellite photographs of LANDSAT-TM, J-ESR1 and NOAA that cover the whole Study Area photographed in 1995 and 1996. The list of those photographs is given in Table 2.1.1. Using remote sensing technique, flood area maps, land use maps, and geomorphologic survey maps are developed out of those photographs with computer processing. The land use map is given in Fig. 2.1.1. The other types of maps are scattered around the study report, but mainly shown and used in 'Hydrological Analysis.'

(2) Flood Area Maps by RID

Several flood area maps to the floods in 1995 and 1996 are available in RID and they have been collected. The list of those maps is given in Table 2.1.2.

(3) Urban Land Use Maps by DTCP

The DTCP is responsible for urban planning, and sixteen (16) urban planning maps of major cities in the Study Area have been collected from DTCP. The list of the maps with their locations is shown in Table 2.1.3.

(4) Agricultural Land Use Maps by LDD

LDD has provincial agricultural land use maps covering the whole Study Area that have been collected. The list of those provincial maps is shown in Table 2.1.4. In addition, LDD has agricultural land resources maps and recommended agricultural land use maps that can be useful information for a future land use projection. The collected those maps are for Northern Region and Central Plain Region that can cover the whole Study Area.

## 2.2 Regional Land Use Conditions

The Study Area is composed of the whole Chao Phraya River basin. As is well known, the Chao Phraya River has contributed to making Thailand the major rice supplier in the world. In terms of land use as well as geographic and geological points of view, the Study Area can be demarcated into three: the Highlands, the Upper Central Plain and the Lower Central Plain, as shown in Fig. 2.2.1. Land use conditions of each demarcated area are discussed in the subsequent sections. Please note, however, that there is another demarcation appearing later, but that demarcation is applicable to only the floodplain which is divided into four areas and that demarcation has nothing to do with the discussion here.

### 2.2.1 Highlands

The upstream area of the Basin is made of hills and mountains. Hills were once overwhelmingly covered by forest and the many people living in the hills were engaged in slash-and-burn agriculture. Nowadays the forest has been considerably encroached by people's invasion for development. The majority of the people are living in limited flat areas where water is affluent and irrigation systems have been installed since many years ago due to severe constraints of limited natural resources.

(1) Agricultural Area

The adequate area for agriculture is really scarce and only observed in small spaces in valleys. Plenty of water supplied from the hills is available in these valleys and intensive rice farming has been practiced for a long time. Irrigation was already developed even in the era of Chiengmai as well as Nan. Double cropping is practiced in most places in the valleys while the second crop is not rice, but usually bean, garlic, or other vegetable. A while ago, slash-and-burn agriculture was so popular in the hills.

Table 2.2.1 shows agricultural land use in the Study Area. The demarcation of the Study Area is made roughly on the basis of provinces because the available data is compiled on the basis of provinces. For example, the Phitsanulok province should be divided into two pieces: The west side belongs to the Upper Central Plain and the east side to the Highlands. It is, however, demarcated as in the Upper Central Plain in Table 2.2.1 for convenience of easy data handling. The same goes to Table 2.2.2, too.

According to Table 2.2.1, the agricultural land use in the Highlands has two remarkable points: The share of forest area is far larger than the national average, and the farm land has just 14 % share of the whole area which is far below the national average of 41 %.

Table 2.2.2 shows the information on rice cultivation in the Study Area. Out of the whole farm land, 46 % is used as paddy field, and 111 % of it is irrigated. The share of irrigated paddy field is huge in comparison with the national average. Comparing with the Upper and the Lower Central Plains, the share of the land for second rice is very small, which implies that double cropping is not popular or that second crop is not rice.

It is noted that the most irrigation systems in the valleys have been historically developed by people themselves (so-called "People Irrigation"), not by any public assistance from, e.g., RID. Hence the systems are usually not so sophisticated and internal disputes among people about water management occur frequently. However, as seen in Fig. 2.2.2 in which RID's irrigation projects are shown, some governmental irrigation development projects have been carried out around Chiengmai, Lampang and Phrae although their areas are relatively small.

Around cities and towns where the food market is large, not only rice but cash crops like fruits and vegetables are cultivated. In the terraces located nearby all along the border to the Central Plains, sugarcane is observed to grow in

many places. Corn is produced mainly in the Nan province as shown in Fig. 2.1.1.

(2) Urban Area

There are some ancient cities such as Chiengmai and Nan. Future urban development in the Highlands is minimal because the monocentric development around Bangkok Metropolis still continues and there is few development potential in the Highlands. Population pressure in urban areas has already reached to a certain level where no further increase in population is allowed in terms of availability of land and other resources.

Chiengmai is the largest municipality with the population of about 173,000 and Lampang is the second with 65,000 in 1995. Other major municipalities such as Nan, Tak, Payao, and Phetchabun, are relatively small with 20,000 to 30,000 of population. Almost all municipalities do not show any future expansion of urbanization very much. These figures are shown in Table 2.2.3 in which only tesaban (municipalities) are indicated.

(3) Forest Area

The Highlands was once covered by dense forest, but economic development with population increase made the forest area reduced by half in this past half century. Though slash-and-burn was traditionally practiced everywhere for years, its impact on environment was trivial due to low population pressure. Owing to the recent prohibition of tree felling by law, the forest has been recently conserved well.

Tables 2.2.1 and 2.2.4 indicate that the forest area shares almost 60 % of the whole area which is far larger than the national average of 26 %. The dominance of forest is easily acknowledged by the observation of Fig. 2.1.1.

### 2.2.2 Upper Central Plain

The Upper Central Plain lies in between the Highlands and the Lower Central Plain. It is made mainly of riverine terraces and alluvial fans, as well as floodplain along the major tributaries of the Chao Phraya River, such as the Nan and the Yom Rivers. This area almost coincides with the midstream of the Chao Phraya River.

(1) Agricultural Area

The riverine terraces and alluvial fans have basically poor soil quality as well as poor water supply for agriculture. In those areas, sugarcane is mainly cultivated due to these natural conditions. On the other hand, the floodplain lying along the Nan and Yom Rivers is mainly used for cultivating traditional rice varieties, though some areas are used intensively with irrigation systems and land consolidation works these days. Fig. 2.2.2 shows that the RID's irrigation projects are located between the Nan and Yom Rivers and along the Ping River.

The pattern of agricultural land use in the Upper Central Plain looks very similar to that of the national land use, with a little more share of paddy field

in the Upper Central Plain according to Table 2.2.1. As for rice cultivation, Table 2.2.2 also shows that the paddy field in the Upper Central Plain has a little bigger share than that of the national average. The share of irrigated paddy field, however, is relatively small when it is compared with those in the Highlands and the Lower Central Plain.

On the terraces, sugarcane is observed everywhere. Along the rivers near urban areas, fruits and vegetables are cultivated as shown in Fig. 2.1.1.

(2) Urban Area

Nakhon Sawan is the largest municipality in population in the Upper Central Plain with the population of about 110,000. The second is Phitsanulok with 78,000. All other municipalities are relatively small with 10,000 to 40,000. These municipalities listed up in Table 2.2.3. are located basically on rivers, so that they are likely to suffer from flooding.

(3) Forest Area

The forest area is 24 % of the whole area, which is almost the same as that of the national average. The Phitchit province has no forest area. As mentioned before, the whole provinces of Uttaradit and Phitsanulok are classified as in the Upper Central Plain for convenience of data processing, although half of them should have belonged to the Highlands. If a correct demarcation had been made, the forest area would have been smaller than 24 %.

### 2.2.3 Lower Central Plain

The Lower Central Plain can be simply characterized as a delta. This area lies from Chai Nat down to the mouth of the Chao Phraya River. Although the average annual rainfall is relatively small for rice production, there is plenty of water during the rainy season flowing down from upstream and well-stretched irrigation canals and impounding systems have made this delta the most active rice production area for the last century or so. With land consolidation and development of rice varieties, double cropping and triple cropping are undertaken in many paddy fields. Bangkok is located here. Bangkok is still growing as a mono-center of the country. Urbanization and industrialization are easily recognized in Bangkok Metropolis and its vicinity.

(1) Agricultural Area

There is plenty of agricultural land in the Lower Central Plain with 39 % of paddy field to the whole area, whose number is relatively large in comparison with 22 % of the national average as shown in Table 2.2.1. Table 2.2.2 shows the same character, and on top of that, the share of irrigated paddy field is enormous with 121 % to the whole paddy field. Double rice cropping can be said to be popular based on the fact that the share of the second rice field to the whole paddy field is 24 %.

Fig. 2.2.2 shows that the whole delta has been already irrigated by the RID. Fig. 2.2.3, which was prepared by the Kasetsart University and the ORSTOM, shows the details of agricultural land use in the Lower Central Plain. Around

Ayutthaya, Ang Thong and Singburi, traditional rice varieties are still cultivated. Except this area, the high yield varieties grow in almost all paddy fields, and double and sometimes triple cropping are conducted. The West Bank and the Rangsit are typical areas for intensive rice production. Along the coastal line the brackish water aquaculture, e.g., shrimp farming, is observed. Fruits are produced mostly in the west of Bangkok as well as in a part of Rangsit. Sugarcane grows in the north of Nakhon Pathom and in the west of Singburi where soil conditions and water availability are not much suitable for rice cultivation.

(2) Urban Area

As seen in Fig. 2.1.1, the Bangkok Metropolitan region is colored in red which is so noticeable at the first sight. Bangkok itself has a little more than 7 million of people, and it is surrounded by those vicinities with larger population. As shown in Table 2.2.3, those provinces adjacent to Bangkok, such as Nonthaburi and Samut Prakan, have huge populations and they form a gigantic urban region, so-called the Bangkok Metropolitan Region.

(3) Forest Area

Table 2.2.1 shows that the share of forest area is only 3 % to the whole Upper Central Plain. Instead, there once were a lot of mangrove and nipper in the lower delta and bushes in the middle, but due to development in this century, the majority of them have been wiped out, and urban areas and paddy fields have been developed over them.

## 2.3 Land use Control and Guidance Practiced in Foreign Countries

In this section, laws and regulations related to land use control and guidance for flood mitigation in other countries are reviewed. The purpose for the review is to get familiar with what other countries are doing for flood mitigation by means of land use control and guidance and to form the basis to analyze what type of land use control and guidance can be applied to the floodplain in Thailand.

### 2.3.1 Japan

(1) General View

The whole picture of the overall structure of Japan's land use-related major laws is given in Fig. 2.3.1. The laws related to land use control and guidance are Urban Planning Act, Agricultural Land Act with Act for Agricultural Promotion Areas, Forest Act, Natural Park Act, and Environmental Conservation Act as shown in Fig. 2.3.1. On top of these, there is National Land use Planning Act with which each of them should comply.

Although Fig. 2.3.1 shows five laws, excluding National Land use Planning Act, by which land use can be controlled, only three laws such as Urban Planning Act, Agricultural Land Act with Act for Agricultural Promotion Areas, and Forest Act are the ones that are operated in consideration of flood

mitigation. In general, Natural Pack Act and Environmental Conservation Act are not concerned about technical aspects on hydrology or floods.

(2) National Land use Planning Act

In this law, a Prime Minister formulates a national plan that must be approved by the cabinet decision. Then complying with it, governors formulate prefectural plans that must be approved by prefectural assemblies. Governors must ask for consultations and have discussions with regional national development planning councils as well as mayors concerned in the course of formulating prefectural plans. Similarly, mayors formulate their city or town plans as governors do.

After all plans in all territorial levels are formulated, governors are responsible to formulate general land use plans in their prefectures. Again those plans must be approved by a Prime Minister after consultations and discussions with councils and mayors concerned.

In those land use plans, lands are demarcated into five categories: urban area, agricultural area, forest area, natural park area, and natural conservation area. In each of those areas, different land use strategies with different laws are applied.

The rules described above are stipulated by National Land use Planning Act.

(3) Urban Planning Act

This act is enforced in urban areas designated by the general land use plans. When designating urban areas, governors must make hearings with concerned mayors and regional councils of urban planning, then their plans must be approved by a Minister of the Ministry of Construction.

Urban areas are demarcated into three: urbanization areas, controlled urbanization areas, and others. Urban Planning Act stipulates different rules and regulations on each of three areas.

Urbanization areas are the ones that are already urbanized or should be urbanized under good control. Urbanization areas are demarcated into 13 categories in terms of land use, from high quality residential area to commercial to exclusive industrial area. Among them, seven categories are related to residential areas.

For example, in a class one low-rise residential area, a floor space is index should be between 50 to 200% and only those public facilities such as schools and clinics are allowed to build except for residential houses. That is, no large factory or department store is allowed to build so as to keep the residents comfortable for living there. With rules and regulations pertaining to land use types designated, each area of 13 categories is controlled and directed to a desirable shape of land use.

In the urbanization area, any development activity with a size of more than 1,000 square meters should be reported to a prefectural government and

approved by a governor. Each prefectural government has a right to change this minimum value between 300 to 1,000 square meters.

A controlled urbanization area is the one where development is to be controlled and contained. One of the criteria to demarcate a urbanization area and a controlled urbanization area is that the area where useful natural functions such as water cultivation function and sediment control function should be preserved is designated as a controlled urbanization area. In this way, mitigating natural disasters is explicitly considered in Urban Planning Act. Development activities are strictly controlled in a controlled urbanization area.

An area that does not belong to either an urbanization area or a controlled urbanization area in an urban area is classified into others. Even in such an area, similar rules and regulations as those in an urbanization area are to be applied and a permission from a governor is required to do any development activities. Basically, any development with a size of more than 3,000 square meters should be reported and permitted by a governor in others.

(4) Agricultural Land Act and Act for Agricultural Promotion Areas

Since the above two acts go along together to control land use in agricultural lands, they are regarded as a single act in this chapter for convenience. In fact, Agricultural Land Act was enforced first, then Act for Agricultural Promotion Areas was enforced to cover such issues that Agricultural Land Act could not handle well.

Agricultural Land Act is to control acquisition and transfer of property rights over agricultural lands; to prevent speculators from acquiring agricultural lands without an intention of cultivating those lands and to promote the efficient use of agricultural lands. Once agricultural lands are converted into other types of land use, it would cost enormously to get them back for agriculture, thus this act is to control disorderly development of agricultural lands by means of a permit system of transactions of property rights.

When an ownership of an agricultural land is transferred or its property rights are changed, such a move should be permitted by a local agricultural committee, even though its type of use, i.e., agricultural use, remains the same.

When an agricultural land is converted into other use, such a move should be permitted by a governor if it is less than or equal to 2 ha, or by a Minister of the Ministry of Agriculture, Forest and Fishery if it is more than 2 ha. However, in case that that agricultural land is located in an urbanization area designated by Urban Planning Act, it is not required to receive a permit, only a reporting to a local agricultural committee is enough to change the land use type from agriculture to other.

Act for Agricultural Promotion Areas is to designate the lands to be used for agriculture. Such lands are called the agricultural land use areas. Those lands are strategically selected in consideration of securing and conserving clusters of efficient agricultural lands in coordination with other use of lands nearby.

Once those lands are designated as the agricultural use, all transactions of rights over them and types of use are strictly restricted. Basically, any change in land use type is not permitted in the agricultural land use area by this act.

(5) Forest Act

The purposes in this act are, by means of setting up forest plans as well as rules and regulations, to conserve forests and to enhance forest productions so as to conserve the national land and contribute to the national economic growth. Basically, forests owned by the country can be controlled at its disposal. The point is how to control private forests.

In the act, a Minister of the Ministry of Agriculture, Forestry and Fishery must formulate a national forest plan every five years. Based on this national plan, governors must formulate regional forest plans in their prefectures every five years. Unlike the national forest plan, regional plans are formulated only on those private forests that are designated as forest planning areas by a Ministry of Agriculture, Forest, and Fishery. In this way, part of private forests is controlled by Forest Act. Development in such a private forest that belongs to a forest planning area is not allowed unless a governor gives a permit for it.

With regard to national forests, a director at a regional forestry office must formulate a forest plan over national forests in each forest planning area every five year. Thus, national forests are fully controlled by Forest Act.

Most noticeable point in Forest Act in terms of flood mitigation is that the act can designate preserved areas for the purpose of natural disaster mitigation. In case a certain forest area has one of functions of; water cultivation; sediment control; landslide protection; wind damage mitigation; and so on, that forest area can be designated as a preserved forest and all activities there are strictly prohibited except for those activities that are permitted by a governor.

(6) Other Laws and Regulations Related to Land use

There are several others that are able to control and guide land use indirectly. For example, Building Control Act supports Urban Planning Act and contains disorderly construction. In this way, Building Control Act can indirectly control land use.

River Law is a fundamental law for managing rivers. This can, in a sense, control land use in and around rivers where river managers expropriate under River Law. Coast Law can control the land use of coasts and neighbors. Preserved forests are often observed along coastal lines and they are strictly controlled by Coast Law. And there are many other laws and regulations that are supplement to major laws and that are indirectly control land use.

Most of them, however, are in principle not intended to control land use for flood mitigation. Each law has its own purpose; Urban Planning Act is for controlling as well as promoting urban land use developments, Agricultural Land Act is for making efficient use of agricultural lands and controlling buying and selling lands, Act for Agricultural Promotion Areas is for

designating productive agricultural lands, Forest Act is for securing public functions of forest, and so on.

Although there is no specific land use law intended to mitigate floods in Japan, concerned agencies in charge of the laws described above cooperate each other and make use of their laws to control land use for flood mitigation.

(7) Problems and Concerns

From the viewpoint of flood mitigation, there are several problems or concerns with respect to land use control and guidance in Japan that are summarized as follows:

- Since technical flood analyses such as flood risk maps are not very often publicized, there may be some damages unexpected by developers and others when a flood happens.
- Technical flood analyses are done by appointed river managers and river basin committees, not enough communication and cooperation with concerned agencies such as the Urban Planning Division of the Ministry of Construction and with the people are exchanged and provided. Therefore, there is no proof of its rationality and equity about flood mitigation measures formulated by river managers.
- At present, while flood control is taken care of by river managers, land use control is carried out by different agencies on different areas. Coordinating bodies, however, are not always established to coordinate them well.

### 2.3.2 Other Countries

(1) France

In France, there is a specific land use law for flood mitigation. France is actively controlling land use in floodplains POS (Le Plan d'Occupation des Sols: in English translation, Land Possession Planning Act) is to plan and control land use. POS is practiced in urban areas in line with SD (Schemas Directeurs: in English translation, Basic Design) and in rural areas in line with CIDA (in English translation, Municipal Union Charter).

POS was merely a law for efficient land use and not originally intended to mitigate flood damage by means of land use control. Based on the recognition that POS was effective to mitigate natural and man-made disasters, the function of mitigating those disasters was stipulated in POS in 1987.

In addition to POS, there are some other laws related to land use control indirectly or supplementary to POS. Before POS has been promulgated, PSS (Le Plan de Surface Submersible: in English translation, Floodplain Plan) existed and still exits now. PSS demarcates areas with high flood potential and clarifies responsibilities about land use. Clause R111-3 in Urban Planning Act is also able to control land use in urban areas for flood mitigation. Flood risk maps are to be open to the public by law, that is, PER (La Plan d'Exposition aux Risque: in English translation, Exposition Plan of Natural

Disaster Risks). The relationship among POS, PSS, PER, and Clause R111-3 in Urban Planning Act is shown in Fig. 2.3.2.

(2) USA

In the United States, there is no specific land use control law for flood mitigation. Each local government has a master plan with land use zoning, but in general, there is no land use plan or control law over agricultural lands.

With state laws, urban planning is designated to be done by local government such as counties and districts, they are the ones that make land use plans in urban areas.

The flood insurance can indirectly control land use in floodplains in the United States. For the people to buy the flood insurance supported by the Federal government, a local government where they live must clear some strict rules. Y means of those rules, land use is indirectly guided and become in good shape. A schematic picture of the structure is shown in Fig. 2.3.3.

(3) Germany

Based on land use plans (F Plan) detailed area plans (B Plan) are formulated and practiced in Germany. There is no specific land use law for flood mitigation.

F Plan is formulated by each municipality and approved by a state government. F Plan covers a whole territory of a municipality and basic land use plan is formulated. In conformity with F Plan, detailed land use plans and building codes are specified in B Plan. Thus a structure that will be constructed should conform to B Plan, otherwise the construction of that structure will not be permitted by a mayor. A schematic picture of the structure is shown in Fig. 2.3.4.

### 2.3.3 Review of Land Use Regulations in Thailand

The land use control laws and regulations are fully discussed in the chapter of Institutions and Organization, just a brief review is given here. In Thailand, there are several laws and regulations related to land use. For example, Town Planning Act B.E. 2518 has taken into effect in place of Town and Country Planning Act B.E. 2495 to control urban land use for desirable urban development. On the basis of this act, the DTCP makes urban planning over all municipalities in Thailand. The DTCP, however, has no executing unit to actually implement their plans. As of August 1990, 84 municipalities have had urban plans. Building Control Act plays a supplemental role of Town Planning Act and has been put in force since 1979.

Bangkok is a single mega-city in Thailand, thus in combination with the above two acts, Bangkok has its own: Bangkok General Plan and Bangkok Building Regulation.

When it comes to agricultural land, there is no such law or regulation in agricultural land use. Agricultural Land Reform Act B.E. 2518 is to improve rights and holdings in agricultural land to help poor farmers, and it is basically not intended to regulate agricultural land use for the purpose of development. In other words, there exists no

particular law or regulation to control agricultural land use right now.

# 3. PROJECTION OF FUTURE LAND USE

## 3.1 Demographic and Economic Trends

The population projection in the Study Area has been done by the Study Team on the basis of the NESDB projection and is given in Table 3.1.1 in which provincial population projections are shown.

According to these tables, the national population growth rate will be going downward, so will each provincial population growth rate. The Bangkok Metropolitan Region consists of Bangkok, Samut Prakan, Pathum Thani, Samut Sakhon, Nakhon Pathom, and Nonthaburi, and this area except Bangkok will be growing rapidly with, for example, the speed of 2.26% per year between 2000 to 2005. The Bangkok Metropolis itself will also be growing faster than the projected national average in population. Chaechoengsao and Nakhon Nayok in the eastern region will be growing a little faster than the national average. Except these areas, all other areas in the Study Area will be growing far slower than the national average. Populations in the northern region, for example, are estimated to remain almost the same for the next two decades. Populations in the central region can be said to be the same as well. It is obvious that monocentric growth in and around Bangkok will continue in the future.

The regional economic growth projection has been developed by the Study Team on the basis of the most recent NESDB projection and is given in Table 3.1.2. In this projection, the annual economic growth rate is estimated at 0.6% from 1997 to 2001, 6.5% from 2002 to 2015, and 6.0% from 2006 to 2008. There is no regional difference in the rate applied. Thus, the GRP shares among all provinces will not change throughout the concerned period.

## 3.2 Agricultural Trend

The composition of the national agricultural land use during the period of 1975 to 1991 is shown in Table 3.2.1. This table shows that the area for agriculture slightly increased while the forest area decreased dramatically. In agricultural land, paddy field decreased a little while other agricultural land use for upland crops, orchard, vegetables, and pasture increased dramatically in compliance with rapid economic growth in Thailand. Since the whole national territory is fixed, agricultural land increased in exchange for forest encroachment.

As far as floating rice is concerned, the paddy field in which floating rice is cultivated is decreasing rapidly in the area of the RID irrigation projects according to the RID statistics shown in Table 3.2.2. The area for floating rice was reduced by almost half from 1986/87 to 1996/97. This implies that much intensive production by, e.g., HYV may be being introduced in the irrigation area in place of traditional varieties.

The forest area decreased as mentioned before. However, Table 2.2.4 shows that the recent reduction speed has been slowed down. In 1990s, the share of the forest area to the whole Kingdom has been kept around 26%. This implies that the law enforced in 1989 for prohibiting tree felling has effectively conserved the existing forest. In addition, community forest and reforestation programs have been prevailing in local areas. Table 3.2.3 shows the reforestation programs for the next five years from 1997

to 2001. If all these programs can achieve their goals, the area of 22,000 sq. km will be converted into forest by 2001 which is 15 % of the existing forest area as of 1993.

## 3.3 Urban and Regional Development Plans

There are several urban and regional development plans and on-going projects that will affect land use in the Study Area in the future. Some of them that are considered to be important are selected and discussed in the following:

(1) Second Bangkok International Airport

This project is to construct a new international airport at Nong Ngu Hao in the Samut Prakan province, 30 km east of Bangkok because the existing international airport at Don Muang is forecasted to reach its full capacity by the end of this century. Master plan and feasibility study had been done by the Office of the Second Bangkok International Airport Development Committee (OSBAC) and the NESDB by 1994, though it is not yet known whether and when it will be actually implemented. Its land use planning map is shown in Fig. 3.3.1.

Along with this new airport construction, surroundings and related infrastructure are planned to be developed significantly. Moreover, the area designated to have drainage function called "the Green Belt" might be disturbed by the airport construction and subsequent development of surroundings unless special attention to drainage in the area is paid. It is, however, also known that a drainage project called "the Chola Han Phitchit Project" is under consideration for improving drainage function around there.

Along with this development plan, land speculation and pulic investment like road constructions are observed already in the area between Bangkok and Chachoangao.

(2) Outer Ring Road and Truck Route

Around Bangkok, the construction of the Outer Ring Road and the Truck Route as shown in Fig. 3.3.2 is going or under consideration to improve the ties among neighboring cities and to reduce extreme concentration of all functions in Bangkok. This kind of development is observed in many places in the world and it is quite natural to be actually realized soon in line with the decentralization policy after monocentric rapid growth of a big city like Bangkok.

The Outer Ring Road is an inner circle and makes the 11 existing cities the sub-centers by connecting them each other in order to absorb the future development in the suburban area of Bangkok. The Ring Road has been proposed by the BMA as a part of its Bangkok plan of Metropolitan sub-centers. Its construction of the western side of Bangkok has been almost completed.

The Truck Route will be an outer circle and link those cities that do not have a function of sub-centers now, but will grow to have such a function later.

Although it is not clear right now how likely and when these road projects will start and complete, it is thought that they will be definitely implemented in the near future.

(3) Urban Development Planning in the Delta

In connection with the Second Bangkok International Airport Project and the Outer Ring Road and the Truck Route projects, there are some other development projects in the Delta. Other express ways and highways as seen Fig. 3.3.2 prepared by the DTCP are under consideration to enlarge the Bangkok Metropolitan Region much wider than that envisaged in the Outer Ring Road and the Truck Route. For example, Saraburi, Lopburi and Suphanburi will be satellite towns that will be connected by a circular highway. This kind of development will take place in the later stage after the Outer Ring Road and the Truck Route projects are completed and related cities are well developed.

DTCP recently presented a concept paper titled "City Planning as a Method to Solve Traffic Problem" (September 1996), demonstrating the DTCP's strategies for new satellite town projects which would be developed within a radius of not more than 100 km from Bangkok or reachable within a traveling time of one hour. The satellite towns will accommodate 100,000 to 150,000 population to be removed from Bangkok and its vicinity with at least 100 sq. km.

The NHA has had a new town development plan to meet the housing demand for low- and middle-income households. The NHA is seeking potential and suitable areas in and around the Bangkok Metropolitan Region.

(4) Others

Many major cities have their own urban development plans that will be and/or are being implemented. Basically, however, those plans do not have any large-scale impacts on land use in the Study Area as a whole. Most of them intend to improve efficiency of city functions and living conditions. The local governments as well as the central government agencies play their own roles to develop cities. For example, the PWD takes responsibility for construction of dikes and drainage facilities along major rivers to protect cities, the RID to protect irrigation facilities, the BMA to develop Bangkok and protect it from flooding, and so on.

The RID have some new large/medium-scale irrigation projects. The Pasak dam and the Bang Pakong diversion are under construction and will be completed soon. By these, the areas downstream will become irrigable. The irrigation area around Phitsanulok will be expanded by the construction of the Kwae Noi dam (second phase) which is under planning. There are many small-scale irrigation projects proposed most of which are for irrigating upland, not the area in the floodplain.

## 3.4 Land Use Projection

In this section, projection of future land use is undertaken. The targeted future year is 2018, which is 20 years ahead from the present. It should be noticed that the projection in this section is only undertaken for the area inside the floodplain. The reason for focusing only on the floodplain is: Considering that what is important in the Study is to mitigate flood damage, the land use in the floodplain is the one that should be analyzed most in order to formulate effective flood mitigation plans. In fact, floods can occur only in a floodplain by definition. Thus the land use in the floodplain is the most concern for everyone in the Study.

The floodplain has about 35 thousand sq. km, which is about 22% of the whole Study Area. The area of the floodplain has been determined by the Study Team with the analysis of the past flooding record. For convenience, the floodplain is demarcated into four regions in accordance with their features. Fig. 3.4.1 shows this demarcation. The Upper Central Plain is the area located in the north of the floodplain where the major cities, such as Phitsanulok, Sukhotai and Uttradit, are located. The Nakhon Sawan Area is situated between Nakhon Sawan and Chai Nat which looks like a bottleneck of the whole floodplain. Then the Chao Phraya delta is divided into two: the Higher Delta in the Lower Central Plain and the Lower Delta in the Lower Central Plain. The Higher Delta in the Lower Central Plain is located between Chai Nat and a little south of Ayutthaya, and the Lower Delta in the Lower Central Plain is from a little south of Ayutthaya down to the coast.

### 3.4.1 Methods and Procedure of Projection

In the following, the methods and the procedure of how land use projection in the year of 2018 is made are explained:

(1) Setting of Present Land Use

Before making any projection, what should be done first is to fix present conditions that will be the basis for all projections. The projection bases the present land use on the GIS data made by the MOAC in 1997. The agricultural land use data in this GIS is based on the data obtained in 1994. The present land use of the four regions are described in Table 3.4.1. This GIS data is desginated as the present land use conditions in the Study.

(2) Projection of Agricultural Land Use

Agricultural land can be classified into several categories by crop types. In the projection, it is classified into four: paddy, fruits & trees, vegetables & flowers, field crops. There must be some types of crops that cannot belong to any of the four. Those types of crops, however, are classified as others that contain not only such other farm land but also other land use such as barren land, water, swamp, unclassified, etc. These four agricultural land use types are thought to be enough due to the land use features in the floodplain, so this classification does not hinder to achieve the goal of the land use projection.

Now the growth rates of these four types of agricultural lands are to be determined. After a survey, it is decided that the growth rates in the projection

be derived from the projection given by the JICA study named "the Kok-Ing-Nan Water Diversion Project" for the Chao Phraya Delta. In addition, the report named "Chao Phraya Basin Water Management Strategy" for the whole Study Area is used to supplement the analysis of projection.

In the report of the Kok-Ing-Nan Water Diversion Project, the projection of irrigable areas in the delta is given, which does not cover the whole floodplain and does not mention about agricultural land use types though crop intensities in wet and dry seasons are discussed. Therefore, the information that can be used in the agricultural land use projection here is only about rice in the delta.

In the report of the Chao Phraya Basin Water Management Strategy, there are mainly three projection scenarios, which are called High, Low and Median. Multiple scenarios are often adopted in many projection analyses because the future is unpredictable and it is better to study multiple cases instead of only a single case to say something about the future. The report looks back the last decade of data about the change in agricultural land use and determines three possible scenarios by the method of simple extrapolation of past trend.

In the projection of agricultural land use, the growth rates given by the Kok-Ing-Nan Water Diversion Project and the Median scenario given by the Chao Phraya Basin Water Management Strategy are chosen to be used for the projection of agricultural land use. The rates actually adopted here to the crop types in the floodplain are shown in Table 3.4.1. For example, in the whole floodplain, the growth rates are -1.0 % for rice, 2.4 % for fruits & trees, 3.6 % for vegetables & flowers, and -1.1 % for field crops.

(3) Projection of Urban Land Use

For urban land use projection, the urban plans made by DTCP and PWD are used. For Bangkok, however, BMA's plan is used. The information of the designated urban planning areas as well as the urban planning maps of many municipalities prepared by DTCP are the ones mostly utilized in the urban land use projection. For urban protection dikes, so-called, ring dikes, the plans by PWD are used.

In addition, some of development plans and on-going projects are integrated into the projection. Though the Bangkok Second International Airport Project is still merely a plan, it is incorporated into the projection. Thus, the urban development to the east of Bangkok is estimated to carry on very fast. Furthermore, the construction of the Outer Ring Road is considered to continue in the eastern part, which makes the Bangkok Metropolitan Region and its vicinity grow rapidly. There must be some other regional development plans with large impacts on urbanization, but they are ignored by the assumption that DTCP has already incorporated those plans into their urban plans.

(4) Projection of Forest

Thailand has experienced a rapid reduction of the forest area, Observing the recent trend, however, it is natural to think that no further reduction of the

forest occur in the future. Thus in the projection, the forest area is estimated to remain the same in the future.

(5) Others (Residuals)

In this classification, there are several land use types. Others consist of farm holdings, water, fish pond, swamp, mangrove, barren land, and unclassified land.

Since the agricultural lands of four major crops grow with fixed rates and the urban land also grows independently without any connection with the overall land use, there will be residuals generated in the floodplain. The land use changes of others are thus exogenously determined by the agricultural and urban land use.

(6) Calibration

Based on (i) to (v), the first calculation of the land use projection can be done. Because each land use type is set to change independently and the total land is fixed, others are to be set to those values which make the summation of all areas of the future land use types equal to the fixed whole area.

In the first iteration of calculation, the area of others is increased dramatically, and some calibration work seems necessary. To reduce the future area of others which is increased too much, the most increment is to be re-distributed to the future agricultural lands such as rice, fruits, vegetables, and field crops, in proportion to the sizes of their areas. By doing this re-distribution in the second iteration of calculation, the future area of others can be suppressed to an appropriate level in exchange for increased areas of rice, fruits, vegetables, and field crops. The growth rates adopted from the report, "Chao Phraya Basin Water Management Strategy," are replaced by new rates.

The result of the projection is shown in Table 3.4.1.

(7) Types of Rice

Since rice has a large share in land use, it is better to analyze the types of rice. In the Study, rice is demarcated into four: high yield variety (HYV), general traditional variety (GTV), deep water rice, and floating rice. Based on the DORAS report, the information collected mainly from the RID, and other survey, the present land use in the types of rice is determined as shown in Table 3.4.2.

The area change in rice as a whole has been determined as in Table 3.4.1 and no further modification is to be made.

First of all, the Upper Central Plain is discussed. There are some large/medium-scale irrigation projects and a number of small-scale irrigation projects planned by the RID. By using these information and others, it is assumed that the newly irrigated area in the future in this region is 1,663 sq. km, and it is also assumed that this area is to be used for HYV. Because there are few reasons for deep water rice and floating rice to increase in the future in

this region, the areas of deep water rice and floating rice will remain the same as zero. Thus the future area of GTV is given by subtracting the future area of HYV from the future area of rice.

In the Nakhon Sawan Area, there is no particular reason to reduce the area of HYV, unlike in the Lower Central Plain. That is, it is considered that the force of urbanization in this region is not so strong enough to convert the area of HYV into urban or more productive land use. Thus it is assumed that the area of HYV remains the same. With regard to GTV, deep water rice, and floating rice, their future areas are determined by the same ways as described above in the Upper Central Plain.

In the Higher Delta in Lower Central Plain and the Lower Delta in Lower Central Plain, deep water rice and floating rice are focused. From Table 3.2.2, it is concluded that the floating rice area was decreased with -3.0 %, which is the annual average growth rate from 1986 to 1995 in the RID's Regions 7 and 8. Hence it is assumed that the areas of deep water rice and floating rice decrease with this rate. Accordingly, the area of HYV is determined to make the total area of the four rice types equal to the given total.

Table 3.4.2 shows the result of the future rice type projection.

### 3.4.2 Result of Projection

The result of the land use projection is given in Tables 3.4.1 and 3.4.2, and the comparison of the present and the future land use is visualized in Fig. 3.4.2. Tables 3.4.1 and 3.4.2 give the projections of land use in 2005 and 2018, where the same annual growth rates are applied.

As shown in these tables and figures, the most noticeable change is the dramatic reduction of paddy field in all four areas. This reduction is replaced mainly by the increase in fruits & trees as well as urban areas. It is concluded that not much profitable rice production will be decreasing while diversification of agriculture for seeking more profits and urbanization through industrialization will be prevailing in the course of development.

It should be noticed that it is not easy to determine an agricultural land use type which characterizes the representative use of that piece of farm land. For example, if a concerned agricultural land can be used for double cropping or triple cropping, it becomes difficult to represent it as a single type. If the second crop is more profitable and farmers count more on that crop rather than the first crop which is usually rice, that land may be classified as the second crop. But in the projection here, the focus is on the land use in the flood season. Because rice is always cultivated in the flood season, the concerned land should be classified as paddy land in the projection regardless of profitability or reliability of the second or third crops.

# 4. ANALYSIS F LAND USE CONTROL AND GUIDANCE

## 4.1 Introduction

In this chapter, land use control and guidance for flood damage mitigation is analyzed. It is easy to say, for example, that development in this area is strictly prohibited because a flood potential is high and any development will reduce inherited natural retarding and retaining functions attributed to this area. In reality, however, enforcing such a command on land use is not that easy and cannot be permitted without having strong scientific proofs as well as people's consent and will.

Obviously, there are many areas in the floodplain where some kinds of land use control and guidance are necessary to mitigate flood damage. In fact, by definition, floodplains are those areas that are likely to suffer from flooding. Excessive control, however, is not appropriate because it hampers free competition, people's independent choices, and economic growth. There should be some criteria to scientifically determine which areas need control to what extent, which is the main issue to be discussed here.

The main issue here is how to maintain and preserve those areas that have retarding and retaining functions of flood water naturally in order to keep flood potential in the Chao Phraya River basin low. This chapter is devoted to construct analytical tools and find a solution to this issue.

## 4.2 Recent Trends on Major Rivers in the World

It is wise to review what is being done in other major rivers in the world against flooding and learn something out of it.

In China, the Yangtze River and the Songhuajiang River suffered unprecedented flooding in 1998. Since then, the Chinese Government proposes a series of strategies in restoring the flood-hit areas. One of them is to get a total area of 9,770 sq. km back to lakes to restore natural retarding and retaining functions, and as a result, 4 million people living there will have to be relocated.

In the USA, the floodplain management for the Mississippi River is famous and give a lot of insights for how to control and manage flooding for large rivers. One of non-structural approaches to flood damage reduction formulated in response to the 1993 Mississippi flood was to relocate over 25,000 homes from the floodplain and to make thousands of hectares of marginally productive bottomland habitat transfer from agriculture to natural uses.

In Germany, there was a severe flooding in the Rhine River in 1995, which caused the second hardest flood damage in this century. Many reasons were raised for this much severe flooding, but the main reason is now thought to be too much development in the floodplain that made natural retarding and retaining functions lower. Hence, it is under planning to get the developed floodplain back to the original situation as much as possible. This kind of strong movement is also observed in France.

## 4.3 Preparation of Maps

For flood risk mapping, which is the most important matter for analyzing land use control and guidance, there are three typical kinds of maps; a historical flood map; a hydrological-hydraulic flood map; and a flood damage map. In this subsection, these three kinds of maps are presented with land use maps in the following:

(1) Present and future land use maps

As described in the previous subsection, the present land use map is derived from the GIS data prepared by the Agricultural Economic Department, MOAC, made in 1994, as already shown in Fig. 3.4.2.

The future land use map in the year of 2018, shown also in Fig. 3.4.2, is provided by the Study Team, the details of derivation is also given in the previous subsection.

The main issue is changes in land use from the present to the future, not land use patterns themselves. If a paddy field is converted into an urban area, a flood damage potential will be dramatically increased and a retarding function in that area will disappear. Those changes should be focused and will be useful information for constructing the criteria of choosing those areas that need some land use control and guidance.

(2) Historical flood maps

Prior to making a flood potential map, the flood maps actually happened in 1983, 1995 and 1996 are prepared by means of computer simulation as shown in Fig. 4.3.1. An inundation is given in each cell of 5 km square grid. The return period is evaluated by frequency analysis with the data of the past 45 years from 1952 to 1996.

(3) Hydrological-hydraulic flood map

Based on the flood maps described above, a hydrological-hydraulic flood map is prepared as shown in Fig. 4.3.2. The 5-year return period is used for making this map. Flood potential is classified into three grades; Low, Middle and High.

An evaluation of Low flood potential is given to such an area where an inundation depth is lower than 20 cm when a flood of 5-year return period occurs. When an inundation depth is the same as or more than 20 cm, but lower than 100 cm, an evaluation is Middle. For more than 100 cm, such an area is evaluated as a High inundation potential area. This classification is summarized as follows:

Classification of Flood Potential

| Flood Potential | Inundation Depth in 5-year return period |
|---|---|
| Low | lower than 20 cm |
| Middle | 20 cm to 100 cm |
| High | higher than 100 cm |

The values of 20 cm and 100 cm that demarcate the floodplain into three types are determined in proportion to seriousness of flood damages by each depth.

With this map, the degrees of inundation depths are clearly visualized and so is flood damage potential. Without any countermeasure for floods, it is not wise to develop such an area where flood potential is high. At the same time, if an area with high flood potential is developed, negative effects on surroundings, i.e., increases in flood potential, are highly expected because the development may reduce the retarding function originally inherited there to a considerable extent.

(4) Present and Future Flood Damage Maps

The present and the future flood damage maps are given in Figs. 4.3.3 and 4.3.4, respectively. The present flood damage map shows how much damage in each 5 by 5 km grid is generated when the flood of 5-year return period given in Fig. 4.3.2 occurs over the present land use given in Fig. 3.4.2. The future flood damage map also shows the same information, but in this case, the land use is the future one, instead of the present one.

## 4.4 Flood Risk Maps and Their Analyses

Three kinds of flood risk maps have been prepared in the previous subsection, and now they are analyzed individually here.

(1) Historical flood maps

These maps represent the real flooding situations. Although they do not represent any probability of flood occurrence, they are the most fundamental resources for considering land use control and guidance.

The deeper the purple color is, the deeper the inundation depth is. Those areas filled with deeper purple must have natural retarding and retaining functions and should be preserved as they are. If their land use is changed, it will surely have adverse impacts on surroundings due to a loss of retarding and retaining functions of flood water. The central and local governments should give a careful consideration when land use change is likely to take place in those areas.

From these three maps, it is seen that Sukhothai, Nakhon Sawan, the area between Nakhon Sawan and Chai Nat, and the area around Singburi and Ayutthaya had experienced severe flooding in all three occasions and that those areas need special attention to land use change.

(2) Hydrological-hydraulic flood map

This map represents a flooding of 5-year return period. The areas with deep red color indicate that the inundation depth is more than one meter, so that they are the ones where special attention has to be paid with regard to land use change.

As discussed in historical flood maps, natural retarding and retaining functions should be preserved in those areas with deeper color. If development with land use change takes place, some measures to keep natural retarding and retaining functions and to reduce vulnerability to flooding should be carried out by some means.

(3) Present and Future Flood Damage Maps

The above two kinds of maps are only concerned about inundation depth. The flood damage maps, however, are concerned about a degree of damage though it is closely related to inundation depth.

The areas with deeper color should require some measures to reduce the damage potential of the existing and future facilities and activities. For example, houses may need more flood-resistant structures. If agricultural damages are large, then cropping patterns or crop types may be modified to reduce vulnerability to flooding.

Using the above three kinds of flood risk maps, the following measures are proposed:

(1) Integration of land use plans with flood risk maps

Since very useful information can be derived from these flood risk maps, they should be utilized by governments when they make land use plans and urban/regional development plans. What is proposed is to integrate of their plans with the flood risk maps.

To do so, the flood risk maps should be distributed to all concerned government officials.

(2) Preservation of natural retarding and retaining functions

To keep or lower flood damage potential, it is necessary to preserve the existing natural retarding and retaining functions of flood water possessed by the floodplain. As seen in Section 4.2, many countries are trying to get back natural uses of lands through creating lakes, wetlands, and barren floodplains. As for the Chao Phraya River, the same approach is applicable.

(3) Publication of flood-prone areas

Based on the information derived from the flood risk maps, flood-prone areas can be identified, and the people in those areas are informed that they live in flood-prone areas so that they can prepare for future floods.

Publicizing can be done through efforts of the governments with some means of advertisement. One of means is a bulletin board standing on a main street in a town or a village where people can easily find.

It should be noticed that publicizing these information will have some influence on land prices and will increase people's fear of flooding. Special care must be required when it is actually conducted.

# 5. PROPOSED MEASURES OF LAND USE CONTROL AND GUIDANCE

## 5.1 Summary of Proposed Measures

Based on three flood risk maps, the Study Team proposes the following non-structural measures:

### (1) Integration of land use plans with flood risk maps

The central and local governments are encouraged to make use of these three flood risk maps by integrating them with their urban/regional development plans. Distribution of these maps to all concerned government officials are first necessary.

### (2) Preservation of natural retarding and retaining functions

Preserving natural retarding and retaining functions in the floodplain should not be forgotten as far as flood mitigation measures are concerned.

### (3) Publication of flood-prone areas

By TVs, radios, newspapers, bulletin boards on streets, or by any other means of advertisement, people living in the floodplain should be noticed that their places belong to flood-prone areas so that they can prepare for future floods and reduce their vulnerability to flooding.

There are many other non-structural measures that are not listed up here. Many of those, however, are discussed in other parts of this study report. For example, flood fighting is one of main topics in non-structural measures, but it is discussed in "Institutions and Organizations."

## 5.2 Concluding Remarks

What is most important to think about land use for flood mitigation is to preserve or regain retarding and retaining functions naturally inherited to the concerned area. This approach is being taken in many countries these days. The maps prepared in this report such as the historical flood maps, the hydrological-hydraulic map, and the flood damage maps, are very useful instruments to think about this approach.

Based on these maps, there will be many non-structural measures applicable and effective to the floodplain in the Chao Phraya River basin. It is hoped that the people suffering from floods will get better off by means of those non-structural measures.

# *Tables*

Table 2.1.1 LIST OF PHOTOGRAPHS OF LANDSAT-TM, J-ERS1 AND NOAA

| Type | S.N. | Code Number | Date | Remarks |
|---|---|---|---|---|
| LANDSAT-TM | | | | |
| | 1 | path129-row49 | 2/17/96 | Dry Season |
| | 2 | path129-row50 | 2/17/97 | Dry Season |
| | 3 | path129-row51 | 12/31/95 | Dry Season |
| | 4 | path130-row48 | 1/23/96 | Dry Season |
| | 5 | path130-row49 | 1/23/96 | Dry Season |
| | 6 | path130-row50 | 2/8/96 | Dry Season |
| | 7 | path129-row49 | 10/12/95 | Flood Period |
| | 8 | path129-row50 | 10/12/95 | Flood Period |
| | 9 | path129-row51 | 9/26/95 | Flood Period |
| | 10 | path130-row48 | 12/6/95 | Flood Period |
| | 11 | path130-row49 | 1/23/96 | Flood Period |
| | 12 | path130-row50 | 12/22/95 | Flood Period |
| J-ESR1 SAR | | | | |
| | 1 | path125-row274 | 9/26/95 | Flood Period |
| | 2 | path125-row275 | 9/26/95 | Flood Period |
| | 3 | path125-row276 | 9/26/95 | Flood Period |
| | 4 | path125-row277 | 9/26/95 | Flood Period |
| | 5 | path125-row278 | 9/26/95 | Flood Period |
| NOAA | | | | |
| | 1 | | 9/22/95 | Flood Period |
| | 2 | | 10/22/95 | Flood Period |
| | 3 | | 11/6/95 | Flood Period |
| | 4 | | 11/25/95 | Flood Period |
| | 5 | | 12/7/95 | Flood Period |

Table 2.1.2 LIST OF FLOOD AREA MAPS FROM RID

| Location | Purpose | Year | Scale (reciprocal) |
|---|---|---|---|
| Phichit City | Flood Area | | 20,000 |
| Phichit City | Pump Stations | | 20,000 |
| Nakon Sawan City | Urban Area | | |
| Ayutthaya and Its Vicinity | | | |
| Chai Nat City | Flood Area | 1995 | 1,750 |
| Chai Nat City | Embankment | 1995 | 1,750 |
| Sukhotai City | Flood Mitigation Facilities | | |
| Area of Regional Irrigation Office 3 | Flood Area | 1995 | |
| Area of Regional Irrigation Office 3 | Flood Area | 1996 | |
| Area of Regional Irrigation Office 3 | Projects | | |
| Nakon Sawan and its Northern Area (part I) | Flood Area | 1995 | 490,000 |
| Nakon Sawan and its Northern Area (part II) | Flood Area | 1995 | 490,000 |
| Ang Thong City | Urban Area | | 5,000 |
| Towns in Northern Region | Flood Area | | |
| Area Between Bangkok and Nakhon Sawan (part I) | Flood and Damage Areas | 1995 and 1996 | 400,000 |
| Area Between Bangkok and Nakhon Sawan (part II) | Flood and Damage Areas | 1995 and 1996 | 400,000 |
| Area Between Bangkok and Nakhon Sawan (part III) | Flood and Damage Areas | 1995 and 1996 | 400,000 |
| Area Between Bangkok and Nakhon Sawan (part IV) | Flood and Damage Areas | 1995 and 1996 | 400,000 |
| Sing Buri and its Vicinity | Flood Area | 1995 and 1996 | |
| Sing Buri and its Vicinity | Flood Area | | |
| Northen Region (part I) | Flood and Irrigation Areas | 1995 and 1996 | |
| Northen Region (part II) | Flood and Irrigation Areas | 1995 and 1996 | |
| Northen Region (part III) | Flood and Irrigation Areas | 1995 and 1996 | |
| Northen Region (part IV) | Flood and Irrigation Areas | 1995 and 1996 | |
| Chao Phraya River | Canals | | |
| Rural Towns | Pump Stations | | |
| Phitsanulok City | Flood Area | | 250,000 |
| Nakon Sawan and its Vicinity | Flood Area | 1996 | |
| Phichit Province | Flood Area | | 50,000 |

Table 2.1.3 LIST OF URBAN LAND USE PLANNING MAPS FROM DTCP

| S.N. | City | Province | Year | Scale (reciprocal) |
|---|---|---|---|---|
| 1 | Ang Thong | Ang Thong | 1988 | 15,000 |
| 2 | Bangkok | Bangkok Metropolis | 1992 | 75,000 |
| 3 | Chachoengsao | Chachaengsao | 1987 | 20,000 |
| 4 | Chai Nat | Chai Nat | 1989 | 20,000 |
| 5 | Kratum Baen | Samut Sakhon | 1990 | 20,000 |
| 6 | Lop Buri | Lop Buri | - | - |
| 7 | Nakhon Nayok | Nakhon Nayok | 1996 | |
| 8 | Nakhon Sawan | Nakhon Sawan | 1990 | 20,000 |
| 9 | Phetchabun | Phetchabun | 1990 | 20,000 |
| 10 | Phitsanulok | Phitsanulok | 1989 | 20,000 |
| 11 | Prachin Buri | Nakhon Nayok | 1988 | 20,000 |
| 12 | Samut Sakhon | Samut Sakhon | 1987 | 20,000 |
| 13 | Sara Buri | Sara Buri | 1996 | |
| 14 | Sing Buri | Sing Buri | 1988 | 20,000 |
| 15 | Sukhothai | Sukhothai | 1989 | 20,000 |
| 16 | Uthai Thani | Uthai Thani | 1996 | |

Table 2.1.4 LIST OF PROVINCES WITH AGRICULTURAL LAND USE MAPS BY DLD

| S.N. | Province | Year | Scale |
|---|---|---|---|
| 1 | Ang Thong | 1992 | 1:100,000 |
| 2 | Ayutthaya | 1992 | 1:100,000 |
| 3 | Bangkok Metropolis | 1988 | 1:100,000 |
| 4 | Chai Nat | 1992 | 1:100,000 |
| 5 | Kamphaeng Phet | 1978 | 1:100,000 |
| 6 | Kanchanaburi | 1986 | 1:100,000 |
| 7 | Lamphun | 1978 | 1:100,000 |
| 8 | Lop Buri | 1992 | 1:100,000 |
| 9 | Nakhon Nayok | 1988 | 1:100,000 |
| 10 | Nakhon Pathom | 1988 | 1:100,000 |
| 11 | Nakhon Sawan | 1978 | 1:100,000 |
| 12 | Phichit | 1986 | 1:100,000 |
| 13 | Phitsanulok | 1986 | 1:100,000 |
| 14 | Phrae | 1978 | 1:100,000 |
| 15 | Saraburi | 1992 | 1:100,000 |
| 16 | Sing Buri | 1988 | 1:100,000 |
| 17 | Sukhothai | 1978 | 1:100,000 |
| 18 | Suphan Buri | 1986 | 1:100,000 |
| 19 | Tak | 1988 | 1:100,000 |
| 20 | Uthai Thani | 1986 | 1:100,000 |
| 21 | Uttaradit | 1992 | 1:100,000 |

## Table 2.2.1 AGRICULTURAL LAND USE IN CHAO PHRAYA RIVER BASIN (1992 YEAR)

(Unit: ha)

| Province | Area | Forest Area | Farm holding land | | | | | | | | | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Paddy Land | Under Field (crops) | Under fruit tree and tree crops | Under vegetable and flowers | Grass Land | Housing Area | Idle land | Other | Total | |
| **Highlands** | | | | | | | | | | | | |
| 1 Chiang Mai | 2,010,706 | 1,456,445 | 108,332 | 35,223 | 40,664 | 12,983 | 228 | 10,374 | 1,212 | 1,034 | 210,051 | 344,210 |
| 2 Lamphun | 450,588 | 225,962 | 44,793 | 5,768 | 25,137 | 4,371 | 0 | 5,152 | 1,720 | 2 | 86,942 | 137,684 |
| 3 Lampang | 1,253,396 | 820,621 | 90,841 | 53,874 | 11,585 | 2,077 | 0 | 8,824 | 11,051 | 386 | 178,638 | 254,137 |
| 4 Phayao | 633,506 | 253,086 | 91,757 | 39,964 | 11,234 | 3,296 | 92 | 5,428 | 1,755 | 99 | 153,624 | 226,795 |
| 5 Phrae | 653,860 | 245,883 | 44,419 | 40,823 | 9,115 | 202 | 0 | 5,008 | 1,917 | 0 | 101,485 | 306,492 |
| 6 Nan | 1,147,207 | 488,432 | 37,830 | 78,022 | 13,668 | 1,015 | 0 | 6,234 | 2,468 | 892 | 140,129 | 518,646 |
| 7 Tak | 1,639,601 | 1,213,350 | 42,610 | 85,610 | 0 | 13,333 | 1,204 | 0 | 6,207 | 1,697 | 150,662 | 275,590 |
| 8 Phetchabun | 622,514 | 220,237 | 54,385 | 31,927 | 15,450 | 737 | 975 | 5,145 | 887 | 310 | 109,814 | 292,462 |
| Sub-total (%) | 100.0% | 58.5% | 6.1% | 4.4% | 1.5% | 0.5% | 0.0% | 0.5% | 0.3% | 0.1% | 13.5% | 28.0% |
| **Upper Central Plain** | | | | | | | | | | | | |
| 9 Sukhothai | 659,609 | 227,548 | 160,496 | 107,887 | 13,898 | 1,405 | 0 | 10,579 | 2,490 | 2,604 | 299,360 | 132,702 |
| 10 Uttaradit | 783,859 | 304,943 | 84,310 | 73,866 | 25,132 | 1,832 | 0 | 6,327 | 3,027 | 581 | 195,074 | 283,841 |
| 11 Phitsanulok | 1,081,585 | 246,152 | 254,472 | 127,072 | 15,478 | 1,575 | 1,090 | 12,991 | 4,901 | 486 | 418,064 | 417,369 |
| 12 Kampheang Phet | 860,741 | 211,994 | 215,159 | 206,802 | 15,940 | 1,172 | 1,558 | 13,195 | 1,678 | 2,932 | 458,437 | 190,310 |
| 13 Phichit | 453,101 | 0 | 280,848 | 43,015 | 9,869 | 389 | 236 | 8,963 | 789 | 147 | 344,256 | 108,845 |
| 14 Nakhon Sawan | 959,768 | 70,103 | 383,550 | 223,700 | 19,291 | 5,929 | 3,403 | 12,898 | 1,468 | 1,198 | 651,437 | 238,228 |
| 15 Uthai Thani | 673,025 | 265,143 | 100,683 | 87,881 | 11,263 | 1,936 | 2,478 | 6,440 | 2,849 | 1,047 | 214,576 | 193,305 |
| Sub-total (%) | 100.0% | 24.2% | 27.0% | 15.9% | 2.0% | 0.3% | 0.2% | 1.3% | 0.3% | 0.2% | 47.2% | 28.6% |
| **Lower Central Plain** | | | | | | | | | | | | |
| 16 Chai Nat | 246,975 | 698 | 151,319 | 16,944 | 5,120 | 197 | 229 | 4,247 | 2,026 | 242 | 180,325 | 65,952 |
| 17 Sing Buri | 82,248 | 0 | 61,681 | 5,873 | 3,649 | 164 | 62 | 1,962 | 279 | 152 | 73,822 | 8,426 |
| 18 Lop Buri | 619,975 | 20,521 | 155,604 | 220,680 | 8,401 | 1,158 | 3,200 | 6,493 | 1,576 | 4,572 | 401,684 | 197,770 |
| 19 Suphan Buri | 535,801 | 59,815 | 219,357 | 118,754 | 11,661 | 2,458 | 3,018 | 11,762 | 2,619 | 1,779 | 371,407 | 104,579 |
| 20 Ang Thong | 96,837 | 0 | 64,274 | 1,751 | 6,758 | 1,562 | 0 | 3,576 | 0 | 1,498 | 79,418 | 17,419 |
| 21 Autthaya | 255,664 | 0 | 174,041 | 0 | 5,547 | 172 | 81 | 6,232 | 1,020 | 1,284 | 188,377 | 67,287 |
| 22 Saraburi | 357,649 | 6,672 | 87,111 | 69,957 | 12,580 | 284 | 11,995 | 6,019 | 651 | 1,062 | 189,658 | 161,318 |
| 23 Nakhon Pathom | 216,833 | 0 | 78,607 | 26,815 | 13,895 | 6,142 | 0 | 6,998 | 2,405 | 4,564 | 139,425 | 77,407 |
| 24 Nonthaburi | 62,230 | 0 | 20,065 | 0 | 4,939 | 1,016 | 0 | 971 | 228 | 323 | 27,542 | 34,688 |
| 25 Pathum Thani | 152,586 | 0 | 73,350 | 0 | 28,678 | 939 | 923 | 3,078 | 717 | 2,689 | 110,374 | 42,212 |
| 26 Samut Sakhon | 87,235 | 0 | 18,121 | 0 | 14,314 | 1,660 | 0 | 1,287 | 121 | 1,869 | 37,372 | 49,863 |
| 27 Bangkok Methropolis | 156,522 | 0 | 27,903 | 330 | 7,948 | 3,334 | 0 | 873 | 358 | 746 | 41,493 | 115,029 |
| 28 Samut Prakan | 100,409 | 0 | 15,920 | 0 | 8,755 | 0 | 0 | 1,635 | 0 | 7,058 | 33,368 | 67,041 |
| Sub-total (%) | 100.0% | 3.0% | 38.6% | 15.5% | 4.5% | 0.6% | 0.7% | 1.9% | 0.4% | 0.9% | 63.1% | 34.0% |
| Total in the Study Area | 16,854,029 | 6,337,607 | 3,141,837 | 1,702,537 | 369,969 | 71,339 | 30,770 | 172,691 | 56,442 | 41,249 | 5,586,814 | 4,929,608 |
| Total (%) in the Study Area | 100.0% | 37.6% | 18.6% | 10.1% | 2.2% | 0.4% | 0.2% | 1.0% | 0.3% | 0.2% | 33.1% | 29.2% |
| Whole Kingdom | 51,311,502 | 13,495,067 | 11,013,699 | 5,247,202 | 3,335,915 | 1,410,276 | 119,954 | 553,848 | 531,151 | 185,349 | 21,128,193 | 16,688,242 |
| Whole Kingdom (%) | 100.0% | 26.3% | 21.5% | 10.2% | 6.5% | 2.7% | 0.2% | 1.1% | 1.0% | 0.4% | 41.2% | 32.5% |

## Table 2.2.2 RICE CULTIVATION IN CHAO PHRAYA RIVER BASIN

(Unit : ha)

| Province | Farm Land (1992) | Paddy Field (1992) | | Major Rice (1994) | | Second Rice (1992) | | Irrigated Paddy Field | |
|---|---|---|---|---|---|---|---|---|---|
| | | | (%) | Harvested Area | (%) | Harvested Area | (%) | | (%) |
| **Highlands** | | | | | | | | | |
| 1 Chiang Mai | 210,051 | 108,332 | 51.6% | 83,068 | 76.7% | 4,253 | 3.9% | 202,464 | 186.9% |
| 2 Lamphun | 86,942 | 44,793 | 51.5% | 23,611 | 52.7% | 1,550 | 3.5% | 60,429 | 134.9% |
| 3 Lampang | 178,638 | 90,841 | 50.9% | 68,490 | 75.4% | 801 | 0.9% | 61,746 | 68.0% |
| 4 Phayao | 153,624 | 91,757 | 59.7% | 72,727 | 79.3% | 146 | 0.2% | 37,354 | 40.7% |
| 5 Phrae | 101,485 | 44,419 | 43.8% | 34,929 | 78.6% | 112 | 0.3% | 66,192 | 149.0% |
| 6 Nan | 140,129 | 37,830 | 27.0% | 26,970 | 71.3% | 629 | 1.7% | 38,407 | 101.5% |
| 7 Tak | 151,725 | 42,610 | 28.1% | 34,995 | 82.1% | 1,113 | 2.6% | 25,256 | 59.3% |
| 8 Phetchabun | 109,814 | 54,385 | 49.5% | 49,932 | 91.8% | 12,968 | 23.8% | 77,742 | 142.9% |
| **Sub-total** | 1,132,408 | 514,967 | 45.5% | 394,722 | 76.6% | 21,572 | 4.2% | 569,590 | 110.6% |
| **Upper Central Plain** | | | | | | | | | |
| 9 Sukhothai | 299,360 | 160,496 | 53.6% | 116,111 | 72.3% | 6,491 | 4.0% | 44,483 | 27.7% |
| 10 Uttaradit | 195,074 | 84,310 | 43.2% | 70,800 | 84.0% | 10,693 | 12.7% | 16,654 | 19.8% |
| 11 Phitsanulok | 418,064 | 254,472 | 60.9% | 177,986 | 69.9% | 37,040 | 14.6% | 71,588 | 28.1% |
| 12 Phichit | 344,256 | 280,848 | 81.6% | 196,688 | 70.0% | 41,601 | 14.8% | 147,296 | 52.4% |
| 13 Kampheang Phet | 458,437 | 215,159 | 46.9% | 186,445 | 86.7% | 29,252 | 13.6% | 74,048 | 34.4% |
| 14 Nakhon Sawan | 651,437 | 383,550 | 58.9% | 289,510 | 75.5% | 26,344 | 6.9% | 150,666 | 39.3% |
| 15 Uthai Thani | 214,576 | 100,683 | 46.9% | 73,279 | 72.8% | 2,157 | 2.1% | 94,400 | 93.8% |
| **Sub-total** | 2,581,204 | 1,479,518 | 57.3% | 1,110,819 | 75.1% | 153,578 | 10.4% | 599,135 | 40.5 |
| **Lower Central Plain** | | | | | | | | | |
| 16 Chai Nat | 180,325 | 151,319 | 83.9% | 130,201 | 86.0% | 26,146 | 17.3% | 140,009 | 92.5% |
| 17 Sing Buri | 73,822 | 61,681 | 83.6% | 51,789.0 | 84.0% | 6,287 | 10.2% | 67,840 | 110.0% |
| 18 Lop Buri | 401,684 | 155,604 | 38.7% | 143,606.0 | 92.3% | 1,633 | 1.0% | 105,779 | 68.0% |
| 19 Suphan Buri | 371,407 | 219,357 | 59.1% | 142,392.0 | 64.9% | 75,091 | 34.2% | 278,512 | 127.0% |
| 20 Ang Thong | 79,418 | 64,274 | 80.9% | 55,128.0 | 85.8% | 5,264 | 8.2% | 81,178 | 126.3% |
| 21 Autthaya | 188,377 | 174,041 | 92.4% | 140,153.0 | 80.5% | 34,250 | 19.7% | 197,571 | 113.5% |
| 22 Saraburi | 189,658 | 87,111 | 45.9% | 62,640.0 | 71.9% | 4,228 | 4.9% | 58,632 | 67.3% |
| 23 Nakhon Pathom | 139,425 | 78,607 | 56.4% | 51,872.0 | 66.0% | 50,840 | 64.7% | 142,318 | 181.1% |
| 24 Nonthaburi | 27,542 | 20,065 | 72.9% | 18,085.0 | 90.1% | 15,766 | 78.6% | 36,766 | 183.2% |
| 25 Pathum Thani | 110,374 | 73,350 | 66.5% | 47,389.0 | 64.6% | 37,061 | 50.5% | 110,958 | 151.3% |
| 26 Samut Sakhon | 37,372 | 18,121 | 48.5% | 5,894.0 | 32.5% | 5,293 | 29.2% | 37,696 | 208.0% |
| 27 Bangkoks Methropolis | 41,493 | 27,903 | 67.2% | 22,826.0 | 81.8% | 7,514 | 26.9% | 74,864 | 268.3% |
| 28 Samut Prakan | 33,368 | 15,920 | 47.7% | 9,465.0 | 59.5% | 6,543 | 41.1% | 60,528 | 380.2% |
| **Sub-total** | 1,874,265 | 1,147,353 | 61.2% | 881,440 | 76.8% | 275,916 | 24.0% | 1,392,651 | 121.4% |
| **Total in the Study Area** | 5,587,878 | 3,141,837 | 56.2% | 2,386,980 | 76.0% | 451,065 | 14.4% | 2,561,376 | 81.5% |
| **Whole Kingdom** | 21,128,193 | 11,013,699 | 52.1% | 8,295,107 | 75.3% | 700,671 | 6.4% | 4,589,677 | 41.7 |

**Source : Crop Year 1994/95**

## TABLE 2.2.3 MUNICIPAL POPULATION (1/2)

| Province | Municipalities | Type | Population 1995 | Area Km2 | Density |
|---|---|---|---|---|---|
| **Highlands** | | | | | |
| Chieng Mai | Chiengmai | 2 | 172,714 | 40.00 | 43.18 |
| Phayao | Phayao | 2 | 22,267 | 9.00 | 24.74 |
| Phetchaboon | Phetchaboon | 2 | 28,017 | 8.60 | 32.58 |
| | Lomsak | 3 | 16,082 | 2.08 | 77.32 |
| Tak | Tak | 2 | 22,032 | 7.27 | 30.31 |
| | Measod | 3 | 21,765 | 13.94 | 15.61 |
| Nan | Nan | 2 | 23,381 | 5.40 | 43.30 |
| Phrae | Phrae | 2 | 19,024 | 9.00 | 21.14 |
| Lampang | Lampang | 2 | 65,450 | 10.86 | 60.27 |
| Lamphun | Lamphun | 2 | 15,374 | 6.00 | 25.62 |
| | | | | | |
| **Upper Central Plain** | | | | | |
| Phichit | Phichit | 2 | 24,832 | 12.02 | 20.66 |
| | Bangmoomnak | 3 | 10,258 | 2.50 | 41.03 |
| | Tapanhin | 3 | 22,066 | 5.20 | 42.43 |
| Phitsanulok | Phitsanulok | 2 | 78,469 | 18.26 | 42.97 |
| Sukhothai | Sukhothai | 2 | 21,712 | 3.50 | 62.03 |
| | Sawankalok | 3 | 19,345 | 6.46 | 29.95 |
| Kamphaengphet | Kamphaengphet | 2 | 27,257 | 14.90 | 18.29 |
| Nakornsawan | Nakornsawan | 2 | 109,708 | 27.87 | 39.36 |
| | Chumsaeng | 3 | 11,690 | 2.40 | 48.71 |
| | Takree | 3 | 30,446 | 16.00 | 19.03 |
| Uthaithani | Uthaithani | 2 | 19,599 | 8.20 | 23.90 |
| Uttaradit | Uttaradit | 2 | 41,145 | 96.00 | 4.29 |
| | Sripanommad | 3 | 3,740 | 29.00 | 1.29 |

Note: Type 1 is Tesaban Nakhon, Type 2 is Tesaban Muang, Type 3 is Tesaban Tambon.

TABLE 2.2.3 MUNICIPAL POPULATION (2/2)

| Province | Municipality | Type | Population 1995 | Area Km2 | Density |
|---|---|---|---|---|---|
| **Lower Central Plain** | | | | | |
| Supanburi | Supanburi | 2 | 27,788 | 9.01 | 30.84 |
| | Songpenong | 3 | 12,848 | 10.40 | 12.35 |
| Angthong | Angthong | 2 | 11,662 | 3.37 | 34.61 |
| | Pamok | 3 | 10,704 | 12.00 | 8.92 |
| P.N.S. Ayutthaya | P.N.S. Ayutthaya | 2 | 70,623 | 14.00 | 50.45 |
| | Sena | 3 | 5,175 | 1.20 | 43.13 |
| | Thareau | 3 | 7,746 | 3.00 | 25.82 |
| Chainat | Chainat | 2 | 15,872 | 6.06 | 26.19 |
| | Watsing | 3 | 3,936 | 2.00 | 19.68 |
| Lopburi | Lopburi | 2 | 31,414 | 6.85 | 45.86 |
| | Banmee | 3 | 5,251 | 0.67 | 78.37 |
| | Koksamrong | 3 | 8,872 | 1.50 | 59.15 |
| Singburi | Singburi | 2 | 21,232 | 7.81 | 27.19 |
| Saraburi | Saraburi | 2 | 57,410 | 20.13 | 28.52 |
| | Phaphuttabat | 3 | 36,021 | 29.600 | 12.17 |
| | Nongkea | 3 | 8,769 | 5.00 | 17.54 |
| | Keangkoy | 3 | 13,648 | 4.05 | 33.70 |
| Nonthaburi | Nonthaburi | 2 | 251,468 | 38.90 | 64.64 |
| | Bangbuathong | 3 | 25,950 | 1.00 | 259.50 |
| | Bangkruay | 3 | 47,169 | 9.90 | 47.65 |
| | Pakkret | 3 | 137,866 | 42.72 | 32.27 |
| Pathumthani | Pathumthani | 2 | 14,680 | 7.10 | 20.68 |
| | Prachatipat | 3 | 50,301 | 22.58 | 22.28 |
| Samutpakran | Samutpakran | 2 | 70,450 | 7.33 | 96.11 |
| | Phapadaeng | 3 | 11,059 | 0.615 | 179.82 |
| | Larluang | 3 | 72,716 | 15.50 | 46.91 |
| | Samrongneau | 3 | 35,506 | 20.59 | 17.24 |
| Nakornpatom | Nakornpatom | 2 | 92,372 | 5.28 | 174.95 |
| Samutsongkram | Samutsongkram | 2 | 35,752 | 8.05 | 44.41 |
| | Ampawa | 3 | 6,939 | 2.82 | 24.61 |
| Samutsakorn | Samutsakorn | 2 | 54,335 | 10.33 | 52.60 |
| | Katumban | 3 | 14,677 | 2.18 | 67.33 |
| | Aomnoy | 3 | 29,882 | 30.00 | 9.96 |
| Nakornnayok | Nakornnayok | 2 | 19,737 | 15.87 | 12.44 |
| Chachengsao | Chachengsao | 2 | 40,888 | 12.76 | 32.04 |
| | Bangkra | 3 | 8,682 | 3.18 | 27.30 |

Note: Type 1 is Tesaban Nakhon, Type 2 is Tesaban Muang, Type 3 is Tesaban Tambon.

**Table 2.2.4 CHANGE OF FOREST AREA IN THAILAND IN THE PAST 32 YEARS (1961-1993)**

| Year | Forest Area in Thailand | | |
|---|---|---|---|
| | km2 | Rai | % |
| 1961 | 273,628.50 | 171,017,812.50 | 53.33 |
| 1973 | 221,725.00 | 138,578,125.00 | 43.21 |
| 1976 | 198,417.00 | 124,010,625.00 | 38.67 |
| 1978 | 175,224.00 | 109,515,000.00 | 34.15 |
| 1982 | 156,600.00 | 97,875,000.00 | 30.52 |
| 1985 | 150,866.00 | 94,291,349.00 | 09.40 |
| 1988 | 143,803.00 | 89,877,182.00 | 28.03 |
| 1989 | 143,417.00 | 89,635,625.00 | 27.95 |
| 1991 | 136,698.00 | 85,436,284.00 | 26.64 |
| 1993 | 133,521.00 | 83,450,623.00 | 26.02 |

Table 3.1.1 POPULATION PROJECTION BY REGION AND CHANWAT IN THE STUDY AREA

| Areas | Annual Average Growth Rate (%) | | | | | Population Projection | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2000-2005 | 2005-2010 | 2010-2015 | 2015-2018 | 2018-2020 | 2000 | 2005 | 2010(P) | 2015(P) | 2018(P) | 2020(P) |
| **Highlands** | | | | | | | | | | | |
| 1 Chiang Mai | 0.09 | 0.06 | 0.04 | 0.01 | 0.01 | 1,458,052 | 1,464,327 | 1,468,373 | 1,470,973 | 1,471,513 | 1,471,743 |
| 2 Lamphun | 0.06 | 0.04 | 0.02 | 0.01 | 0.00 | 435,535 | 436,903 | 437,702 | 438,145 | 438,221 | 438,245 |
| 3 Lampang | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | 778,363 | 779,593 | 780,042 | 780,035 | 779,967 | 779,905 |
| 4 Phayao | 0.06 | 0.04 | 0.02 | 0.01 | 0.00 | 504,858 | 506,443 | 507,369 | 507,881 | 507,969 | 507,997 |
| 5 Phrae | 0.06 | 0.03 | 0.02 | 0.00 | 0.00 | 513,133 | 514,620 | 515,461 | 515,900 | 515,969 | 515,987 |
| 6 Nan | 0.06 | 0.04 | 0.02 | 0.01 | 0.00 | 442,873 | 444,263 | 445,075 | 445,524 | 445,601 | 445,6[illegible] |
| 7 Tak | 0.08 | 0.05 | 0.03 | 0.01 | 0.01 | 357,084 | 358,442 | 359,288 | 359,807 | 359,909 | 359,950 |
| 8 Phetchabun | 0.06 | 0.04 | 0.02 | 0.01 | 0.00 | 924,990 | 927,895 | 929,592 | 930,532 | 930,693 | 930,745 |
| Sub-total | 0.06 | 0.04 | 0.02 | 0.01 | 0.00 | 5,414,888 | 5,432,486 | 5,442,902 | 5,448,798 | 5,449,842 | 5,450,197 |
| **Upper Central Plain** | | | | | | | | | | | |
| 9 Sukhothai | 0.02 | 0.00 | -0.01 | -0.01 | -0.01 | 593,029 | 593,536 | 593,532 | 593,245 | 593,121 | 593,037 |
| 10 Uttaradit | 0.02 | 0.00 | -0.01 | -0.01 | -0.01 | 460,895 | 461,273 | 461,257 | 461,023 | 460,925 | 460,858 |
| 11 Phitsanulok | 0.10 | 0.06 | 0.04 | 0.02 | 0.01 | 806,835 | 810,722 | 813,296 | 815,010 | 815,379 | 815,542 |
| 12 Kamphaeng Phet | 0.05 | 0.03 | 0.01 | 0.00 | 0.00 | 683,709 | 685,520 | 686,503 | 686,976 | 687,039 | 687,048 |
| 13 Phichit | 0.04 | 0.02 | 0.01 | 0.00 | 0.00 | 582,649 | 583,925 | 584,547 | 584,775 | 584,783 | 584,768 |
| 14 Nakhon Sawan | 0.00 | -0.01 | -0.02 | -0.01 | -0.01 | 110,538 | 110,538 | 110,461 | 110,346 | 110,307 | 110,284 |
| 15 Uthai Thani | 0.02 | 0.00 | -0.01 | -0.01 | -0.01 | 309,455 | 309,750 | 309,773 | 309,642 | 309,583 | 309,542 |
| Sub-total | 0.05 | 0.02 | 0.01 | 0.00 | 0.00 | 3,547,110 | 3,555,264 | 3,559,370 | 3,561,018 | 3,561,137 | 3,561,079 |
| **Lower Central Plain** | | | | | | | | | | | |
| 16 Chai Nat | 0.14 | 0.10 | 0.07 | 0.03 | 0.02 | 372,884 | 375,421 | 377,211 | 378,496 | 378,792 | 378,933 |
| 17 Sing Buri | 0.14 | 0.10 | 0.07 | 0.03 | 0.02 | 241,225 | 242,866 | 244,024 | 244,855 | 245,047 | 245,137 |
| 18 Lop Buri | 0.14 | 0.10 | 0.07 | 0.03 | 0.02 | 760,604 | 765,778 | 769,429 | 772,049 | 772,653 | 772,939 |
| 19 Suphan Buri | 0.63 | 0.49 | 0.39 | 0.16 | 0.13 | 872,524 | 900,471 | 922,956 | 941,257 | 945,912 | 948,290 |
| 20 Ang Thong | 0.14 | 0.10 | 0.07 | 0.03 | 0.02 | 274,225 | 276,091 | 277,408 | 278,353 | 278,571 | 278,6[illegible] |
| 21 P.Nakhon Si Ayutthaya | 0.14 | 0.10 | 0.07 | 0.03 | 0.02 | 733,379 | 738,368 | 741,889 | 744,414 | 744,998 | 745,27[illegible] |
| 22 Saraburi | 0.14 | 0.10 | 0.07 | 0.03 | 0.02 | 537,937 | 541,596 | 544,178 | 546,030 | 546,458 | 546,660 |
| 23 Nakhon Pathom | 2.26 | 1.80 | 1.46 | 0.62 | 0.48 | 866,741 | 969,364 | 1,060,064 | 1,139,834 | 1,161,135 | 1,172,244 |
| 24 Nonthaburi | 2.26 | 1.80 | 1.46 | 0.62 | 0.48 | 798,294 | 892,813 | 976,351 | 1,049,821 | 1,069,440 | 1,079,672 |
| 25 Pathum Thani | 2.26 | 1.81 | 1.46 | 0.62 | 0.48 | 574,355 | 642,360 | 702,464 | 755,325 | 769,440 | 776,802 |
| 26 Samut Sakhon | 2.26 | 1.81 | 1.46 | 0.62 | 0.48 | 442,670 | 495,083 | 541,407 | 582,148 | 593,027 | 598,701 |
| 27 Samut Prakan | 2.26 | 1.80 | 1.46 | 0.62 | 0.48 | 1,037,857 | 1,160,740 | 1,269,347 | 1,364,865 | 1,390,370 | 1,403,673 |
| 28 Bangkok Metropolis | 1.86 | 1.48 | 1.20 | 0.51 | 0.39 | 7,637,000 | 8,375,000 | 9,014,514 | 9,567,977 | 9,714,319 | 9,790,383 |
| Sub-total | 1.57 | 1.27 | 1.04 | 0.44 | 0.34 | 15,149,695 | 16,375,951 | 17,441,242 | 18,365,424 | 18,610,162 | 18,737,381 |
| **Total in the Study Area** | 1.02 | 0.84 | 0.69 | 0.30 | 0.23 | 24,111,693 | 25,363,701 | 26,443,514 | 27,375,240 | 27,621,141 | 27,748,658 |
| **Other Area** | 0.71 | 0.56 | 0.44 | 0.19 | 0.14 | 38,293,307 | 39,670,299 | 40,786,486 | 41,700,760 | 41,934,859 | 42,055,342 |
| **Whole Kingdom** | 0.83 | 0.67 | 0.54 | 0.23 | 0.18 | 62,405,000 | 65,034,000 | 67,230,000 | 69,076,000 | 69,556,000 | 69,804,000 |

Note: Projection of 1995 and 2000 for all areas and the Whole Kingdom projection of 2005,2010,2015 and 2018 are adopted from "Population Projections For Thailand 1990-2020, Human Resouces Division, NESDB.

TABLE 3.1.2 PROJECTION OF GROSS DOMESTIC PRODUCT (GDP) AT 1997 PRICE BY REGION AND CHANGWAT COVERING THE STUDY AREA

Unit: million Baht

| Region and Chagwat | 1994 | Share in 1994 (%) | Whole Kingdom (1997) | Province (1997) | Province (2001) | Province (2010) | Province (2018) |
|---|---|---|---|---|---|---|---|
| (1) Study Area | | | | | | | |
| **Bangkok Metropolis** | 1,380,343 | 38.3 | | 1,786,356 | 1,829,616 | 3,224,827 | 5,139,885 |
| Bangkok Vicinity | | | | | | | |
| Samut Prakan | 155,706 | 4.3 | | 201,505 | 206,385 | 363,768 | 579,791 |
| Pathum Thani | 120,322 | 3.3 | | 155,713 | 159,484 | 281,102 | 448,034 |
| Samut Sakhon | 93825 | 2.6 | | 121,423 | 124,363 | 219,199 | 349,369 |
| Nakhon Pathom | 60,167 | 1.7 | | 77,864 | 79,750 | 140,565 | 224,040 |
| Nonthaburi | 45,531 | 1.3 | | 58,923 | 60,350 | 106,372 | 169,541 |
| Sub Total | 475,551 | 13.2 | | 615,429 | 630,333 | 1,111,006 | 1,770,775 |
| **Central Region** | | | | | | | |
| Saraburi | 54,260 | 1.5 | | 70,220 | 71,921 | 126,765 | 202,044 |
| Sing Buri | 7,947 | 0.2 | | 10,285 | 10,534 | 18,566 | 29,592 |
| Chai Nat | 12,195 | 0.3 | | 15,782 | 16,164 | 28,491 | 45,410 |
| Ang Thong | 8,993 | 0.2 | | 11,638 | 11,920 | 21,010 | 33,487 |
| Lop Buri | 25,486 | 0.7 | | 32,982 | 33,781 | 59,542 | 94,900 |
| Phra Nakhon Si Ayutthaya | 54,173 | 1.5 | | 70,107 | 71,805 | 126,562 | 201,720 |
| Sub Total | 163,054 | 4.5 | | 211,015 | 216,125 | 380,935 | 607,153 |
| **Western Region** | | | | | | | |
| Kanchanaburi | 32,558 | 0.9 | | 42,135 | 43,155 | 76,064 | 121,234 |
| Rachaburi | 41,624 | 1.2 | | 53,867 | 55,172 | 97,244 | 154,992 |
| Samut Songkhram | 7,030 | 0.2 | | 9,098 | 9,318 | 16,424 | 26,177 |
| Suphan Buri | 29,570 | 0.8 | | 38,268 | 39,194 | 69,083 | 110,108 |
| Sub Total | 110,782 | 3.1 | | 143,367 | 146,839 | 258,815 | 412,511 |
| **Eastern Region** | | | | | | | |
| Chachoengsao | 45,427 | 1.3 | | 58,789 | 60,213 | 106,129 | 169,153 |
| Nakhon Nayok | 9,017 | 0.3 | | 11,669 | 11,952 | 21,066 | 33,576 |
| Sub-Total | 54,444 | 1.5 | | 70,458 | 72,164 | 127,195 | 202,729 |
| **Northeastern Region** | | | | | | | |
| Loei | 13,116 | 0.4 | | 16,974 | 17,385 | 30,642 | 48,839 |
| **Nothern Region** | | | | | | | |
| Chiang Mai | 65,084 | 1.8 | | 84,228 | 86,267 | 152,053 | 242,349 |
| Chiang Rai | 27,701 | 0.8 | | 35,849 | 36,717 | 64,716 | 103,148 |
| Lampang | 27,849 | 0.8 | | 36,040 | 36,913 | 65,062 | 103,699 |
| Uttaradit | 13,229 | 0.4 | | 17,120 | 17,535 | 30,906 | 49,260 |
| Mae Hong Son | 4,341 | 0.1 | | 5,618 | 5,754 | 10,142 | 16,164 |
| Phrae | 11,080 | 0.3 | | 14,339 | 14,686 | 25,886 | 41,258 |
| Lamphun | 26,103 | 0.7 | | 33,781 | 34,599 | 60,983 | 97,198 |
| Nan | 9,578 | 0.3 | | 12,395 | 12,695 | 22,377 | 35,665 |
| Phayao | 11,754 | 0.3 | | 15,211 | 15,580 | 27,460 | 43,768 |
| Nakhon Sawan | 34,118 | 0.9 | | 44,153 | 45,223 | 79,708 | 127,043 |
| Phitsanulok | 23,005 | 0.6 | | 29,772 | 30,493 | 53,745 | 85,662 |
| Kamphaeng Phet | 20,226 | 0.6 | | 26,175 | 26,809 | 47,253 | 75,314 |
| Uthai Thani | 9,199 | 0.3 | | 11,905 | 12,193 | 21,491 | 34,254 |
| Sukhothai | 14,744 | 0.4 | | 19,081 | 19,543 | 34,446 | 54,901 |
| Tak | 11,676 | 0.3 | | 15,110 | 15,476 | 27,278 | 43,477 |
| Phichit | 13,015 | 0.4 | | 16,843 | 17,251 | 30,406 | 48,463 |
| Phetchabun | 20,783 | 0.6 | | 26,896 | 27,547 | 48,554 | 77,388 |
| Sub Total | 343,485 | 9.5 | | 444,517 | 455,282 | 802,467 | 1,279,011 |
| **Total of Study Area** | 2,540,775 | 70.6 | | 3,288,117 | 3,367,745 | 5,935,887 | 9,460,902 |
| (2) Other than Study Area | 1,060,131 | 29.4 | | 1,371,957 | 1,405,182 | 2,476,732 | 3,947,534 |
| **Whole Kingdom** | 3,600,906 | 100.0 | 4,660,074 | 4,660,074 | 4,772,926 | 8,412,619 | 13,408,436 |

Source: Gross Domestic Products & Gross Regional Products,NESDB.

Note : Average Annual GDP Growth Rate at 1997 Constant Prices

1997-2001 0.6 %, 2002-2015 6.5 %, 2006-2008 6.0 % (Midium Scenario)

Table 3.2.1 COMPOSITION OF AGRICULUTRAL LAND USE, 1975-1991

Unit: thousand rai, %

| Land Use Type | 1975 | 1980 | 1985 | 1990 | 1991 | Share |
|---|---|---|---|---|---|---|
| National land | 320,697 | 320,697 | 320,697 | 320,697 | 320,697 | 100.0 |
| Forest | 130,762 | 103,419 | 93,158 | 87,489 | 85,436 | 26.6 |
| Agricultural land | 112,211 | 118,999 | 128,603 | 132,124 | 133,076 | 41.5 |
| Paddy | 71,239 | 73,563 | 73,902 | 69,436 | 69,313 | 21.6 |
| Upland crops | 19,953 | 25,758 | 31,605 | 33,415 | 33,519 | 10.5 |
| Orchard | 10,413 | 11,142 | 13,464 | 19,429 | 20,098 | 6.3 |
| Vegetables & vacant la | 358 | 314 | 474 | 806 | 858 | 0.3 |
| Pasture | 487 | 523 | 848 | 740 | 707 | 0.2 |
| Recess | 4,552 | 3,064 | 3,750 | 3,680 | 3,621 | 1.1 |
| Others | 2,372 | 2,113 | 1,531 | 1,257 | 1,423 | 0.4 |
| Farmers' houses | 2,837 | 2,521 | 3,031 | 3,362 | 3,536 | 1.1 |
| Unable to classify | 77,723 | 98,279 | 98,935 | 101,084 | 102,184 | 31.9 |

Source: Ministry of Agriculture and Cooperative

**Table 3.2.2 AREA UNDER FLOATING RICE BY IRRIGATION PROJECT**

Unit : ha

| Location | Total Area | | | Floating Rice Area | | | |
|---|---|---|---|---|---|---|---|
| | 1974 - 86 | 1987 - 91 | 1992 - 96 | 1976 | 1986/87 | 1995/96 | 1996/97 |
| Region 7 | 361,955 | 372,440 | 364,215 | 86,537 | 104,246 | 67,120 | 58,485 |
| Don Chedi | 22,519 | 21,556 | 20,238 | 720 | 2,304 | 1,044 | 1,034 |
| Pho Phraya | 42,839 | 25,713 | 43,884 | 13,270 | 2,562 | 832 | 758 |
| Borommathat | 58,153 | 57,287 | 54,648 | 4,259 | 4,327 | 4,033 | 5,766 |
| Chanasutr | 73,762 | 64,066 | 54,752 | 6,838 | 13,913 | 10,236 | 9,480 |
| Yangmanee | 30,490 | 29,557 | 28,964 | 11,802 | 22,116 | 21,792 | 18,918 |
| Phak Hai | 31,318 | 30,429 | 22,280 | 28,896 | 31,896 | 17,024 | 14,848 |
| Bang Bal | 16,088 | 21,130 | 15,933 | 8,848 | 16,497 | 11,760 | 7,680 |
| Chao Chet B.Y. | 27,630 | 35,821 | 35,044 | 11,904 | 10,632 | 400 | 0 |
| Phraya Ban Lu | 18,350 | 45,445 | 50,628 | 0 | 0 | 0 | 0 |
| Phra Phimon | 16,194 | 31,262 | 33,485 | 0 | 0 | 0 | 0 |
| Phasi Charoen | 24,702 | 10,175 | 4,359 | 0 | 0 | 0 | 0 |
| Region 8 | 466,499 | 424,325 | 384,130 | 93,282 | 124,076 | 106,091 | 55,508 |
| Khao Kaeo | | | | 0 | 0 | 0 | 0 |
| Manorom/K.K. | 37,222 | 40,087 | 40,742 | 640 | 0 | 0 | 0 |
| Chong Kaeo | 37,887 | 37,761 | 37,849 | 6,224 | 6,258 | 13,120 | 3,385 |
| Khok Katiem | 32,456 | 31,654 | 32,890 | 15,268 | 17,928 | 15,430 | 16,656 |
| Roeng Rang | 28,407 | 27,137 | 25,841 | 3,195 | 10,597 | 8,684 | 6,666 |
| Maharaj | 73,782 | 74,785 | 70,315 | 35,544 | 30,331 | 35,536 | 19,046 |
| Nakhon Luang | 42,085 | 34,786 | 33,109 | 20,089 | 22,060 | 22,962 | 7,563 |
| Pasak Tai | 37,199 | 32,280 | 32,337 | 5,048 | 4,160 | 0 | 0 |
| Rangsit Nua | 58,310 | 39,404 | 22,940 | 3,764 | 5,739 | 1,864 | 2,192 |
| Rangsit Tai | 67,915 | 68,407 | 65,238 | 231 | 0 | 0 | 0 |
| Khlong Dan | 52,236 | 38,024 | 22,870 | 3,280 | 27,003 | 8,495 | 0 |
| Total | 828,454 | 796,764 | 748,345 | 179,819 | 228,322 | 173,211 | 113,993 |

Table 3.2.3 REFORESTATION PROGRAM IN THE NEXT 5 YEARS (1997 - 2001)

| Standard Activity | No. | 1997 | 1998 | 1999 | 2000 | 2001 | Total |
|---|---|---|---|---|---|---|---|
| **1. Planting forest by government in government** | Rai | 31,700 | 270,900 | 265,500 | 260,500 | 263,500 | 3,092,100 |
| 1.1 Planting forest following for King's project | Rai | 24,000 | 62,000 | 62,000 | 62,000 | 65,000 | 275,000 |
| 1.2 Planting forest at the estuary of a river safety | Rai | - | 10,000 | 10,000 | 10,000 | 10,000 | 40,000 |
| 1.3 Plantin example forest | Rai | 3,000 | 6,000 | - | - | - | 9,000 |
| 1.4 Planting forest for research work and product a seed | Rai | 2,200 | 4,900 | 4,500 | 4,500 | 4,500 | 20,600 |
| 1.5 Planting rattan following for King's project | Rai | 2,500 | 30,000 | 30,000 | 25,000 | 25,000 | 112,500 |
| 1.6 Regain forest by natural rule | Rai | - | 150,000 | 150,000 | 150,000 | 150,000 | 600,000 |
| 1.7 Planting forest following for King's Majesty Project | Rai | - | - | - | - | - | 2,000,000 |
| 1.8 Planting forest for Pasak basin project | Rai | - | 8,000 | 9,000 | 9,000 | 9,000 | 35,000 |
| **2. Promoting private individual planting economic forest in owner land.** | Rai | 831,250 | 831,250 | 831,250 | 831,250 | 831,250 | 4,156,250 |
| 2.1 Project Promotion planting economic forest | Rai | 531,250 | 531,250 | 531,250 | 531,250 | 531,250 | 2,656,250 |
| 2.2 Project regain forest structural and production agricultural system | Rai | 300,000 | 300,000 | 300,000 | 300,000 | 300,000 | 1,500,000 |

Source : Royal Forest Department

## Table 3.4.1 PRESENT & FUTURE PROJECTION OF LADUSE IN THE FLOODPLAIN

| Landuse Type | Upper Central Plain | | | | | | |
|---|---|---|---|---|---|---|---|
| | Annual Growth (%) | Present (1998) | | Future (2005) | | Future (2018) | |
| | | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) |
| Urban | 3.9% | 206 | 1.6% | 270 | 2.1% | 461 | 3.5% |
| Rice | -1.0% | 9,544 | 72.6% | 8,921 | 67.9% | 7,794 | 59.3% |
| Fruits & Trees | 3.3% | 1,195 | 9.1% | 1,500 | 11.4% | 2,361 | 18.0% |
| Vegetables & Flowers | 5.3% | 206 | 1.6% | 297 | 2.3% | 614 | 4.7% |
| Field Crops | -0.3% | 1,386 | 10.6% | 1,360 | 10.4% | 1,308 | 10.0% |
| Forest | 0.0% | 202 | 1.5% | 202 | 1.5% | 202 | 1.5% |
| Others | 0.0% | 400 | 3.0% | 400 | 3.0% | 400 | 3.0% |
| Total | | 13,139 | 100.0% | 13,139 | 100.0% | 13,139 | 100.0% |

| Landuse Type | Nakhon Sawan Area | | | | | | |
|---|---|---|---|---|---|---|---|
| | Annual Growth (%) | Present (1998) | | Future (2005) | | Future (2018) | |
| | | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) |
| Urban | 3.9% | 43 | 3.1% | 56 | 4.1% | 95 | 7.0% |
| Rice | -1.2% | 890 | 65.1% | 818 | 59.8% | 691 | 50.6% |
| Fruits & Trees | 2.1% | 271 | 19.8% | 313 | 22.9% | 419 | 30.7% |
| Vegetables & Flowers | 1.6% | 41 | 3.0% | 46 | 3.4% | 58 | 4.2% |
| Field Crops | -2.9% | 40 | 3.0% | 33 | 2.4% | 22 | 1.6% |
| Forest | 0.0% | 17 | 1.2% | 17 | 1.2% | 17 | 1.2% |
| Others | 0.0% | 64 | 4.7% | 64 | 4.7% | 64 | 4.7% |
| Total | | 1,367 | 100.0% | 1,367 | 100.0% | 1,367 | 100.0% |

| Landuse Type | Higher Delta in Lower Central Plain | | | | | | |
|---|---|---|---|---|---|---|---|
| | Annual Growth (%) | Present (1998) | | Future (2005) | | Future (2018) | |
| | | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) |
| Urban | 3.8% | 185 | 1.7% | 239 | 2.2% | 403 | 3.7% |
| Rice | -0.4% | 9,133 | 83.4% | 8,859 | 80.9% | 8,336 | 76.1% |
| Fruits & Trees | 2.9% | 669 | 6.1% | 817 | 7.5% | 1,217 | 11.1% |
| Vegetables & Flowers | 2.4% | 165 | 1.5% | 195 | 1.8% | 270 | 2.5% |
| Field Crops | -2.2% | 299 | 2.7% | 256 | 2.3% | 188 | 1.7% |
| Forest | 0.0% | 12 | 0.1% | 12 | 0.1% | 12 | 0.1% |
| Others | 0.4% | 492 | 4.5% | 504 | 4.6% | 530 | 4.8% |
| Total | | 10,955 | 100.0% | 10,955 | 100.0% | 10,955 | 100.0% |

| Landuse Type | Lower Delta in Lower Central Plain | | | | | | |
|---|---|---|---|---|---|---|---|
| | Annual Growth (%) | Present (1998) | | Future (2005) | | Future (2018) | |
| | | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) |
| Urban | 3.7% | 1,348 | 14.1% | 1,734 | 18.1% | 2,868 | 30.0% |
| Rice | -2.1% | 5,411 | 56.5% | 4,653 | 48.6% | 3,441 | 35.9% |
| Fruits & Trees | 1.1% | 1,251 | 13.1% | 1,354 | 14.1% | 1,584 | 16.5% |
| Vegetables & Flowers | 0.6% | 74 | 0.8% | 78 | 0.8% | 85 | 0.9% |
| Field Crops | -3.8% | 405 | 4.2% | 308 | 3.2% | 178 | 1.9% |
| Forest | 0.0% | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| Others | 1.3% | 1,086 | 11.3% | 1,188 | 12.4% | 1,420 | 14.8% |
| Total | | 9,576 | 100.0% | 9,576 | 100.0% | 9,576 | 100.0% |

| Landuse Type | Total (4 Basins) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Annual Growth (%) | Present (1998) | | Future (2005) | | Future (2018) | |
| | | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) |
| Urban | 3.7% | 1,782 | 5.1% | 2,299 | 6.6% | 3,827 | 10.9% |
| Rice | -1.0% | 24,978 | 71.3% | 23,251 | 66.4% | 20,262 | 57.8% |
| Fruits & Trees | 2.4% | 3,387 | 9.7% | 3,983 | 11.4% | 5,581 | 15.9% |
| Vegetables & Flowers | 3.6% | 488 | 1.4% | 616 | 1.8% | 1,027 | 2.9% |
| Field Crops | -1.1% | 2,130 | 6.1% | 1,957 | 5.6% | 1,696 | 4.8% |
| Forest | 0.0% | 230 | 0.7% | 230 | 0.7% | 230 | 0.7% |
| Others | 0.8% | 2,042 | 5.8% | 2,156 | 6.2% | 2,414 | 6.9% |
| Total | | 35,037 | 100.0% | 35,037 | 100.0% | 35,037 | 100.0% |

**Table 3.4.2 PROJECTION OF FUTURE LANDUSE IN RICE CULTIVATION IN THE FLOOD PLAIN**

| Landuse Type | Upper Central Plain | | | | | | |
|---|---|---|---|---|---|---|---|
| | Annual Growth (%) | Present (1998) | | Future (2005) | | Future (2018) | |
| | | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) |
| Rice | -1.0% | 9,544 | 100.0% | 8,614 | 100.0% | 7,794 | 100.0% |
| 1) HYV | 3.7% | 1,466 | 15.4% | 1,887 | 21.9% | 3,129 | 40.1% |
| 2) General | -2.6% | 8,078 | 84.6% | 6,727 | 78.1% | 4,665 | 59.9% |
| 3) Deep Water | 0.0% | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| 4) Floating | 0.0% | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |

| Landuse Type | Nakhon Sawan Area | | | | | | |
|---|---|---|---|---|---|---|---|
| | Annual Growth (%) | Present (1998) | | Future (2005) | | Future (2018) | |
| | | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) |
| Rice | -1.2% | 890 | 100.0% | 814 | 100.0% | 691 | 100.0% |
| 1) HYV | 0.0% | 301 | 33.8% | 301 | 36.9% | 301 | 43.5% |
| 2) General | -1.9% | 589 | 66.2% | 513 | 63.1% | 390 | 56.5% |
| 3) Deep Water | 0.0% | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| 4) Floating | 0.0% | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |

| Landuse Type | Higher Delta in Lower Central Plain | | | | | | |
|---|---|---|---|---|---|---|---|
| | Annual Growth (%) | Present (1998) | | Future (2005) | | Future (2018) | |
| | | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) |
| Rice | -0.4% | 9,133 | 100.0% | 8,684 | 100.0% | 8,336 | 100.0% |
| 1) HYV | 0.3% | 6,038 | 70.5% | 6,183 | 71.2% | 6,703 | 80.4% |
| 2) General | 0.0% | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| 3) Deep Water | -3.0% | 2,539 | 16.5% | 2,051 | 23.6% | 1,339 | 16.1% |
| 4) Floating | -3.0% | 556 | 13.0% | 449 | 5.2% | 293 | 3.5% |

| Landuse Type | Lower Delta in Lower Central Plain | | | | | | |
|---|---|---|---|---|---|---|---|
| | Annual Growth (%) | Present (1998) | | Future (2005) | | Future (2018) | |
| | | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) |
| Rice | -2.1% | 5,411 | 100.0% | 4,653 | 100.0% | 3,441 | 100.0% |
| 1) HYV | -2.1% | 5,308 | 98.1% | 4,570 | 98.2% | 3,387 | 98.4% |
| 2) General | 0.0% | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| 3) Deep Water | 0.0% | 0 | 0.0% | 0 | 0.0% | 0 | 0.0% |
| 4) Floating | -3.0% | 103 | 1.9% | 83 | 1.8% | 54 | 1.6% |

| Landuse Type | TOTAL (4 BASINS) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Annual Growth (%) | Present (1998) | | Future (2005) | | Future (2018) | |
| | | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) | Area (sq. km) | Share (%) |
| Rice | -1.0% | 24,978 | 100.0% | 22,765 | 100.0% | 20,262 | 100.0% |
| 1) HYV | 0.1% | 13,113 | 52.5% | 12,941 | 56.8% | 13,520 | 66.7% |
| 2) General | -2.5% | 8,667 | 34.7% | 7,240 | 31.8% | 5,055 | 24.9% |
| 3) Deep Water | -3.0% | 2,539 | 10.2% | 2,051 | 9.0% | 1,339 | 6.6% |
| 4) Floating | -3.0% | 659 | 2.6% | 532 | 2.3% | 348 | 1.7% |