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AN AGROECOSYSTEM ANALYSIS OF NORTHEAST THAILAND

BY

KKU-FORD CROPPING SYSTEMS PROJECT

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PREFACE

The ultimate goal of the Cropping Systems Project is to increase farmers' income through improved cropping systems. Such systems must fit the prevailing socio-economic and cultural conditions and be accepted by the farmers. In order to develop these,it is thus necessary to have a clear understanding of the socio-agroeconomic and cultural background of the target areas and target groups. This requires analysis of the system as a whole by an interdisciplinary team. The Project, therefore, arranged a workshop that would allow an interdisciplinary team to analyze the whole agroeconomic system of the Northeast.

The main objectives of this workshop were (a) to review the progress of the Cropping Systems Project, and (b) to gain a better understanding of problems of agricultural development in the Northeast. The resulting information has been used as a basis for establishing relevant cropping systems research and its future direction. The seven-day workshop was held at Khon Kaen University in December 1980.

This workshop report contains considerable detailed information on cropping systems and on the socio-economic and cultural background of the Northeast. We believe this will be of use to a variety of individuals and institutions. First, it will serve as the baseline for the Cropping Systems Project's research priorities and future direction. Key questions have been identified which will become research topics of the Project. In addition, we believe this report will also be of value to extension workers, researchers, and administrators who are planning or conducting research and development projects in the region.

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We are very grateful to all the participants of the workshop. A draft of this report has been read by Dr.Sam H. Johnson III of Illinois University, Dr.Gordon Banta of IDRC, and Dr.Leedom Lefferts, Fulbright visiting professor at KKU. We are grateful for their invaluable comments.

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Currency Equivalents

1.00 US $ ≃ 20 baht up to 1981
≃ 23 baht in 1982

Metric Equivalents

1 rai = 0.16 ha
= 0.41 acre

1 tang of rice = 10 kg.

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CHAPTER ONE
INTRODUCTION

The Northeast of Thailand comprises roughly a third of the population and of the area of the country (Figure 1.1). But the per capita income is only 40% of the national average. This is due primarily to low agricultural production which, in turn, is a function of poor soil and erratic rainfall.

The soils are mostly light and sandy with low moisture holding capacity and fertility. Average annual rainfall is over 1,000 mm, but it varies greatly in amount and intensity, both within the rainy season and from year to year. Floods and droughts are common. Rainfall occurs only occasionally in the dry season and irrigation is restricted to less than 5% of the cultivated land.

As a consequence, very few crops can be grown. Most of the land is under a monoculture of rice, kenaf, or cassava. Glutinous rice is the subsistence crop but its yield is very variable. There is a declining market for kenaf, and cassava has an uncertain future.

1. The Cropping Systems Project (CSP).

In 1975, the Faculty of Agriculture of Khon Kaen University initiated a cropping systems project, with financial assistance from the Ford Foundation and The Government of Thailand. The main objective of the project was to develop cropping systems for rainfed areas of the Northeast. From the outset, the project was seen as necessarily a multidisciplinary research endeavour which would also have a significant influence on the agricultural training offered by the University.

The formal objectives of the project are:

1. To develop cropping systems for rainfed cultivated areas of the Northeast Thailand.

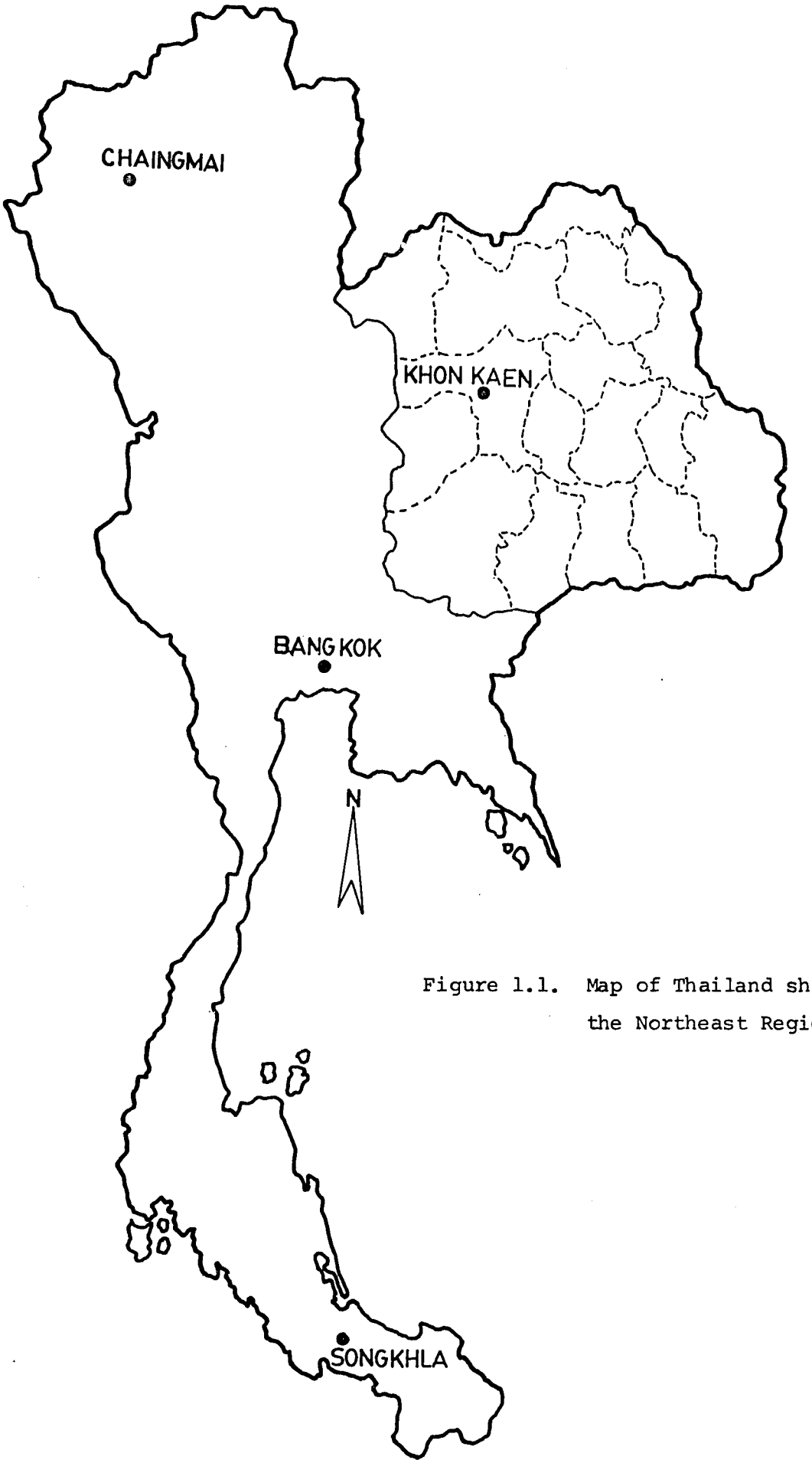


Figure 1.1. Map of Thailand showing the Northeast Region.

2. To identify crop varieties and to improve cultural practices suitable for the cropping systems under rainfed conditions, and

3. To provide a research framework in which staff members and students can participate in the problem-solving efforts at the farmers' level.

Suitable cropping systems are defined as those which would provide better income to the farmers than existing systems, fit the physical and socio-economic conditions of the rainfed areas in the Northeast Thailand, be acceptable to farmers, and be applicable to a reasonably large area. Other desirable characteristics of the systems include: stability of production, established markets and reasonably good prices for the crops, minimum cash inputs and inexpensive equipment needs, good distribution of labour requirements, and maintenance of soil productivity. These characters are deemed necessary for the systems to be suitable for small farmers who have limited land and access to capital.

The initial research goal of the CSP was to design and test cropping systems which would make full use of the whole available growing season. The period during which rainfall is adequate for the growing of field crops in the Northeast is from 150 to 190 days, but many annual crops (with the exception of cassava and kenaf) can mature in 100-120 days. By adjusting planting times and selecting suitable varieties, it is thus theoretically possible to produce two or even three crops during the growing season. Over the past five years, a number of cropping systems have been developed with this aim and have been tested, with variable results, both on the University farm and on farmers fields in five villages. This work has also been complemented by investigations on component technology (e.g. varieties, spacing, fertilizers, insect and disease control, soil moisture requirements etc.) and a limited number of socio-economic studies. (KKU-Ford Cropping Systems Project, Annual Reports 1975, 1976, 1977, 1978).

2. An Interdisciplinary Workshop

After five years, it seemed timely to review the progress of the CSP's program and to draw up research priorities for the next five years. Accordingly, in December of 1980, a special seven-day workshop was held at Khon Kaen University. The aim of the workshop, however, was not to carry out a formal review of the research program but rather, through an intensive interdisciplinary analysis, to gain a better understanding of the problems of agricultural development in the Northeast as a whole and hence to establish more firmly the relevance of the existing cropping systems research and its future direction.

The workshop was thus designed to include both natural and social scientists from Khon Kaen University, together with a team from the Multiple Cropping Project (MCP) at Chiang Mai University who had recently successfully carried out a similar interdisciplinary analysis of their study area. Two groups representing resource management teams in the Philippines and Indonesia were also invited, plus a number of experts from the Ford Foundation and from institutes in the UK and Hawaii. The total workshop thus comprised some 30 individuals; their names and affiliations are listed on page ix of this report.

3. Outline of the Study Procedure

We used a procedure of analysis for the workshop which has been developed by the MCP at Chiang Mai University (Gypmantasiri et al., 1980; Walker et al., 1978). The procedure has the advantage of being systematic, yet is flexible and rapid in operation, so ensuring a productive interaction between the different disciplines involved in the analysis.

The critical assumption underlying the procedure is that, although large agro-ecosystems are complex, their essential features are determined by a limited number of key processes and, while policy issues and management problems are also complex, major improvements can be achieved by changes in a small number of key decisions. The primary aim of

the analysis is thus to identify and formulate a set of key questions which related to these processes and decisions.

The pattern of work in the procedure is specifically designed to ensure that agricultural, ecological, socio-economic, and management issues are raised simultaneously, so allowing a cross-fertilisation of ideas, out of which the key questions emerge and are recognised. The stages of the procedure were tackled systematically in seminars, involving the whole team, interspersed with detailed working sessions of smaller groups.

Figure 1.2 outlines the procedure. It begins with one or more seminars in which the group agrees on the systems to be studied, their boundaries and their position in the system hierarchy. The seminars then concentrate on analysing the patterns and processes in the systems. This involves explicit examination of (1) the structure of the systems, their spatial relations, (2) the dynamic processes that characterise the relationships in time of each system, and (3) the pattern of utilisation and decision making present in the systems. Existing knowledge is reviewed by the groups, making extensive use of dioristic models, that is schematic maps, graphs, flow diagrams, Venn diagrams, etc., to encourage communication within the group and to ensure a common group understanding.

This phase of the procedure has three purposes. First, it serves to establish a holistic framework for the study, ensuring as far as possible that existing and potential interactions and relationships are not overlooked. Second, it serves to uncover gaps in existing knowledge. Finally, out of the discussions and arguments generated by the seminars, there emerges the first outlines of the key questions.

Initially the questions tend to reflect the interests of individual disciplines. However, through further discussions concentrating on the system properties and interactions which characterise each system and the system hierarchy as a whole, the questions are reformulated and refined so that eventually very powerful key questions emerge, which expli-

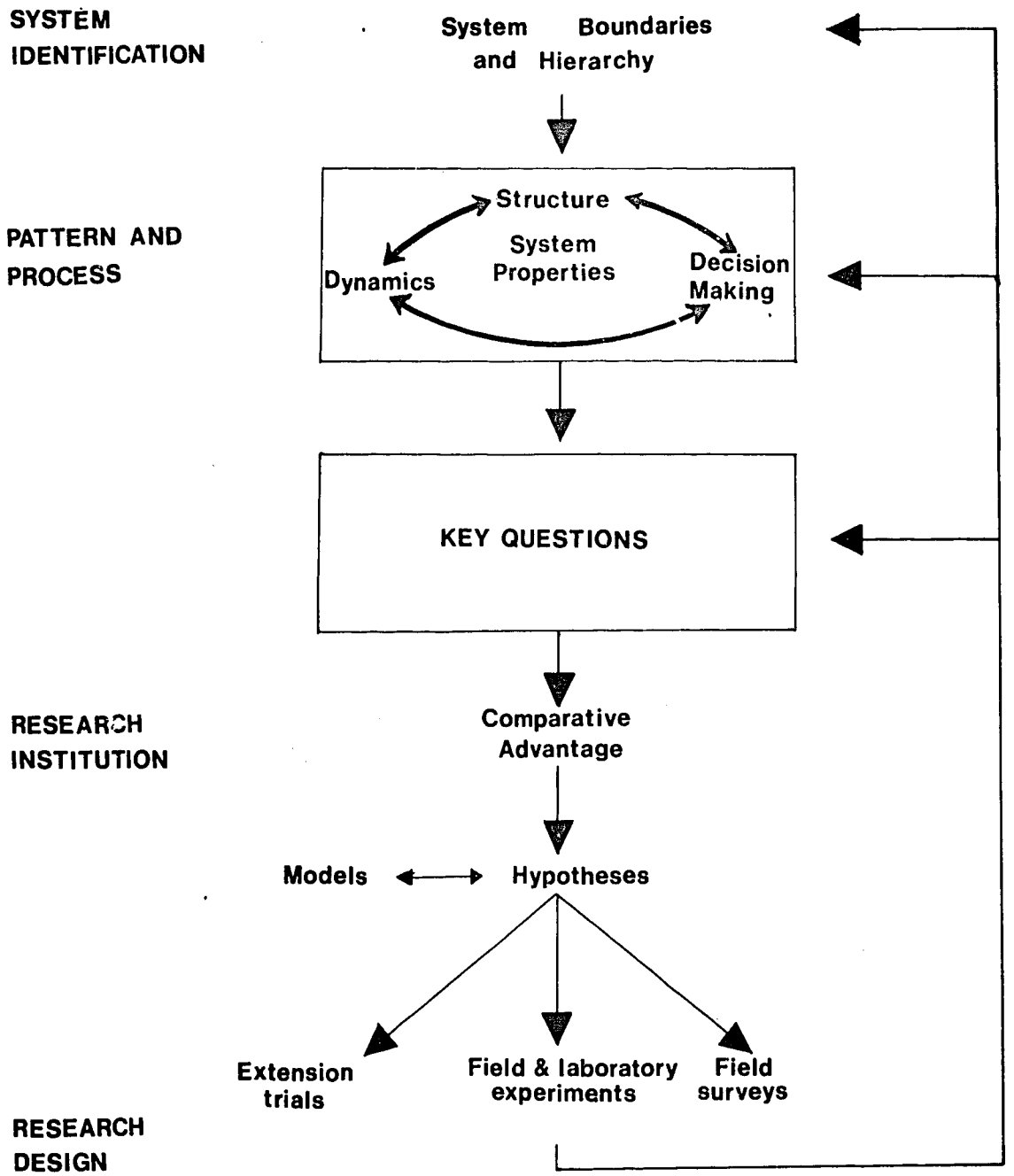


Figure 1.2. Outline of the procedure of interdisciplinary analysis.

citly or implicitly combine different disciplines and interests.

Once the questions have been determined, the procedure then requires the research team to analyse its own capacity to answer each of the questions, by assessing the team's comparative advantage with respect to other research groups with an existing or potential interest in the system. This screening process then leaves a limited set of key questions for the group to consider further, and the penultimate phase of the procedure is to turn these into testable hypotheses. Laboratory and field experiments, extension trials, and field surveys are then used to test the hypotheses. The results from these modify what has gone before; new key questions emerge, and the process repeats itself.

4. The System Hierarchy

We decided that the relevant system hierarchy is as shown in Figure 1.3. The major political systems at the macrolevel are the Kingdom of Thailand, and its Northeast Region with its capital at Khon Kaen (Figure 1.4). Outside of Thailand lies the world market, and particularly the European Economic Community which has a major influence on the Northeast through its large purchases of cassava.

Within the Northeast, we decided to focus on a region we have called the Korat Triangle, which includes most of the flat and undulating paddy land in the Northeast having an average annual rainfall of less than 1,400 mm. A full definition and description of the Triangle is given in the next chapter.

Within the Triangle are parts or all of 11 changwats (provinces) and numerous amphoes (districts), but the important mesolevel systems are three distinctive agroecosystems: (1) the "mini watershed", typical of the undulating land; (2) the "non-flood" or elevated flat paddy land, and (3) the flood plain, immediately adjacent to the major rivers. Villages and farms lie in these agroecosystems.

At the microlevel in the hierarchy is the field plot which defines the boundary of each cropping system.

5. Outline of the Report

In the next four chapters we discuss these different levels in the system hierarchy. Chapters 2 and 3 deal with the Northeast Region and the Korat Triangle, respectively. Chapter 4 describes the three agro-ecosystems and the characteristic villages and farms of the region. Chapter 5 focusses on the cropping systems, and we include here a summary and review of the objectives, methodology, and results of the Cropping Systems Project's research program over the past five years.

Using the information presented and analysed in the preceding five chapters, we then review and discuss, in Chapter 6, the distinctive system properties we have uncovered and the key questions we have formulated.

A concluding chapter presents the priorities for future research.

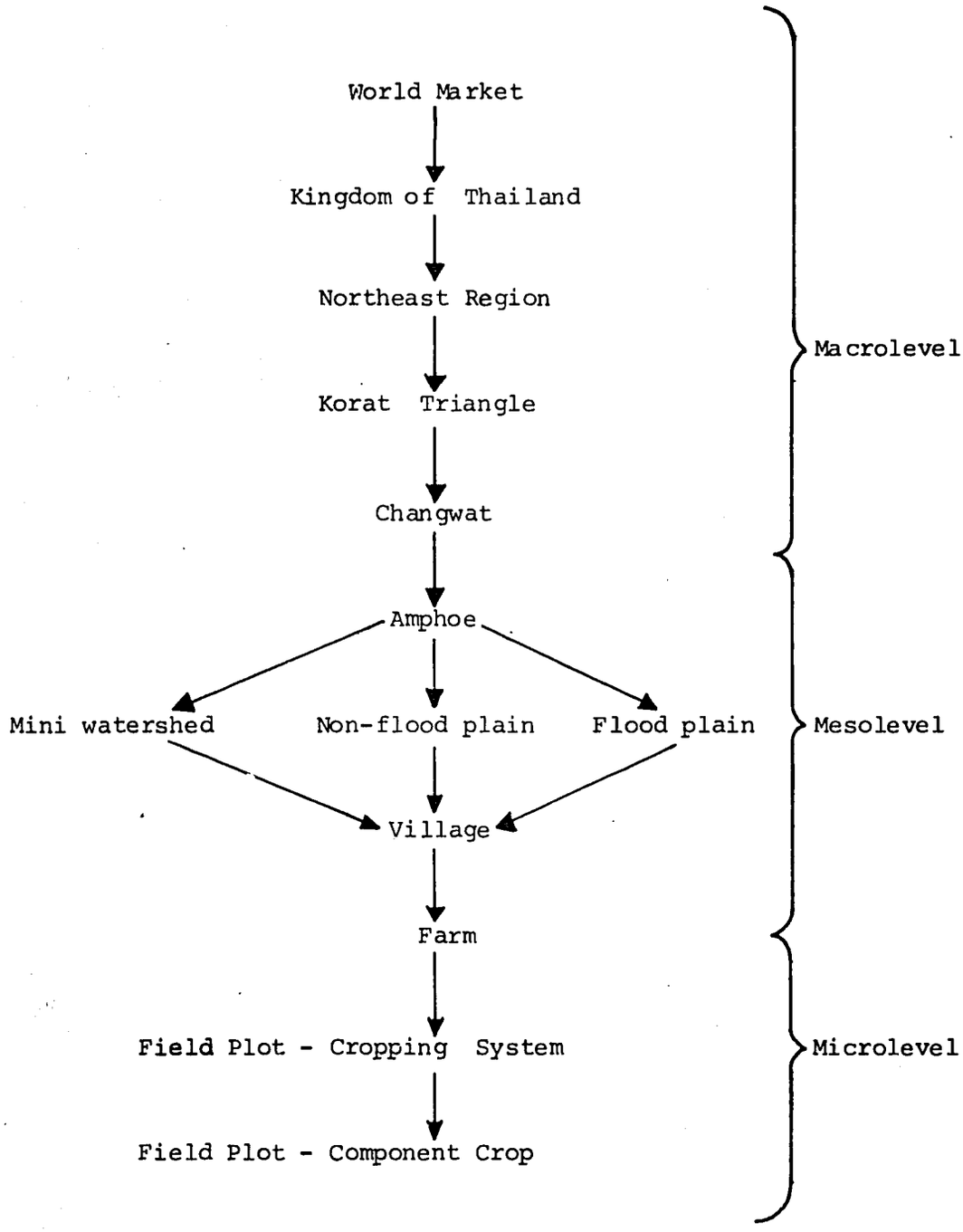


Figure 1.3. The system hierarchy.

Figure 1.4. The Northeast Region showing Changwat (provincial) boundaries.

CHAPTER TWO
THE NORTHEAST REGION

1. Structure

Topography and Geology

The Northeast Region extends over some 170,000 km^2 It is bounded by the Mekong River to the north and east, and by high hills to the west and south, which separate it from the Central Plain and from Cambodia. The land bounded in this way is a high plain or plateau (known as the Korat Plateau), which slopes in a gently undulating manner to the Southeast, and is drained by two rivers, the Chi and Mun (Figure 2.1).

Geologically, the plateau is composed of fine-grained sandstone and shale strata, which are overlain in the valley depressions by alluvium and river terrace deposite. The sandstones in the upper strata are highly pervious.

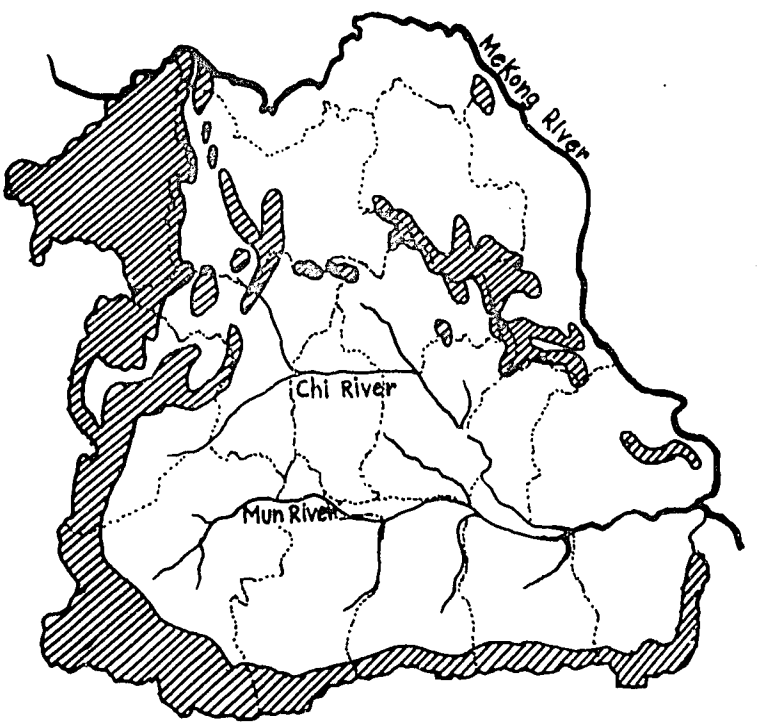


Figure 2.1. Topography of the Northeast, showing approximate 300 m contour and major rivers.

Soils

There are 35 different soil types in the Northeast, but the majority of the agricultural soils fall into one of the following five great groups:

Great Groups	Series
Ustifluvents	Tamuang, Sanphaya
Tropaquepts	Ratchaburi, Pimai
Dystropepts	Ubon
Paleaquults	Roiet, Tatum
Paleustults	Korat, Warin, Satuk, Yasothon

The recent alluvial soils lie along the rivers, the ustifluvents on the natural levees, and the tropaquepts and dystropepts on the adjacent flood plain. The former are fine to medium textured, well drained, and slightly acid; they are used primarily for garden crops and vegetables. The latter are fine textured and poorly drained, and are used for rice cultivation.

Both the paleaquults and paleustults are terrace soils, with more clay and a finer texture in the lower horizon than the surface. They also typically have a low base saturation ($<35\%$). The paleaquults have developed on the lower terraces; they are poorly drained and are saturated with water at some time during the year, and hence may be used for rice cultivation. The paleustults are on the higher terraces; they have a low water holding capacity and are dry for more than 90 days in the year. They are suitable for field crops such as cassava, kenaf, and sugar cane.

The distribution of these four soil great groups in given,very approximately, in Figure 2.2. It should be stressed that the areas indicated are by no means uniform. As the land form map (Figure 2.3) shows, much of the land is gently undulating, forming "miniwatersheds", with paleaquult soils in the depressions and paleustults on the higher land. It is only between the Chi and Mun rivers and to the south of the Mun

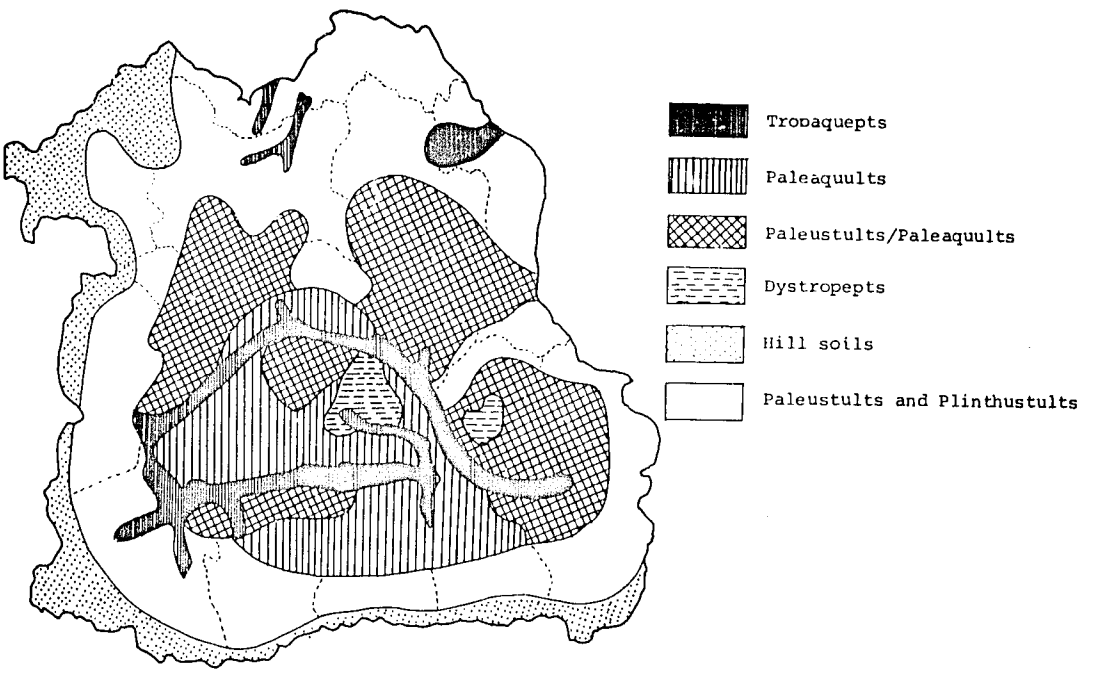


Figure 2.2. Simplified soil map of Northeast Thailand (Adapted from Dept. of Land Development, 1979).

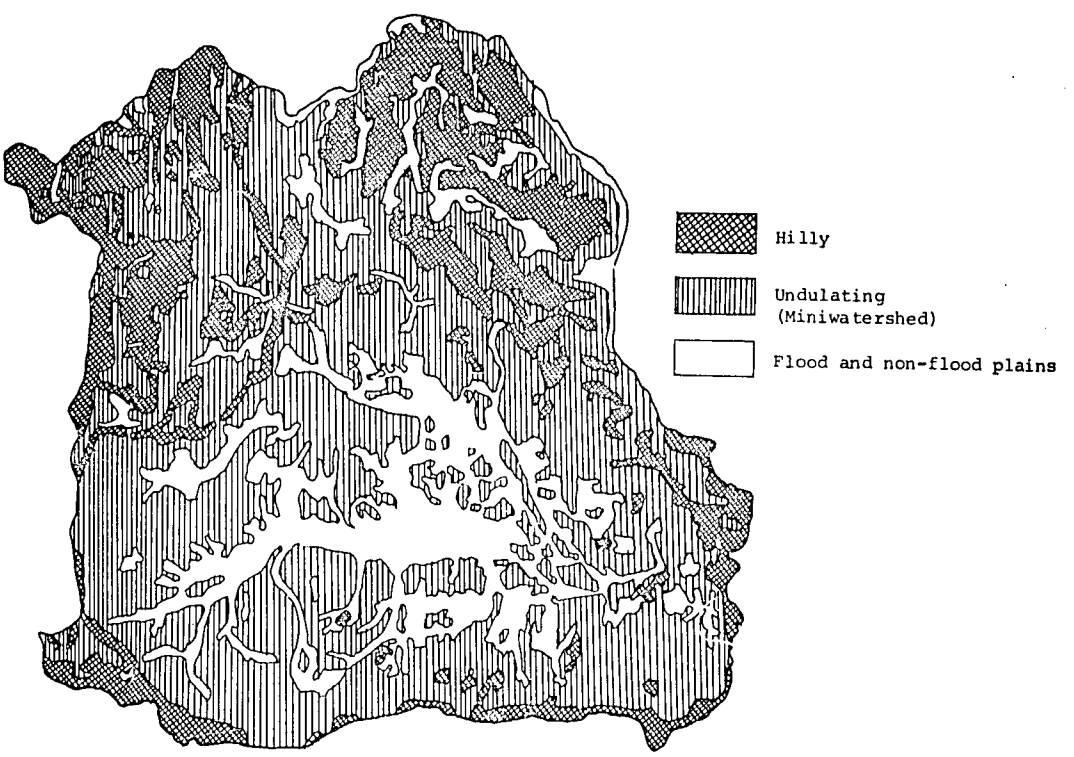


Figure 2.3. Land form map of the Northeast (adapted from Department of Land Development, 1972).

that the tropaquepts, paleaquults, and dystropepts form more or less continuous plains. The schematic cross section of Figure 2.4 summarizes the various topographic and soil patterns to be found in the region.

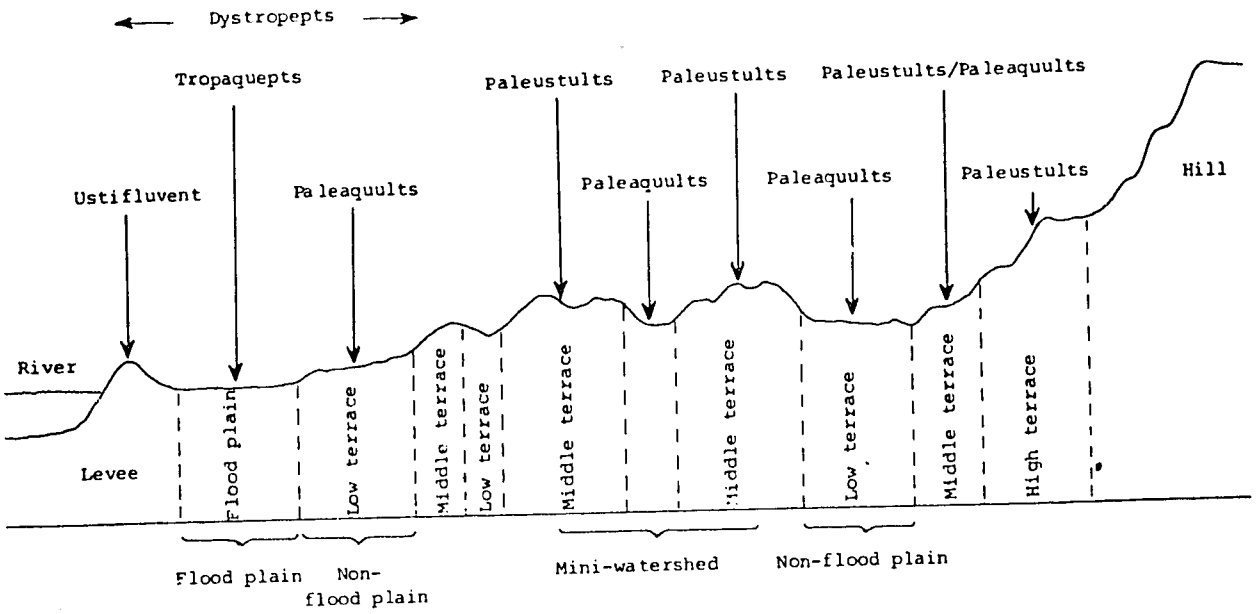


Figure 2.4. Schematic cross section of topography and soils in the Northeast.

Water Supply

Because of the topography, the provision of irrigation water is difficult in the Northeast. Three zones are distinguishable (Asian Institute of Technology, 1978).

Zone 1 comprises all the land irrigable by large reservoirs. There are currently seven such reservoirs in the Northeast (Figure 2.5) which can potentially supply 1,200,000 rai[1/]. If all proposed large scale projects are undertaken, a total of 2.2 million rai or 8-9% of the farmer families could be supplied with irrigation water.

Zone 2 covers areas irrigable by pumping from the river. About 20 pump stations exist along the Mekong, although a potential of 1 mil-

1/ 6.25 rai = 1 ha.

lion rai could be irrigated. There are also 15 stations along the Chi and Mun; but while the potential for the wet season is similar to the Mekong, only 320,000 rai could be irrigated in the dry season. A total of 10% of all farm families in the Northeast potentially could be supplied with pump water.

The remaining 80% of farm families, however, live in Zone 3, which is land inaccesible from large reservoirs and reliable rivers and where supplemental irrigation must be supplied, if it can, by small reservoirs or tanks, natural or dug ponds, weirs, and groundwater wells. So far 182 tanks have been constructed in the Northeast, but in only a few cases are they linked to irrigation systems.

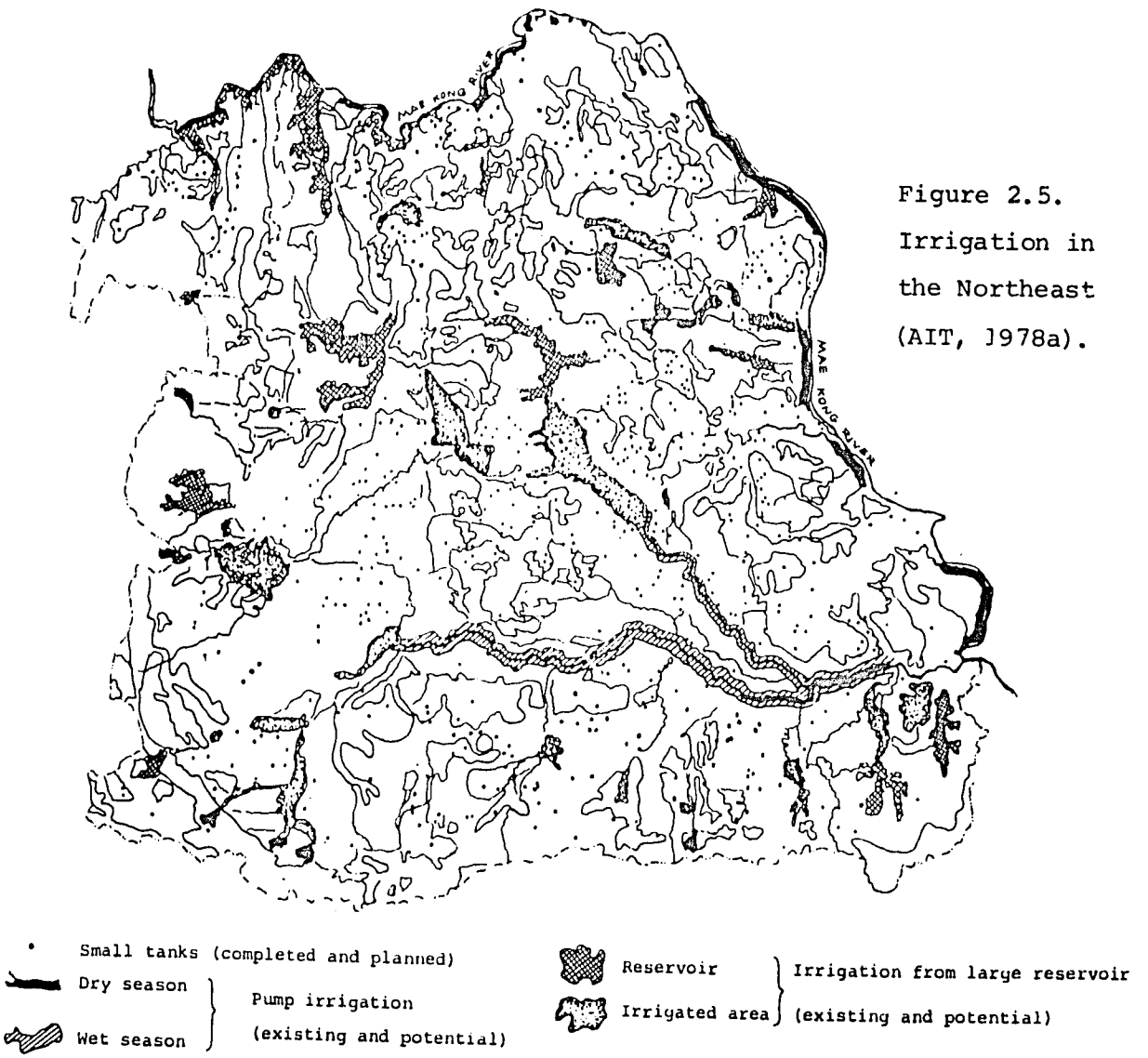


Figure 2.5. Irrigation in the Northeast (AIT, 1978a).

Climate

The rainfall patterns of the Northeast are, to a great extent, dominated by the annual visits of the southwest monsoon and of tropical cyclones, which originate over the Indian Ocean and South China sea, respectively. The rainy season, however, begins with the arrival of the Bengal cyclones from the Andaman Sea, which carry light rain during February to April. The main part of the rainy season normally occurs from May to October. During this period, the south-west monsoon and tropical cyclones bring heavy rains in the earlier and later parts of the season, respectively. The rainy season ends abruptly in November, with the dry and cold Northeast monsoon coming to the region from the mainland of the continent.

Based on the isohyets for mean annual rainfall (Fig. 2.6), boundaries can be drawn which divide the Northeast into 3 distinct regions: above 1,400 mm to the north and east, below 1,200 mm to the west, and a central band of 1,200-1,400 mm.

The mean monthly rainfall data reveal distinct wet and dry seasons; the dry months defined as those with less than 100 mm average rain.

According to IRRI (1974), a mean monthly rainfall of 200 mm represents a critical threshold for rice production in Southeast Asia, based on the crude assumption that 100 mm a month is lost through evapotranspiration and another 100 mm to percolation and seepage. Figure 2.7 shows the 200 mm isohyets for the Northeast. To the west and southwest, there is only one month (September) with more than 200 mm. A central, fairly narrow, band has 2 to 4 months, while only in the north and east are there more than 5 months. Again according to IRRI (1974), two crops a year are only possible in the latter situation.

Following Oldeman (1976), we have also taken the 100 mm isohyet as an indication of the threshold for growing field crops. On this basis, the region is divided into 2 halves, with the monthly rainfall greater than 100 mm for either 5 (top half of the region) or 6 months (bottom half of the region) (Figure 2.8).

In the Northeast, the high irregularity in rainfall during the rainy season is more important, however, in determining crop yields than the mean monthly values. As an indicator of this irregularity, we have plotted the total drought days (calculated for paddy growth) occurring from May to October (Figure 2.9). Again there are three distinct zones in the Northeast, with more than 100 days to the west and less than 80 days to the north and east. The high incidence of drought in the west is probably a rain shadow effect of the hills.

We also attempted to zone the Northeast occording to minimum temperature since this is critical for the yield of crops grown in the cool season. Figure 2.10 indicates that Loei province in the Northeast has particularly low January temperatures.

A key question we have yet to answer is: what is the most useful climatic zonation of the Northeast for agricultural research and development?

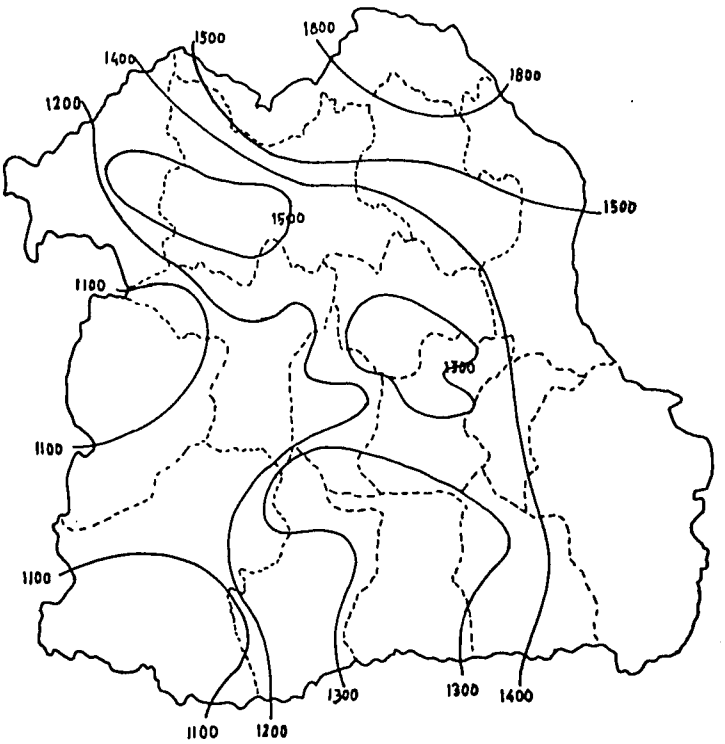


Figure 2.6. Isohytes for the annual rainfall.

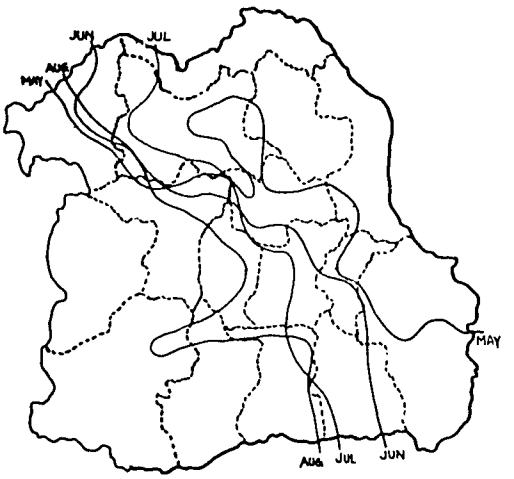


Figure 2.7. 200 mm isohyets for the monthly mean rainfall (AIT, 1978b).

Figure 2.8. 100 mm isohyets for the monthly mean rainfall (AIT, 1978b).

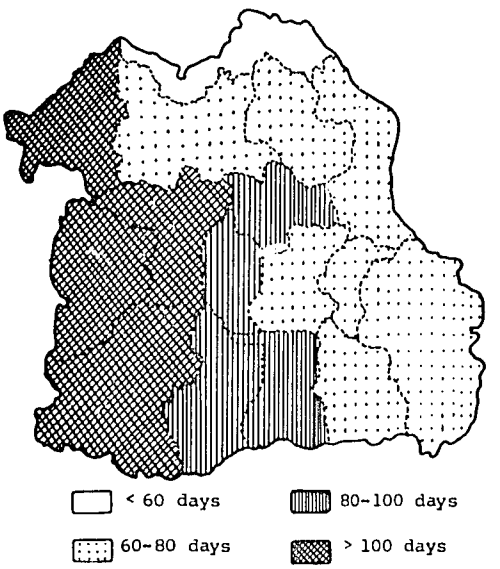


Figure 2.9. Number of total drought days (calculated for paddy) for the period of May to October (UN, 1974).

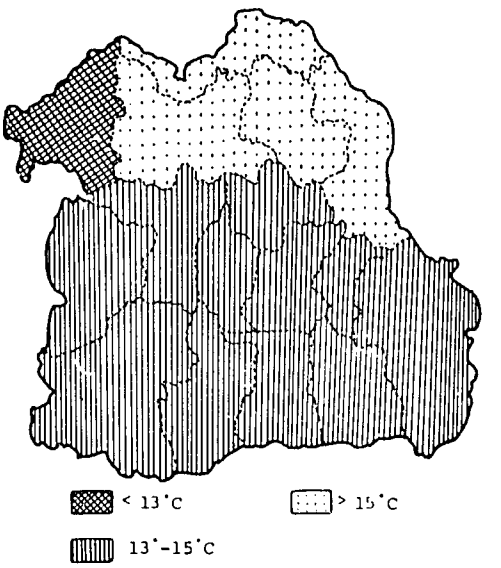


Figure 2.10. Minimum temperature for January (Meteorological Department, 1977).

Cropping Patterns - Rice

Rice, the staple food crop in the region, is grown, on average, on 80% of the total cultivated land. Of the remaining land, 90% is devoted to field crops. Fruit trees and vegetables occupy less than 3% of the total cultivated land.

The paddy land is fairly evenly distributed by province; only Ubon Ratchathani having slightly more than 10% of the total (Figure 2.11).

The highest proportion of cultivated land under paddy occurs in the eastern provinces, on the flood plains beside the Mekong, and in the central southeastern provinces of Roiet, Yasothon, Surin and Srisaket, i.e. on the plains along the lower reaches of the Chi and Mun rivers (Figure 2.12). In these latter provinces, over 90% is under paddy, even in a drought year such as 1976 or 1977.

However, the important pattern of variation in the region is in the stability of rice planting, yields, and production (Figure 2.13-2.15). The most stable acreages occur in the north and eastern provinces where the annual mean rainfall is greater than 1,400 mm (see Figure 2.6). They also tend to have stable yields per rai and stable total production, with the exception of Ubon Ratchathani.

The least stable acreages occur in the western hilly provinces where rainfall is less than 1,200 mm per year; there are more than 100 drought days in the May to October period (Figure 2.9), and the land is more generally suited to field crops. Loei and Chaiyaphum also have unstable yields and total production, but Khon Kaen and Nakhon Ratchasima show high stability particularly in the total rice production for each province. In the centre, Kalasin and Mahasarakham are moderately stable in all respects, while in the south Burirum is very stable, particularly in yields and total production. The most complex pattern, however, is produced by the three provinces of Roiet, Surin, and Srisaket. They have a high constant paddy acreage from year to year but very unstable yields and total production. This pattern is summarized in Figure 2.16.

The proportion of paddy land actually planted depends on the occurence of droughts early in the season, while the yields per rai depend on the rainfall pattern later on. Flooding, for example, may destroy the rice crop after transplanting. In the central southeastern provinces of Roiet, Surin, and Srisaket, conditions in the flood and non-flood plains are normally favorable for full planting each year, but floods later in the year may greatly reduce yields. However, in provinces such as Khon Kaen, Nakhon Ratchasima, Mahasarakham, and Burirum, although flooding may reduce yields on the plains, there appears to be a compensation effect, the higher rainfall benefiting rice growing in the miniwatersheds of the undulating land.

The most important measure of stability for the individual farmer and his family, however, is the annual fluctuation in rice production per capita. Figure 2.17 and 2.18 show the provincial figures for 1977 (a drought year) and 1978 (a good crop year). If we take 300 kgs paddy per head as the basic requirement (NESDB 1973 cites a figure of 285 kg paddy per head), it appears that in a bad year only 5 provinces (Nong Kai, Sakhon Nakhon, Undon Thani, Chaiyaphum, and Burirum) meet their subsistance requirement. In a good year, however, all of the provinces, except for Loei, are in surplus.

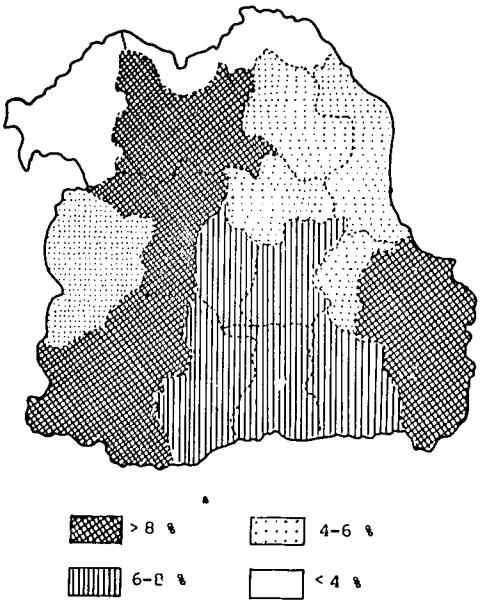


Figure 2.11. Proportion of the total Northeast paddy acreages which occurs in each province.

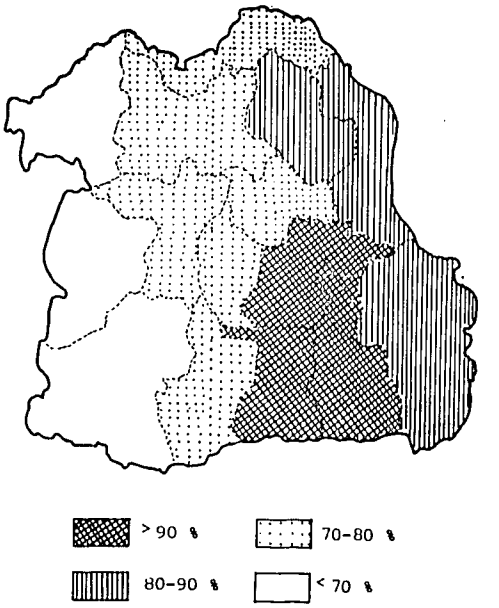


Figure 2.12. Percentage of cultivated land in each province planted to paddy (1976)

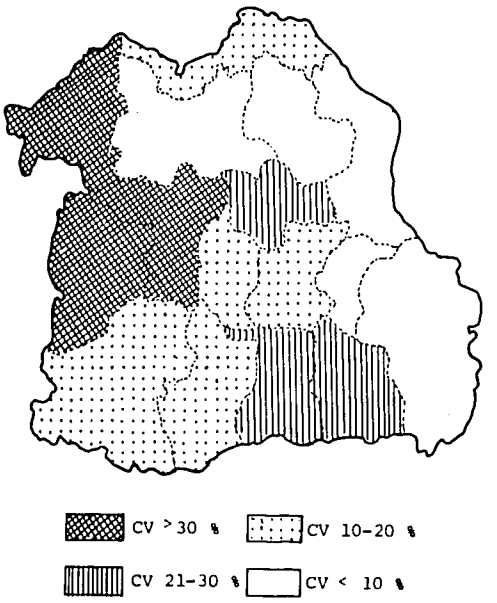


Figure 2.13. Coefficient of variation of area planted to paddy (1973-77).

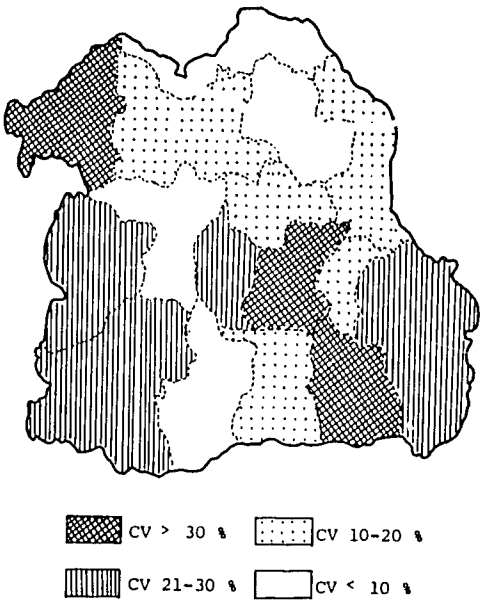


Figure 2.14. Coefficient of variation of paddy yield/rai (1973-77).

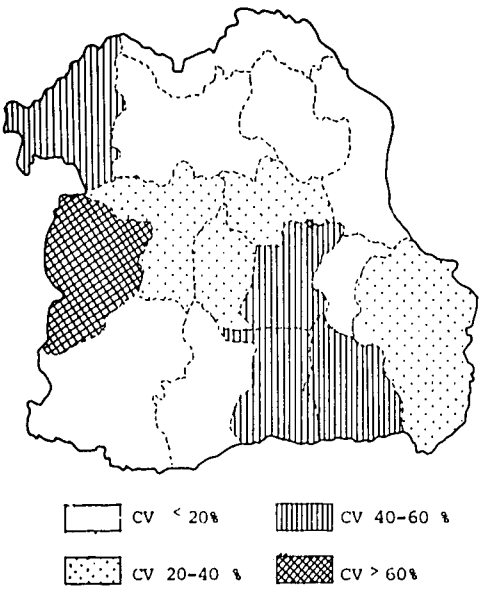
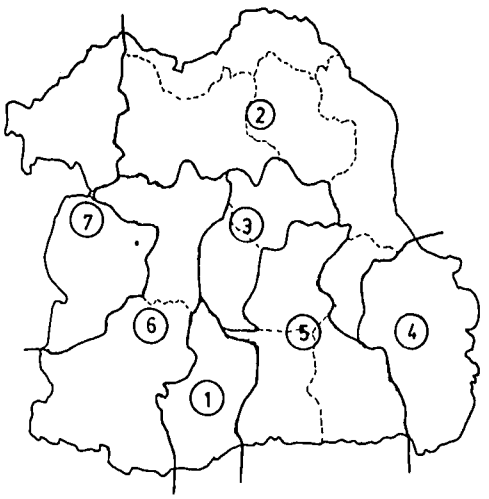


Figure 2.15. Coefficient of variation of total rice production per year (1973-77).



① Highly stable ② Stable ③ Moderately stable
④ Stable acreages, moderately stable yields and production
⑤ Moderately stable acreages, unstable yields and production
⑥ Unstable acreages, stable yields and production
⑦ Unstable

Figure 2.16. Zones of rice production stability.

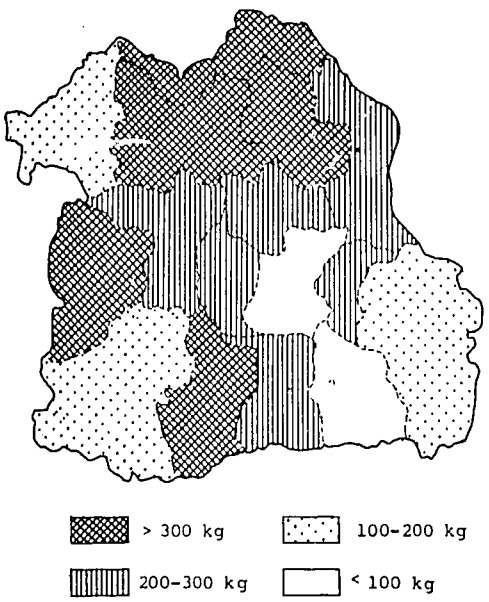


Figure 2.17. Paddy production/capita (1977).

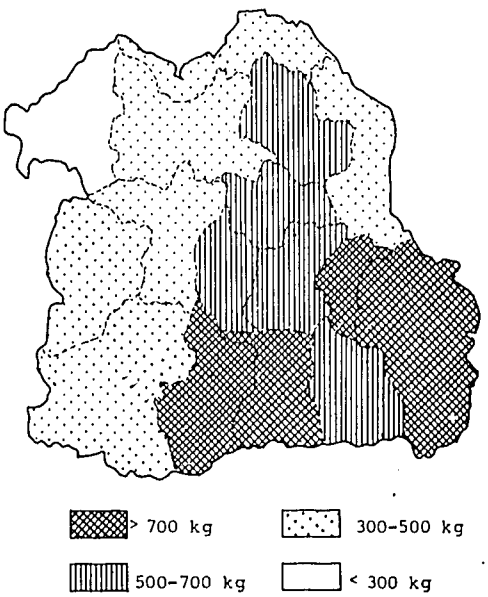


Figure 2.18. Paddy production/capita (1978).

Cropping Patterns - Field Crops

Most of the land suitable for field crops lies in the western provinces (Figure 2.19). These receive an annual rainfall of less than 1,200 mm, have the greatest number of drought days in the rainy season (> 100), and have six months with a rainfall greater than 100 mm. Most of the land is deeply undulating or mountainous and thus more appropriate for field and upland crops than for paddy.

Ten to twenty-five per cent of the cultivated land in a central band of the Northeast is also suitable for field crops. This lies mostly in the shallow undulating land, where paddy is grown in the depressions and field crops on the higher land in between. To the east, the rainfall is higher (1,400 mm), and more than 5 months have rainfall exceeding 200 mm. As a consequence, there are only small acreages of field crops.

Cassava, kenaf, and corn are the most important field crops, comprising 95% of the upland acreage. In 1977, cassava was the most favoured, occupying 49% of the acreage, with kenaf and corn planted to 21% and 25% respectively.

Cassava and kenaf are planted throughout the region, with some concentration in certain provinces (Figure 2.20 and 2.21). Corn, however, is highly localised, with more than 90% of the acreage in the three provinces of Nakhon Ratchasima, Loei, and Sisaket (Figure 2.22). Corn requires more fertile soil and is less tolerant to drought, and this restricts its distribution to the fertile foothills. Cassava and kenaf, however, are better adapted to the infertile sandy soil of the undulating topography of the region.

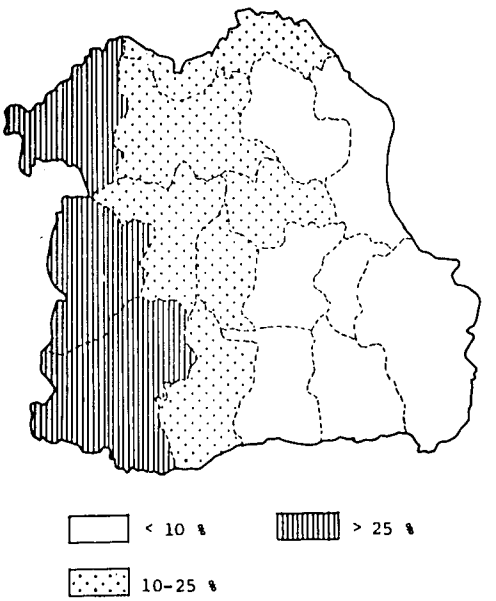


Figure 2.19. Percentage of cultivated land in each province suitable for field crops.

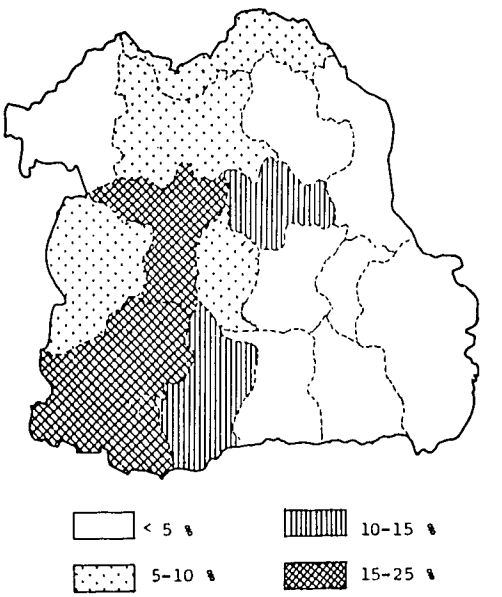


Figure 2.20. Proportion of the total Northeast cassava acreage which occurs in each province (1978)

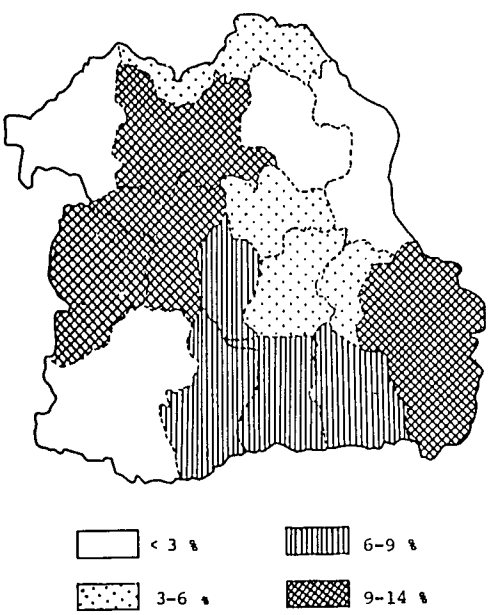


Figure 2.21. Proportion of the total Northeast kenaf acreage which occurs in each province (1978).

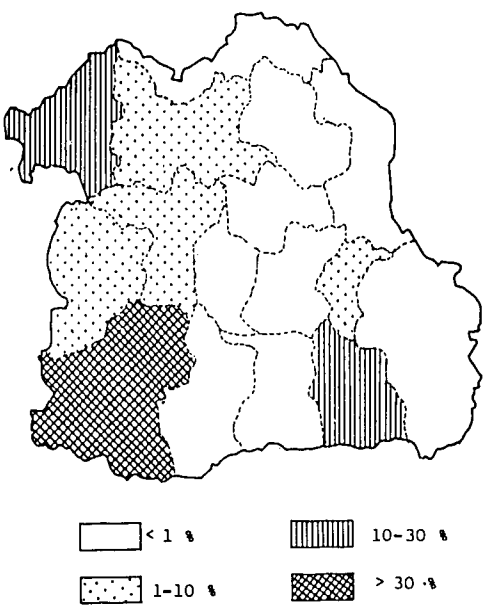


Figure 2.22. Proportion of the total Northeast corn acreage which occurs in each province (1978).

Livestock

The number of livestock per capita is relatively low and evenly distributed throughout the provinces (Figure 2.23-2.27), with the exception of Khon Kaen, which has a particularly high density of buffaloes (0.59 per capita), and Sakon Nakhon, which has a particularly high density of chickens (3.33 per capita).

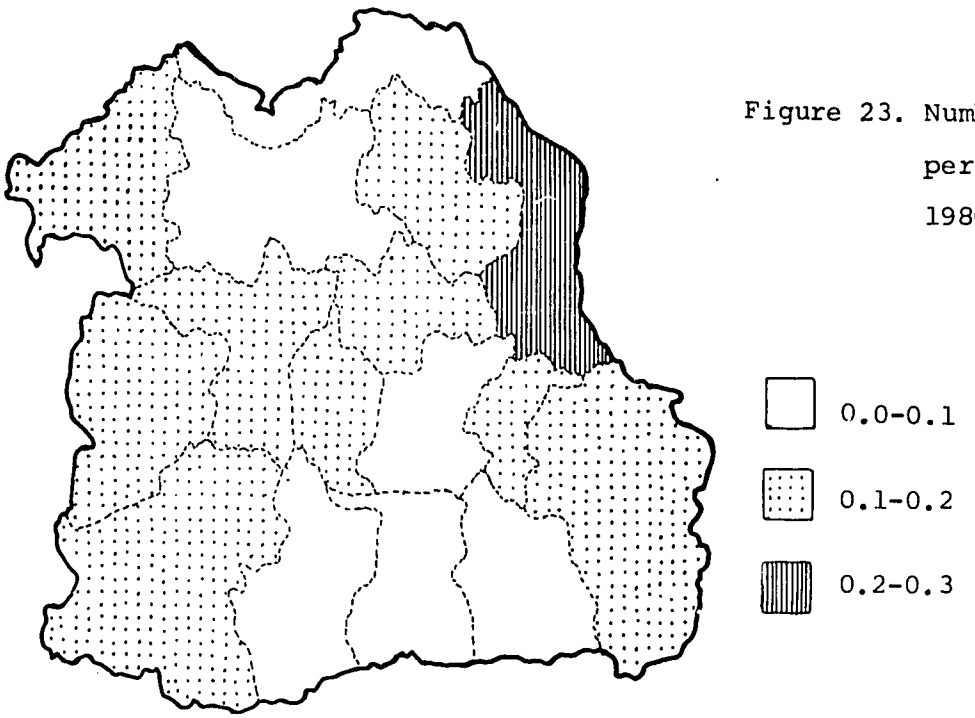


Figure 23. Number of cattle per capita (MOAC, 1980)

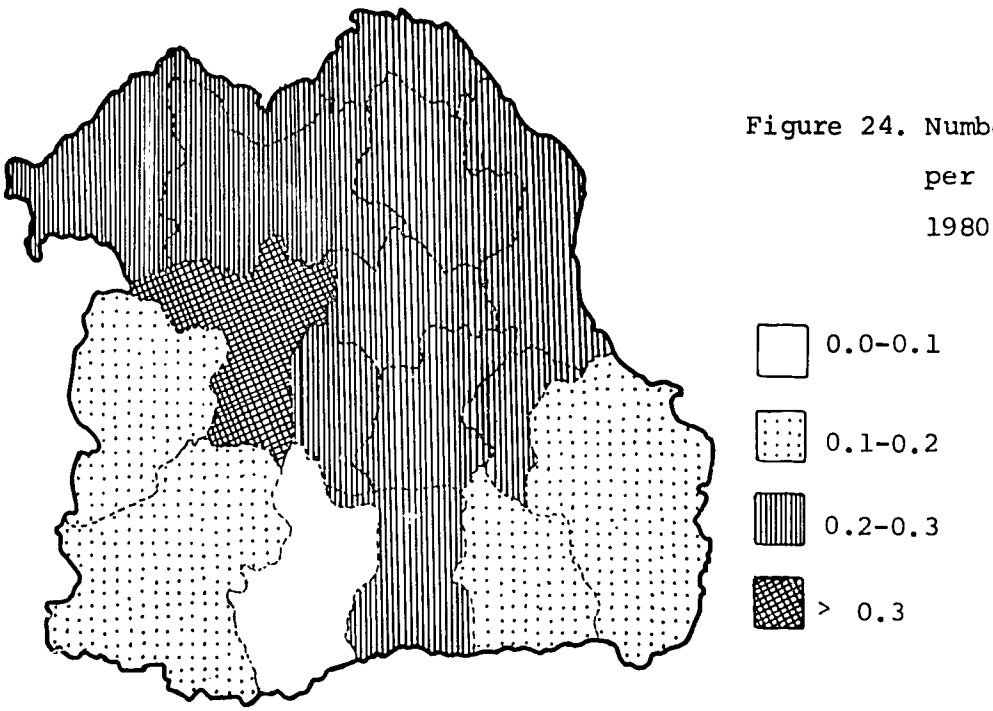


Figure 24. Number of buffaloes per capita (MOAC, 1980)

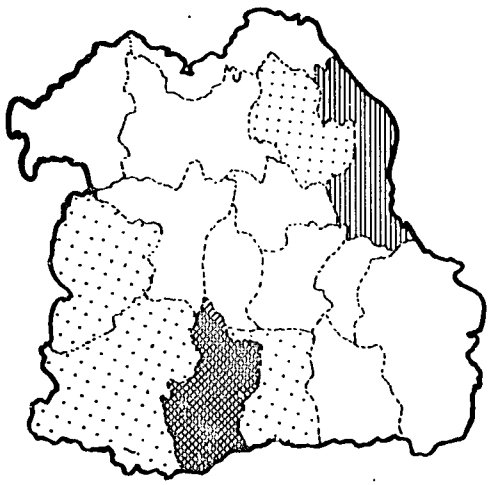


Figure 2.25.

Figure 2.25. Number of swine per capita (MOAC, 1980).

0-0.04

0.04-0.08

0.08-0.12

> 0.12

Figure 2.26. Number of ducks per capita (MOAC, 1980).

0-0.1

0.1-0.2

0.2-0.3

> 0.3

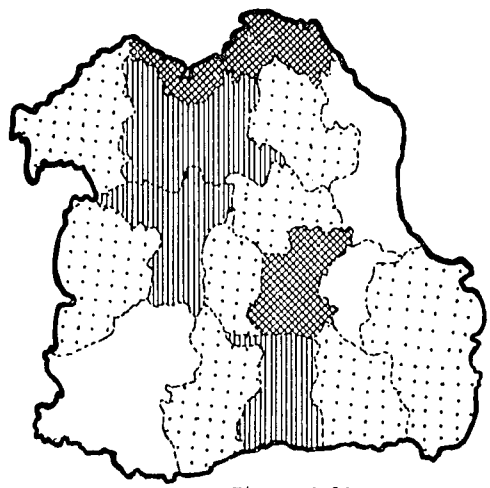


Figure 2.26.

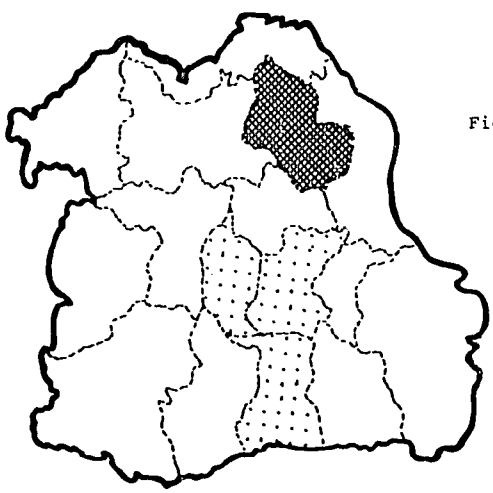


Figure 2.27.

Figure 2.27. Number of chickens per capita (MOAC, 1980).

0-1

1-2

2-3

> 3

Population

The Northeast contains 14.8 million people or about a third of the total population of Thailand (Ministry of Interior, 1976). The majority of the population belong to the Phaw-Thai (Thai-isan) who migrated across the Northeast from Laos and the left bank of Mekong over the past several hundred years (Scidenfuden, 1976; Schrock et al., 1968; Udom Bausri, 1980). There are seven distinctive sub-groups, the largest being the Laos-Wieng who live in the centre and northeast of the region (Figure 2.28). The second largest group are the Thai Khorat, numbering 3 million in the southwest. The region also contains nearly 1/2 million Khmer in the three southern provinces, and 85,000-100,000 Vietnamese who are recent migrants and have settled in the towns or large villages. Finally, there is a large long-standing population of Chinese, again mostly in the towns and large villages.

The most noticeable effect on agriculture of this pattern of ethnic groups is in the type of rice grown (Figure 2.29). Over most of the region, the various cultures prefer glutinous or sticky rice, but in the southern and southwestern provinces, the Thai Khorat, the Khmer Soai, and the Laos Soai prefer non-glutinous rice.

The average population density is 88 per km^2 (86 per km^2 for the whole kingdom), but the provinces of Mahasarakham, Roiet, Surin, and Srisaket, which contain the plains along the lower reaches of the Chi and Mun rivers, all have densities greater than 100 per km^2 (Figure 2.30)

Average family size is 6.58 persons per family, and the population growth rate is 2.37%. However, the variation between provinces (Figures 2.31 and 2.32) reveals no easily explicable pattern, except that the very high growth rates are probably due to in-migration (from Loas into Nongkai; from the Northeast generally into Nakhon Ratchasima).

There also appears to be very little correlation between any of these demographic characteristics and the size of the average farm holding (Figure 2.33).

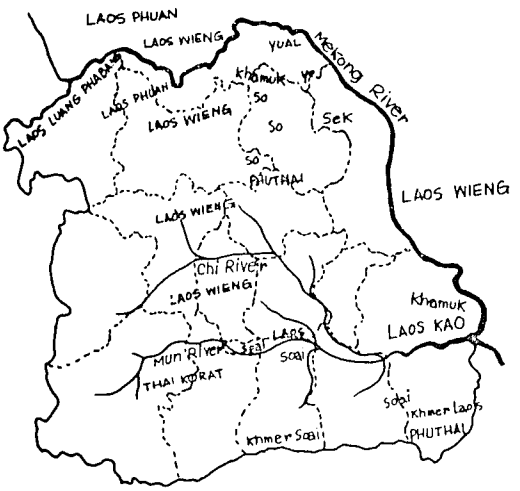


Figure 2.28. Distribution of ethnic group in the Northeast.
Thai groups: Capital letters
Other groups: Small letters

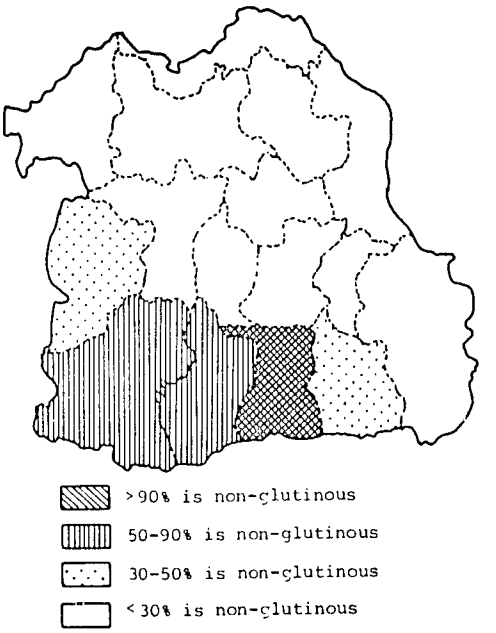


Figure 2.29. Relative production of glutinous and non-glutinous rice.

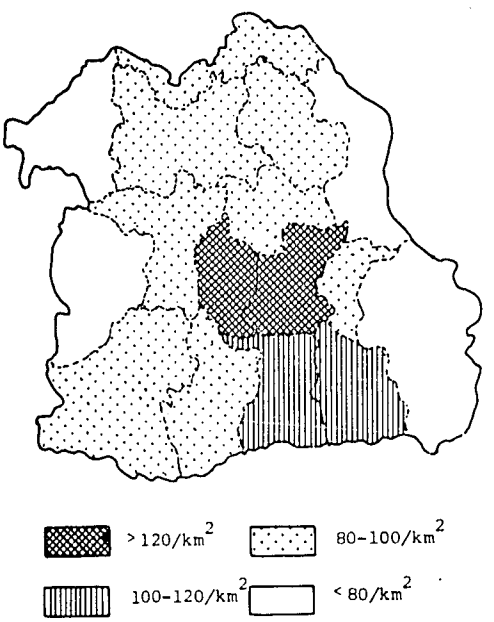


Figure 2.30. Population density by province (MOAC, 1980).

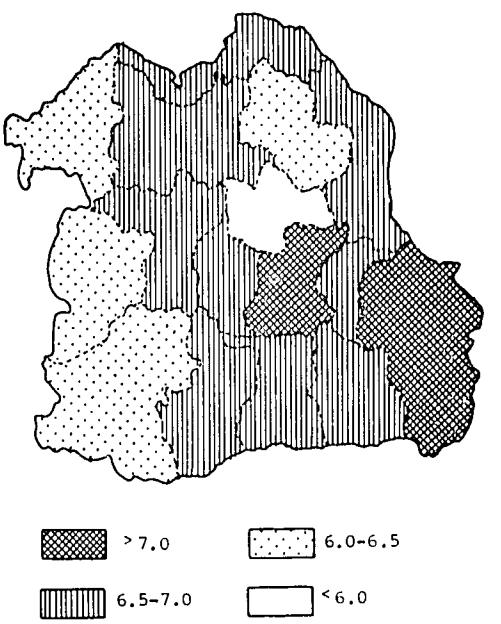


Figure 2.31. Average family size (MOAC, 1980).

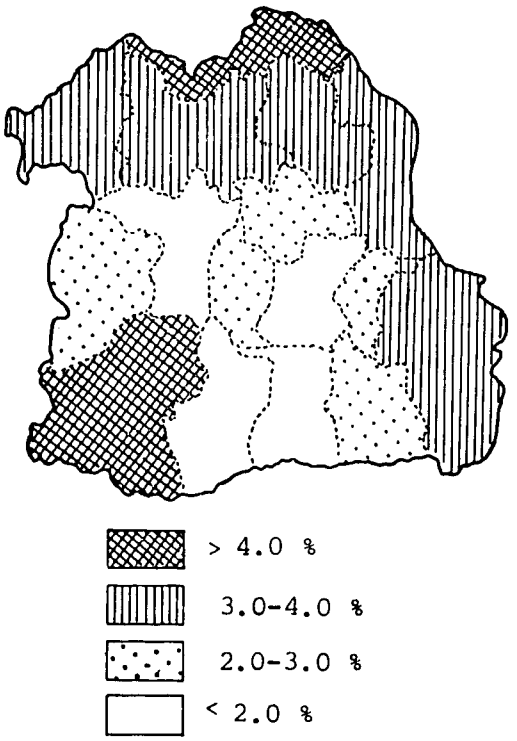


Figure 2.32. Population growth rate, 1979 (MOAC, 1980)

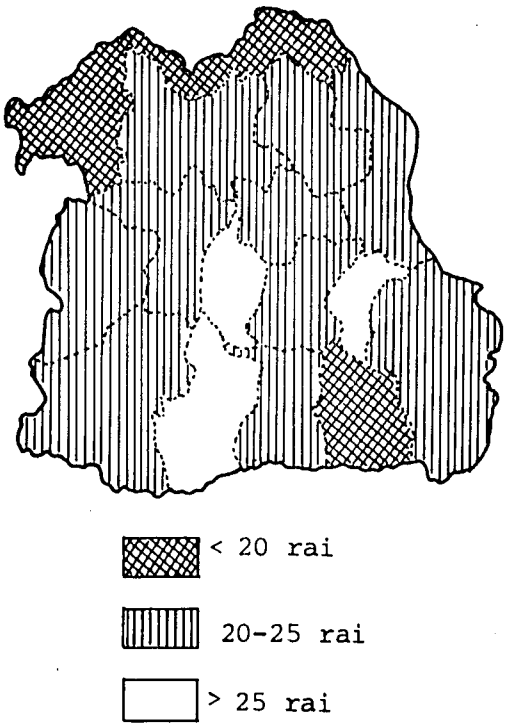


Figure 2.33. Average size of farm holding.

Infrastructure

The region has an extensive and high quality road network. The Friendship Highway links the region with Bangkok and runs through Nakhon Ratchasima to Khon Kaen and north. There are 1,456 km of surfaced highways linking the provincial capitals, and a further 4,528 km linking the districts (Figure 2.34). Gravelled or dirt roads serve the villages. The region is also well served by air and rail, but there is very little river transport either on the Mekong or the Chi or Mun rivers.

Although Khon Kaen is the regional centre, it is not the principal market. Each province has one or more independent markets which deal direct with Bangkok. Even in Khon Kaen Province, farmers may receive higher prices, for example, in Chumpae or Ban Pai and prefer to sell there. In general, farmers sell direct in the market rather than through local middle men. Processing factories for cassava and kenaf are heavily concentrated in Khon Kaen and Nakhon Ratchasima (Figure 2.35-2.37).

Electricity is generated locally at the Ubonrathana, Sirinthon, Juraporn, and Nam Phung Dams, and is also purchased from Loas. About 60% of the villages can receive radio broadcasts from Bangkok and Khon Kaen. In addition to the distribution of Bangkok newspapers, some provinces have a locally based weekly newspaper.

About 80% of the population have completed primary school (Prathom 4). Nursery schools (4-6 years old) are currently being promoted. There are 1,053 secondary schools, mostly in provincial or district centres. The institutes of higher education are shown in Figure 2.38; they include 8 agricultural colleges.

Health in the region is served by two major hospitals at Nakhon Ratchasima and Khon Kaen. Each province also has a hospital, and at subdistrict level there are public health stations. Most villages, however, are only served by volunteer medical-care villagers and by Medical Service Mobile Units.

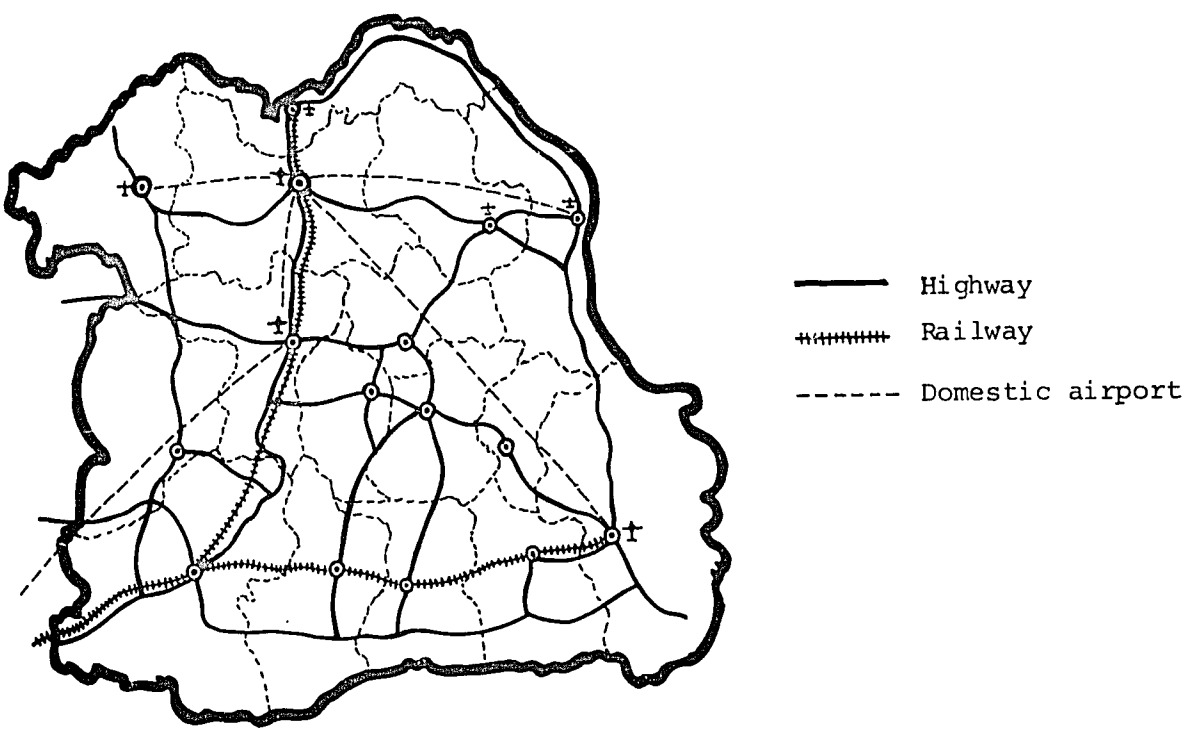


Figure 2.34. Transportation and main market towns in the Northeast.

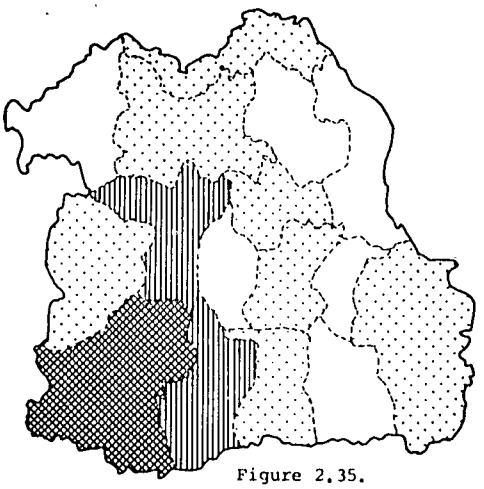


Figure 2.35.

Figure 2.35. Capacity for cassava production (chips plus pellets) (Rujirakul, 1982).

0-100 tons/day
1,000-5,000
100-1,000
> 5,000 tons/day

Figure 2.36. Capacity for kenaf sack production (Rujirakul, 1982).

0
>100
1-100 tons sacks/day

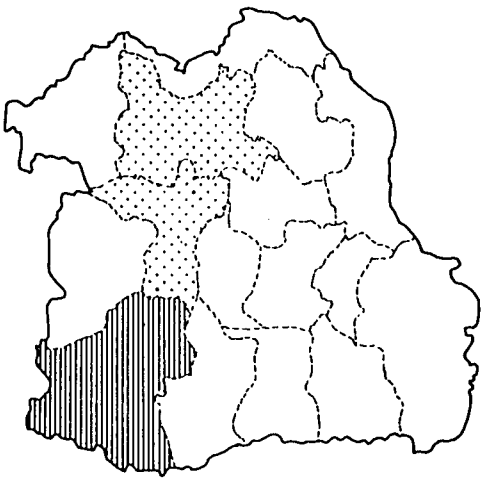


Figure 2.36.

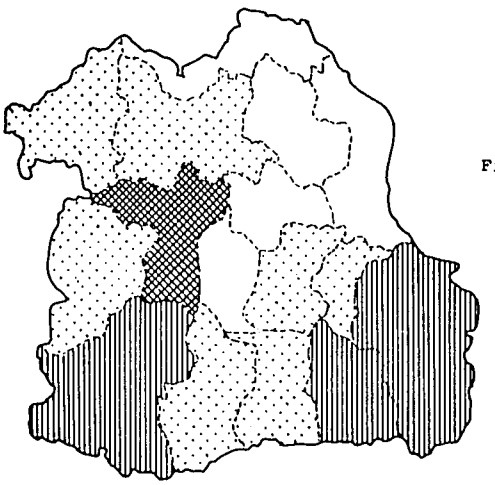
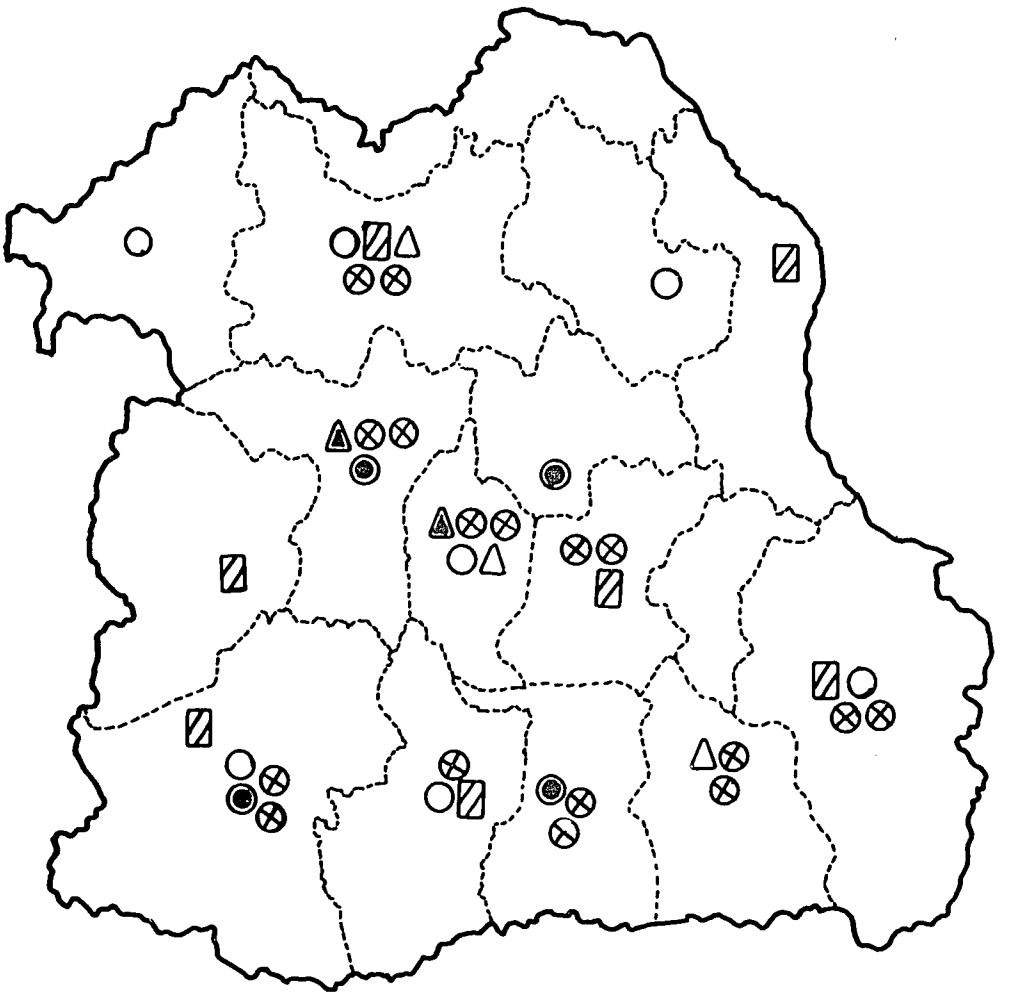


Figure 2.37.

Figure 2.37. Capacity for kenaf bale production (Rujirakul, 1982).

0
500-1,000 bales/day
1-500
> 1,000 bales/day



Symbol	Institute	Degree or certificate	No.
▲	University	Bachelor and higher	2
○	Teacher training college	B.S. and higher teaching cert.	7
△	Physical education college	Higher vocational cert.	3
●	College of technology and vocational education	Secondary ed. cert. and high vocational cert.	4
⊗	Vocational college	High vocational cert.	17
▨	Agricultural college	High vocational cert.	8

Figure 2.38. Higher education institutes in the Northeast.

Income

The average income (gross provincial product) per capita was 3,962 baht in 1978. The variation within the region is shown in Figure 2.39.

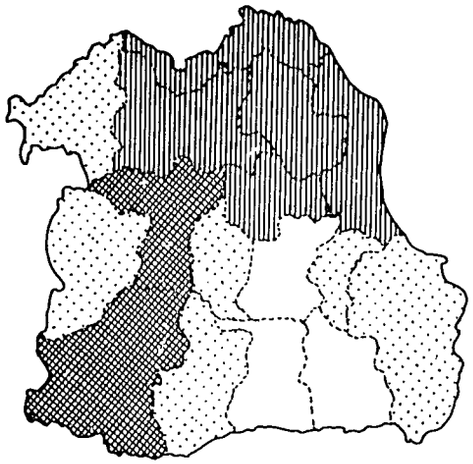
Agriculture accounts for over 40% of the regional gross product (Table 2.1),but there appears to be little correlation between the provincial product/capita and agricultural production (see Figure 2.18 and 2.40-2.42).

The higher products per capita for Nakhon Ratchasima, Khon Kaen, and Udon Thani are probably a function of their leading roles in processing, trade, and transportation.

Table 2.1. Gross Product of Northeast by Sector, 1979.

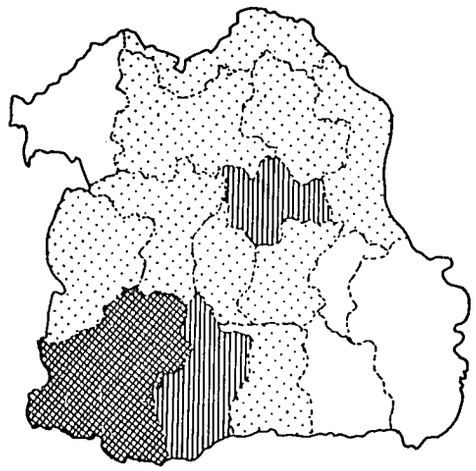
Agriculture	44%	(Crops 36%, Livestock 5.5%,
Trade	19%	Fisheries 4%)
Manufacture	10%	
Service	9%	
Construction	6%	
Public administration	3%	

Source: National Economic and Social Development Board.



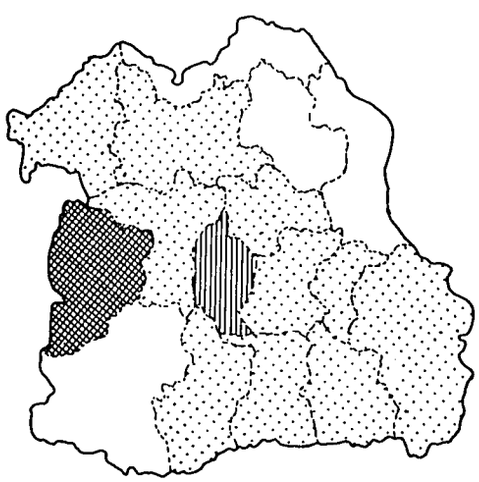
> 5,000 baht
3,000-4,000
4,000-5,000
< 3,000 baht

Figure 2.39. Percapita gross provincial product for 1978 (at current price).



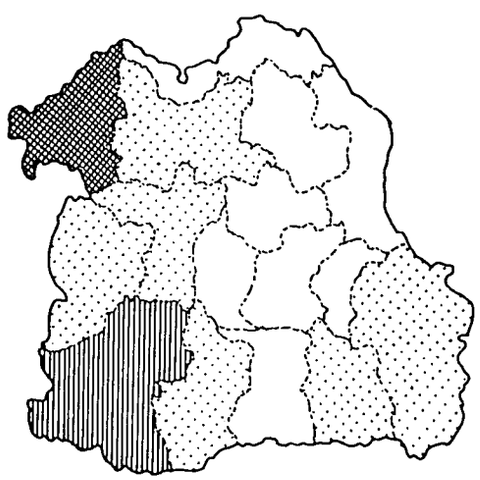
> 1,200 kg
100-600 kg
600-1,200 kg
< 100 kg

Figure 2.40. Cassava production per capita for 1978 (0.39 baht/kg).



> 50 kg
10-30 kg
30-50 kg
< 10 kg

Figure 2.41. Kenaf production per capita for 1978 (3.32 baht/kg).



> 500 kg
10-100 kg
100-500 kg
< 10 kg

Figure 2.42. Corn production per capita for 1978 (1.66 baht/kg).

2. Dynamics

The most significant dynamic changes at the macrolevel of the Northeast are the long term trends and the year to year fluctuations.

Crop Production and Prices

Rice acreage and production has grown steadily, if erratically, in recent years (Figures 2.43, 2.44). Maize and cassava production both increased steadily in the 1960's. Maize has subsequently fluctuated in importance, but cassava production trebled between 1973 and 1980, largely in response to demand on the world and, in particular, European market. Kenaf was the most important field crop in the 1960's, but production slumped in the early 1970's due to declining world prices, with a partial recovery in 1979. Figure 2.45 suggests that maize, cassava, and kenaf substitute, to some extent, for one another from year to year.

The price fluctuations over the past two decades are shown in Figure 2.46. The Northeast clearly suffers from its exclusive dependence on three major cash field crops which are subject to fluctuating world prices. The problem could become acute if the EEC cuts off its cassava imports from Thailand. A key question is: what effective measures need to betaken if the cassava market deteriorates?

A general solution is clearly to provide a greater range of substitutable field crops. In recent years, there has been a fairly rapid growth in production of sugar cane, cotton, soybean, peanut, and mungbean, although in the case of the latter two crops the planted area has fluctuated wildly (Figure 2.47).

At present, there are 3 sugar refineries in the Northeast, but at least one (in Khon Kaen) is operating at only 50% capacity; thus, there is considerable potential for expanding production of this crop. There are also plans for a pulp mill at Khon Kaen which will require whole kenaf stalks. Since this will obviate the need for kenaf retting, it may provide an increased incentive for kenaf production.

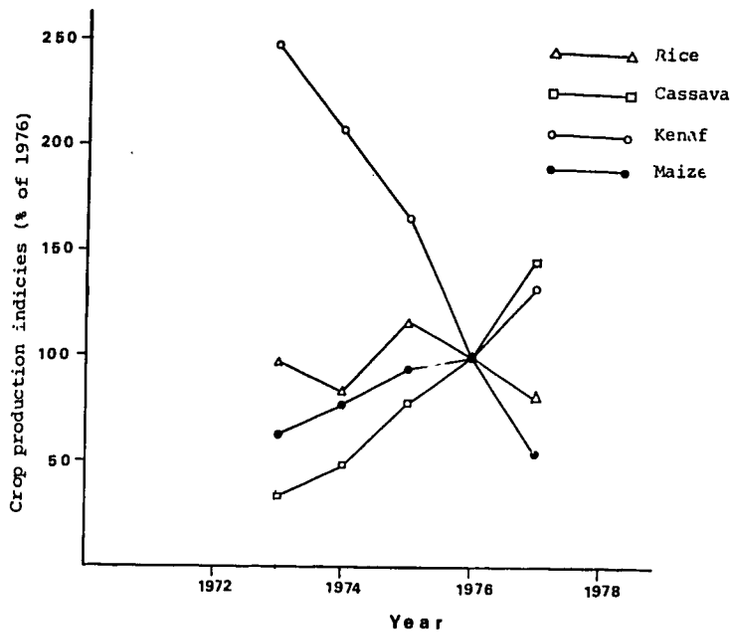


Figure 2.43. Crop production indicies for rice, cassava, kenaf, and maize in the Northeast (1976 = 100%).

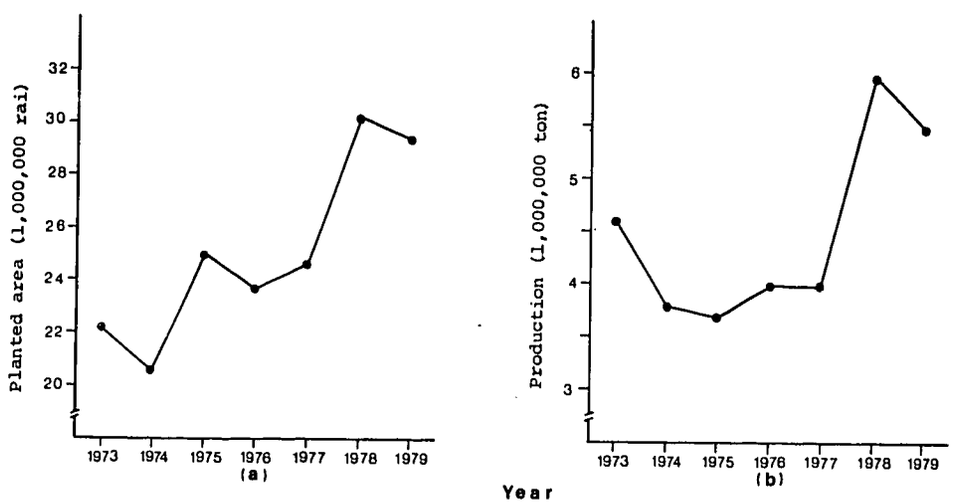


Figure 2.44. Rice production in the Northeast
a) Planted area, b) Annual production.

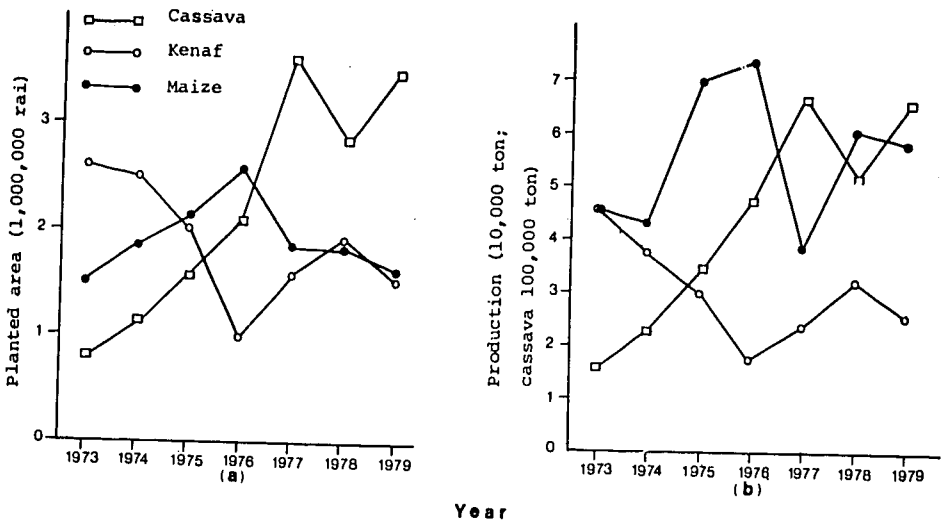


Figure 2.45. Production of cassava, kenaf, and maize in the Northeast
a) Planted area, b) Annual production.

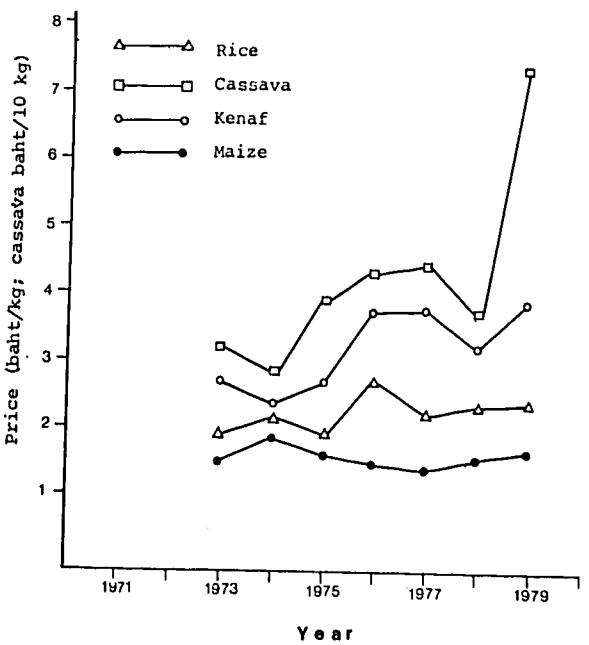


Figure 2.46. Market prices for major crops in the Northeast (Survey report, Northeast Regional Office of Agriculture, Tha Phra, Khon Kaen).

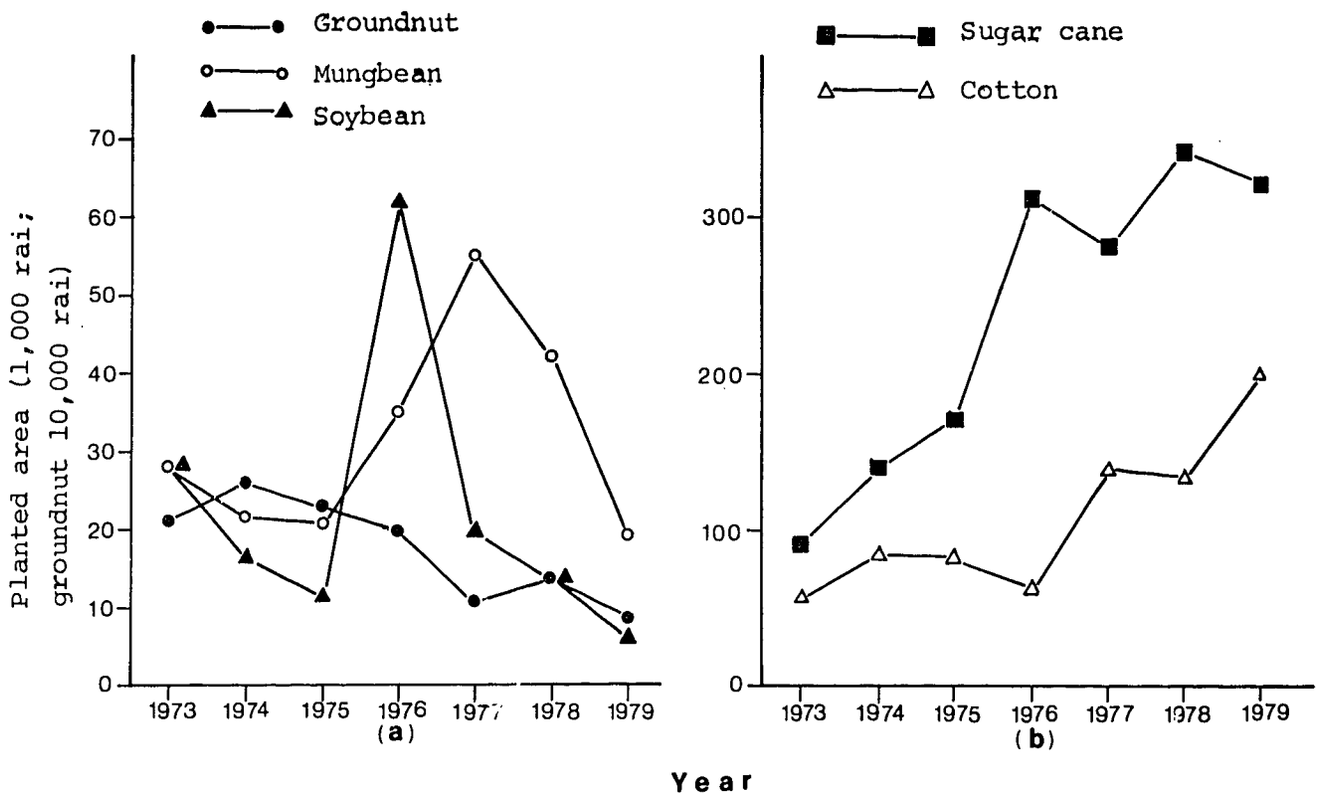


Figure 2.47. Planted areas of minor crops in the Northeast
a) Legumes: groundnut, mungbean, soybean,
b) Other field crops: sugar cane, cotton.

Population

From the end of the Second World War until 1970, the population increased at a fairly constant annual growth rate of 2.9%. But in the 1970's, there has been a slow decline in birth rates (Figure 2.48) which coincided with the introduction of family planning in 1971. The principal method used has been the pill.

Changes in population growth, however, are complicated by the pattern of migration, both into the region from Laos and Cambodia and out of the region to the Central Plain. Overall, there has been a significant decrease in growth rate in the region, down to 2.37% by 1978.

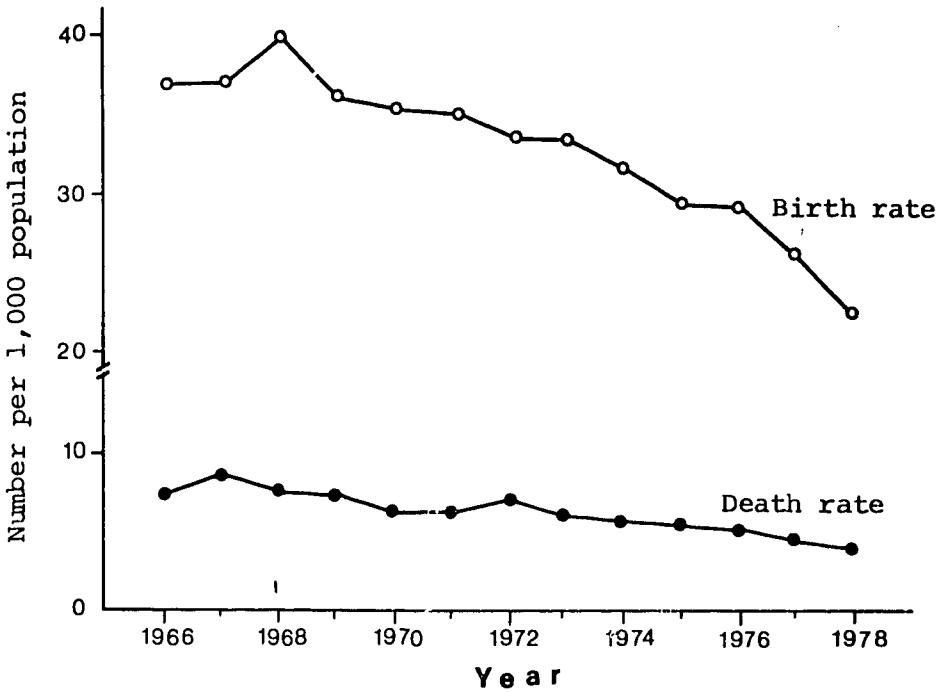


Figure 2.48. Birth and death rates in the Northeast.

Economic Indicators

We have already described the overall trends in production of the major crops (Figure 2.43). Over the past two decades, there have been real increases in the area of cultivated land (Figure 2.49), which indicate a slow progress in agricultural development in the region.

Figure 2.50 gives the overall growth trend in Gross Regional Product since 1970. This overall trend, however, is characterised by considerable fluctuation in the rate of growth (Figure 2.51), which in turn, we suspect, indicates very high instability in the per capita income of the average farmer in the region.

The years of low growth rate tend to be the drought years when the GRP for the agricultural sector has fallen.

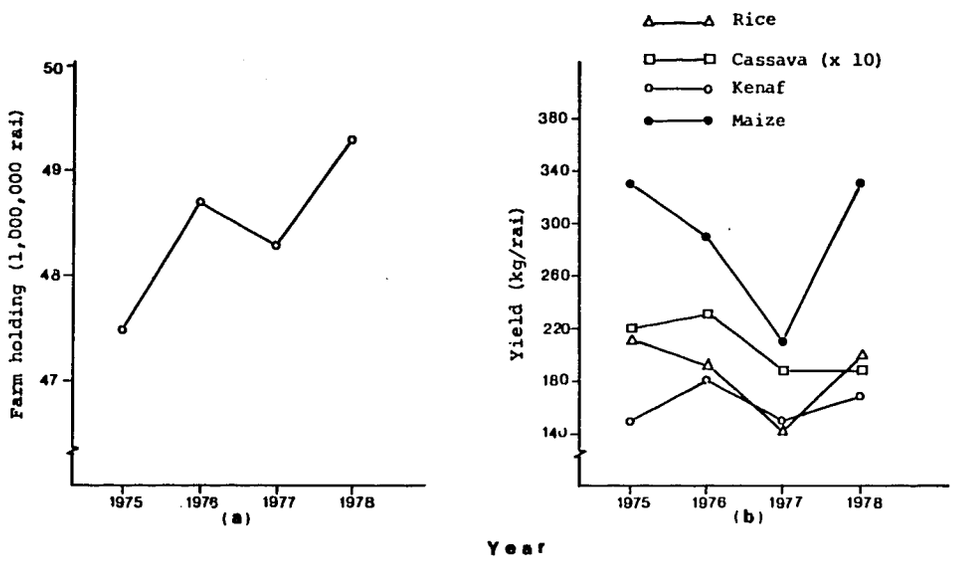


Figure 2.49. Agricultural productivity in the Northeast
a) Farm holdings, b) Yields per rai of major crops.

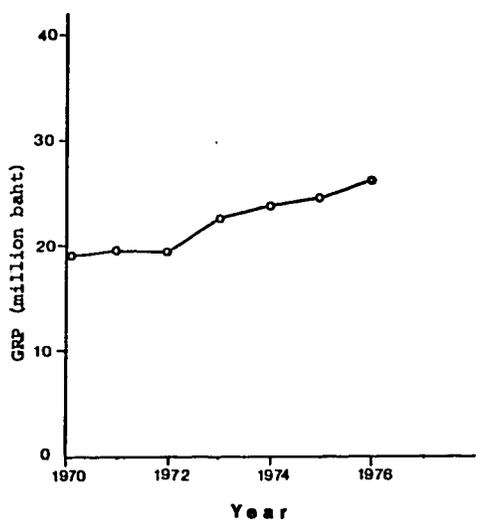


Figure 2.50. Gross regional product at constant price (1962).

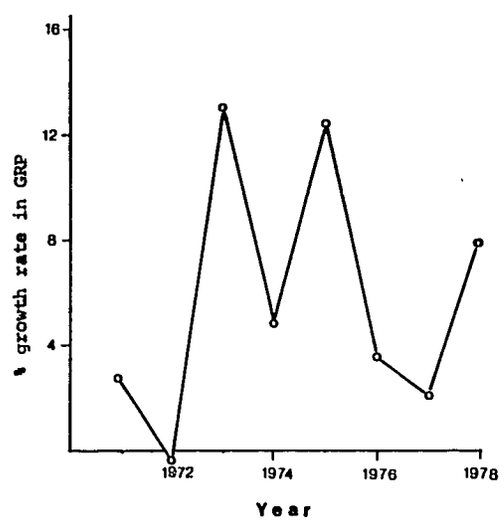


Figure 2.51. Annual growth rate in gross regional product for the Northeast.

In several of these years, the total rice production falls below the subsistance requirement for the region, calculated at 300 kg paddy per head (see Figure 2.52). In general, surplus years appear to be necessary to tide over subsequent shortages. However, the surpluses are mostly of glutinous rice, and the suggestion has been made that if a higher proportion of the paddy land was under non-glutinous rice the surplus would be more profitable. This would be risky at present but it is conceivable that the value of the surpluses could become considerable in the future. A key question is: would substitution of non-glutinous rice for part of the glutinous acreage increase farm income and its stability in the region and, if so, what measures are required by the government to encourage this?

Overall, the largest percentage increases in growth in the Northeast economy have come in the non-agricultural sectors (Table 2.2), and the largest growth rate within agriculture has come from livestock production. A key question is: what is the interaction between livestock production and crop production?

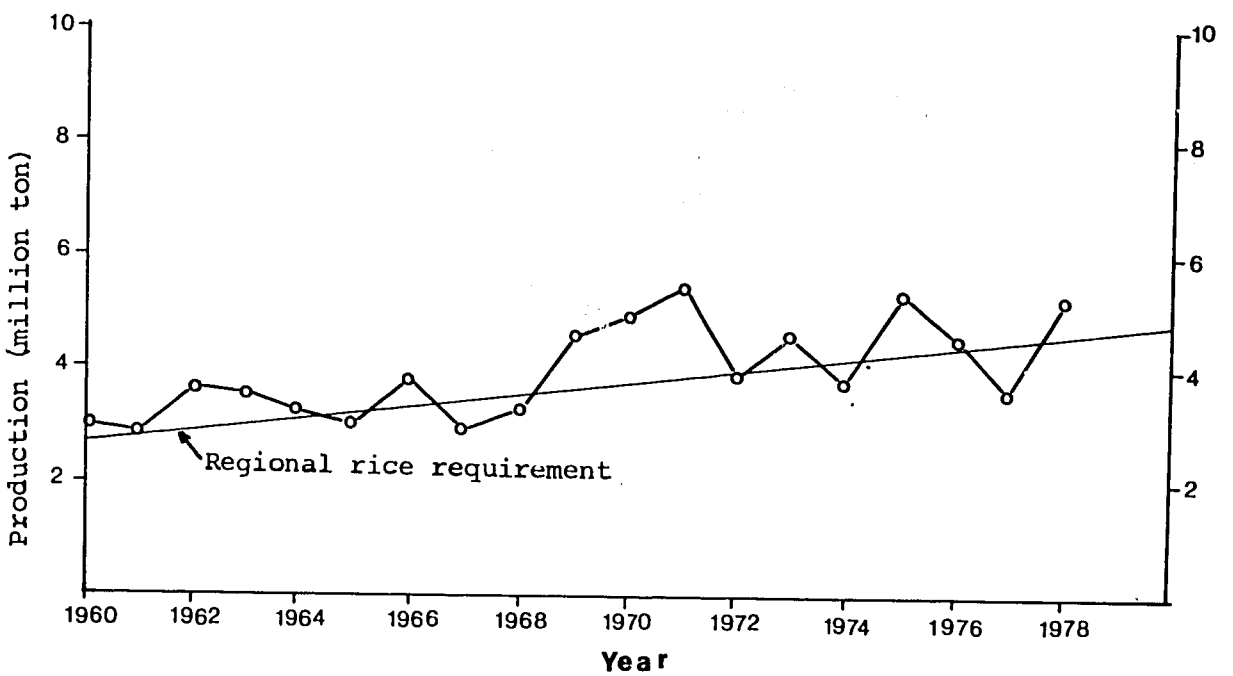


Figure 2.52. Regional rice requirement and annual production (per capita annual rice requirement assumed to be 300 kg).

Two important questions for the region are: (1) what measures are needed at regional level to reduce the instability in farmer's incomes, and (2) how can the growth rate in crop production in the region be improved?

Table 2.2. Growth rates in the gross regional product by sector (1974-78).

		Percent growth rate
Agriculture		22.0
Crops	18.7	
Livestock	41.4	
Fisheries	26.6	
Forestry	3.4	
Mining and quarrying		179.0
Industry		19.4
Construction		116.0
Electricity and potable water		52.2
Transportation		7.3
Wholesale and retail trade		27.3
Banking, insurance, and estate		71.7
Ownership of dwellings		20.6
Public administration and defense		41.4
Services		24.8
Total GRP		28.2

Source: Ministry of Agriculture and Cooperatives, 1980.

Seasonal Price Movements

The important crops grown in Khon Kaen province are storable, the prices nevertheless vary seasonally. They are low shortly after harvest, and become highest during the growing season (Figure 2.53).

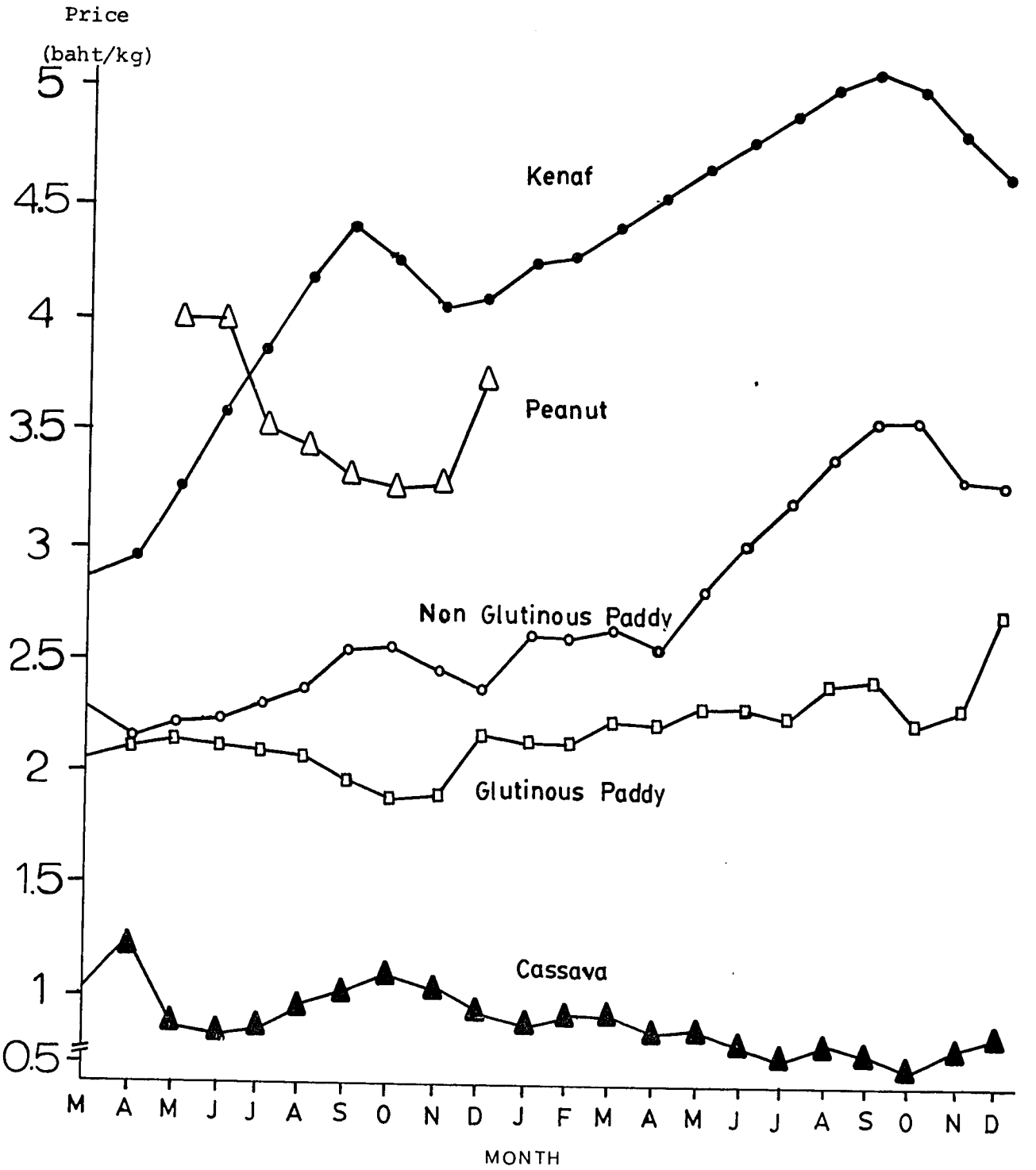


Figure 2.53. Seasonal price movements of paddy, peanut, kenaf and cassava, 1979-80.

The price of glutinous paddy varies less than non-glutinous paddy because farmers tend to store glutinous rice over the year for home consumption. Small amounts of glutinous rice may be sold but only if cash is needed.

The price of kenaf is highest in August and September before the harvest starts in November and December, and then drops rapidly when the new crop is supplied to the market.

Cassava price also varies seasonally; the price tends to be low at the beginning of rainy season since most farmers have to quickly harvest in order to prevent the harvested cassava from deteriorating.

Records for the price of unshelled peanut is very limited. The price is highest in April and starts to decline in July and August when peanuts are harvested.

Stress and Perturbation

An important aspect of dynamic behavior is the response of the system to adverse factors. Information on how a system withstands, adapts to, or absorbs such factors is essential if management of the system is to be improved. We define stress as an adverse factor which acts continuously or with frequent regularity and with low to moderate intensity. Stress is a common accepted fact of agricultural life, and farmers usually evolve ways of coping with it. By contrast, perturbations act with great intensity or considerable force and occur infrequently or unpredictably. Usually, farmers have only partially adapted to them or have no defense at all; thus, the consequence is often a major disaster.

Floods and drought are usually regarded as perturbations, but in the Northeast they are so common, if relatively unpredictable, that they count as stresses at the regional level. (Over much of the region, however, drought and floods are perturbations to the individual farmer, and we will discuss the farmers response later in Chapter 4). There are

no good direct measures, as yet, of drought or flood in the region, but the proportion of paddy land planted each year is an adequate indicator. Figure 2.54 shows the range of patterns within the region. The main effect is in loss of the paddy crop, and Figure 2.55 shows the annual paddy production for the region as a function of annual rainfall at Khon Kaen and Roiet. The major crop losses occured in 1968, 1972, 1974, and 1977, but it is evident that at this level of aggregation there is no clear relationship with annual rainfall. A key question is: what are the climatic predictors of rice production at the regional level?

The most common response at the regional level to poor harvests as well as to the normal expansion in population inherent in the domestic cycle (see Chapter 4) is migration. People leave their farms or those of their parents in law and move to other rural locations, Northeast towns such as Khon Kaen or Nakhon Ratchasima, or Bangkok. Table 2.3 shows the typical pattern of migration into Khon Kaen city from four villages with varying resources and spaced at different distances from Khon Kaen.

Table 2.3. Pattern of rural migration to Khon Kaen City.

Village	Population	Daily work in city		Migration	
		No.	%	No.	%
Nong Hin	1,326	59	60.82	38	39.17
Kokphanpong	1,004	69	82.14	15	17.86
Chaiso	1,200	15	39.48	23	60.52
Hoo Ling	700	-	-	42	100.00
Total	4,230	144	54.58	119	45.42

Source: Prapertchob, 1980.

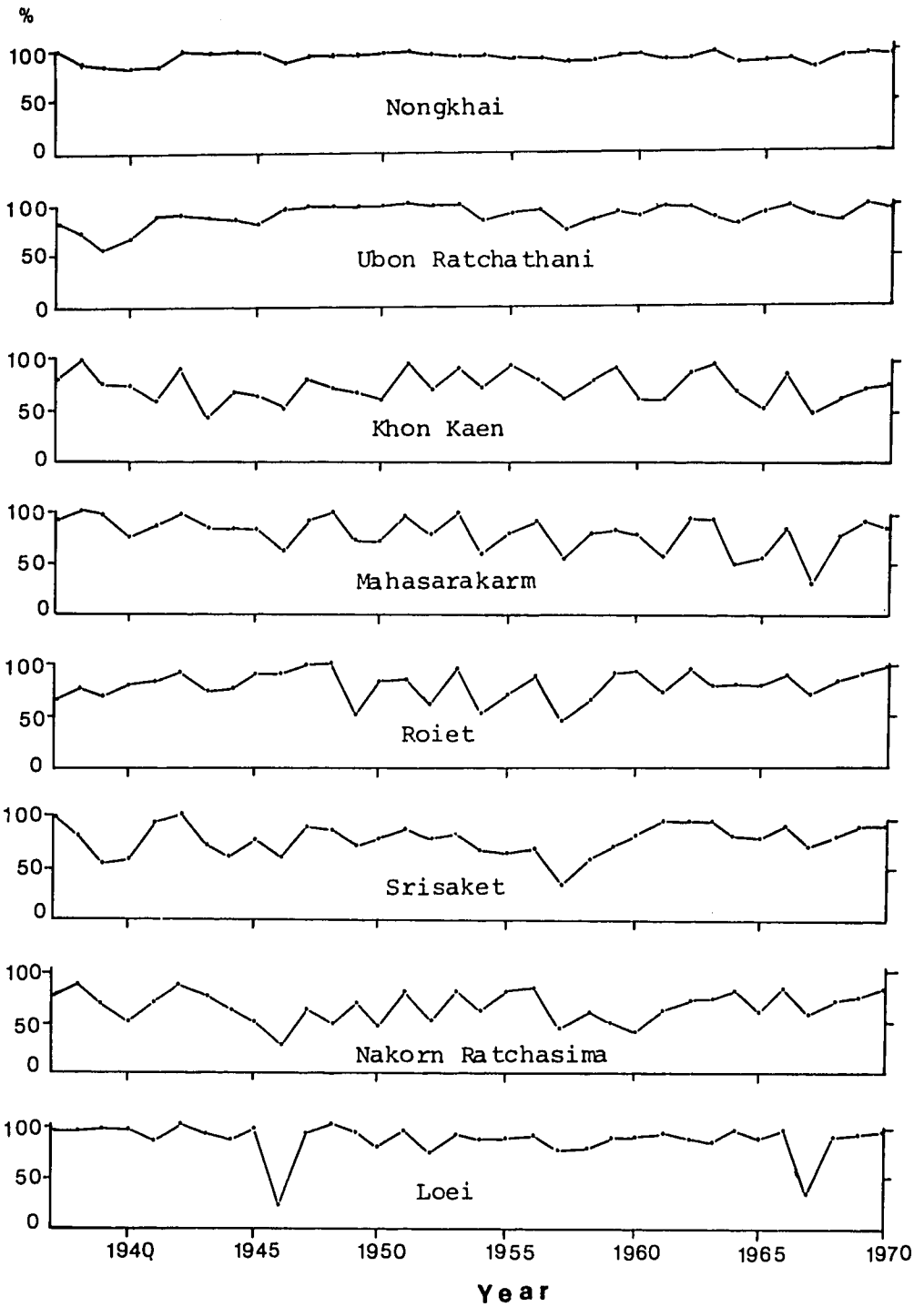


Figure 2.54. Percentage of planted area to total paddy holding area for selected provinces.

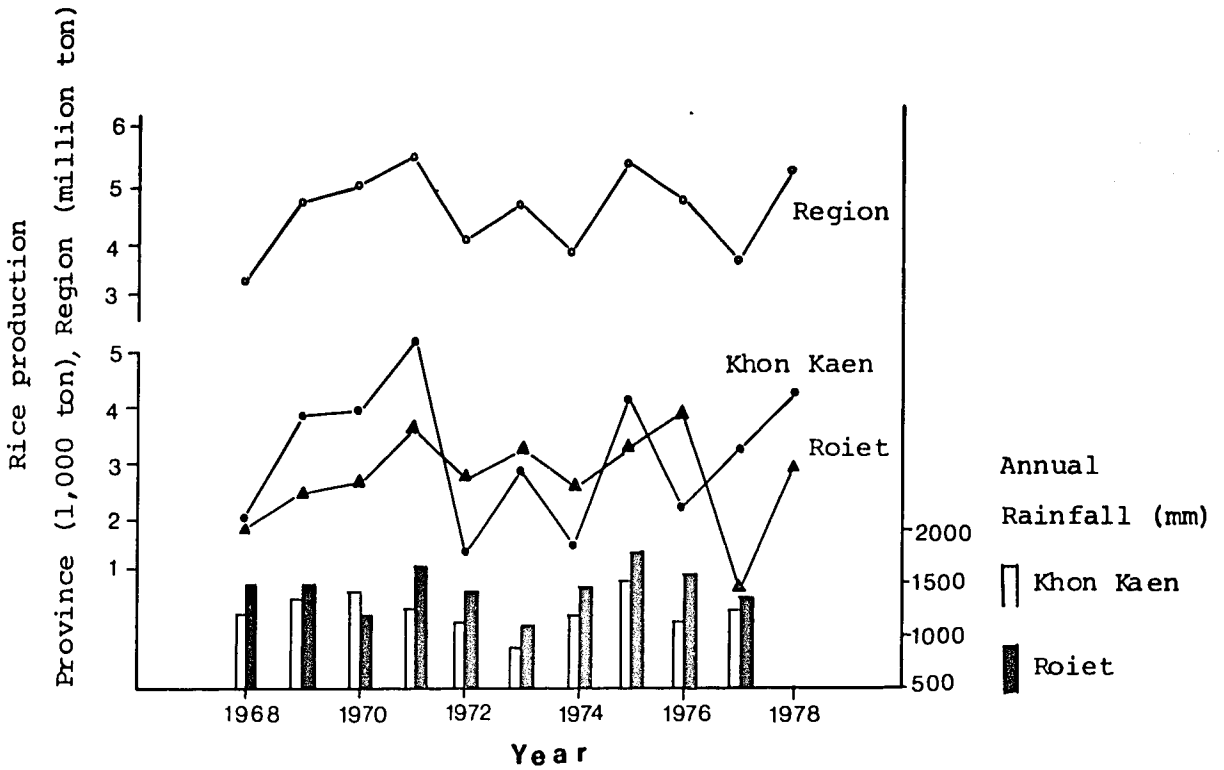


Figure 2.55. Regional and provincial rice production for Khon Kaen and Roiet as a function of annual rainfall.

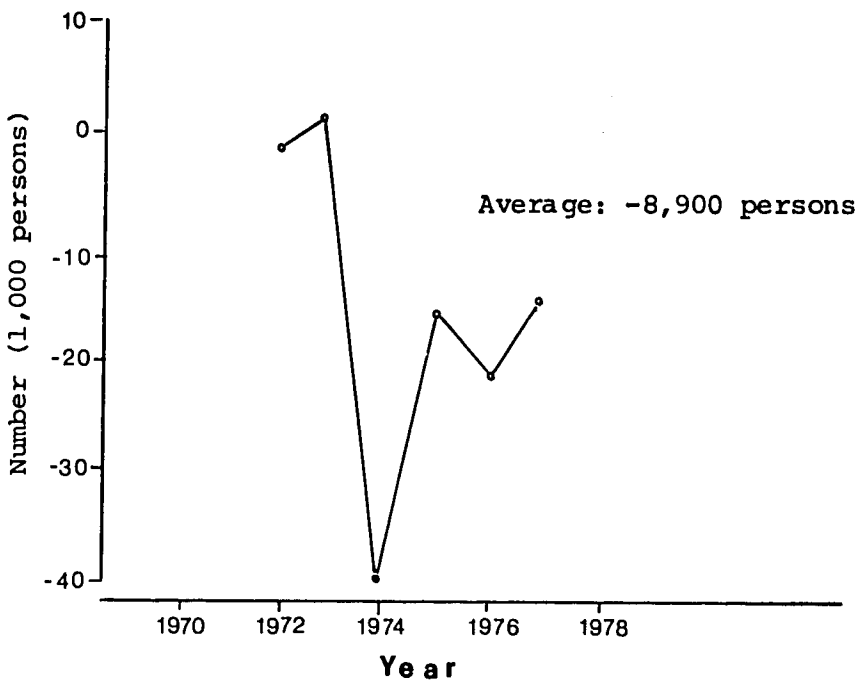


Figure 2.56. Net migration for Khon Kaen, 1972-1977.

As one moves away from Khon Kaen city, past Nong Hin and Kokphanpong to Chaiso and Hoo Ling, the distance for daily commuting becomes increasingly prohibitive. Commutation turns into migration, with, at times, remittances and return visits to help with the rice transplanting and harvesting and field crop cultivation taking the farmers' place. Many migrants to Khon Kaen city move out to Bangkok. Prapertchob (1980) noted that 40.34% of the migrants listed in Table 2.3 moved on to Bangkok.

An indication of the extreme fluctuations in population that can be observed, even at the relatively gross level of the province, is seen in Figure 2.56. From 1972 through 1978, Khon Kaen Province lost an average of 8,900 people per annum. Most of this deficit was due to population migration in 1974. After the severe drought of 1973 which adversely affected the rice harvest of 1973-1974, there was a loss of 40,000 people.

Of all the migrants reaching Bangkok, 45% came from the Northeast in the period 1974-76. The typical migrant is young, unmarried, either male or female, who arrives in the city unaccompanied by a family and seeks a job (National Statistical Office, 1977). Sixty-nine per cent are seasonal workers moving to Bangkok in the agricultural slack period of the late "hot season" April through June. In-migration declines in the July-September paddy planting season, increases during the slack period between September and November (between rice transplanting and harvesting), then decreases during harvesting, and start picking up again in March-April. The remaining 31% of in-migrants stay in Bangkok and do not return at periods of peak agricultural demand.

A key question for the region is: <u>what are the costs and benefits of Northeastern migration - rural, regional, and extra-regional - and what measures are required to control it and, if deemed necessary, to reduce it?</u>

The biggest perturbations in the region over the past decade have been the sudden and rapid rises in fertilizer and oil prices. However, it is not known whether the use of fertilizer in the region has been reduced. The high oil price has resulted in higher transportation costs, but again it is not known whether this has seriously affected the pattern of crops grown. We might also expect a slowing down in the substitution of tractors for buffalo and in the installation of small irrigation pumps.

A key question is: how are production and marketing systems affected by energy prices, and what alterations should be encouraged in these systems which will reduce the burden on farmers?

3. Decision Making

National policy objectives

The first economic development plan was launched in 1961, and Thailand is now in the last period of the fourth plan (1977-81). It will soon adopt a fifth plan for the next five years. The plan is customarily regarded as the basic document of government policies and programs on economic and social development. Although the actual stated objectives of each plan may vary, each one (with the exception of the first which stated only economic objectives) has the same elements, with varying degree of emphasis: of the maintenance of economic growth and stability, national security, and more equitable distribution of income.

As a background to understanding the shift of policies and programs of national economic and social development as proposed in the fifth plan, it is necessary to review the results of the past as well as the current plan. Although social objectives were only included in the second and subsequent plans, the first three were similar in that they put primary emphasis on the provision of infrastructure and the expansion of productive economic activities. Few concrete action programs were initiated to fulfill social objectives. As a result, the economic

and social development program tended to benefit only a minority of people. The income gap, notably between rural and urban people and between people living in different regions, became increasingly wide. The fourth plan was thus launched with the objective, among other things, of rectifying this problem. But it is now apparent that the approach and programs adopted cannot achieve the social objectives set forth in the plan. The gap in income is widening even more and proverty is widespread (NESDB, 1980). It is estimated that 25per cent of the total population still live in poverty. Of this number, 52per cent are in the Northeast (NESDB, 1981).

The fifth plan, now in the process of preparation, aims at solving the problem of distribution of income and eradicating the poverty problem. It aims to restructure the national economy in such a way that not only economic stability and national security can be maintained but also that the benefit accrues to the majority of people. In order to eradicate proverty, high priority in terms of development funds and services will be given to the so called poverty areas. The government has decleared 246 amphoes as poverty areas; of these, 146 amphoes are in the Northeast (NESDB, 1981).

Agricultural development will also have the highest priority in the fifth plan because of its relative importance in terms of employment generation, capacity for export earning, and its lower dependency on import inputs. Within this sector, apart from the continuation of tne programs adopted under the present plan, greater attention will be given to the programs more relevant to the rainfed and poverty areas. A notable change from the previous plans is that the fifth one will rely more on local initiative and participation. It is invisaged that, by doing so, the development programs will solve local problems and thus serve the real needs of the people.

A number of specific component policies, initiated during the last decade, have particular relevance for agricultural development. They have been reviewed elsewhere in terms of their impact on agricultural development in the Chiang Mai valley (Gypmantasiri et al., 1980), and we believe that essentially the impacts will be similar in the Northeast, so we will confine ourselves here to a brief summary.

Land Policy

The government's land policies based on the 1954 Land Code, the Land Allocation Occupature Acts of 1942 and 1957, and the Agricultural Land Reform Act of 1976 aim at improving ownership and tenurial rights and the opening up of new land for settlement. Tenancy is uncommon in the Northeast, but development of new land has been a major feature of agricultural development in the region over the past two decades. In general, government aided settlement has been on poor quality state and forest land and on acid and saline soils. These have been largely developed for cattle raising and, to a limited extent, for fresh water fish farming. The great bulk of new land development has been carried out by individual farmers converting forested upland in the watersheds and reclaiming swamp and flooded land. In addition to providing new land for the upland crops, this has effectively doubled the land area under rice since 1960, and it is this, rather than increased yields, which account for the increased rice production in the region. There is now probably little opportunity left in the Northeast for further expansion.

Price and marketing policy

The government sets minimum guaranteed prices for the major crops of the Northeast - rice, cassava, kenaf, sugar cane, cotton, soybean, and tobacco. It also attempts to control the overall production of cassava.

A key question is: to what extent are government price and production policies important in the pattern of development of the Northeast, and do they significantly help to stabilise farmers' income?

Of the government price policies, the most important appears to be that for rice. In addition to the rice price support guarantee program, the government has instituted a rice premium and a rice quota and reserve system. The former is a varying premium added to the regular export tax; under the latter, export volume is controlled by setting quotas to each exporter and also requiring delivery of a certain portion of the

export volume to a rice reserve at less than tne market price. The net effect has been to create a new monopoly market structure which ensures relatively low prices to farmers. A key question is: would higher prices encourage farmers in the Northeast to switch from glutinous to non-glutinous rice varieties and/or to purchase more inputs, particularly, fertilizers and pesticides?

Fertilizer Policy

This is closely linked to the question just raised, since the government's policy since 1970 of protecting the domestic fertilizer industry has greatly interfered with the competitive nature of the fertilizer market. This has meant high prices for fertilizers which have been exacerbated by the dramatic oil price rises. The government has attempted to overcome the problem by direct distribution of low cost fertilizers both for cash and credit, but fertilizer use remains very low in the Northeast.

Credit

As in other regions of Thailand, northeastern farmers obtain cash for production expenditures, either from their own saving or by using credit from local money lenders or from institutions. Lending institutions include commercial banks, the Bank of Agriculture and Agricultural Cooperatives, as well as farmers' cooperatives. For sugar cane growers, credit is often obtained through a contract with a sugar refinery, usually in the form of inputs.

The provision of production credit given by the bank varies by crop. Table 2.4 indicates the maximum credit for rice and other cash crops that farmers may acquire from the bank of Agriculture and Agricultural Cooperative in Khon Kaen. Credit is given to the farmers on a compoment crop basis, and is required to be repaid after harvest. Although the maximum credit amount for different crops are higner than the average actual requirement per rai, not every farmer is able to obtain credit from the banks, since farmers have to obtain loans upon a security pledge or group

guarantee basis, and this depends upon the bank's evaluation of a farmer's repayment ability. Therefore, cash demands are often met by borrowing from money lenders or by other non-farm income source or from previous crop sales.

Table 2.4. Maximum credit given by the Bank of Agriculture Cooperatives and actual cash expenditures.

Crops	Maximum credit available (Baht per rai)	Actual cash expenditure (Baht per rai)
Wet season rice	400	214
Dry season rice	450	225
Kenaf	600	265
Cassava	500	255

Source: The Bank of Agriculture and Agricultural Cooperatives based on surveyed information in 1979/1980.

Water resources

The provision of water and the transfer of technology are commonly considered by policy makers and government officials to be crucial to the agricultural development of the Northeast. These two factors also are often looked upon as interrelated, and thus there is a strong bias towards irrigated agricultural technology.

Although water resource development projects have been operating in the Northeast since 1939, the irrigated areas covered only 1.8 million rai by 1978. It is estimated that if all the existing and planned irrigation systems were completed, they would serve only 7.2 million rai or about 16 per cent of the total cultivated area of the region, and serve about 18-19 per cent of the total number of farm families. This would leave 84 per cent of the cultivated area or 81-82 per cent of the total farm families still in rainfed agriculture. A new program has thus been devised to meet the water requirements of these farm families by providing

partial irrigation through small scale water resources development projects. Under the proposed program, greater emphasis is to be put on local people participation in initiating the project, in contributing labor from construction, in cost sharing, and in operation and maintenance of the system. The objective is to ensure that local people feel the system belongs to them. It is also proposed that the provincial authority is given the task of planning the small water resources development projects in its province. But since the provincial authorities do not have sufficient capability for this task at present, they will need to be strengthened. At the beginning, the task of studying, planning, and designing the systems may be given to other agencies or to private firms (AIT,1978).

Since the proposed program has not yet been put into operation, it would be premature to evaluate its impact on agricultural development in the region. However, a word of caution may not be out of place. If the programs materialize, they may help to stabilize agricultural production, if other things remain unchanged. However, in the long run, the benefits may not be certain. The systems, although small in size, are to be spread throughout the region, and may have other as yet unknown adverse effects on the physical, social, and economic environment. For example, there may be long term consequences for local water tables, perhaps depriving farmers on adjacent land of their shallow wells. There may also be increasing problems of salinity unless the water is accompanied by appropriate management practices. A key question is: <u>what are best type and design of water resource projects in the Northeast for providing stable and durable agricultural production?</u>

The problems which have arisen on irrigation schemes in the Northeast also highlight the problems of technology transfer if conditions are not right.The attempts to introduce irrigated agriculture into the schemes have generally proved disappointing. Of the 1.2 million rai potentially irrigable by the existing dams, less than a third is irrigated in the wet season, and less than 5% in the dry.

With few exceptions, farmers do not take up the new opportunities which the improved water supply is supposed to provide. Closer exa-

mination suggests that, it is not the lack of technology per se which is the problem, but it is the farmers' lack of certainty and confidence brought about by the new and changing situations which the water resources development project have created. In these areas where farmers have a high degree of control over water, and the production of irrigated crops does not interfere with other farm activities, and is expected to yield markedly better return, the farmers quickly take up the new opportunities. They are as innovative as farmers elsewhere. For this reason, extension or the transfer of technology alone, when other conditions have not been met, is insufficient for agricultural development to take place.

A second general conclusion is that, it is perhaps more important to concentrate extension effort on providing appropriate technology for existing rainfed agriculture than for the new irrigation schemes.

Rural work programs

A final policy of particular relevance to the Northeast is represented by the government's program of funding rural projects. The intention is to provide employment in the dry season and so stop the heavy seasonal migration. Subdistrict boards composed of local government agencies and farmer representatives submit project proposals to central government for approval. Road building, land reclamation, etc. are typical projects.

The policy has very beneficial effects in the short run, but there likely to be problems in the long term. First, the wages paid are tied to the minimum industrial rate and hence are considerably higher than alternative rural employment or the income that could be derived from farm activity (including cropping in the dry season, livestock production, silk manufacture, etc.). Second, many of the projects are those which might otherwise be carried out as voluntary communal activity which has been traditional to the area for centuries. There are danger that the rural work program will destroy the willingness to undertake communal work. A key question: what are the precise costs and benefits of the rural work program in the Northeast?

Systems of decision making

The principal systems of decision making in the Northeast exhibit two major characteristics. First, there is considerable overlap of responsibility, and second, in many instances, the key decisions are made at national rather than regional level.

1) Extension

The large number of major agencies concerned with agricultural development in the Northeast are listed in Table 2.5. Most of these, including the National Energy Authority and the Office of Accelerated Rural Development through their water resource development projects, get involved in extension work.

Since each agency acts separately in providing advice, farmers in the Northeast have somehow to take all these into consideration in the operation of their agricultural systems (Figure 2.57). Each piece of advice is usually given without taking into account its relation to other farm and non-farm activities. Frequently, each piece of advice is also given in very positive and certain terms.

The Department of Agricultural Extension, for example, demonstrates and promotes new crop variaties, fertilizer application, and pest control, trains young farmers and housewives, and sponsors competitions and exhibitions. But, as is clear from Figure 2.58, the work plans of the provincial, amphoe, and tambon extension offices are drawn up nationally rather than at regional level, and, as a consequence, some of the technology being extended may not be particularly appropriate for the region.

Extension is also carried out by the Northeast Regional Agricultural Center at Ta Phra, which is responsible to the Office of the Under Secretary in Bangkok. In addition to research, they also undertake demonstrations, exhibitions, training programs, and talk directly to farmers via their mobile unit and radio broadcasts.

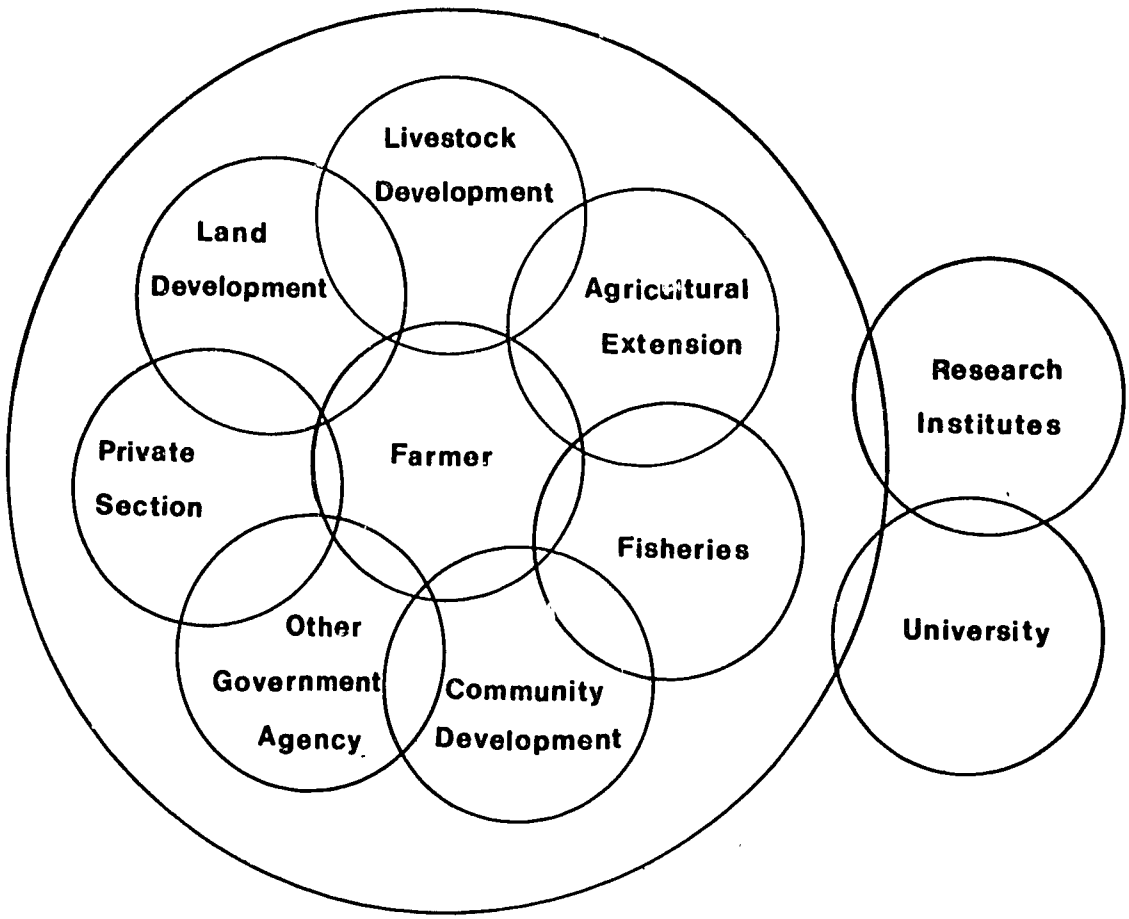


Figure 2.57. Overlapping agencies involved in extension in the Northeast.

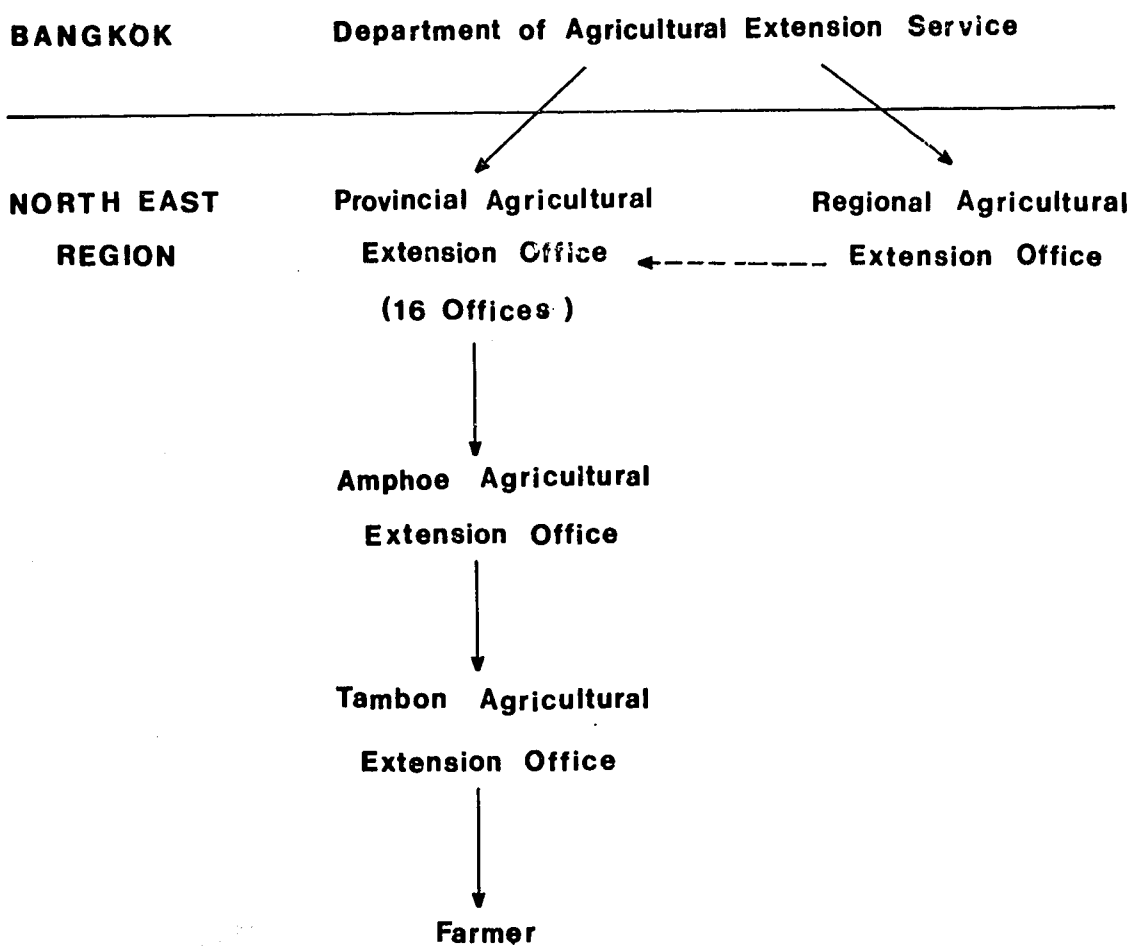


Figure 2.58. The agricultural system in the Northeast.

Table 2.5. Government agencies concerned with agricultural development in Northeast.

MINISTRY OF AGRICULTURE AND COOPERATIVE		
	Department of	
		Agriculture
		Livestock Development
		Fisheries
		Agricultural Extension
		Cooperative Promotion
		Land Development
		Irrigation
		Forestry
		Planning and Special Projects
	Offices of	
		Agricultural Economics
		Agricultural Land Reform
MINISTRY OF INTERIOR		
	Department of	
		Community Development
		Public Welfare
PRIME MINISTERS OFFICE		
	Office of Accelerated Rural Development	
NATIONAL ENERGY AUTHORITY		

Finally, the private sector plays a major role similar to that in the Chiang Mai Valley (see Gypmantasiri et al., 1980). Figure 2.59 illustrates some of the pathways linking the private sector to the farmers. For several crops (cassava, kenaf, sugar cane, and oriental tobacco), much of the technical advice and promotion of the crop has come from this sector.

A more unified extension service is urgently needed in the Northeast, particularly for rainfed agriculture.

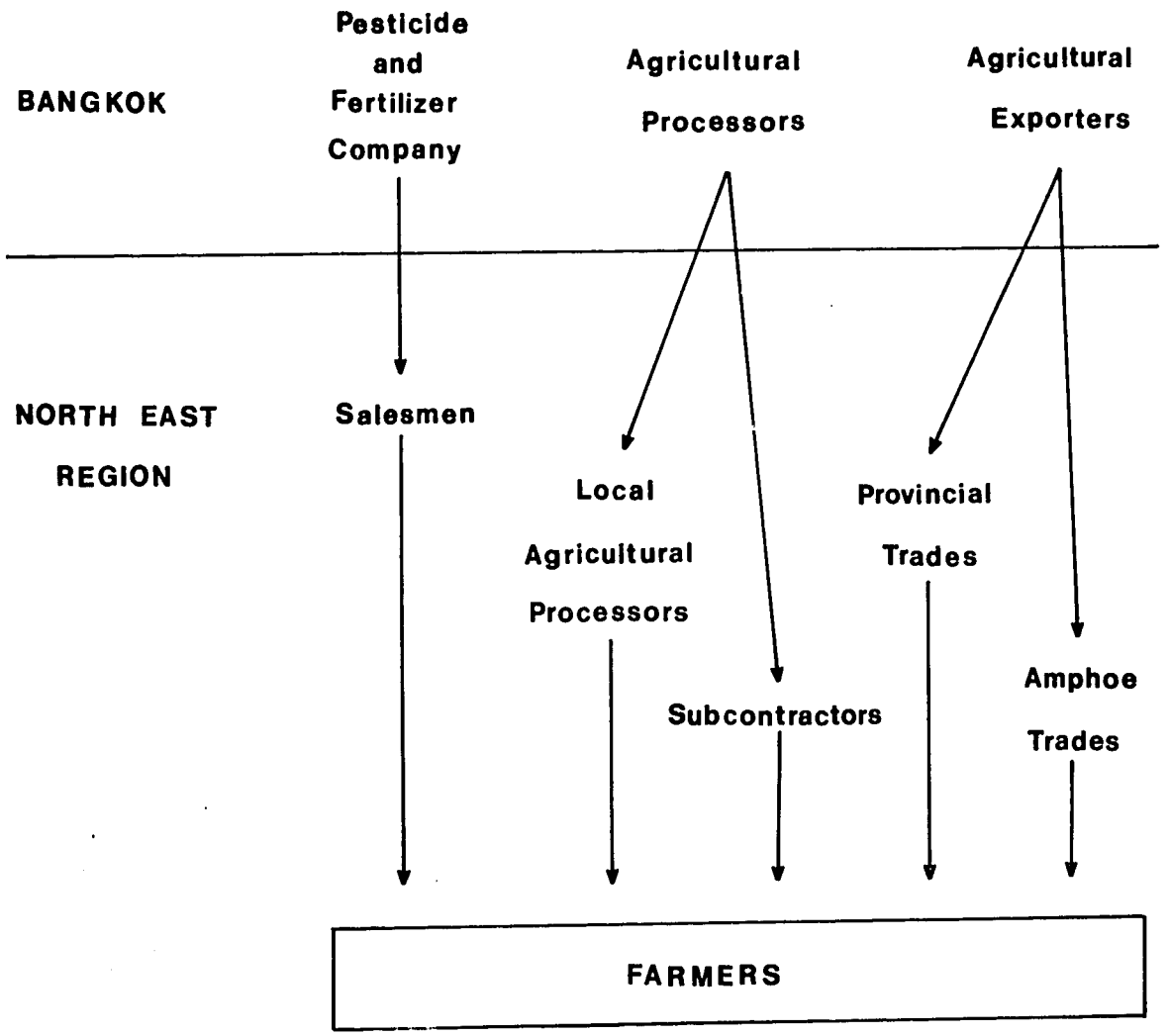


Figure 2.59. Private sector involvement in agricultural development.

2) Water resources

There are also several government agencies concerned with water resources development in Thailand. Figure 2.60 shows the systematic diagram of water resources development and possible conflict of interest among the agencies. The illustration can be applied to both the national and regional levels. But since the problem of water is relatively more acute in the Northeast, it is believed that the activities of these agencies are relatively more intensified as well.

At the national level, the Water Resources Planning Sub-Committee of the National Economic and Social Development Board, with the Accelerated Water Resource Development Committee acting as its technical arms, is responsible for water resources development planning. Although the Sub-Committee does not act as a coordinating body, by planning, it can potentially coordinate and streamline the activities of the agencies concerned. Duplication of effort could thus be avoided and full utilization of funds and resources of all the agencies could be achieved at the regional level. This would also ensure that the people reap the full benefit from the development programs.

Because of the large number of agencies responsible for distributing water to the people in the Northeast, it is impossbile to generalize the decision making processes of all the systems in a few paragraphs. For the government irrigation projects, the operation will be similar to those of the Chiang Mai Valley (see Gypmantasiri et al., 1980). For the other systems, a detailed discussion is presented elsewhere (AIT, 1978).

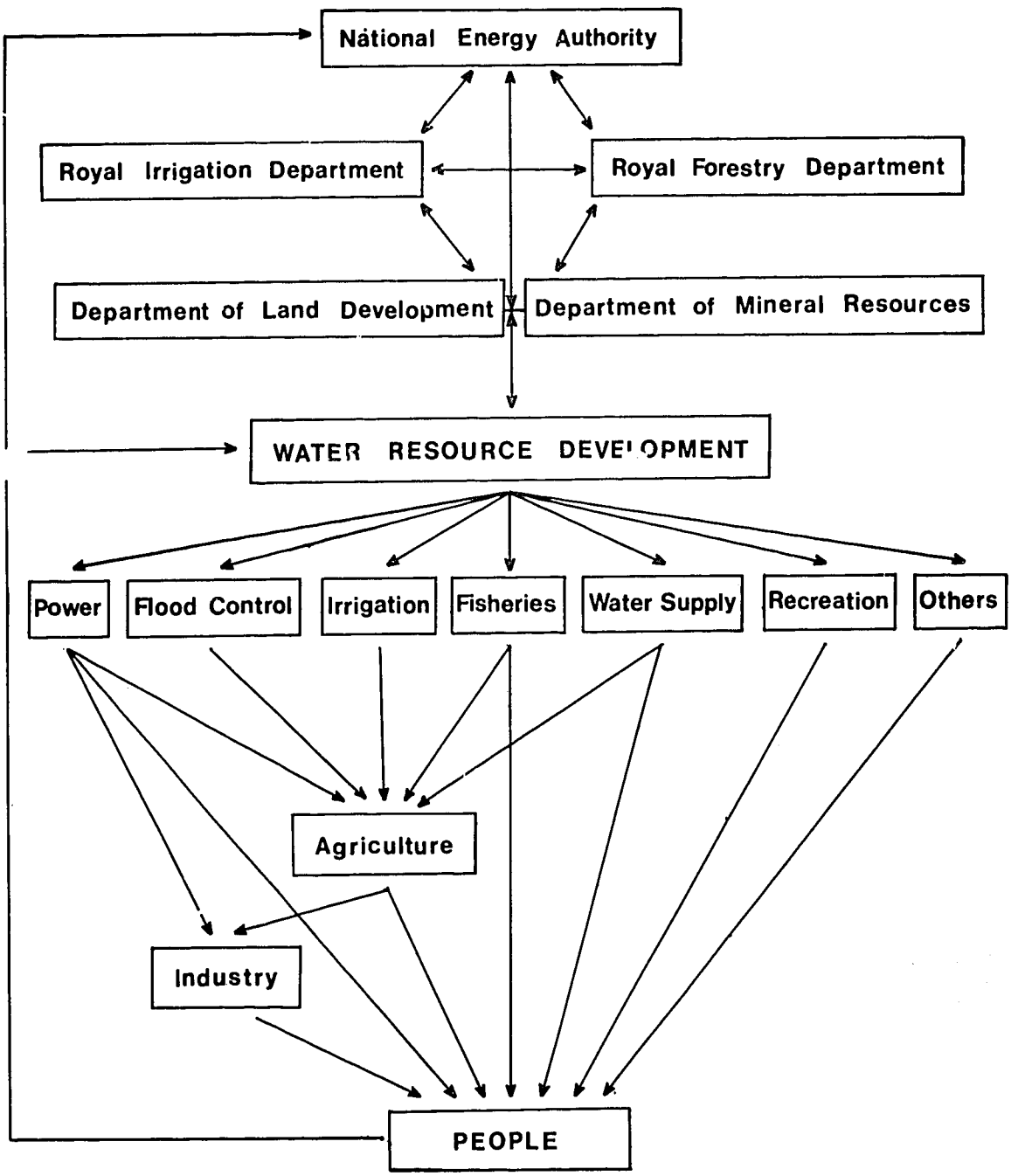


Figure 2.60. Agencies involved in water resources development in the Northeast.

CHAPTER THREE
THE KORAT TRIANGLE

1. Definition

On the basis of the analysis presented in the previous chapter, we have identified a major system in the Northeast which we have called the Korat Triangle. Our goal was to identify and define a real system which would serve as the primary framework for the work of the Cropping System Project. Hitherto, the project has been concerned with rainfed agriculture in general, but it was felt that a target system needed to be identified which would contain those area in the Northeast:

1) having the most critical problems of rainfed cultivation,
2) with the lowest productivities and stability of production,
and 3) where improvement appear most difficult to achieve.

With these criteria in mind, we decided to exclude those provinces to the north and east, lying within the watershed of the Makong, which have an annual rainfall of more than 1,400 mm, growing a small acreage of field crops, and generally having fairly stable paddy cultivation and production. As can be seen from Figure 2.6, the isohyet for 1,400 mm was close to the provincial boundaries and separates off Nong Kai, Sakon Nakhon, Nakhon Phanom, and Ubon Ratchathani. We also decided to exclude the heavier soils of the hilly and mountainous land of the west and south, which occur primarily above the 300 metre contour. These are mostly devoted to field crops with little or no paddy production. The contour separates off Loei and most of Chaiyaphum, the southwest of Nakhon Ratchasima, and the southern parts of Burirum, Surin, and Srisaket.

The Northeast Region on this basis consists of four major systems - the Korat Triangle, the Mekong Provinces, the Western Hills, and the Southern Hills (Figure 3.1). A key question is: <u>how is the productivity and stability of the Triangle affected by the other systems?</u>

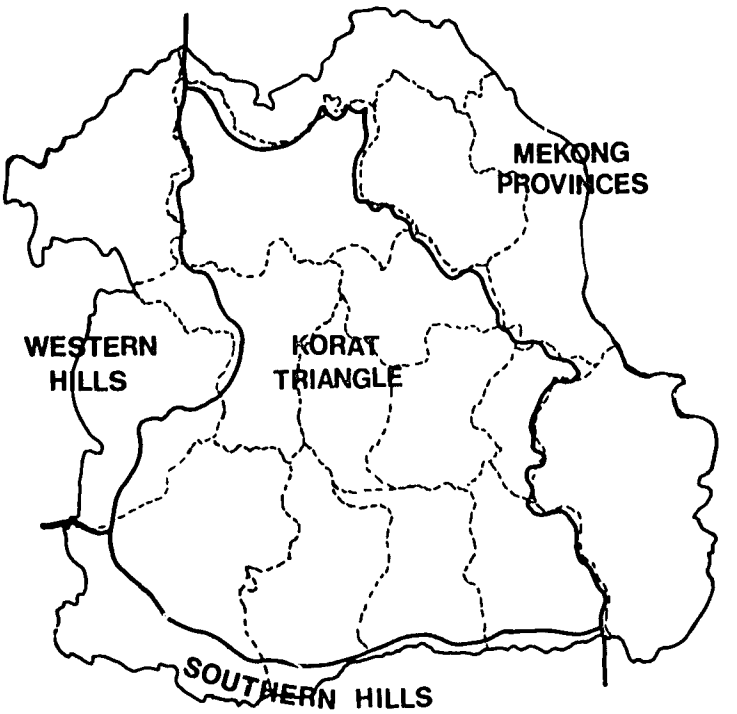


Figure 3.1. The major systems of the Northeast.

2. Description

The system so described is probably best visualised on the basis of the land form map (Figure 2.3) as comprising the bulk of the land designated flat or shallow undulating rainfed land. It consists of a fine or course mosaic of paleaquult and paleustult soils, with a block of dystropepts in Roiet.

The annual rainfall ranges from 1,100 to 1,400 mm, and there are 1 to 4 months having a rainfall greater than 200 mm. There is moderate to high number of drought days during the rainy season. In the north of the Triangle, there are five months with rains exceeding 100 mm but six months in the South.

The planted acreage of paddy is moderately to highly unstable, and the yields and production vary in stability, being highly unstable in some provinces. Up to 25% of the cultivated land is devoted to field crops, more in the west than the rest of the Triangle. The whole area is very marginal for two crops in a year without irrigation.

A key question is: how can the stability of paddy production in the Triangle be improved?

Administratively, the Triangle contains all or parts of 11 provinces (Udonthani, Kalasin, Khon Kaen, Mahasarakham, Roiet, Yasothon and parts of Chaiyaphum, Nakhon Ratchasima, Burirum, Surin, and Srisaket). It also contains the main regional administrative centre of Khon Kaen and the marketing and trade network centred on the Friendship Highway.

Most of the population consists of Laos Wieng, with Thai Khorat and various Khmer groups in the South. Population densities are all above $80/km^2$.

3. The Triangle's Agroecosystems

Within the Korat Triangle, the next levels down in the system hierarchy are the administrative system of the province and districts (amphoes). However, our analysis suggested that these are not very powerful or meaningful systems in agricultural terms. Their boundaries, although often following the rivers, do not usually reflect changes in topography, soil type, land capability, or climate, and thus do not conform with agroecological zones (Figures 3.2-3.3). It is true that the province and district centres are often markets for crops and source of credit and inputs, but there is considerable movement across boundaries in pursuit of these.

The most important agroecosystems lie one more levels down in the hierarchy. We have identified four such systems in the Korat Triangle - mini watersheds, non-flood plains, flood plains, and irrigation systems.

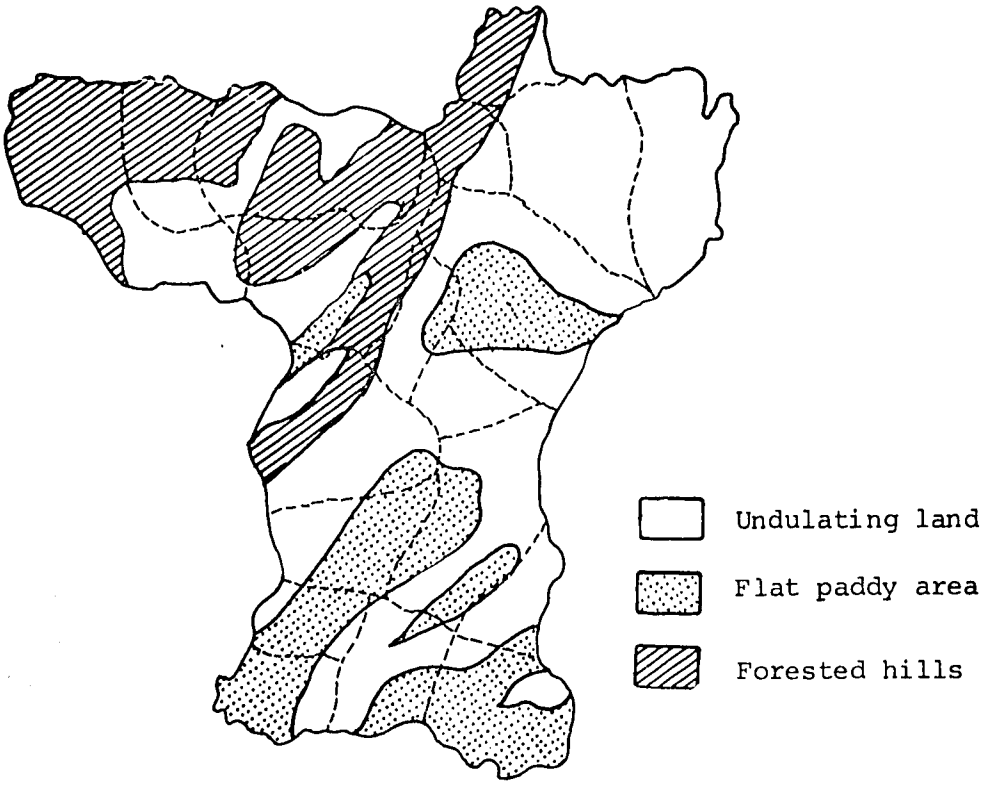


Figure 3.2. Map of Khon Kaen province showing land forms.

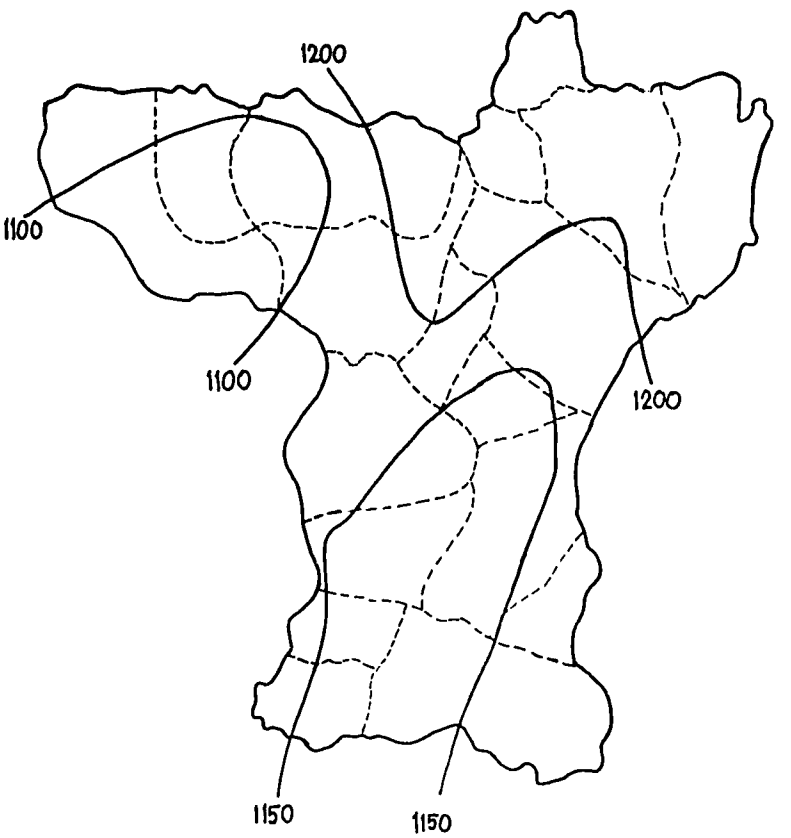


Figure 3.3. Map of Khon Kaen province with rainfall isohyets.

Mini Watershed

This is the characteristic agroecosystem of the gently undulating land common throughout the Triangle. Its main features are shown in Figure 3.4.

The watersheds may be shallow or fairly deep, measuring from a half to several kilometres across from ridge to ridge, and the distance from the lower paddy to the top of the ridge varies from 5 to 30 metres. Figure 3.5 illustrates a range of watersheds in part of Khon Kaen province.

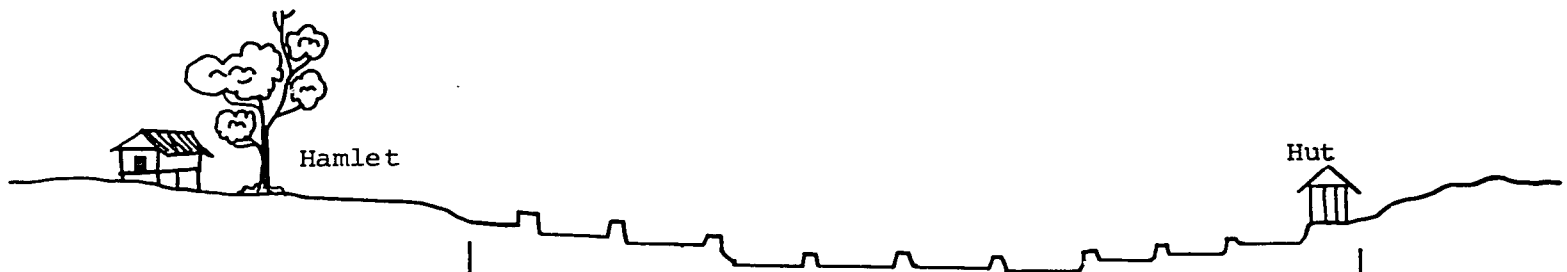
The depression at the bottom of each watershed does not support a stream, but the soils usually belong to the paleaquult group and thus have a high enough water holding capacity to retain sufficient water in the rainy season to form paddies. In virtually all years, enough water has accummulated, both directly and by run off from the upper paddy and upland areas, to allow transplanting in July or August. Farmers also often construct a small pond in the lower paddy area close to the village to retain water from the rainy season. They then use this to irrigate, by hand, a small area after the rice harvest in order to grow vegetables for home consumption.

Cultivation of the upper paddy area depends critically on the rainfall pattern. Only in some years has sufficient water collected by August/September to permit rice transplanting. In the drier years, it is usually left idle.

The upland area are planted each year to cassava, kenaf, sugar cane, watermelons, or some other field crops. The soils, being mostly Paleustult, have very poor water holding capacity and low fertility, and crop yield are low.

Key questions for the mini-watershed are:

1. How can the watershed be best managed as a system? and in particular,



	Upland	Upper paddy	Lower paddy	Upper paddy	Upland
Soils	Paleustult	Paleaquult/ Paleustult	Paleaquult		
Crops	Cassava Kenaf Sugarcane Water melon	Cassava Rice	Rice followed by vegetables		
Problems	Drought Erosion	Insufficient water			

Figure 3.4. Schematic cross section of a mini watershed.

2. How can the upper paddy area be best managed?

3. What is the precise nature of the interactions between the various land uses in the watershed? For example, how does the use of the upland areas affect the water supply to the paddy areas, and can improved systems of water management be designed which optimise the performance of the watershed in all years?

4. Would contouring and reconstruction of the bunds improve the overall performance of the typical watershed?

5. What role have tanks to play in improving the performance of the watershed?

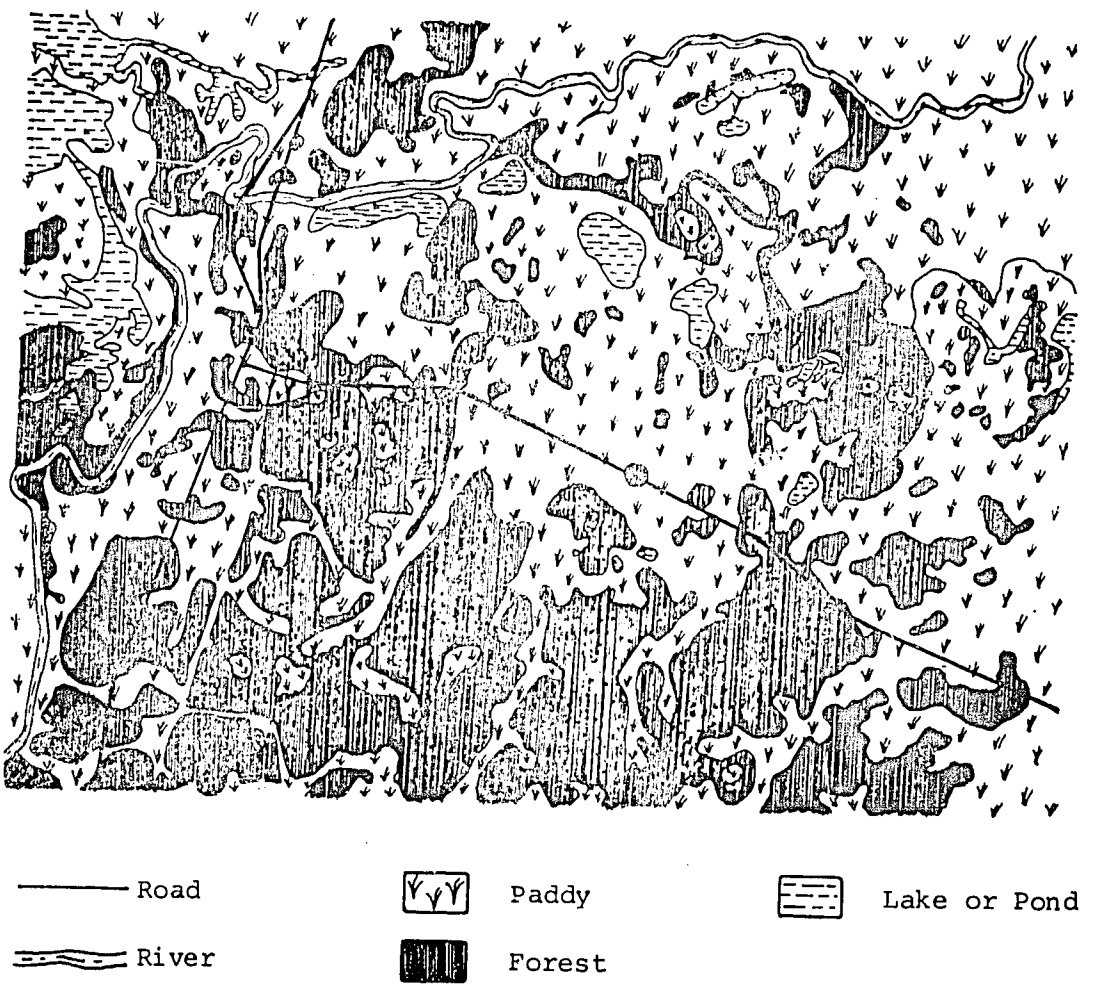


Figure 3.5. Part of Khon Kaen province showing various watersheds.

Non-Flood Plain

These occur throughout the Triangle but particularly prodominate in the southern part of Mahasarakham, in Roiet and Yasothon, and in the northern part of Srisaket, Surin, Burirum, and Nakhon Ratchasima. The main features of the non-flood plain are shown is Figure 3.6.

These plains are usually some distance from the village and are formed on the geological lower terrace. They are at a slightly higher elevation than the flood plains, and hence they rarely, if at all, are flooded from the rivers. The soils are usually good paddy soils, and in all years there is sufficient water accumulated from rainfall to allow transplanting of rice in July/August.

As in the lower paddies of the watershed, farmers often construct small ponds and use them to hand-irrigate vegetable grown for home consumption after the rice harvest. Some farmers, particularly in Roiet and Yasothon, also dig shallow wells which may be used for irrigation. In particular, this may permit the growing of tobacco after the rice crop.

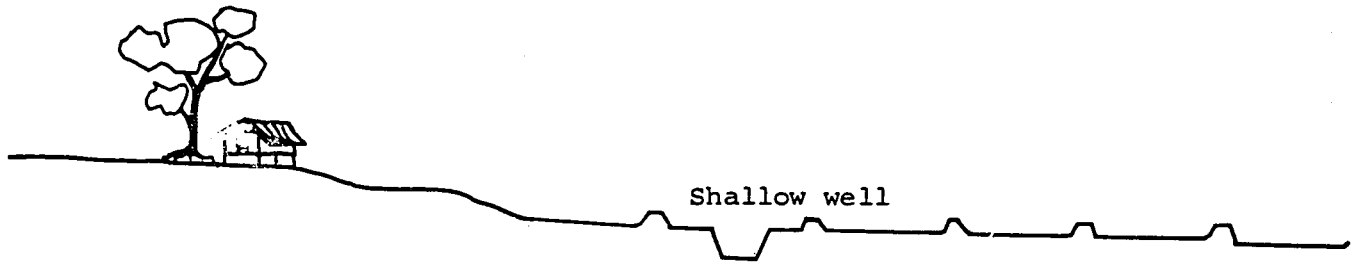
In some limited areas, for example in Surin, there is sufficient residual soil moisture to permit the cultivation of peanuts after the rice crop. In Burirum, a two-crop system is followed in which sesame is grown before the rice crop.

Upland areas within the non-flood plains are usually small, of low elevation, and far apart. The villages are sited on them, and small areas are grown to field crops such as cassava, kenaf, sugar cane, peanuts, and watermelons.

Key questions for the non-flood plain are:

1. How can the upland and flat paddy areas of the non-flood plain be managed as an integrated system?

2. How can double cropping in the non-flood plain be made more extensive?



	Upland	Flat paddy
Soils	Paleustult	Paleaquult or Dystropept
Crops	Cassava Kenaf Sugarcane Peanut Watermelon	Rice In limited areas: Rice followed by peanut or tobacco; Sesame followed by rice; Rice followed by vegetables

Figure 3.6. Schematic cross section of a non-flood plain.

Flood Plain

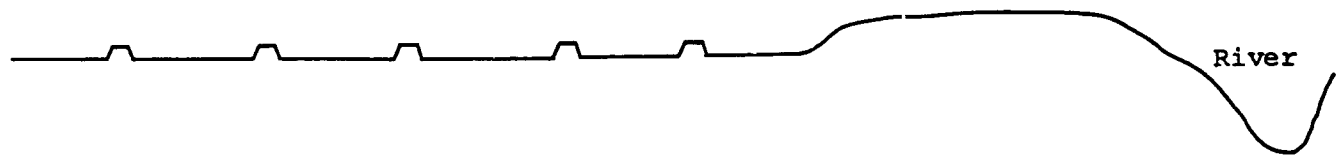
The flood plains occur along the Chi and Mun rivers in the Triangle. Their main features are shown is Figure 3.7.

These systems are inundated each year by the annual flood caused by the overflowing of the river banks. The soils are mostly tropaquept along the rivers, but a considerable portion of the flood plains have paleaquult soils.

The pattern of cultivation is very similar to the non-flood plains, rice being the main crop with, in limited areas, a subsequent crop of vegetables, providing the farmers are able to dig shallow wells. A number of small pump irrigation schemes have also been established along the lower reaches of the Chi and Mun. These, however, mostly provide supplemental irrigation to the flood plains in the rainy season. They have little capacity for dry season irrigation.

Between the flood plain and the river, there is usually a narrow levee composed of ustifluvent soils. On these, the farmers may grow a variety of vegetables after the floods have subsided.

The critical problem of the flood plain is flooding after transplanting. A key question is: how can farmers in the flood plain best respond to flooding? Another is: how can double cropping in the flood plain be made more extensive?



	Flood plain	Levee	
Soils	Paleaquults or Dystropepts or Tropaquepts	Ustifluvents	
Crops	Rice Rice followed by vegetables	Vegetables	
Problems	Flooding		

Figure 3.7. Schematic cross section of a flood plain.

Irrigation Systems

We have already referred to irrigation of the mini watersheds and plains by farmers ponds, wells, and by tanks, and to the use of pump irrigation in the flood plains. Within the Triangle, however, there are several major irrigation schemes based on large dams and reservoirs. There are listed in Table 3.1.

Table 3.1. Large scale irrigation systems in the Korat Triangle.

Province	Reservoir	Irrigable area (rai) 1/
Khon Kaen/Mahasarakham	Nam Pong	293,750
Kalasin/Roiet	Lam Pao	303,750
Nakhon Ratchasima	Lam Takhong and Lam Phra Phleng	180,000

Source: Asian Institute of Technology, 1978. 1/ 1 rai = 0.16 ha.

The main features of these irrigation systems are shown in Figure 3.8.

The soils are of various kinds but mostly paleaquult.

Rice is grown in the rainy season, while in the dry season there may be a second crop of rice, glutinous corn, peanuts, watermelon, or vegetables.

A description of one of these systems with special reference to the environmental aspects is given in Interim Committee for Coordination of Investigations of the Lower Mekong Basin 1979.

	Irrigated paddy
Soil	Paleaquult
Crops	Rice Rice-rice Rice- peanut - corn - watermelon - vegetables

Figure 3.8. Schematic cross section of a irrigation system.

CHAPTER FOUR
VILLAGE AND FARM

1. Village

Within the 16 changwat (provinces) of the Northeast, there are 193 amphoe (districts), 3 king-amphoe ("mini" districts), 1981 tambon (communes), and 20,828 muban (villages) (NESDB, 1980).

Structure

The average village in the region has a population of 710 people grouped in 105 households. Typically, these households are clustered on rather small homesites, separated from the surrounding agricultural fields by a fence, shrub, or tree line. Some villages have a dispersed housing arrangement and some others are linear, with the houses scattered along a road (see figures 4.1-4.4). Usually, each village also consists of a wat (monastery), probably at the east end of the housing area, a sala klang bann (small meeting hall for government and village purposes, located in the approximate middle of the village), and perhaps a few stores, most of them under their owner's raised houses.

Houses are built on raised piles, 1.5-2.5 meters above the ground, with one or more rooms, a kitchen, and a large open area in front. The size of the house, its altitude above ground, the permanence of its construction material, and the size of the homesite depend on the economic status of the owners and the number of kin families living in the same compound. Some compounds are well-defined by a fence and flowering shrubs, and are planted with fruit trees and have kitchen gardens. Poorer households may share homesites with neighbors or relatives. Livestock are quartered under the house, where also are kept useable and worn out agricultural implements, lumber, water jars, etc. A section that includes a raised bed may be set apart as a resting place for sitting, talking and working, tending or nursing children,

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Figure 4.1. A clustered village served by an irrigation scheme. (Source: Chulalongkorn Univ. Social Research Institute, 1976).

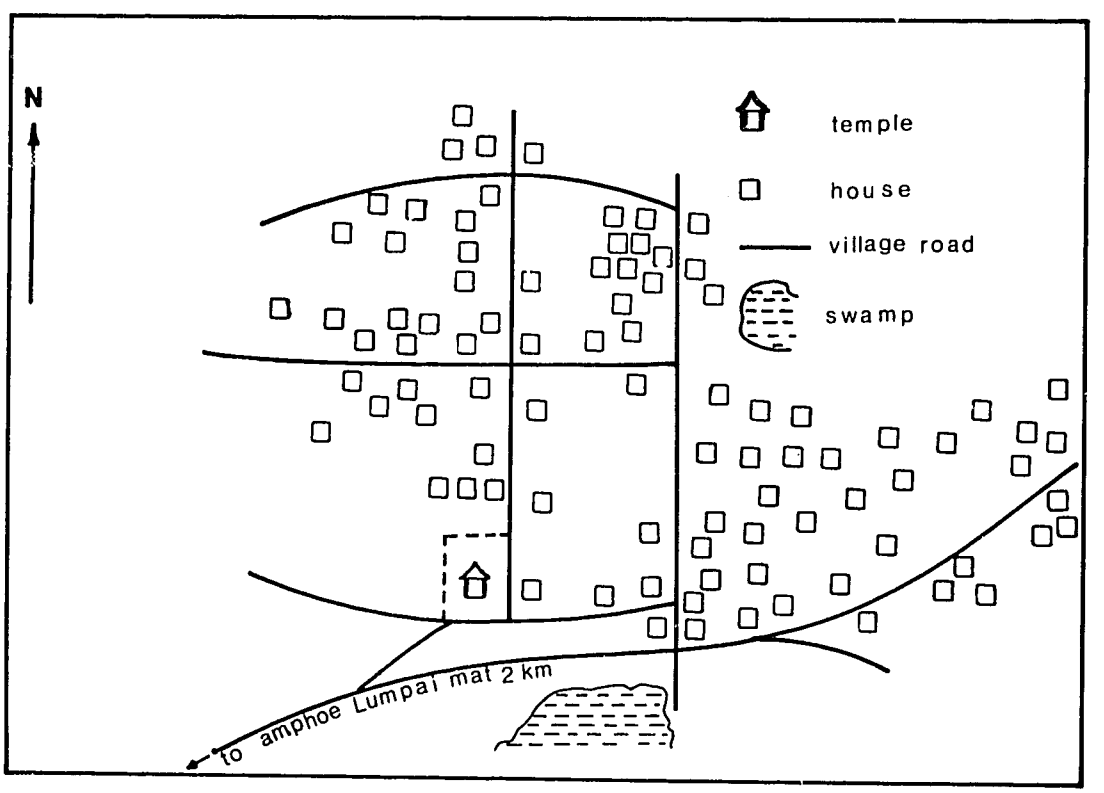


Figure 4.2. A clustered village in Burirum province. (Source: Srinakarinviroj Univ., 1973).

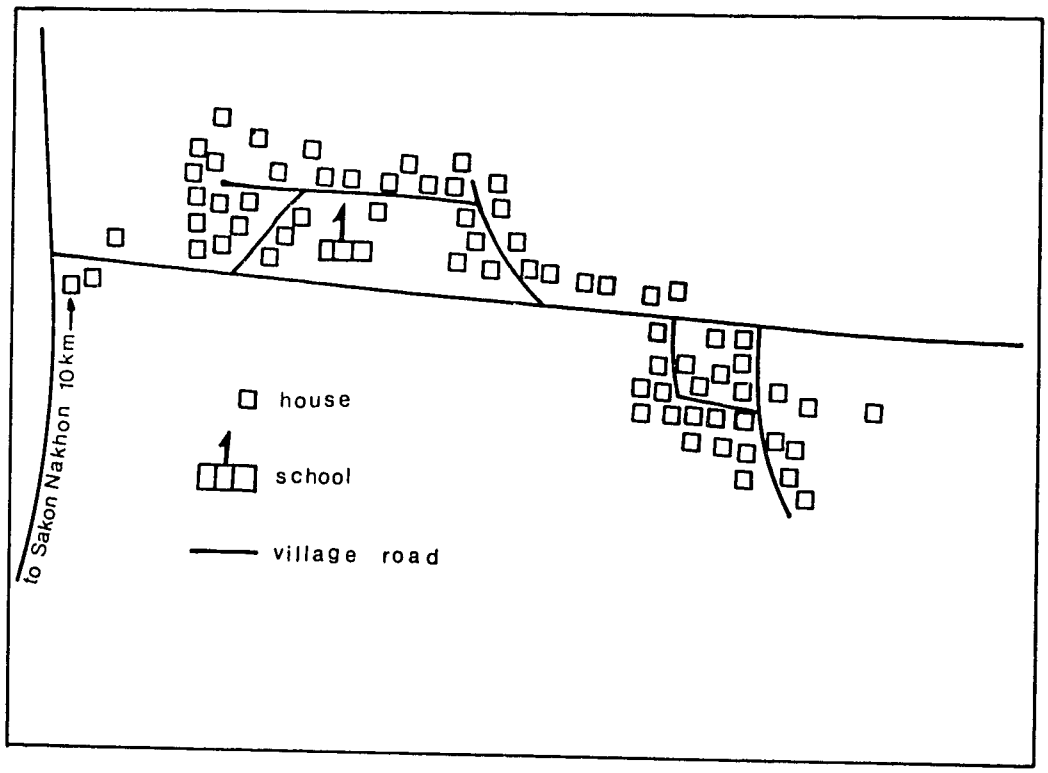


Figure 4.3. A fragmented village in Sakon Nakhon province.
(Source: Srinakarinviroj Univ., 1973).

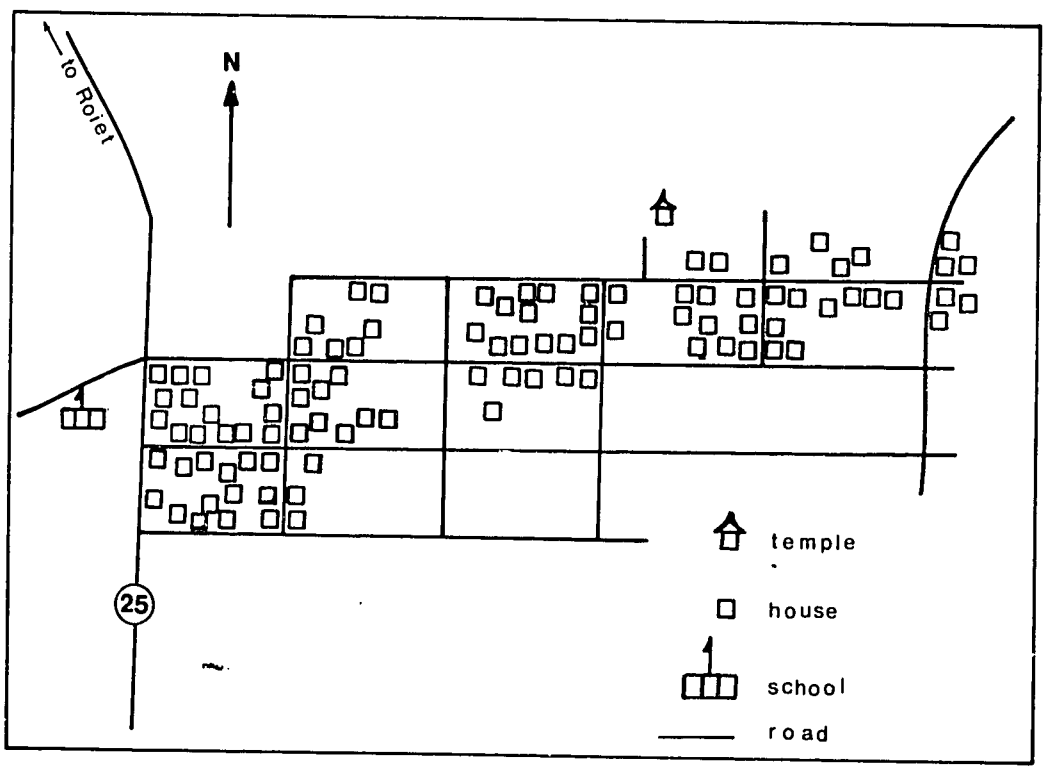


Figure 4.4. A linear village in Roiet province.
(Source: Srinakarinviroj Univ., 1973).

etc. Underneath the house may also be an easily constructed loom on which household women and relatives or friends can weave cotton, silk, or synthetic cloth. During the hotter times of the year, the area under the house assumes the function of the veranda, which can become too hot for comfort during the day.

Since the homesite is relatively small and usually does not have an easily replenished water supply, extensive vegetable gardens are seen only in some compounds. Generally, vegetables are grown near canals or ponds where water supply is available. In addition to serving as a playground for the children, the granaries are found here.

Traditionally, there is no public market in a village. However, there usually are one or more small stores where household necessities, medicine, small guantities of fertilizer and other agricultural inputs, and food are sold. Most villagers go to the town or district center for their supplies. The social centers in the village are the wat, village meeting hall, school, and the public wells, which serve as places for people to gather for either formal or informal discussion. Some small villages have no wat or school and share these with nearby larger villages. The wat is where religious, festive, and at times, scholarly activities take place. Villagers come to the wat for community activities and, at other times, to satisfy their personal desire for peace and quiet. The village school, which may or may not be colocated with the wat, has classes at the elementary level through either the 4th or 6th grade. Meeting between villagers and administrators may also be held here, while sports events between the village schools in the same tambon and recreational activities such as occasional movies may take place on its field. Public wells also serve an informal meeting place where the people go to get their domestic water in the morning or evening.

Dynamics

The prevailing tendency in Thai-Lao (Isan) culture is for daughters women to inherit the house, rice, and other land of their parents. Young men principally acquire land by marriage. The normal marriage pattern is uxorilocal, that is, the groom goes, at the time of marriage, to live with his bride, who is usually resident in the home of her parents. Depending on the economic circumstances of the bride's parents, this period of co-residence may last from a few nights to a lifetime. The parent's desire to give the young couple plots of land to farm, thus encouraging them to stay close to home. However, young men may also acquire land by inheritance from their parents, or by the clearance of forested areas, or by purchase on the part of the man and his wife. These lands may be a some distance from the bride's village, thus forcing a move. The youngest daughter and her husband are expected to stay in the parental home and tend to her parents until their deaths. This couple then inherits the house and homesite together with their share of rice and other land. This share is usually larger than that distributed to elder siblings, since it was designed to aid in supporting the parents during their lives. The normal procedure is for this land to be cultivated in the parent's names for several years after death, in the expectation of an occasion of relious merit to be performed on their behalf in the future.

The consequence of this pattern of marriage and land inheritance is an expansionist system, consisting of a fairly rapidly shifting movements by individuals between households and villages, and by families between villages, sometimes at great distance. This results in a constantly varying array of fragmentation, acquisition, and extension of agricultural holdings at both the local and regional levels (Klausner, 1982; Lefferts, 1974; von Fleckenstein, 1980; Ng, 1970). Virtually all agricultural land in the Northeast is owner occupied and farmed. There are few tenant farmers and few villagers without land, in contrast with the Chiang Mai Valley experience (Gypmantasiri et al., 1980). Rentals are even relatively rare under this system, designed to accomodate only minor variations in household labor resources.

Because of the pattern of female inheritance, young men have traditionally left home to seek a wife and land or a job in another province. The Northeast Thai-Lao pattern of internal and external migration thus has deep origins. Today, young girls are also going or are sent away to work, sometimes to improve the household's access to external resources, at other times, seemingly, for adventure.

In the annual village calendar, the main communal events have religious overtones or are imbued with relious significance. These include the annual cycle of the twelve religious festivals,plus occasions such as the ordination of young men as monks. Some of these festivals focus on the household, some on the village, and some on a ceremonial community that includes a number of surrounding villages. Thus, religion may be seen as facilitating a range of social relationships throughout the Northeast. These festivals may last from half a day to three or more days, depending on the festivals significance, and may include folk opera performances, a tournament of fights, movies, gambling, etc., as well as the presentation of gifts and copious food to the monks, which will later be shared among villagers.

There are also a series of household ceremonies, some of which have religious overtones, such as death and the ordination of a son as a monk, and some less apparently religious, such as births and weddings. On some of these occasions, monks and/or neighbors from the home and nearby villages will be invited,and the latter may reciprocate with cash presents (Table 4.1).

An important traditional custom in the Northeast village had been that of labor exchange (long khak), principally used during times of transplanting and harvesting rice. Farmers were helped by relatives and neighbors on these tasks, and they in turn provided a meal during the workday, and incurred an obligation to reciprocate with their own labor for the same type of task. Usually, a village had several of these groups, within which labor was exchanged.

Labor exchange is now much less common, partly because of upland cropping, which requires a much tighter scheduling of labor, and partly because money is the accepted medium of exchange in the region. Another common traditional practice is to hire a young man for the rice season, who would live with the landowning family and who would be paid 100 tang[1/] of rice at harvest (Table 4.1). Hired casual labor, by the day or season, has become increasingly common with the spread of a monetized economy. Labor exchange, however, is still important for house construction.

Community labor has been important in the past. Farmers have worked during the dry season for the village in the construction of or maintenance of roads, ditches, wells, bridges, and irrigation systems, schools, etc. But this practice is also declining, particularly under the influence of the government's rural work program whereby farmers, their spouses, and dependents, are hired for wages to carry out this work.

Decision making

The appointment, promotion, demotion, or transfer of the provincial governer and the amphoe head is under the authority of the Ministry of Interior. Apart from the changwat governor and the amphoe head, there are also officials from other ministries stationed in every changwat and amphoe administration. These are directly under the control of the central government in Bangkok. However, the leaders at the lower level, tambon and muban, are popularly elected. The muban head is directly elected by the people in the muban. Muban heads in a tambon then can be the candidates for the tambon head who is also popularly elected. Both tambon and muban head men may be, depending on personal characteristics, influential people in the daily life of the people in rural areas. Both leaders are not civil servants, but are entitled to wear uniforms and be paid a small honorarium for their services.

1/ 1 tang = 10 kg.

Table 4.1. Labour, goods and money balances in six farms in the rainfed village of Ban On (Roiet).

Item	Mean	Range
Man equivalents available for work	3.2	1.1-5.1
No of rai	27.5	17.3-40.5
Labour (mandays)		
Family on own farm	759	323-1,274
Exchange		
received	85.5	33-188
given	31	5-69
Hired	70.3	0-211
Community (not school)	98.5	26-293
Wage labour	126.3	16-319
Goods (baht)1/		
To monks	229.3	0-849
To others	703.8	193-1,390
Household goods received	588.5	274-1,484
Agricultural inputs received	984	805-1,688
Money (baht)1/		
To monks	771	42-2,531
To others	1,225.7	309-3,701
Received	853.2	0-3,597
Balance (goods and money)		
Given	2,929.8	995-5,771
Received	2,426.7	1,141-5,886

Source : Fleckenstein (1980). 1/ 1 U.S. $ ≈ 23 bahts.

The tambon kamnan and muban headman can be considered quasi-agents of the central government. They are responsible for transmitting to the people the directions of the government as handed down through the chain of command, and responding upwards with specific information and answers to questions. Their functions include the supervision of law and order in the tambon or muban, the supervision of agricultural projects, participation in ceremonial duties, recording vital statistics, tax collection, and exofficio membership on the tambon council. They should try to maintain the peace and happiness of their tambon or muban by settling disputes, promoting village projects, and communicating with the amphoe officials. Farmers' Associations, Village Development Organizations, Voluntarily Security Forces, etc. have also been recently established in the villages. As these developments occur, the kamnan and headman's lives have become increasingly busy and filled with government directed tasks.

Probably the most important decisions at the village level are those concerning the management of communal resources. For each farm household and farm resource system, access to village level resources and the need to meet demands of the village level social system may critically constrain farmer decision making. For example, access to communal grazing lands may be a key factor in determining size of livestock herd raised by individual families. Also village norms about communal sharing of available water during the dry season may limit individual opportunity for small scale irrigation activity.

Key questions for the village level are :

1. What is the nature and extent of communally managed resources (grazing land, water, fish ponds, forests, etc.)?

2. How are these communal resources actually managed, individual access to them allotted, and conflicts resolved?

3. Will the loss of communal linkages in the villages seriously threaten the durability of the village in the face of crop instability and, if so, which linkages should be preserved or strengthened?

2. Farm Household

A detailed survey of 165 farm households in the four villages in Khon Kaen province (later used for testing the CSP's cropping systems, see next chapter), was carried out in 1976 (Chayabuthi and Kongkajandr, 1977). The survey was repeated, taking 129 households, in 1980 (Prapertchob, 1980). The crop years referred to are thus 1975 and 1979. These villages lie in the undulating land characterised by miniwatersheds. Von Fleckenstein (1980) has also carried out a detailed survey of six households in the village of Ban On in Roiet province where the land is mostly non-flood plain and miniwatersheds.

Structure

The rural household in the Northeast consists of a nuclear family of 6 to 7 people (Table 4.2). This typically comprises of parents plus 2 to 3 school age children, the remaining adults being the grand parents or a married daughter and her husband.

Table 4.2. Characteristics of farm households in Khon Kaen Province.

Number of households surveyed		129
People per household		7
Average number working fulltime		3
Average age of head of household		50
Education of household head		
No formal education	9.2%	
Prathom 1-4 (Elementary grades 1-4)	84.1%	
Above Prathom 4	6.9%	
Experience of formal farm training	34.6%	
Average land holding/household	31.8 rai	

Virtually all the households farm their own land, with over 16 rai being paddy land (Table 4.3). Farmers usually own both upland and paddy land but little is known of the relative distribution of upland, upper paddy and lower paddy. Distribution of such land types should greatly influence farmer selection of cropping systems, and a key question is : what is the pattern of distribution of land types on individual farms? In Roiet and neighbouring provinces, in addition to paleaquult and paleustult soils, farms may also be partially or wholly on dystropept and tropaquept soils, but again the typical distribution of soil types on farms in the non-flood and flood plains is not known.

Table 4.3. Average land holding and land use for 4 villages in Khon-Kaen Province.

Land holding	25.53		rai 1/
Owned land		25.06	"
Rented land		0.47	"
Paddy	16.75		"
Upland crops	6.00		"
Horticulture	0.09		"
Residential	0.51		"
"Idle"	2.17		"

Source: Chayabuthi and Kongkajandr (1977). 1/ 6.25 rai = 1 ha.

In addition to the major crop land, the farm usually consists of clumps of trees or individual trees. According to von Fleckenstein (1980), these are mostly kapok, coconut, banana, papaya, and mango, all grown for subsistance and sale, together with Leucaena grown principally for subsistance, the pods and tender shoots being eaten with almost every meal.

Most farms also have a vegetable garden for subsistance, located near the village and a good water supply. (The average size in Ban On, Roiet, was 48 sq. m.-von Fleckenstein 1980). Vegetables commonly include yardlong bean, chillis, garlic, onions, and chinese cabbage.

Livestock are also important. In the villages of Khon Kaen province, each household had on average 3 buffaloes, 1 cow, a pig, and several chickens. The buffaloes are used for farm work; oxen are no longer used for transportation in Isan. The cattle are stabled under the house at night, and the manure used on the land.

Silk worm rearing is also important in much of the Northeast. Mulberry bushes are grown either close to the village and near to the huts placed in the paddy land.

The final agricultural enterprise is fishing, and most farms have access to a fish pond, swamps, streams, or rivers. This is particularly true of those located in the flood plains. Rice paddies also serve as fish ponds during the wet season.

Dynamics

Rice is the dominant crop on virtually every farm in the Korat Triangle. The villages surveyed in Khon Kaen province produced about 227 kgs/rai in 1975 (a good year). Estimating an annual requirement of between 250 and 300 kg per capita implies that 16 rai of paddy land per family produces a large surplus over the needs of the 6-7 people in each family. However, the survey showed that 84.2% of the rice was consumed, i.e. nearly 500 kg/person, and only 7% sold for cash. As table 4.4 shows, the actual surplus was less than 25%.

In the village in Roiet province, the average yield was 300 kg/rai in 1978 (also a good year), but varied according to the soil type. Von Fleckenstein (1980) calculated that a family of 7 (4.5 man equivalents) required 246 kg/person. He estimated that a family would need, on this basis, 3.3 rai of alluvial complex (tropaquept, etc.), 4.8 rai of Roiet (paleaquult), and 6.3 rai of Ubon series (dystropept) soils in a good year, and nearly double the amount in a dry year.

Table 4.4. Rice production and utilization - average for four villages in Khon Kaen Province 1975/76.

Planted area	16.75 rai
Harvested	13.97 rai
Production	380.73 tang 1/
Yield per rai	22.76 tang
Consumption	84.20 %
Seeds	3.05 %
Animal feed	0.12 %
Exchange	0.15 %
Repay debt	0.96 %
To relatives	1.03 %
Wages	2.68 %
Rent	0.96 %
Sale	6.89 %
Surplus	0.23 %

Source : Chayaputhi and Kongkajandr (1977). 1/ 1 tang = 10 kg.

In 1975 the other important crop in the Khon Kaen villages was kenaf, but by 1979, this had been replaced by cassava. The relative contributions of the different crops to farm income are shown in Table 4.5.

Table 4.5. Gross income per household from agriculture for four villages in Khon Kaen province in 1979.

Rice	8,976	Baht 1/
Cassava	4,207	"
Kenaf	578	"
Mungbean	22	"
Peanut	56	"
Others	440	"
Crops total	14,270	"
Livestock & poultry	1,064	"
Total	15,334	

Source: Prapertchob (unpublished). 1/ 1 U.S. $ ≈ 23 bahts.

In the village of Ban On in Roiet, the net figures for cash crops are much less, but livestock and fishing is considerably more important (Table 4.6).

Table 4.6. Net income per household for 6 households in Ban On village, Roiet.

Rice	9,265	Baht 1/
Cassava & kenaf	688	"
Other cash crops	-37	"
Vegetables	115	"
Tree crops	620	"
Livestock and fishing	5,262	"

Source: Von Fleckenstein (1980). 1/ 1 U.S. $ ≈ 23 bahts.

Apart from climate and soil type, the two limiting factors in farm production are labour and credit. Farm size is relatively large for Thailand, exchange labour is restricted, and hired labour essential. Of the 165 farm families surveyed in the 4 villages in Khon Kaen province in 1975, 132 required additional labour (Table 4.7).

Table 4.7. Use of additional labour in four villages in Khon Kaen province in 1975.

Month	Families requiring extra labour	Task	Families requiring extra labour
April	10	Rice	
May	2	Ploughing	4
June	9	Transplanting	32
July	15	Harvesting	37
August	11	Threshing	16
September	1	Weeding	7
October	5	Kenaf	
November	37	Culting	15
December	28	Retting	17
January	7	Cassava	
February	4	Ploughing	1
March	3	Harvesting	7
		Water melon	
		Ploughing	1
		Harvesting	1

Source : Chayabuthi and Kongkajandr (1977).

Fifty-five per cent of the households in the 4 villages in Khon - Kaen province borrow money(average of 1,884 baht per family). About half is for production and half for consumption. Major sources of credit include cooperatives, merchants, the Bank of Agriculture and Agricultural Co-operation (BAAC), with minor sources being neighbours, relatives, and farmer groups. Most were of short and medium term but ranged in interest from 12% for BAAC, cooperatives, and farmer groups to 56% from merchants.

Farm households in the Northeast are not, however, confined to agricultural production. Non-agricultural enterprises and off-farm employment make up a rapidly growing component of farm income.

The range of household enterprises is illustrated by a recent survey (Table 4.8). Members of the household also increasingly work in nearby towns in agricultural processing, construction, textiles, wood, bamboo, and cane manufacture, and services, as well as on the government sponsored rural work program. The relative contribution of these activities to farm income in the Roiet village in shown in Table 4.9.

Table 4.8. Households engaged in non-agricultural household enterprises.

	Khon Kaen	Roiet
Households surveyed	418	278
Silk	132	21
Cotton	30	
Mats	93	
Baskets	44	21
Poultry	18	
Salt		10
Knives		22
Rice containers		13
Oxcarts		22

Source: Mead and Charsombat, 1980.

Table 4.9. Income (baht) from non-agricultural enterprises - Ban On village, Roiet.

Production	1,574
Trading	3,968
Services	17,858 (one sample)
Gambling	-821
Government wages	1,012
Fellow farmers	557
Others	1,039
Gifts in cash & kind	2,743

Source: Von Fleckenstein, 1980.

For the 4 villages in Khon Kaen province, off-farm income per household in 1979 amounted to 10,105 baht (compared with 15,334 from agriculture). The growth rates since 1975 are as follows (in real terms).

	Farm income/capita	Off farm income/capita
1975	1,411	160
1979	1,736	1,144
Growth rate	5.32%	63.52%

Decision Making

Northeastern farmers are not simply rice growers engaging in a single economic activity. Instead, they appear to be managing a quite complex resource system (Figure 4.5) in which their interaction with any single component is likely to affect their relations with other components. For example, even if sufficient water can be provided for second crop, no crop may be grown since off-farm labour employment may yield higher returns, thus drawing off available rural labour supply.

There is little published information on farmer goals and values in the Korat Triangle. However good clues can be obtained from the studies described above and from direct observation and experience.

Farmers appear to highly value independence and freedom. The growing of sufficient rice to feed their family each year is a major goal. They also try to grow sufficient vegetables, fruit and poultry for their own subsistence needs. But, in addition, they value religious merit and need cash to make as gifts to the monks, as contribution to the upkeep of the wat, and for ordination of the young men. They also value education and health and require cash for these, too. Finally, they need to be in good standing with their neighbour and relatives, able to pay off debts, give cash and goods to those who need them, and provide for feasts and ceremonies as the occasion arises. These appear to be basic needs. Over and above these, farmers seek to generally in-

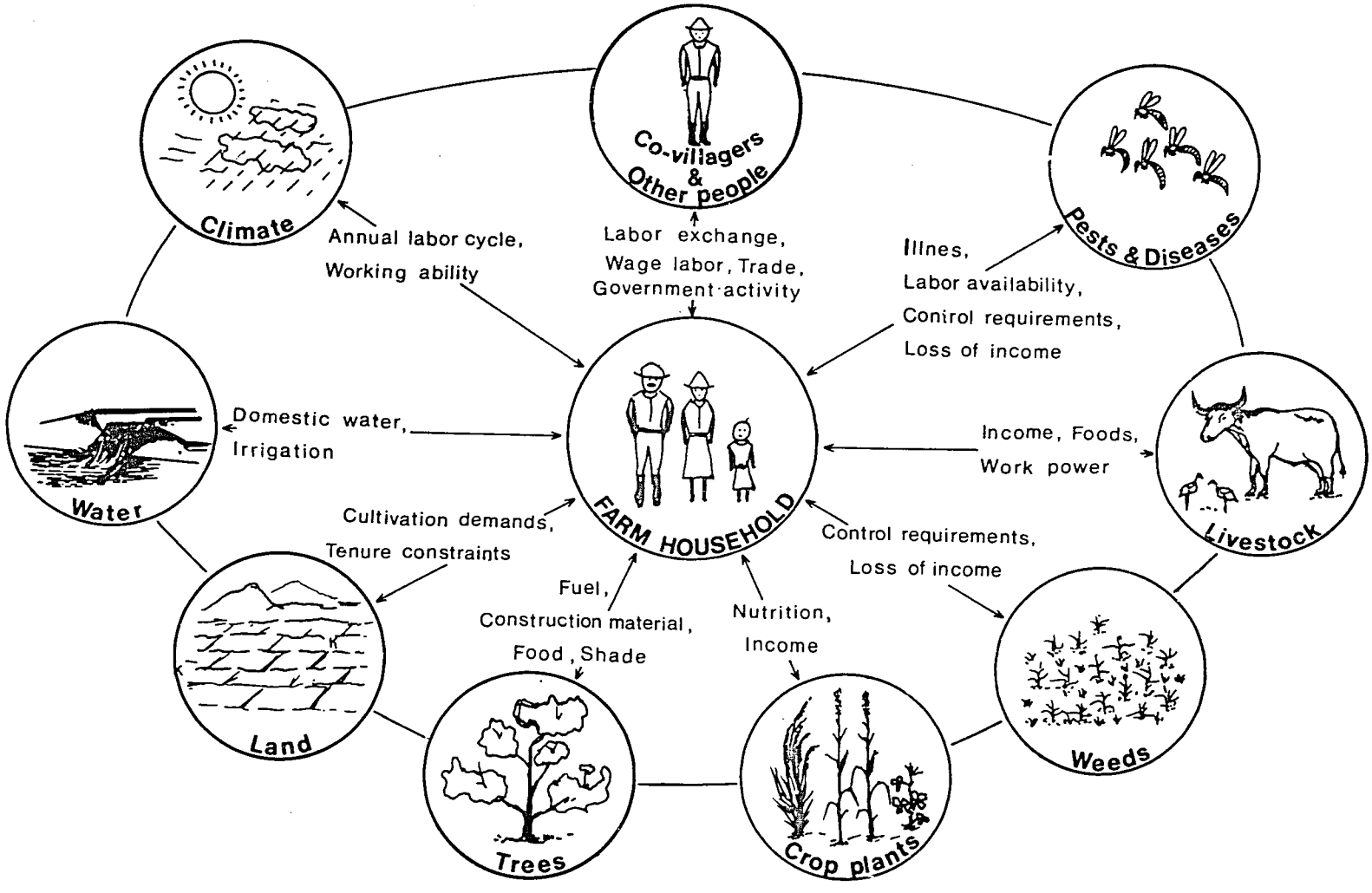


Figure 4.5. The Northeast farm level resource system.

crease their income, and as the rapid growth in recent years of both on-farm and off-farm non-agricultural employment shows, they are quick to take advantage of real opportunities.

Given these goals and their relative priorities, farmers are able to adopt one of the relatively small number of strategies which depend on

1) the amount and type of land available,
2) the amount and skills of labour available,
and 3) opportunities for off-farm employment.

The strategies may be roughly classified as follows:

Conditions	Strategies
1. Subsistance cropping not a goal (rare)	COMMERCIAL (grow cash crops, buy rice)
2. Less than or just sufficient paddy land or labour for subsistence	SUBSISTENCE DOMINATED
a) village or farm labour opportunities	a) PLUS FARM OR VILLAGE LABOUR
b) off-village labour opportunities	b) PLUS OFF-VILLAGE LABOUR
c) craft skills	c) PLUS FARM CRAFTS
3. More than sufficient paddy land for subsistence	CASH DOMINATED
a) uplands and labour available	a) UPLAND CROPPING
b) water in dry season	b) DRY SEASON CASH CROPPING
c) pasture land and labour	c) LIVESTOCK FOR CASH
d) craft skills	d) FARM CRAFTS
e) off village labour opportunities	e) OFF VILLAGE LABOUR

Within these broad strategies, farmers will adopt variable tactics from year to year, season to season, and ever week to week, based on available labor and their control of it, employment opportunities, the relative anticipated prices of the major crops, and rainfall.

A key question which is still unanswered is :

What are the attitudes, values, and goals of farmers in the Triangle, and how do these determine the choices of subsistence and cash strategies?

Other questions concerning the farm are :

How do typical farms behave as resource systems, in particular, what are the key components and the important human management inputs which they require?

What are the critical limiting factors (capita, labor supply, water etc.) at the farm level for expansion and intensification of various kinds of produce? For example, why do not farms in the Triangle raise more livestock, or ducks, or chickens, and silkworms than they do?

and most important

What are the best mixes of land and soil types, and of crops, livestock, farm crafts, and off-farm employment for promoting productivity, stability, and durability of farm income?

CHAPTER FIVE
CROPPING SYSTEMS

1. The Seasonal Climate

We have chosen two climate stations, Khon Kaen and Roiet, in order to describe the main types of seasonal climatic pattern in the Triangle. Khon Kaen has an annual rainfall of less than 1,200 mm, while that of Roiet is over 1,300 mm. Khon Kaen also represents an area dominated by miniwatersheds, while the topography of Roiet mostly consists of flood and non-flood plains.

Rainfall

Despite the differences in total rainfall (Khon Kaen has 1,185 mm and Roiet 1,405 mm), the seasonal patterns in the two areas are quite similar (Figure 5.1a and 5.2a). Over 95% of the rainfall occurs in the months of May to September, with the latter month receiving the heaviest rain (272 mm in Khon Kaen and 314 mm in Roiet). In both locations, potential evapotranspiration fluctuates much less than rainfall, with the lowest values in September (108 mm in Khon Kaen and 75 mm in Roiet) and the highest values in March for Roiet (148 mm) and April for Khon Kaen (174 mm).

In general, the potential evapotranspiration is lower in Roiet than Khon Kaen. Coupled with the greater rainfall, this results in an extra 357 mm of water for crop growth in Roiet (more than double Khon Kaen water) during the May to October period. The water balance becomes positive two weeks earlier in Roiet and progressively increases, while for Khon Kaen there is barely a positive balance for the first three months.

A key question is: <u>what is the soil moisture storage potential under these two regimes, and how can it best be exploited for more intensive cropping ?</u>

The number of rainy days in each location closely follows the rainfall pattern. There is no significant difference in the pattern of

rainy days between the two locations (Figure 5.1b and 5.2b), and this is also true for the other climatic parameters.

The major feature of the rainfall is the very marked contrast between the rainy season May to September, with 80 rainy days out of the total of 107 rainy days in the year, and the dry season with only 17 rainy days in the six months from November to April.

Relative humidity and temperature

Relative humidity and temperature are both high in the Northeast. The mean monthly maximum RH varies slightly from 82 to 92%, although the minimum drops sharply from a peak of 67% in September to about 42% in March (Figure 5.1c and 5.2c).

Mean monthly maximum and minimum temperatures have their lowest values in December/January (29°C and 15.9°C, respectively), and then rise sharply, reaching their highest value by April/May (36°C and 25°C, respectively).

Solar radiation

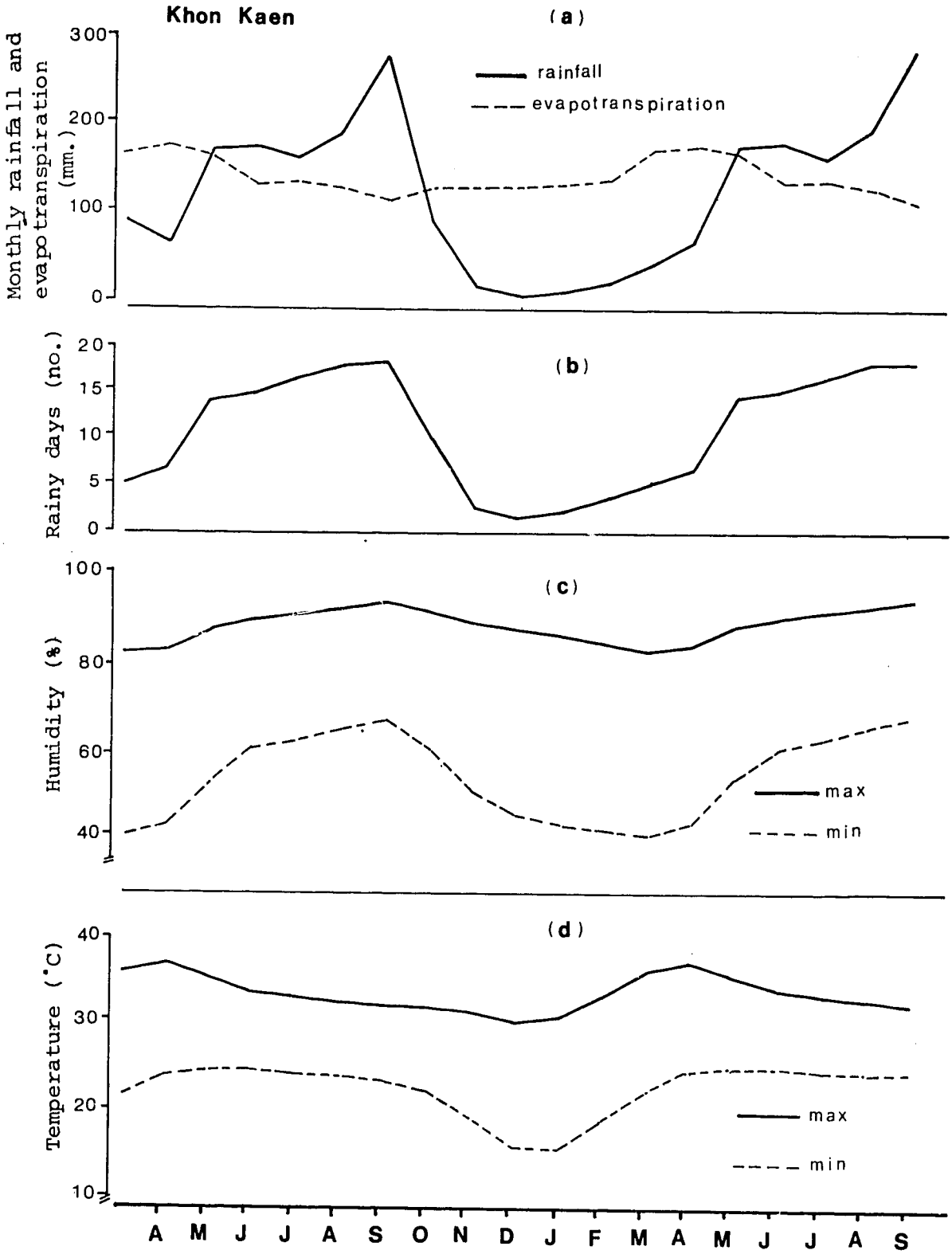
Although there is only two years of solar radiation data available, there is a consistent pattern within the year (Fig. 5.3), with a low of about 9-10 Kcal/cm^2/month in August/September and peak of 15-17 Kcal/cm^2/month in April.

Future Analysis

A key question, which still remains unanswered, is: how can the climatic pattern be most appropriately classified for agronomic purposes, and what extra parameters and analyses are required to do this ?

2. Existing Cropping Systems

The existing cropping systems in the Korat Triangle are described in Figure 5.4.



Figur e 5.1. Seasonal climatological data for Khon Kaen (1951-1975).

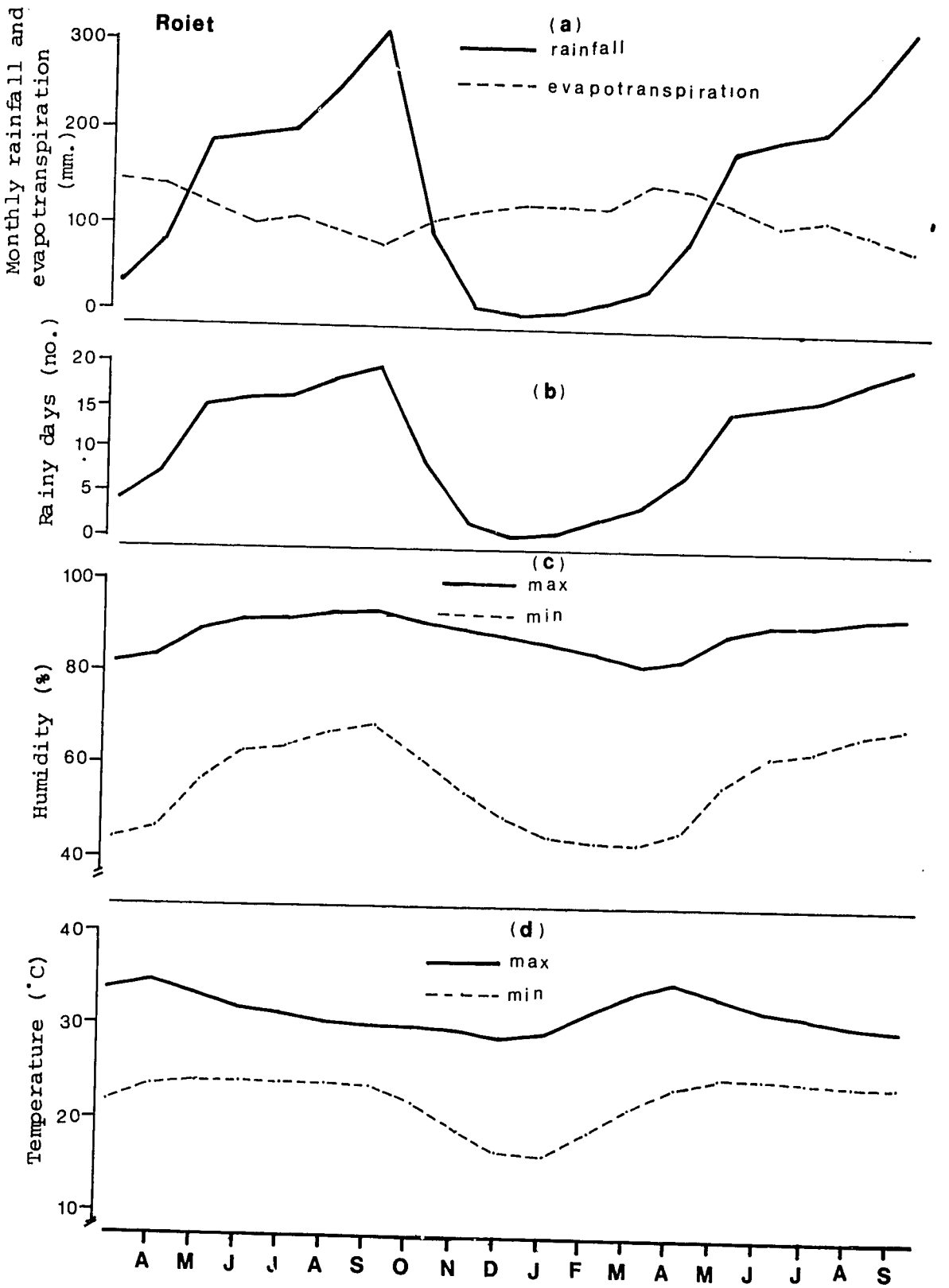


Figure 5.2. Seasonal climatological data for Roiet (1951-1975).

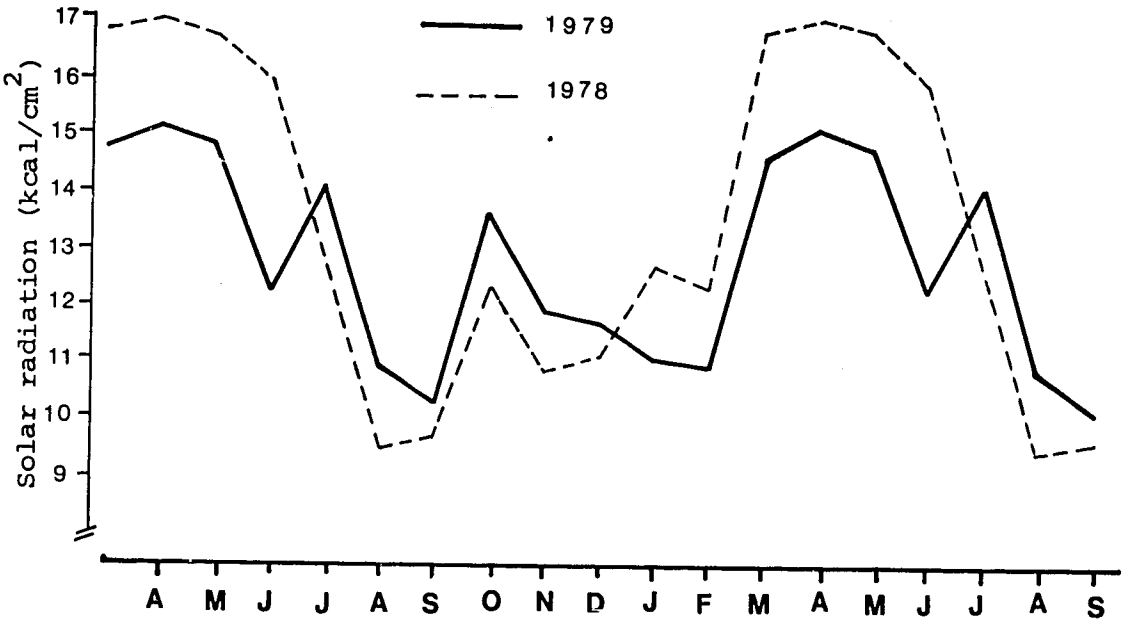


Figure 5.3. Solar radiation for Khon Kaen.

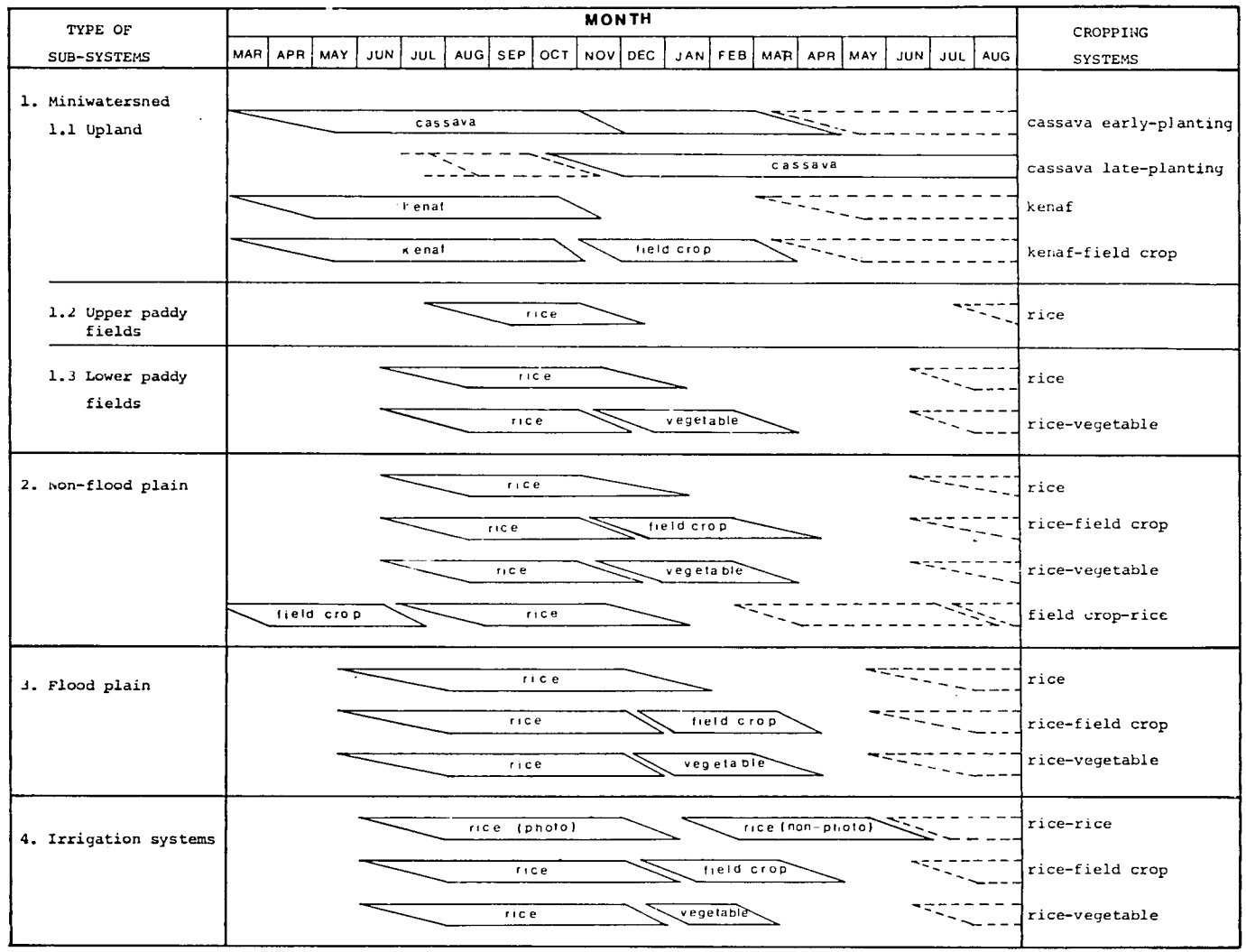


Figure 5.4. Calendar of the existing cropping systems in the Korat Triangle.

Remarks : 1. Field crop = short duration (< 120 days).

2. Vegetables grown after rice need watering from shallow wells or farm ponds.

Mini-watershed

If good rains come early, then land preparation and the sowing of nursery beds can start from the middle of May. The lower paddies will tend to be transplanted first, from mid-June, with the upper paddies as late as mid-September or not at all, depending on the time it takes for sufficient water to accumulate. Harvesting occurs from the end of October to the middle of December, according to variety.

The varieties planted are mostly traditional tall, photosensitive varieties such as the glutinous rice Niew San Pathong, Kam Pai, or in the non-glutinous areas of the south, the variety Khao Dauk Mali.

The upper paddies differ considerably from the lower paddies in terms of the main limiting factors. Transplanting is later, and the upper paddies dry out faster. They are more subject to drought stress. Some farmers plant shorter maturing varieties, such as Pong Aew, in the upper paddies. A key question is: what are the specific desired characteristics of upper paddy varieties; does Pong Aew meet these fully and, if not, is it desirable or feasible to develop special varieties for upper paddy cultivation ?

A related question is: how can low rice yields in the upper paddy due to late planting be improved ? Poor rains mean that in many years the upper paddies are planted very late, and the short growing period plus drought stress at the end results in considerable yield reductions. Can this be avoided, not only by improved varieties, but by new cultural or water management practices, for example, by double transplanting or by altering the number of transplants per hill ?

On the upland, cassava may be grown all year round since it is non-photosensitive, providing there is sufficient soil moisture. There are, however, usually two planting periods. From the end of February to the middle of May, planting occurs right after the first shower of sufficient size ($>$ 15 mm). The second period occurs directly after the rainy season, between early October and early December, the duration depending on the availability of soil moisture.

Kenaf, however, is photosensitive and hence has to be planted after the first rain in April or May, and harvested, at flowering, from the middle of October to early November. Yields are markedly reduced by late planting or early harvesting.

Local varieties of kenaf and cassava are mostly planted.

Following the rice crop in the lower paddy, some farmers dig small ponds, close to the villages, which hold over water from the rainy season. These are used for hand irrigation of small plots of vegetables, including green corn, egg plant, tomato, cucumber, chinese cabbage, kale, shallot, garlic, and yard long bean.

Non-Flood Plain

Rice is grown throughout the non-flood plain in a similar manner to that used in the lower paddies of the watershed. Transplanting occurs from May onwards depending on the presence of sufficient water, arising directly from the rain or from runoff from higher land. Traditional photosensitive varieties are grown, but whenever double cropping is possible, early maturing varieties, such as Pong Aew, are used.

Much of the soil is sandy (paleaquult or dystropept), but in many areas, there is apparently a heavy clay layer beneath, and the water table is only 1-2 meters below the surface in the dry season. Farmers here dig shallow wells and irrigate vegetables on up to 2 rai, by hand, following the rice crop. The vegetables grown are similar to those in the lower paddies.

In some areas, with shallow water tables, a second crop is possible without irrigation. Crops include water melon, pumpkin, sweet potato, peanut, and native cowpea. Presumably, these are sufficiently deep rooted to utilise the existing, if meagre, soil moisture. In Burirum, there is a small area where sesame can be grown before the rice crop. The water table is reportedly less than 2½ meters from the soil surface, and the sesame seed is direct broadcast after a single ploughing and harrowing at

the end of February or March, following the first showers. The crop is harvested in June just prior to transplanting of the rice crop.

Flood Plain

The rice here is generally broadcasted in June or July. Flooding tends to occur from the end of September to the middle of October, lasting 1 to 3 weeks. If the flood is deep or long lasting, or if the water is highly turbid, the rice crop may be seriously damaged.

In general, the same varieties are grown as in the non-flood plain. The deep water or floating rice varieties characteristic of the central plain are not grown, presumably because the flooding is normally of a relatively short duration. Some farmers do, however, grow late maturing varieties which are harvested in January. A key question is: whether varieties can be developed which will give more stable yields under these variable flood conditions?

Vegetables or short duration field crops may be grown after the rice crop, using water from shallow wells and farm ponds, but many farmers find it more profitable to catch fish left over in the ponds and swamps after the floods recede.

Irrigation Systems

Here, in addition to planting traditional photosensitive glutinous rice varieties in the rainy season using supplemental irrigation, farmers may grow non-sensitive, short duration and usually non-glutinous varieties in the dry season. This second crop is transplanted in January/February and harvested in May/June. However, the proportion of irrigated land currently double rice-cropped is still small presumably due to the limitations of labour, cash, and even reliable water supply in many of the schemes.

On the sandier irrigated schemes, field crops including glutinous corn, turkish tobacco, peanut, water melon, and vegetables are grown after the rice. These usually mature in less than 90 days, with the exception of the low water requiring peanut varieties which take 120 days.

3. Labour, credit and prices

On the whole, the seasonal distribution of labor demand is extremely uneven, with the highest demand in the wet season and the lowest in the dry season, resulting in considerable under employment (Ng, 1970). In the typical farm of Khon Kaen, with an average of per family and 17 rai per farm, only three members are working full time (Chayabuthi and Kongkachandr, 1976). Assuming 22 work days in each month for a family, then the labor availability would be about 792 man-day per season (Suphancnaimat, pers. comm.).

The labor demand for various crops are presented in Fig.5.5.

For the glutinous rice (Fig. 5.5a, b), the total labor requirement is slightly greater in rainfed than that in irrigated conditions. This is due to the difference between labor requirement for seed bed and land preparation at the beginning of the growing season. The highest labor requirement may be seen in non-glutinous rice under irrigation (Fig. 5.5c), and the lowest requirement in rainfed non-glutinous rice (Fig.5.5d). The rice yield for the irrigated crop, however, is much higher than those in the rainfed non-glutinous crop (Fleckenstein, 1980). The general patterns of labor requirement for all the rice crops are more or less similar.

In a cool season crop, tobacco (Fig. 5.5e), the high labor requirements from December to January are mainly for harvesting and processing.

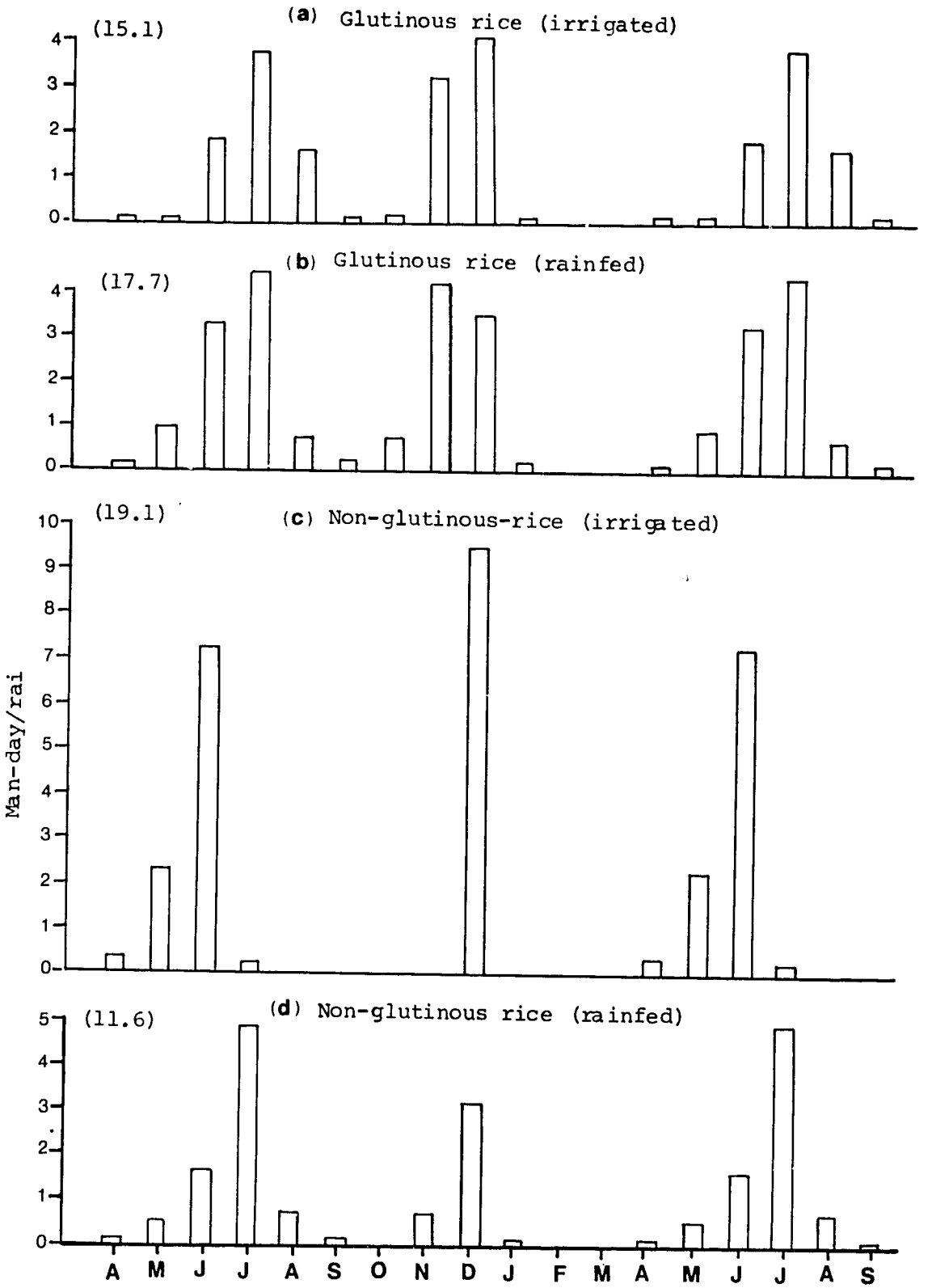


Figure 5.5. Labor demand (man-day/rai) for various crops. Figures in parenthesis indicate the total man-day/rai; 1 man-day = 8 man-hr. (Fleckenstein, 1980).

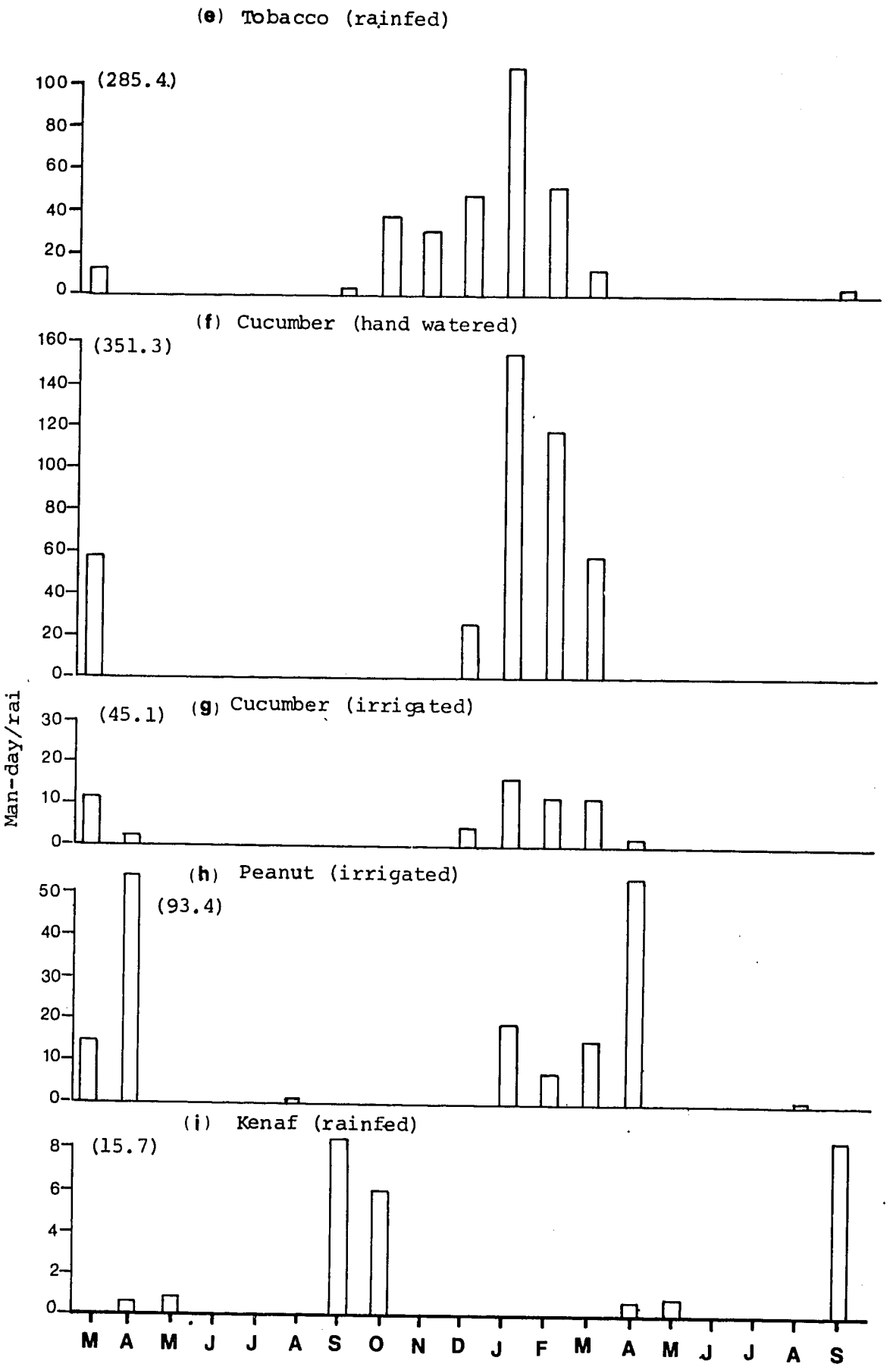


Figure 5.5. (Continued).

4. Stress and Perturbation

Climate

Erratic rainfall, both in intensity and distribution, stresses and perturbs crop establishment and growth in most seasons, and is the main cause of the considerable yield fluctuations which are characteristic of the region.

If the rains are late at the beginning of the paddy season, nursery bed preparation is delayed with consequent late transplanting. The latter may also occur because of a prolonged dry spell after the first rains. Farmers cope with this by transplanting older seedlings (more than 2 months old) direct into the unpuddled soil once it is adequately moist, in the hope that sufficient rain will arrive later. More seedlings per hill will also be transplanted, because older seedlings will produce fewer tillers. To overcome the problem of delayed transplanting, the Rice Division has recommended direct seeding by which rice seeds are sown into the ploughed land around June/July. The technique has shown advantages over transplanting, however, fields sown in this way often suffer from serious weed problem.

Perhaps the greatest perturbation arises when a prolonged drought sets in after transplanting and the young seedlings are killed. This may occur too late in the season for a new nursery bed to be established.

The use of photosensitive varieties seems particularly adapted to drought situations, since with these varieties, the most drought sensitive developmental stage in rice, from panicle initiation to fertilization, occurs in September when the rains are usually high. The importance of October drought, which is more common, on grain filling is not known.

In general, drought stress is more critical on the upper paddies than the lower paddies, and more important in the watersheds than in the plains.

Flooding is not normally a serious problem for rice, since the crop has basically evolved to tolerate flood conditions. But prolonged submergence for a long period (7-10 days), particularly in turbid water, results in reduced photosynthesis and damage to the crop or even crop loss. Flasn floods of 1-3 weeks often occur on the flood plain from September to early October. Farmer here often broadcast the seed which results in plants with stronger roots, more able to withstand such floods.

Drought does not appear to cause serious damage to cassava or kenaf in the Triangle, as the rainfall is already relatively high for these crops. However, they may be seriously damaged by flooding or waterlogging as occurs when they are grown on soils with poor drainage, for example, adjacent to the upper bunded paddy fields. Of the two crops, cassava is more sensitive; a week of waterlogging may rot the cassava roots below ground.

Soils

The primary cause of the soil problems in the Korat Triangle is that most of the soils (other than in the flood plains) are derived from porous sandstone strata, which are low in both macro and micro essential elements. The principal characteristics of the main soil series in the Triangle are shown in Table 5.1.

The paleaquult and paleustult soils are typically sandy, low in organic matter, and have a kaolinitic clay complex in the subsurface. They have, by nature, a low cation exchange capacity (CEC), both in the surface and subsurface, and a low effective water holding capacity.

A major feature of these soils is their very considerable heterogeneity on a microscale. Fields often show patchy, uneven crop growth. Minor lateral variation in such characteristics as the depth and organic matter of the surface layer, the textural profile and pH, base saturation, and trace element content is disproportionately reflected in crop growth, because the variability is not buffered due to the low CEC. It has been

Table 5.1. Salient features of major soil types in the Korat Triangle.

	Great Group Soil Series (examples)	TROPAQUEPT Ratchaburi Phimai	DYSTROPEPT Ubon	PALEAQUULT Roiet	PALEUSTULT Korat
1.	Texture	clay or silty clay over clay	loamy sand over loamy sand to sand	sandy loam or loamy sand over loam to clay	sandy loam over loam to clay loam
2.	Drainage	poor	excessive or well	poor	moderately well
3.	Permeability	slow	rapid	moderate	moderate
4.	Surface run off		slow		rapid
5.	Flooded	to 50 cm. for 3-4 months	to 20 cm. for 2-3 months	to 50 cm. for 3-4 months	none
6.	Dry season water table	1.5 m	4 m	2 m	-
7.	Organic matter	1-1.5%	0.5-1.0%	0.5-2.5%	1-2.5%
8.	Base saturation		35-75%		
9.	Cation exchange capacity	15-30 ppm	<3-5 ppm	<3-10 ppm	3-10 ppm
10.	Available phosphorus	<3-10 ppm	<3 ppm	<3-45 ppm	3-6 ppm
11.	Available potassium	90->120 ppm	<30-60 ppm	30-120 ppm	30-120 ppm
12.	pH	5.0-6.0	5.0-6.0	4.5-5.5	4.5-6.0

found, for example, that differences of a few tenths of a per cent may disinguish good and bad growth spots in a field.

The pattern of previous vegetation may be one basic cause of the variability. Some trees, for example palms, may have increased local organic matter accumulation, while others may have increased leaching. Termite mounds may have a positive or negative effect. Management practices may also be critical, particularly unevenness in clearing, in depth of ploughing, and in fertilizer application. Such practices establish complex patterns of local erosion and sedimentation.

A key question is: what are the principal causes of microvariability in Northeast soils, and can cropping practices and systems be devised which will overcome the instability of yields this creates?

Because the soils are coarse textured and have low organic matter, they are highly erodable, and hence further subject to depletion of essential nutrients. Erosion is particularly severe on the upland areas of the miniwatersheds. A key question is: are there cheap methods of erosion control in the upland areas which will be really effectives ? However a related question is: do the lower paddy fields require a certain level of erosion above them to maintain fertility ?

Erosion is a serious problem under cassava, since it is grown in rows one meter apart, and it takes 3 to 4 months for the canopy to close. Intercropping, particularly with a legume, is a possible answer. Minimum tillage of cassava has also been advocated as being beneficial, not only in reducing soil erosion, but in reducing evaporation and increasing water infiltration.

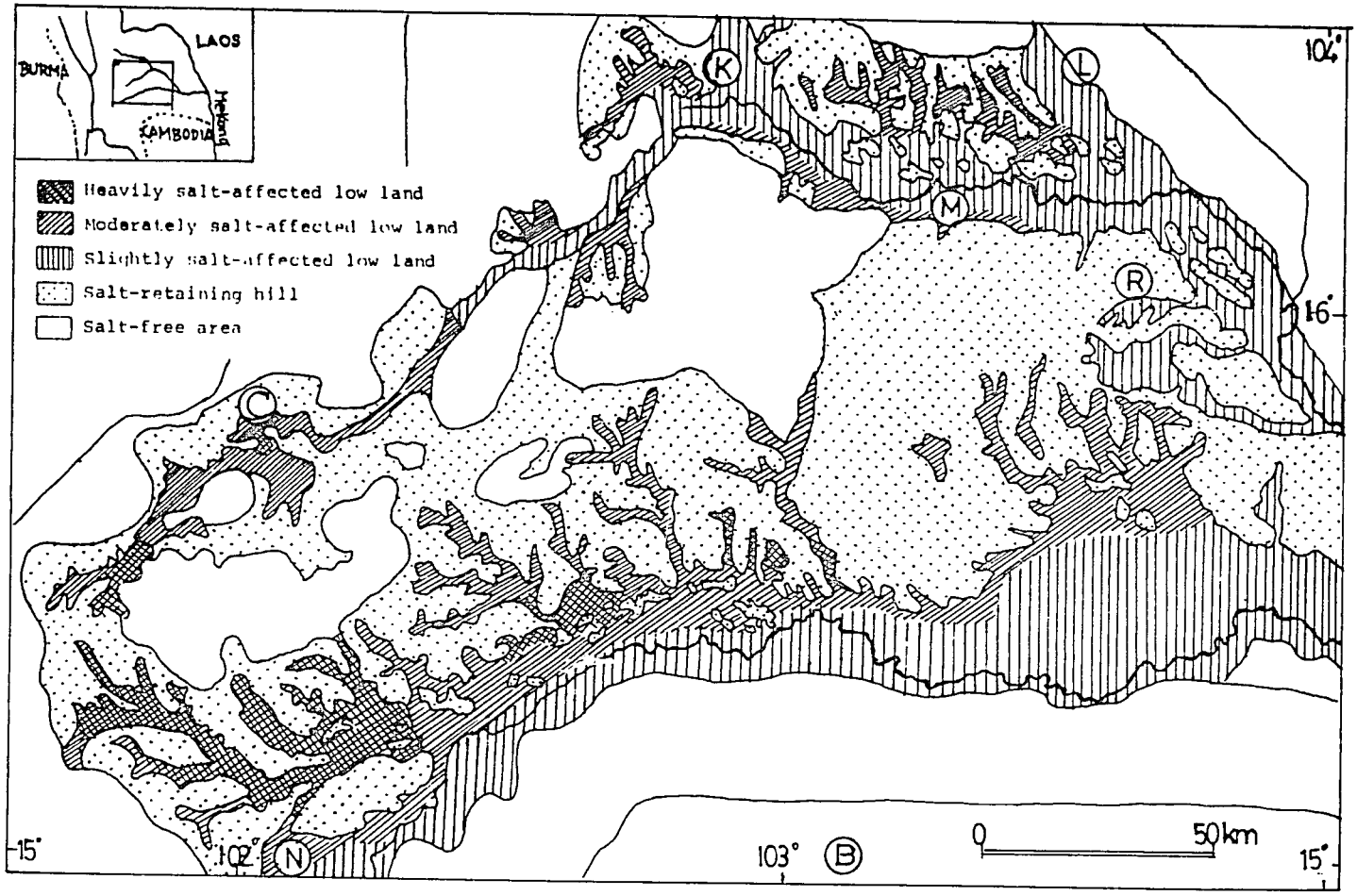
Restoration of organic matter not only reduces erosion but increases the water holding capacity of the soil and the uptake by crops of the existing nutrients. A number of possibilities exist. Kenaf, cassava, and peanut residues, rice straw, and rice hull could be incorporated in the soil after harvest. Difficulties are the transportation costs in-

volved in some cases, and the difficulties of incorporating the material without tractor power. Composting has also been advocated, particularly where legume residues are available. It has the advantage of acting as slow release fertilizer on the sandy soils where nutrients are normally leached away rapidly. Drawbacks are the high labour and water requirements and lack of suitable composting material, but it would see particularly suitable for the post-rice vegetable crops in the non-flood plains and lower paddies of the watershed.

A final soil problem is that of salinity. Figure 5.6 shows the distribution of major areas of salinity in the plains of the Korat Triangle. Suggestions for saline soils (Department of Land Development, 1979) include the use of rice hull mulches to retain soil moisture and the growing of salt tolerant crops. Apparently, two rice varieties, Massuri and Domoder, have demonstrated saline tolerance. The Department also recommends saline tolerant trees for woodlots and certain pasture grasses and legumes.

Weed stress

There are many weed species, ranging from broad leaved weeds, grass weeds, to sedges, present in the Northeast. From a recent survey, Palaluk et al. (1980) identified 42 species which are the most common weeds in the Northeast. There are, however, 17 species identified as noxious weeds, and these are listed in Table 5.2.



(K)	Khon Kaen	(L)	Kalasin	(C)	Chaiyaphum
(B)	Burirum	(M)	Mahasarakham	(R)	Roiet
(N)	Nakhon Ratchasima				

Figure 5.6. Saline soils in the Korat Triangle (Sinanuwong and Takaya, 1974).

Table 5.2. Noxious weeds in the Northeast.

Local name	Common name	Scientific name
Nuad Pla Duk	Hoorah grass	*Fimbristylis* spp.
Yan Hua Ngoke	Pipewort	*Eriocaulon cinereum*
Kra Thin Thung	Yellow-eyed grass	*Xyris indica*
Tien Na	Water primrose	*Jussiace limifolia*
Huay Chin-see	-	*Rotala indice*
Pak Khom	Amaranth weeds	*Amaranthus* spp.
Pak Bea Hin	Giant pigweed	*Triantheme puntulacastrum*
Pak Bea Yai	Purselane weed	*Portulece olerae*
Nam Nom Rachasee	Garden spurge	*Euphorbia hirta*
Barn Hai Rue Roy Pa	-	*Gomphrene celosioides*
Yah Prak	Bermuda grass	*Cynodon dactylon*
Yah Park Kwai	Crowfoot grass	*Dactyloctenium aegyptium*
Teen Tug Kae	Tridex	*Tridex procumbens*
Haew Hu	Nutsedge	*Cyperous rotundus*
Kok Sai	Umbrella sedge	*C. iria*
Kok Dok Ban	Hedgehog cyperus	*C. compressus*
-	-	*Commeline* spp.

Source: Palaluk et al. (1980).

Under rainfed conditions, yield reductions in rice due to weed competition are relatively variable, ranging from 7.2% at Pimai to 33.9% at Ubon (Table 5.3). In Ubon, the glutinous rice Niew San Patung appeared to have a better ability to compete with weeds. The variability was also evident in both years and locations. At present, farmers only control weeds in the rice field once, at about 45 days from transplanting. This is done manually by hand pulling.

Table 5.3. Effects of weed competition on the yields (kg/rai) of two rice cultivars at two locations.

Year	Treatment	Grain yield (kg/rai)		
		Ubon		Pimai
		NSPT	RD 5	RD 5
1976	No weeding	275	235	408
	Weed control	332	318	574
1977	No weeding	207	167	405
	Weed control	282	253	500
1978	No weeding	-	-	347
	Weed control	-	-	373

Note : NSPT is the traditional glutinous rice called Niew San Pa Thong. RD 5 is the high yielding and non-glutinous cultivar. It originated from the cross between Paung Nak 16 and Sigadis, and was released in 1973.

Source : Rice Div., Min. of Agric. and Coop., 1980 note I.D.A. credit No. 461.5H.

In the upland crops such as kenaf, the effects of weeds are to reduce the fibre yield in the order of 28 per cent (Theerawatanasakul et al., 1976). Similarly, yields of cassava may be reduced by as much as 37 per cent (Sintuprapa et al., 1973). Although a number of herbicide screening experiments have been carried out for most crops, a basic understanding of crop and weed relationships has yet to be developed in order to devise effective control programs. This understanding needs to encompass relative changes in weed populations, shifts in weed species, and basic information on crop and weed competition.

Pests and Diseases

The major pests and diseases of rice are listed in Table 5.4.

Table 5.4. Major pests and diseases of rice.

Pests		
	Rice stem borers	Tryporyza incertulas, Chilo suppressalis, Chilo polychrysus, and Sesamia inferens
	Green rice leafhoppers	Nephotettix virescens and N. nigropictus
	Brown planthopper	Nilaparvata lugens
	White-backed planthopper	Sogatella furcifera
	Rice gall midge	Orseolia oryzae
	Rice army worm	Spodoptera mauritia
	Harvest cutworm	Mythimna separata
	Rice trip	Chloethrips oryzae
Diseases		
	Bacterial leaf blight	

The rice stem borer causes dead hearts, when it attacks the young tillers which turn brown and die before producing heads, and white heads, when the older tillers are attacked leaving upright whitish panicles with empty grains. The average damage is about 5% in the first crop and increase to 10-15% in the second crops, but it is likely that the damage is more locally serious than this broad survey suggests.

Leafhoppers and planthoppers suck the plant sap and also transmit virus diseases. The green rice leafhopper transmits yellow orange leaf virus, while the brown planthopper transmits ragged and grassy stunt. In the field, the planthopper is always found on the lower part of the rice stem near the water level, while the leafhopper is feeds on the upper part of the plant. Brown planthopper causes hopperburn, destroying the plants in the late period of the season. It is less serious than in the central region of Thailand where the short, high tillering rice varieties are recommended and widely used. The extensive use of fertilizers and insecticides and planting in irrigated areas appear to favour out-breaks of brown planthopper.

Rice gall midge causes the silver shoot symptom in the tillering stage, the larvae damaging the initial buds, causing the flag leaf to turn silver. This completely inhibits panicle production. Rice thrips generally occur in the dry period of early July. In flood years, there are also outbreaks on rice of armyworms or harvest cutworms after the floods.

Bean fly (Ophiomyia spp.) is a serious pest of mungbean. Up to 80-90% of the seedlings and young plants are destroyed, especially in crops grown in the early rainy season. The larvae usually cause lodging of the seedlings, but cowpea can usually tolerate this damage by producing new shoots. Flower and pod borer (Maruca testulalis) attacks the flowers, peduncles, and pods of legumes. Blister beetle (Mylabris phalerata) damages the flowering stage, and is usually serious in some years. Peanut is often seriously damaged by the pod eating ant (Dorylus orientalis). It is particularly serious is newly cleared forest areas. Major diseases of legumes are Cercospora leaf spot, powdery mildew, and charcoal rot of mungbean; Cercospora leaf spot and rust of peanuts, and bacterial pustule, and rust of soybean.

Red spider mite (Tetranychus truncatus) is a serious pest of cassava, with outbreak during the dry period (February-March) or when heavy rain is followed by a dry period. This pest sucks the sap and causes the leaves to turn yellow, and die. It is also one of the most serious of kenaf pests especially in the seedling and vegetative stage. They suck the sap and cause stunting and curl of the leaves, which become yellow and die. Outbreaks depend on the climate; years with heavy rain followed by a dry period favour the pest. Early planting, before the middle of May, permits the crop to escape from jassid attack.

There are no serious diseases of cassava but Phytophthora stem rot causes damage to keanf in some years.

Corn leaf aphid (Rhophalosiphum maidis) usually sucks the plant sap in the early and late whorl stage, and transmits a virus disease. The

armyworm (Mythimna separata) feeds in the folded leaf, between leaf sheaths and the stem. Corn borer (Ostrinia furnacalis) usually causes serious damage, especially to super sweet corn. It is found in late whorl, tasseling, and ear forming stage. The larvae bore into the stem beneath the node and build a tunnel which causes lodging of the stem. Major diseases of corn are downy mildew and Helminthosporium leaf spot.

The major insect pests of sugar cane are Chilo spp., the larvae attacking all the development stages of the plant. In the tillering period, the larvae damage the growing points, resulting in dead hearts. The infested tillers finally died. In the stem elongation period, the larvae of Chilo and other species bore into top part of the cane stalks. The susceptable sugar cane varieties are Q 83 and H 38. The major diseases of sugar cane are white leaf and smut.

Locusts (Hieroglyphus banian, Patanga succincta, and Locusta migratoria manilensis) also cause sporadic but serious damage in Udon Thani.

Most of the farmers in the Northeast do not apply pesticides to rice, in contrast to farmers in the central plain. They apparently lack money to buy either pesticides or fertilizers. They are, moreover, reluctant to invest in crop protection when there is a higher probability of destruction of the rice crop due to floods and drought. Some farmers are also aware of dangers of toxicity to fish in the rice fields.

Many farmers do, however, apply insecticides to corn and leguminous crops. But in general, farmers in the Northeast have a poor knowledge of the life history of pests and diseases, and often only perceive damage when it is too late to take corrective action.

Some key questions are:

1) what are the actual crop losses due to the major pests and diseases, and their associated probabilities of occurring ?

2) under what circumstances are pesticide applications likely to prove economic, and when should they be made ?

3) what cheap and effective biological and cultural controls potentially exist in particular for legumes ?

5. Improved Systems

Objectives

Within the broad objectives outlined in Chapter one, a number of cropping systems have been developed to suit the range of conditions typical of the mini-watersheds in the region.

These systems fall into the following broad categories:

Upland area

1. Cassava-field crop intercropping
2. Kenaf-field crop double cropping
3. Double cropping of field crops

Upper paddy area

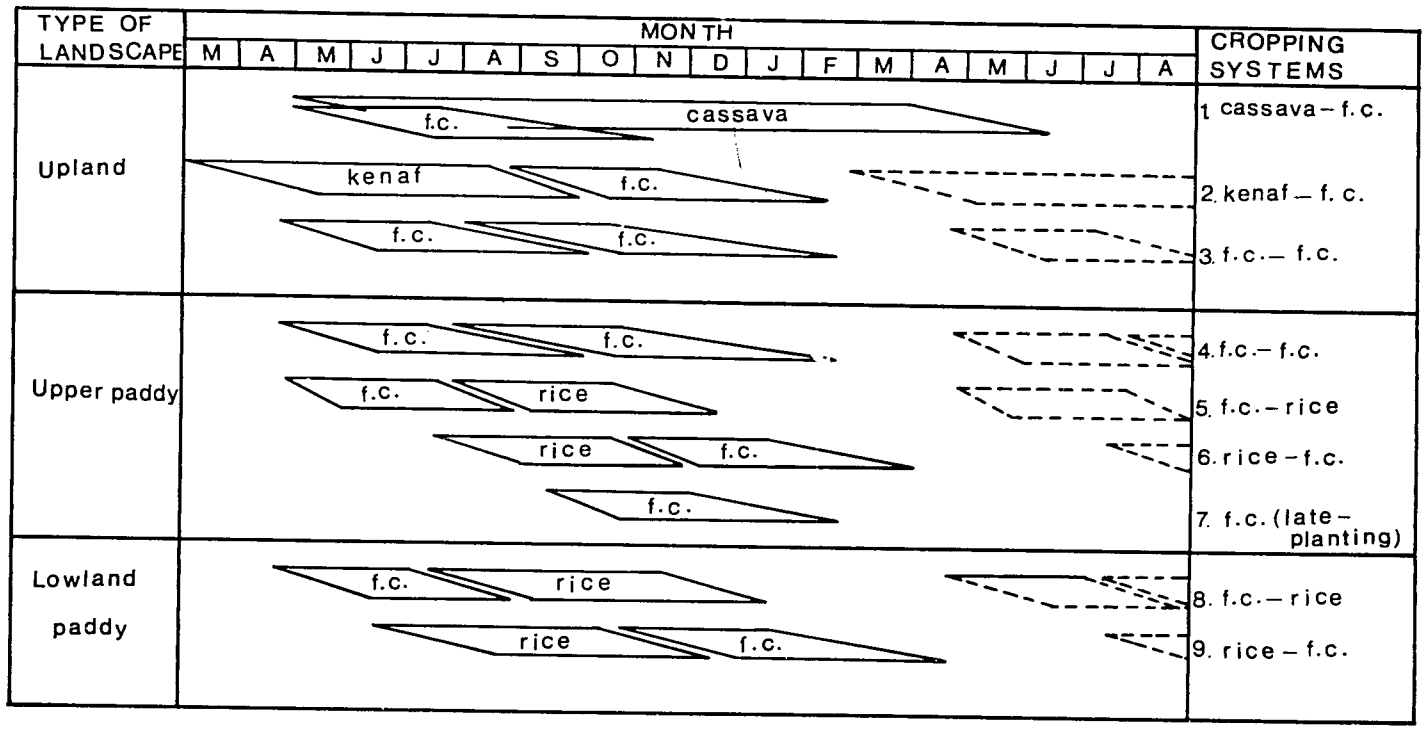
4. Double cropping of field crops
5. A field crop before and/or after rice
6. Late monocropping of field crops

Lowland paddy area

7. A field crop before and/or after rice

(See Figure 5.7)

In the uplands, cassava is generally planted in rows about one meter apart, and it takes about 3-4 months for the canopy to close up the space between rows. Intercropping of cassava with field crops would thus seem to be a logical system, and would slow down the soil fertility depletion characteristic of the uplands; legumes appear to be most suitable as the intercrop.



f.c. = Short duration field crop (2½-4 months)

Figure 5.7. Calendar of the improved cropping systems on the miniwatershed proposed by the KKU-FORD cropping systems project.

Kenaf is normally planted early in April, and cut at the end of the rainy season in October. By cutting the crop earlier than normally practiced, it is theoretically possible to grow early maturing crops on residual moisture after kenaf cutting.

Crops other than kenaf and cassava have also been examined, in case production of kenaf and cassava becomes unprofitable in future. Monocropping of several alternative crops has already been evaluated in other projects. Here we examined these crops in double cropping combinations.

There appears to be at least three possible ways of increasing the productivity of the upper paddies. The first is to change completely to field crop production, and double cropping of field crops might be possible, as in the upland area. Such a practice might not be easily adopted by farmers, since they normally prefer to grow rice for family consumption. However, rice transplanting is late enough to permit growing an early maturing crop. Therefore, the second alternative is double cropping of a field crop with rice. We also examined the possibility of growing field crops after rice on residual moisture, using improved soil management.

Growing field crops before rice is perhaps not likely to be accepted by some farmers, since rainfall is unpredictable and they may be afraid that it might interfere with their rice growing. The third alternative is thus to let them wait until very late in the season. If there is not enough water for rice transplanting, and rice production is not possible in that year, field crops might be planted instead of leaving the land idle.

Lowland paddy generally has sufficient water for rice growing every year, and thus should be used for rice production. Also we have investigated the possibility of increasing cropping intensity by growing field crops before and/or after rice.

Methodology

The urgent need to improve agricultural production in the Northeast and help small farmers called for the CSP to produce some useful results which could be utilized quickly within the time frame of the project. This lead us to move away from the conventional approach whereby the experiments are done repeatedly within the research station and go through various stages of improvement before testing them in the farmers' fields. This approach tends to lead to the development of systems which eventually turn out to be inappropriate when finally tested in the farmer fields. Our approach is to shorten the time frame of testing within the station and combine testing in the farmers' fields within the overall testing scheme. Potential cropping systems have been formed from available crop varieties and production technology and then screened both in the research station and in the farmers' fields. We hoped that, with this approach, we should be able to identify some cropping systems which can be utilized by the farmers in a short period time. Such cropping systems would, by no means, be perfect. However, they could be passed on to the farmers while we work on system improvement, utilizing feedback information from the farmers. A diagram of the work plan is shown in Figure 5.8.

Apart from the university farm, five villages varying in land use from mainly upland to mainly paddy area were selected as the test sites. Two of them are located adjacent to the highways and the other three are linked by gravelled roads to the main highways. All villages are within Khon Kaen province and can be accessed by car within an hour from Khon Kaen University.

Initial screening of the cropping patterns is done in the university farm or in the rented farmers' fields in the five villages, with all management done by project personnel. Various aspects of component technology are also tested initially in the university farm or in the rented fields. Promising systems are then tested by farmer cooperators in their own land. Some of the component technology is superimposed on the pattern trials in the farmers' fields.

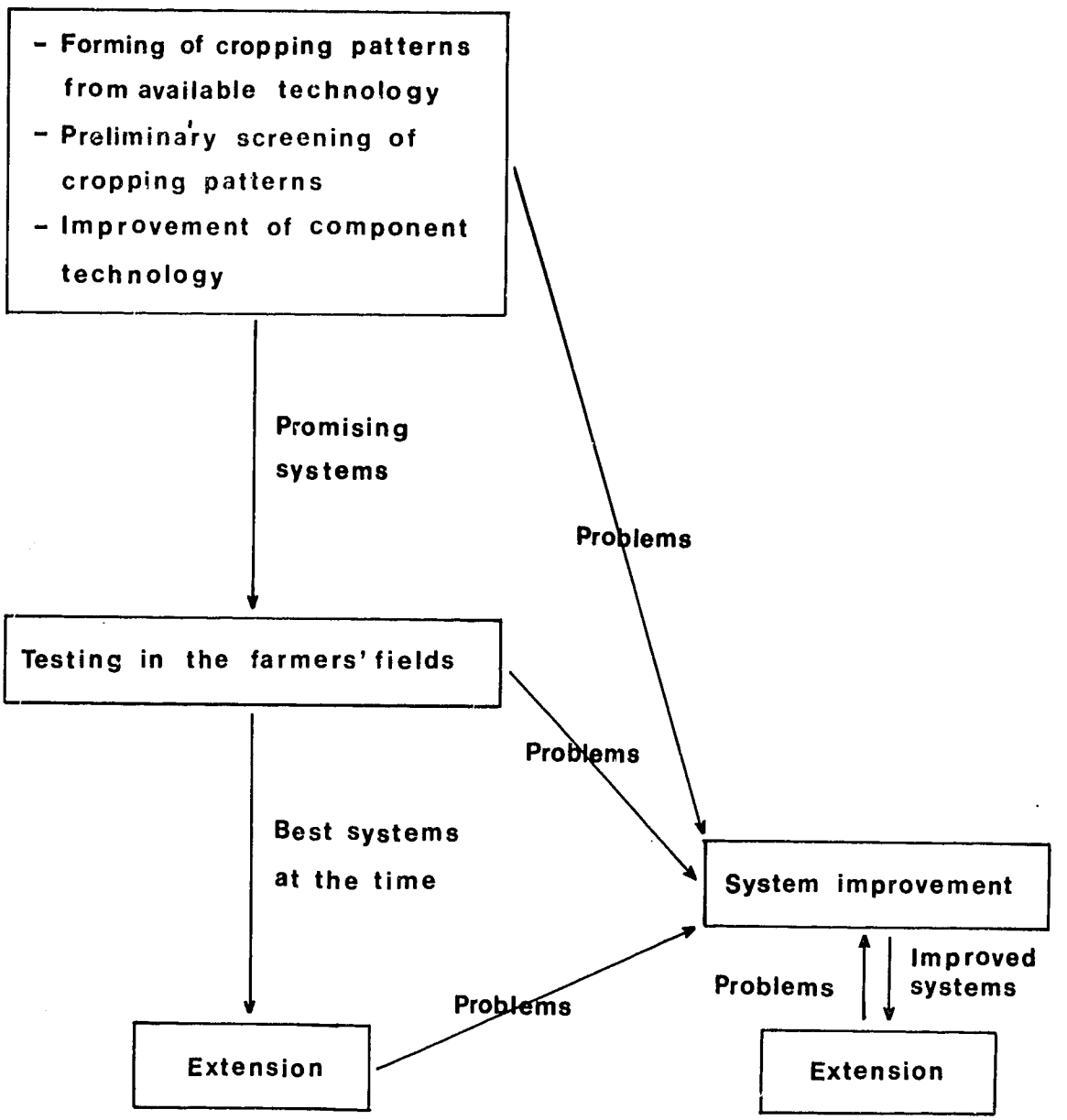


Figure 5.8. Diagram of the Cropping Systems Project work plan.

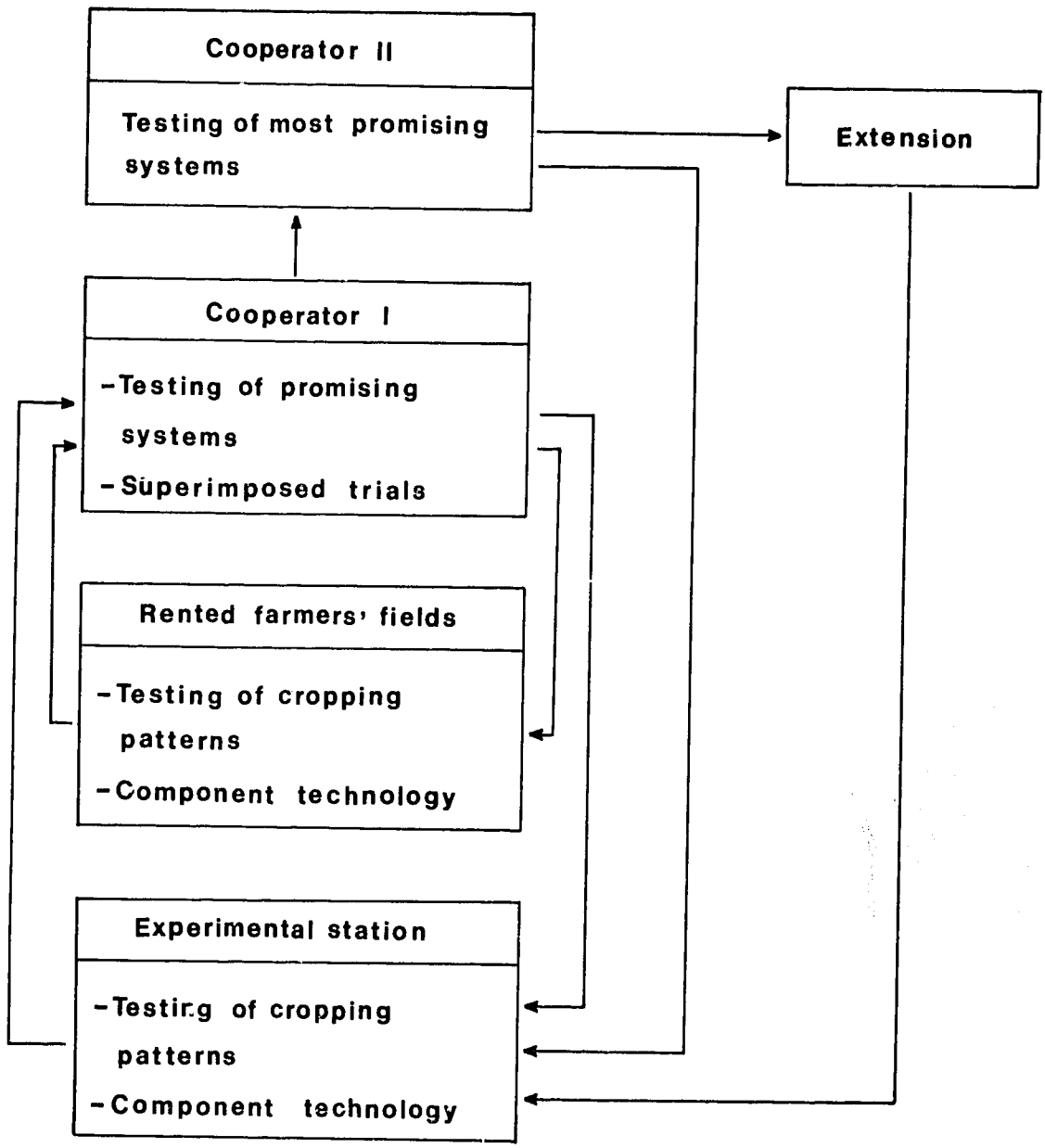


Figure 5.9. Diagram of the testing procedure.

There are two types of farmer cooperators. Cooperator I tests 4-5 promising systems. Seed, fertilizer, and insecticides are provided without charge, and close supervision by project personnel is given. The most promising systems identified are then tested by the second type of cooperator, cooperator II, one pattern for one cooperator. Seed and the necessary input are provided by the project, but the cooperator has to pay back (in seed) after harvesting, if a reasonably good yield is obtained. The total number of farmer cooperators (both types) is about 200 per year. This figure was chosen in order to have a relatively good number of replicates for each cropping system in the different land types, and to test the systems under a range of physical and socio-economic conditions and a range of management capabilities of the farmers.

Diagram of the testing procedure is shown in Figure 5.9. Experiments conducted in the university farm were replicated trials arranged in the usual experimental design patterns; those tested in the farmers' fields were large-plot, demonstration-type experiments without replication.

Summary of Results*

Results of the pattern trials will be summarized in this section; those of the component technology and socio-economic studies were published in the project annual reports and will not be presented here.

1). Cassava field crop intercropping

Several field crops, both legume and cereal, were tested in intercropping with cassava. Crops tested included peanut, mungbean, soybean, cowpea, corn, sorghum, and upland rice. Some studies also were done on spatial arrangements of cassava legume intercropping. The results, though varied, showed that the legumes generally caused little or no reduction in

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* Consult the 1976, 1977, and 1978 annual reports, KKU-FORD Cropping Systems Project, for further details.

cassava yield, and the best results were obtained from cassava + peanut, cassava + mungbean, and cassava + cowpea (determinate type) intercropping (Table 5.5 and 5.6). Early planting generally gave poor performances of the interplanted crops. However, good results were obtained with later planting (around May-June) in the period of more assured rainfall.

Results from the farmer fields were very variable (Table 5.7). The main problems appear to be lack of familiarity with intercropping, weed problems in cassava coinciding with labour requirements for rice, soil heterogeneity and salinity, and serious pest problems on the legumes (bean fly and pod borers on mungbean, leaf miners and seedling blight on peanuts).

At current prices, a substantial increase in net income (>20%) from intercropping is only likely to arise where typical farmers' cassava yields are less than 18 tons/ha. Above this, the legumes may not be able to compensate for lost cassava yield.

2). Kenaf-field crop double cropping

Crops tested included peanut, mungbean, soybean, cowpea, corn, sorghum, pearl millet, yam bean, and water melon. Several dates of kenaf cutting from mid-August to October were also compared. The typical results are shown in Table 5.8. In most cases, none of the field crops grown after kenaf produced yields high enough to be of practical value. Early cutting of kenaf resulted in a significant reduction in fiber yield, and return from the second crop could not compensate for the loss in kenaf yield. However, in one village (Ban Haad) where soil moisture appeared to remain longer after the end of rainfall period, satisfactory yields were obtained for some second crops, suggesting the possibility of the system in certain types of soils.

3). Double cropping of field crops in upland area

Several combinations of crops were tested in the double cropping systems. Crops tested as the first crop were peanut, soybean, mungbean, cowpea, corn, and sorghum. The second crops evaluated were peanut, soy-

Table 5.5. Yields of cassava and a subsidiary crop in an intercropped pattern. Results from University experimental plots; figures in brackets are percentages of the control (solid cassava).

	Yield of cassava (ton/ha)				Yield of other crop (kg/ha)			
	1976	1977	1978	1979	1976	1977	1978	1979
Solid cassava	30.11(100%)	24.54(100%)	24.24(100%)	20.36(100%)	-	-	-	-
Cassava + Peanut	28.34(94%)	26.76(109%)	19.66(81%)	19.46(96%)	259	1,769	95	550
Cassava + Soybean	25.31(84%)	22.91(93%)	15.37(63%)	15.04(74%)	7	1,100	32	906
Cassava + Mungbean	26.54(88%)	22.89(93%)	20.81(86%)	17.13(81%)	80	744	45	1,156
Cassava + Cowpea	12.78(42%)	21.78(89%)	18.38(76%)	11.99(59%)	6	1,994	8	775
Cassava + Upland rice	26.10(87%)	23.43(95%)	-	-	296	-	-	-
Cassava + Sorghum	15.88(53%)	22.68(92%)	-	-	173	-	-	-
Cassava + Corn	24.36(81%)	20.78(85%)	-	-	350	1,938	-	-

Table 5.6. Net income derived from different patterns of cassava + field crop intercrops on university experimental plots.

Planting Pattern	Net income (baht/ha)			
	1976	1977	1978	1979
Solid cassava	13,274	8,038	17,406	9,194
Cassava-Peanut	12,628	17,819	15,844	10,794
Cassava-Soybean	10,609	12,[illegible]94	11,337	10,400
Cassava-Mungbean	11,663	10,688	15,837	13,181
Cassava-Cowpea	4,349	14,519	12,819	7,938
Cassava-Upland Rice	11,823	7,563	-	-
Cassava-Sorghum	6,188	6,975	-	-
Cassava-Corn	10,951	9,956	-	-

Table 5.7. Net income of cassava and other field crop from the intercropping patterns tested by cooperators.

Patterns	Net income (baht/ha)				Total Net income	
	Cassava		Intercrop			
	Mean	SD	Mean	SD	Mean	SD
1978						
1. Cassava + Peanut (n=19)	2,701	1,992	898	1,069	3,599	2,490
2. Cassava + Mungbean(n=12)	2,604	1,980	-65	673	2,539	2,218
1979						
1. Cassava + Peanut(n=4)	586	2,478	-1,819	292	-1,233	3,257
2. Cassava + Mungbean(n=2)	-669	71	-672	676	-1,345	1,903

bean, mungbean, cowpea, sorghum, pearl millet, yam bean, water melon, and sesame. The results are reported in Table 5.9. Better performance was obtained from peanut-mungbean, peanut-cowpea, mungbean-peanut, mungbean-cowpea, cowpea-peanut, and cowpea-mungbean combinations. Considering the limited market for cowpea, peanut-mungbean and mungbean-peanut appeared to be the most promising combinations. The results, however, varied from field to field and from year to year, indicating that the system is unstable. More stable results were obtained from the village where moisture in the soil appears to last longer. But, with the current cassava price, the system requires higher cash inputs and produces lower net income than monocropping of cassava.

4). Double cropping of field crops in upper paddy fields

Evaluation of various double cropping combinations was done in a similar manner as in the upland area, and similar results were obtained (Table 5.10). The results, however, were generally better than in the upland area because of better soil moisture at the end of the growing season. Major problems included poor drainage, long turn over period, poor performance of the second crop in the year which the rain ended early, and insect damage.

5). Growing field crop before rice in the upper paddy field

The patterns tested were mungbean-rice, peanut-rice, soybean-rice, cowpea-rice, sorghum-rice, and baby corn-rice. The outcomes are presented in Table 5.11. Promising combinations were mungbean-rice and cowpea-rice. Peanut-rice was also successful if the peanut could be planted very early and harvested as "boiled peanut". The system worked nicely in the year with dry early season, but gave poor results in the year with heavy rainfall during the early rainy season. Major problems were too much water for field crops if drainage management was not done properly, and limited time for water collection for rice growing.

Table 5.8. Mean yield[1/] and total net income[1/] obtained from kenaf-field crop double cropping in 1977[2/].

Pattern	Crop	Yield (kg/ha)	Total net income (baht/ha)
1	Kenaf[3/]	1,023(401)	3,184(2,498)
	Mungbean	331(247)	
2	Kenaf	1,023(401)	4,969(3,296)
	Peanut	621(476)	
3	Kenaf	1,023(401)	4,078(2,078)
	Cowpea	558(340)	
4	Kenaf	1,023(401)	2,645(2,122)
	Soybean	161(116)	
5	Kenaf	1,023(401)	2,309(1,748)
	Sorghum	406(252)	
6	Kenaf	1,023(401)	4,077(2,326)
	Yambean	2,051(2,411)	
7	Kenaf(single)	1,573(643)	5,367(2,824)

Remark: 1/ presented as mean with standard deviation in parenthesis.

2/ conducted by project personnel in 4 villages.

3/ kenaf in all double cropping patterns was harvested during Sep. 1-20, whereas the kenaf (single) harvesting was done much later during Nov. 8-13.

Table 5.9. Mean yield[1/] and net income[1/] obtained from double cropping of field crops in the upland area in 1977-8[2/].

Pattern	1st crop and 2nd crop	1977		1978	
		Yield (kg/ha)	Total net income (baht/ha)	Yield (kg/ha)	Total net income (baht/ha)
1	Peanut	1,044(566)	3,720(5,193)	1,104(378)	4,335(3,291)
	Mungbean	426(401)		354(406)	
2	Peanut	1,044(566)	4,313(5,131)	1,104(378)	3,736(3,424)
	Peanut	507(386)		411(341)	
3	Peanut	1,044(566)	3,068(4,174)	1,104(378)	3,969(2,953)
	Cowpea	556(348)		398(294)	
4	Peanut	1,044(566)	3,489(4,665)	-	-
	Soybean	299(238)		-	
5	Peanut	1,044(566)	2,683(4,175)	1,104(378)	4,682(2,681)
	Sorghum	988(315)		1,268(688)	
6	Peanut	1,044(566)	3,540(5,946)	1,104(378)	354(2,478)
	Yambean	2,190(2,284)		411(919)	
7	Peanut	-	-	1,104(378)	3,649(1,828)
	Millet	-		457(227)	
8	Peanut	-	-	1,104(378)	14,491(8,732)
	Roselle	-		206(159)	
9	Peanut	-	-	1,104(378)	4,254(2,992)
	Sesame	-		205(210)	

Table 5.9. (Continued).

Pattern	1st crop and 2nd crop	1977 Yield (kg/ha)	1977 Total net income (baht/ha)	1978 Yield (kg/ha)	1978 Total net income (baht/ha)
10 3/	Peanut	-	-	1,104 (378)	8,206
	Baby corn	-		275	
11	Mungbean	265 (211)	110 (3,162)	384 (294)	937 (2,279)
	Mungbean	237 (190)		245 (287)	
12	Mungbean	265 (211)	1,039 (5,035)	384 (294)	2,650 (3,313)
	Peanut	586 (382)		757 (566)	
13	Mungbean	265 (211)	1,727 (3,383)	384 (294)	1,692 (2,456)
	Cowpea	770 (331)		480 (552)	
14	Mungbean	262 (211)	316 (3,119)	-	-
	Soybean	278 (262)		-	
15	Mungbean	262 (211)	1,360 (1,682)	384 (294)	1,667 (2,866)
	Sorghum	664 (384)		1,139 (1,239)	
16	Mungbean	262 (211)	1,228 (7,214)	384 (294)	-2,880 (1,137)
	Yambean	4,562 (5,829)		284 (569)	
17	Mungbean	-	-	384 (294)	1,324 (1,472)
	Millet	-		711 (141)	
18	Mungbean	-	-	384 (294)	17,276 (13,679)
	Roselle	-		314 (252)	
19	Mungbean	-	-	384 (294)	2,456 (2,111)
	Sesame	-		328 (292)	

Table 5.9. (Continued).

Pattern	1st crop and 2nd crop	1977		1978	
		Yield (kg/ha)	Total net income (baht/ha)	Yield (kg/ha)	Total net income (baht/ha)
20 3/	Mungbean	-	-	384 (294)	18,187
	Baby corn	-		663	
21	Cowpea	-	-	799 (243)	3,311 (3,547)
	Peanut	-		582 (607)	
22	Cowpea	-	-	799 (243)	2,712 (1,975)
	Mungbean	-		309 (296)	
23	Cowpea	-	-	799 (243)	3,300 (2,225)
	Cowpea	-		528 (445)	
24	Cowpea	-	-	799 (243)	3,216 (1,945)
	Sorghum	-		1,226 (911)	
25	Cowpea	-	-	799 (243)	2,712 (1,339)
	Millet	-		763 (454)	
26	Cowpea	-	-	799 (243)	18,695 (15,324)
	Roselle	-		313 (275)	
27	Cowpea	-	-	799 (243)	3,300 (1,856)
	Sesame	-		368 (312)	
28	Cowpea	-	-	799 (243)	-352 (2,512)
	Yambean	-		274 (535)	
29 3/	Cowpea	-	-	799 (243)	12,188
	Baby corn	-		406	

Table 5.9. (Continued).

Pattern	1st crop and 2nd crop	1977 Yield (kg/ha)	1977 Total net income (baht/ha)	1978 Yield (kg/ha)	1978 Total net income (baht/ha)
30	Sorghum	340(252)	-2,349(1,194)	-	-
	Mungbean	123(72)		-	
31	Sorghum	340(252)	-2,320(1,435)	-	-
	Peanut	235(207)		-	
32	Sorghum	340(252)	-1,415(1,506)	-	-
	Cowpea	442(212)		-	
33	Sorghum	340(252)	-1,788(1,153)	-	-
	Soybean	184(123)		-	
34	Sorghum	340(252)	-2,265(1,037)	-	-
	Sorghum	712(265)		-	
35	Sorghum	340(252)	-2,995(1,658)	-	-
	Yambean	675(884)		-	

Remarks : 1/ presented as mean with standard deviation in parenthesis.

2/ conducted by project personnel in the rented farmers' fields of five villages.

3/ the results were obtained from only one village.

Table 5.10. Mean yield[1/] and net income[1/] obtained from double cropping of field crops on the upper paddy area in 1977-8[2/].

Pattern	1st crop and 2nd crop	1977		1978	
		Yield (kg/ha)	Total net income (baht/ha)	Yield (kg/ha)	Total net income (baht/ha)
1	Peanut Mungbean	1,083 (480) 435 (254)	4,019 (2,472)	803 (354) 131 (96)	2,279 (1,560)
2	Peanut Peanut	1,083 (480) 300 (160)	3,253 (2,507)	803 (354) 144 (255)	1,559 (1,174)
3	Peanut Soybean	1,083 (480) 329 (230)	3,829 (2,066)	- -	-
4	Peanut Cowpea	1,083 (480) 553 (225)	4,100 (2,595)	803 (354) 284 (411)	2,828 (1,390)
5	Peanut Sorghum	1,083 (480) 528 (873)	2,830 (2,981)	803 (354) 80 (159)	1,942 (1,719)
6	Peanut Yambean	1,083 (480) 4,538 (6,656)	7,930 (9,573)	803 (354) 0	-1,213 (1,916)
7	Peanut Millet	- -	-	803 (354) 208 (292)	2,257 (1,644)
8	Peanut Baby corn	- -	-	803 (354) 22 (44)	2,439 (1,426)
9	Mungbean Mungbean	598 (373) 454 (335)	1,788 (2,432)	374 (120) 106 (114)	425 (391)
10	Mungbean Peanut	598 (373) 410 (184)	1,587 (2,107)	374 (120) 262 (457)	433 (1,820)

Table 5.10. (Continued).

Pattern	1st crop and 2nd crop	1977		1978	
		Yield (kg/ha)	Total net income (baht/ha)	Yield (kg/ha)	Total net income (baht/ha)
11	Mungbean Soybean	598 (373) 260 (135)	1,160 (2,224)	- -	-
12	Mungbean Cowpea	598 (373) 558 (367)	1,785 (1,523)	374 (120) 308 (538)	1,148 (1,714)
13	Mungbean Sorghum	598 (373) 821 (557)	955 (2,215)	374 (120) 80 (159)	300 (224)
14	Mungbean Yambean	598 (373) 2,479 (3,799)	2,517 (6,244)	374 (120) 0	-2,933 (508)
15	Mungbean Millet	- -	-	374 (120) 130 (152)	464 (504)
16	Mungbean Baby corn	- -	-	374 (120) 19 (37)	694 (1,124)
17	Cowpea Mungbean	- -	-	605 (195) 229 (176)	1,485 (939)
18	Cowpea Peanut	- -	-	605 (195) 461 (587)	1,871 (2,729)
19	Cowpea Cowpea	- -	-	605 (195) 318 (319)	1,669 (946)
20	Cowpea Sorghum	- -	-	605 (195) 115 (164)	719 (673)

Table 5.10. (Continued.)

Pattern	1st crop and 2nd crop	1977		1978	
		Yield (kg/ha)	Total net income (baht/ha)	Yield (kg/ha)	Total net income (baht/ha)
21	Cowpea	-	-	605(195)	-1,710(1,988)
	Yambean	-		0	
22	Cowpea	-	-	605(195)	716(854)
	Millet	-		63(102)	
23	Cowpea	-	-	605(195)	1,076(1,084)
	Baby corn	-		14(27)	
24	Sorghum	819(779)	640(2,013)	-	-
	Mungbean	545(270)		-	
25	Sorghum	819(779)	60(887)	-	-
	Peanut	371(137)		-	
26	Sorghum	819(779)	-1,066(1,577)	-	-
	Soybean	134(155)		-	
27	Sorghum	819(779)	1,070(1,444)	-	-
	Cowpea	778(304)		-	
28	Sorghum	819(779)	-1,196(1,424)	-	-
	Sorghum	444(457)		-	
29	Sorghum	819(779)	4,263(9,107)	-	-
	Yambean	4,700(5,752)		-	

Remarks : 1/ presented as mean with standard deviation in parenthesis.

2/ conducted by the project personnel in 5 villages.

Table 5.11. Mean yield[1/] and net income[1/] obtained from field crop-rice double cropping in upper paddy fields in 1977-8[2/].

Pattern	1st crop and 2nd crop	1977		1978	
		Yield (kg/ha)	Total net income (baht/ha)	Yield (kg/ha)	Total net income (baht/ha)
1	Mungbean	548(428)	2,984(4,115)	293(189)	4,661(1,610)
	Rice	1,351(1,113)		2,202(776)	
2	Peanut	965(445)	4,380(4,222)	571(346)	4,747(2,661)
	Rice	1,198(892)		1,850(1,047)	
3	Cowpea	613(427)	2,824(2,920)	376(320)	5,145(1,637)
	Rice	1,404(900)		2,399(552)	
4	Baby corn	364(147)	3,284(1,826)	183(231)	4,932(4,201)
	Rice	1,168(639)		2,088(1,072)	
5	Soybean	225(197)	35(1,422)	-	-
	Rice	506(716)		-	
6	Sorghum	428(409)	-729(852)	-	-
	Rice	331(479)			

Remarks : 1/ presented as mean with standard deviation in parenthesis.
2/ conducted by project personnel in 5 villages.

6). Late monocropping of field crops in the upper paddy field

Several field crops were tested in this system. However, the results were generally unsatisfactory (Table 5.12). The intended planting time in late September was generally too wet for good land preparation for field crops, and planting was possible only in October which appeared to be a bit too late (but see discussion in the later section).

7). Growing field crops after rice in upper and lowland paddy fields

Several field crops were grown after rice in both upper and lowland paddy fields, and several methods of crop establishment were attempted. None of the seeding methods produced satisfactory seed yields. The crops germinated well and grew to a certain size, but later died or produced insignificant seed yield.

Discussion

Work done during the past five years, though giving variable results, has provided a lot of useful information and experience. It has helped us understand the difficulties facing small farmers and the complexity of the system far better than we would have got from working within the research station.

Experimental data obtained from work during the past five years have identified several promising systems. Many of them, however, still showed a high degree of instability - good in certain years or locations but poor in others - and their superiority over the existing systems remain unclear.

The most promising one appeared to be the double cropping system in upper paddy fields. As individual systems per se, the field crop-rice or field crop-field crop systems seemed to be unstable. However, if they are considered together as a flexible system (field crop is planted first early in the season; if heavy rains come early, the field crop is ploughed in as green manure, then the field is planted to rice; if rainfall

Table 5.12. Mean yield[1/] of field crops planted late on upper paddy fields in 1976-8[2/].

Crop	Year		
	1976	1977	1978
Peanut	294(311)	285(219)	371(429)
Mungbean	349(473)	210(166)	374(251)
Cowpea	128(37)	410(257)	242(257)
Soybean	48(83)	173(133)	-
Sorghum	65(81)	431(786)	200(400)
Pearl millet	438(758)	157(201)	50(100)
Pigeon pea	0	-	-
Yambean	0	-	0
Chinese radish	-	-	2,437(4,875)
Baby corn	-	-	8(16)
Upland rice	0	-	-
Sesame	-	66(90)	
Range of planting date	Oct.16-Nov.9	Sept.23-Oct.17	Sept.1-Nov.14

Remarks: 1/ presented as mean with standard deviation in parenthesis.
2/ conducted by project personnel in 4-5 villages.

pattern permits the first crop to mature, rice planting is done after harvesting the field crop; in the exceptionally dry year or in the high fields of upper paddy, field crop may be used as the second crop), the system appeared to be stable and seemed to have advantage over the present system in that the farmer is at least able to harvest a single crop every year, i.e. field crop in the dry year and rice in the wet year, and in some years both the field crop and rice can be harvested. Thus, as a flexible system of cropping, the system should increase the long-run average return for this type of land.

Although, many of the promising systems showed a considerable degree of instability and involve certain risks, there are avenues still to be explored:

First, management practices of several of the tested systems can possibly be improved.

Second, in certain locations soil moisture appears to last longer than other locations, and the experimental results of several cropping systems were better and more stable at these locations.

Third, some of the cropping systems which we tested are commonly used by farmers in certain areas, e.g. peanut is grown after rice and after kenaf is Surin province, sesame is grown before rice is Burirum province, water melon and yard long bean are grown at the end of the rainy season in several locations.

These facts lead us to conclude that there may be places where some of the tested cropping systems would work. Trips were made in early 1981 to places where double cropping systems are normally used, and re-examination of soil moisture in the village test sites were done. Major findings were:

(1) The technique the farmers use in growing peanut after rice or kenaf is different from the one we used. The farmers plant peanut very late after the rains end, make very good land preparation, and plant

the peanut very deep. We have attempted to plant the second crops as early as possible to get the crops in before the rain ended. Thus, land preparation is carried out while the soil is wet, and hence is poorer than that obtained by the farmers. Rainfall also makes the soil compact and soil moisture is lost more rapidly. In growing a field crop before rice, the farmers plant sesame very early in March at the onset of the first rain, while we planted the crops only in late April. In certain locations or with a tractor available, land preparation could be done in the dry season or after rice harvesting; thus, early planting at the onset of the first rain is possible.

(2) The soils in which soil moisture appears to be ample in the dry season, similar to the village where we had good experimental results, cover a considerable area in the Northeast. With proper management practice, double cropping might be a stable system in this type of soils.

(3) In four of the five village test sites, and in the university farm, the soils are rather dry in the dry season.

Key Questions

Our results suggest a number of key questions for future research:

1) What are the critical constraints to planting of cassava-legume intercropping in the period of more assured rainfall, and how can they be overcome ?

2) Is the success of kenaf-field crop systems in the uplands and rice-field crop systems in the upper paddy dependant primarily on location or management practices ?

3) How can the stability of double cropping of field crops in the uplands and upper paddies be improved ?

4) Can the upper paddy be managed using flexible cropping systems to improve productivity and stability ?

5) Would land preparation at the end of the growing season permit earlier planting of the first crop of the following growing season ?

6) What techniques are required to improve establishment of field crops ?

7) What level of input technology is appropriate to growing field crops before rice in the upper paddy ?

CHAPTER SIX
SYSTEM PROPERTIES AND KEY QUESTIONS

1. System Properties

Definitions

System properties are those properties unique to systems which are created by the interaction of the various components in a system. Usually, they are not apparent simply from examining the behavior of the components alone. For example, the yield of a rice plot is not simply the sum of the yields of individual rice plants grown alone. The yield of the whole plot is a function of the competition between the rice plants and their interaction with the water and soil in the plot.

Different systems also have different properties. At each level in a system hierarchy (or, for example, the hierarchy of agroecosystems we have considered in this report), new system properties emerge which are usually not readily apparent simply by examining systems lower in the hierarchy. The net rice production of the Northeast, for example, is not readily calculated simply by extrapolation from the rice yields of a number of individual farms, villages, or even provinces.

The most important properties of agroecosystems are those which relate to the productivity, stability, and durability of agroecosystems. By productivity we usually mean the yield or gross production of crops or livestock, or alternatively the gross or net income. Stability is a measure of the variability in yield or income, and is usually computed as the inverse of the coefficient of variation of these parameters. Stability is a function of how well a system can resist, absorb, or adapt to the stresses and perturbations it experiences. Durability, however, is concerned with the long run performance of the system. It measures how well the system is able to sustain its productivity in the face of repeated stress and/or major perturbation.

These three properties are interrelated but often conflicting. For example, greater productivity may only be attained at the expense of greater instability or poor durability. Alternatively, in some situations, greater productivity may not be possible until stability has been increased. These properties also receive different degrees of emphasis at different stages in agricultural development. Thus, in the Chiang Mai Valley, productivity was given piority a decade ago in the construction of major irrigation works, but attention is now turning to the durability of the new cropping systems (Gypmantasiri et al., 1980). In the Korat Triangle, there have been increases in agricultural productivity, but there have largely been a function of the opening of new land rather than increased yield per rai. The dominant feature of the Triangle's agriculture is its instability. It may well be that this needs to be cured before further major increases in productivity are possible.

Macrolevel (Northeast and Korat Triangle)

Much of the increased agricultural production in the Northeast has been in response to world demand, initially for fibre (kenaf) and more recently for animal feedstuffs (cassava and corn). The Northeast is thus heavily dependant on the stability of the world trade market in animal feedstuffs. The demand generated is good for the region provided it is not accompanied by too great an instability. A key question is: whether alternative crops (or livestock or trees) of strategic export value can be grown in the Korat Triangle in order to stabilize cash crop production.

Productivity in the Triangle is also affected by government policy which, as we have seen, may have both positive and negative effects. For example, the rice and fertilizer policies may be restricting rice production, while problems of conflicting agencies and poor desolution of decision making to the region may discourage crop production generally. The rural works program may also provide less incentive for dry season cropping. The development of water resources, on the other hand, may bring very considerable benefit, but this will depend, as we have argued, on the

type of developments, their design, and the methods of operation. A key question here is: which major changes in government policy, will bring about the greatest increase in agricultural productivity?

The major feature of the Triangle, however, is the great instability in rice production. As we stated, it is not possible, at present, to provide good climatic predictors for rice production in the region. In part, the reason is that considerable buffering appears to exist in the system. Thus, droughts in one place are compensated for by high rain elsewhere; floods by moderate rainfall. For example, in a province where rice on the flood plain is damaged by flooding, there is often compensation through higher yields on the non-flood plain or miniwatersheds elsewhere in the province, benefiting from the higher rainfall which brought about the flooding. A key question is: how does the buffering of rice production in the Triangle works in detail, and how can it be improved?

The major responses to rice production instability is migration, and we have already suggested that the costs and benefits of this need to be evaluated. The growth of income from farm crafts and off-village employment has been considerable in recent years and has compensated for the instabilities in crop production. A key question is: which forms of farm craft and off-village employment should be encouraged so as to improve the overall productivity, stability, and durability of the Triangle?

Meso level (Village and Farm)

The dominant traditional features of the villages in the Triangle have been those which enhance the stability of village life. The resolution of conflict, the communal management of land and water resources, the provision of community services through the temple and school, the construction and maintenance of roads, wells, ditches etc. have been primary objectives of village life and have helped the villages to survive adverse conditions. The villages have also supported informal but very

strong physical, economic, and social links between farm households which have promoted stability. For example, farm waste and manure are often recycled between farms, and there are exchanges of crops and goods (such as mulberry leaves or silk thread). Labour has also been exchanged, and there has been a tradition of bartering goods and of freely giving cash and goods one to another. This has clearly been of critical importance in years of flood and drought, the community helping to buffer the adversity, both by reducing the extent of the potential losses in the rice crop and by supporting those families in greatest need.

Today, these interrelationships are theatened partly by the replacement of barter by a cash economy, partly by the increased size of farm holdings, which become too big for exchange labour and require hired labour, and partly by the attractions of on and off-village employment, including the government public works program. The loss of the communal features accompanied by a growth in potential income would not greatly matter except that the subsistence rice crop remains unstable. A key question is: whether the loss of communal linkages will seriously threaten the durability of the villages in the face of crop instability, and if so, which linkages should be strengthened ?

Productivity on the average farm is limited largely by labour availability. A husband and wife cannot manage the average 20 rai farm, but the movement of young men and women to the towns tends to restrict both the amount of family labour and that which can be hired. Many farmers now also face a wide range of potential choices between upland and lowland cropping, agriculture and farm crafts, and on-farm and off-farm employment. A initial key question, which as yet is only partly answered, is: what are the attitudes, values and goals of farmer in the Triangle, and how do these determine the choices of subsistance and cash strategies ?

When this is answered, we may then ask what are the best mixes of land and soil types (upland, upper paddy, lower paddy; paleustult, paleaquult, dystropept, tropaquept soils), and of crops, livestock, farm crafts,

off-farm employment for promoting productivity, stability, and durability of farm income ?

Microlevel (Cropping System and Crop)

The key factors in crop productivity in the Triangle are:

1) timing of planting, weeding, insect and disease control, harvesting, etc., which in turn, implies appropriate timing of labour availability.

2) soil moisture, which in turn, implies improved land and water management.

3) soil fertility which implies the application of fertilizers, organic wastes and manures, and the use of legume crops, and

4) the cropping system followed.

Several of these factors also affect stability, but in particular, improving stability from place to place depends on a better understanding and management of the meso and micro variation that occurs throughout the Triangle in the heterogeneity of soil fertility, structure, and moisture holding capacity. Similarly, the most important contribution to improving stability over time will come from a better understanding and management, in terms of fitting cropping systems, of the seasonal pattern of climate.

Finally, durability at the plot level is being threatened in a number of ways. Upland crops such as cassava and kenaf are depleting the fertility of newly opened upland soils, while salinity is a growing problem on irrigated and flooded land.

We have discussed these issues and the factors involved in the previous chapter and suggested a number of appropriate key questions.

A Simple Model

Finally, our overall analysis suggests that at the meso and microlevel there are a limited number of key variables which determine the main system properties of the farm and the field plot. The driving variable is clearly rainfall, but its significance is felt on a weekly if not daily time scale. In turn, rainfall affects soil moisture, which sets the pattern for the cropping cycle. This creates demands for labour which are in conflict with labour devoted to other activities. Tying all of these together are the farmer's perceptions of each of these variables, and in particular, his anticipation of the relative incomes from crop labour and labour directed elsewhere.

Figure 6.1 illustrates the simple model linking these variables. Other variables clearly also play important roles, but we believe this is a good starting point for assessing the future role of improved cropping systems in the farm systems of the region.

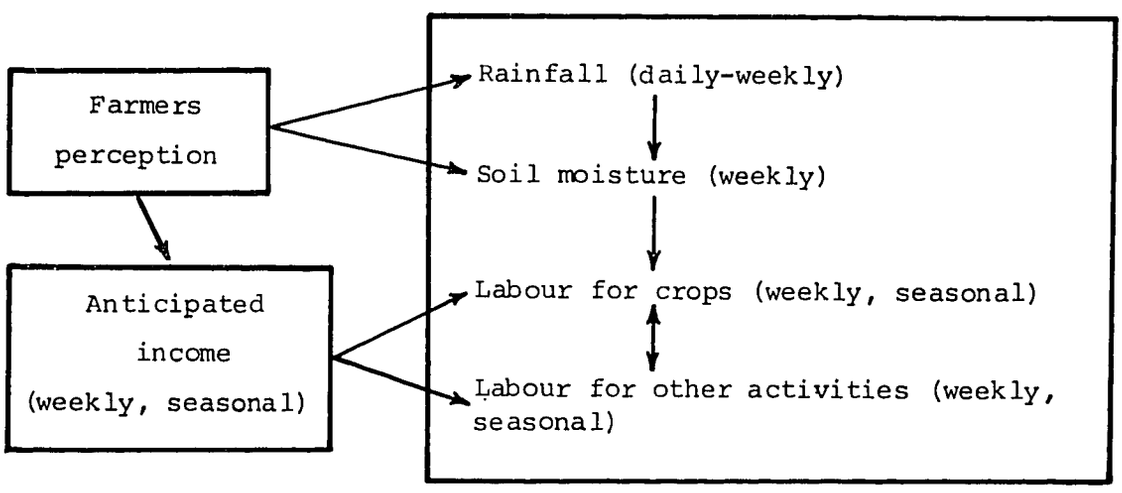

Figure 6.1. A simplified model of farm and field crop production in the Korat Triangle.

2. Key Questions

The final list of key question is as follows:

Macrolevel

1. What is the most useful climatic zonation of the Northeast for agricultural research and development?

2. What effective measures need to be taken if the cassava market deteriorates?

3. Would substitution of non-glutinous rice for part of the glutinous rice acreage increase farm income and its stability and, if so, what measures are required by government to encourage this?

4. What measures are needed at regional level to reduce the instability in farmers' incomes?

5. How can the growth rate of crop production in the region be improved?

6. What are the climatic predictors of rice production at the regional level?

7. What are the costs and benefits of Northeastern migration - rural, regional, and extra-regional,- and what measures are required to control it, and if deemed necessary, to reduce it?

8. How are production and marketing systems affected by energy prices, and what alterations should be encouraged in these systems which will reduce the burdens on farmers?

9. Which major change in government policy will bring about the greatest increases in agricultural productivity?

10. To what extent are government price and production policies important in the pattern of development of the Northeast, and do they significantly help to stabilize farmers' income?

11. Would higher prices encourage farmers in the Northeast to switch from glutinous to non-glutinous rice varieties and/or to purchase more inputs, particularly fertilizers and pesticides?

12. What are the best type and design of water resource project in the Northeast for providing stable and durable agricultural production?

13. What are the precise costs and benefits of the rural work program in the Northeast?

14. How is the productivity and stability of the Taiangle affected by the other systems in the Northeast?

15. How is the stability of paddy production in the Triangle produced, and how can it be improved?

16. Are there alternative crops (or livestock or trees) of strategic export value that can be grown in the Triangle in order to stabilize cash crop production?

17. Which forms of farm craft and off-village employment should be encouraged so as to improve overall productivity, stability, and durability of the Triangle?

Mesolevel

1. How can the miniwatershed be best managed as a system?

2. How can the upper paddy area be best managed?

3. What is the precise nature of the interactions between the various land uses in the watershed?

4. How does the use of the upland areas in the watersheds affect water supply to the paddy areas, and can improved systems of water management be designed which optimize the performance of the watershed in all years?

5. Would contouring and reconstruction of the bunds improve the overall performance of the typical watershed?

6. What role have tanks to play in improving the performance of the watershed?

7. How can the upland and flat paddy areas of the non-flood plain be managed as an integrated system?

8. How can double cropping be made more extensive in the non-flood plain?

9. How can double cropping be made more extensive in the flood plain?

10. How can farmers best respond to flooding after rice transplanting in the flood plains?

11. What is the nature and extent of communally managed resources (grazing land, water, forests, etc.)?

12. How are these communal resources actually managed, and individual access to them allotted, and conflicts resolved?

13. Will the loss of communal linkages in the villages seriously threaten the durability of the village in the face of crop instability, and if so, which linkages should be strengthened?

14. What is pattern of distribution of land types on individual farms representative of the Triangle?

15. How do typical farms behave as resource systems, and in particular, what are the key components and important human management inputs which they require?

16. What are critical limiting factors (capita, labor supply, water etc.) for expansion intensification of use of various components of farm resource system?

17. What are the attitudes, values, and goals of farmers in the Triangle, and how do these determine the choices of subsistence and cash strategies?

18. What are the best mixes of land and soil types, and of crops, livestock, farm crafts, and off-farm employment for promoting productivity, stability, and durability of farm income?

Microlevel

1. What is the soil moisture storage potential under the Khon Kaen and Roiet rainfall regimes, and how can it be best exploited for more intensive cropping?

2. How can the climatic pattern be most appropriately classified for agronomic purposes, and what extra parameters and analysis are required to do this?

3. What are the specific desired characteristics of upper paddy rice varieties; does Pong Aew meet these fully and, if not, is it desirable or feasible to develop special varieties for upper paddy cultivation?

4. How can low rice yield in the upper paddy due to late planting be improved?

5. Can rice varieties be developed which will give more stable yields under the variable flood conditions of the flood plains?

6. What are the principal causes of microvariability in Northeast soil, and can cropping practices and systems be devised which will overcome the instability of yields this creates?

7. Are there cheap and effective means of erosion control in the upland areas?

8. What are the actual crop losses due to the major pests and diseases, and their associated probabilities of occurring?

9. Under what circumstances are pesticide applications likely to prove economic, and when should they be made?

10. What cheap and effective biological and cultural controls potential exist for major pests and diseases, in particular of legumes?

11. What are the critical constraints to planting of cassava - legume intercropping in the period of more assured rainfall, and how can they be overcome?

12. Is the success of kenaf-field crop systems in the uplands and rice-field crop systems in the upper paddy dependant primarily on location or management practices?

13. How can the stability of double cropping of field crops in the uplands and upper paddies be improved?

14. Can the upper paddy be managed using flexible cropping systems to improve productivity and stability?

15. Would land preparation at the end of the growing season permit earlier planting of the first crop of the following growing season?

16. What techniques are required to improve establishment of field crops?

17. What level of input technology is appropriate to growing field crops before rice in the upper paddy?

CHAPTER SEVEN
CONCLUSION

1. An Assessment

After five years of operation, it was time to review the progress of the Cropping Systems Project and draw up research priorities for the future. To this end, the special seven day workshop was held at Khon Kaen University in December 1980. The interdisciplinary team included both natural and social scientists from Khon Kaen and Chiang Mai Universities, together with two groups representing resources management teams from the Philippines and Indonesia, plus a number of specialists from the Ford Foundation, Imperial College, and the East-West Center. The aim of the workshop was not only to review the research program but also to analyze the agroecosystem of the Northeast as a whole as a basis for establishing new research priorities and future directions.

Through the intensive interdisciplinary analysis carried out in the workshop, we gained a better understanding of the problems of agricultural development in the Northeast. The workshop procedure allowed agricultural, ecological, socio-economic, and management issues to be raised simultaneously and for a cross-fertilization of ideas to occur. It also allowed the team to look at the problems at different system levels, i.e. macro, meso, and micro levels. As a consequence, a series of critical questions were raised and recognized. These questions provide a broader contextual framework four our cropping systems research, and thus permit us to formulate better research priorities for the future.

2. The Objectives of the Cropping Systems Project

The original objectives of our cropping systems project focused on cultivated areas of the whole Northeast. However, as a result of the analysis, it was suggested that the region can be classified into four

different agroecological systems,i.e. the Korat Triangle, the Mekong Provinces, the Western Hills,and the Southern Hills. It is the Korat Triangle that covers the major land area of the region and has the most critical problems of rainfed cultivation, with lowest productivity and stability of production, and where improvement appears most difficult to achieve. Hence our target system in the future will be the Korat Triangle.

Many of the key questions identified during the workshop revealed that there is a considerable knowledge gap in our basic understanding of Northeast farmers, in terms of their approach to farming activities, ways of life,and basic needs. A major objective of the project will thus be to gain a better understanding of the farmers in the Triangle and their farming systems.

3. Research Methodology

Our current testing methodology has not followed the conventional approach whereby the experiments are conducted repeatedly within the research station and go through various stages of improvement before being tested in farmers' fields. Our approach has been to shorten the time frame of testing within the station,and combine this with testing in the farmers' fields within an overall testing scheme. Our hope was that this approach would produce fruitful results for the farmers in a relatively short period of time.

Potential cropping systems have been formed from available crop varieties and production technology,and then screened both in the experimental farm and in the farmers' fields. Feedback information from the farmers fields has been used to improve the systems. Improved cropping systems are then extended to the farmers.

Work done during the past five years, though giving variable results, has provided us with a lot of useful information and experience. Although certain promising cropping systems have been identified, many of of them have the drawback of having a high degree of instability. This

leads us to conclude that probably a longer time is needed for system improvement, or our research strategy has to be modified.

A recent trip to various places in the Northeast, especially to areas in Surin and Burirum, indicated that certain cultural practices, particularly land preparation, is a key factor for the success of growing peanuts after rice and kenaf. It, thus, appears that, with the farmers' technique, our cropping patterns of growing field crops after rice might be possible under similar environmental conditions. This suggests that not only theory but also techniques and experience from the farmers themselves should be used in forming new cropping systems. In future we thus plan to place a much greater reliance on using the experience of innovative farmers in our research. Our testing strategy, therefore, will be slightly modified as illustrated in Figure 7.1.

4. Research Priorities for future

In this report a number of key questions have been identified and listed separately in various chapters, and finally listed together in Chapter six. Some of these questions are best answered by other agencies and research groups. We have chosen a number of questions for our own attention, on the basis of their relevance to the goals of our program and our comparative advantage in finding answers. These selected key questions will thus be used in determining our research priorities and future plans. Since the questions relate to the system hierarchy, we will list them according to the macro, meso, and micro levels of agroecosystems, as follows:

Macrolevel

1. What effective measures need to be taken if the cassava market deteriorates?

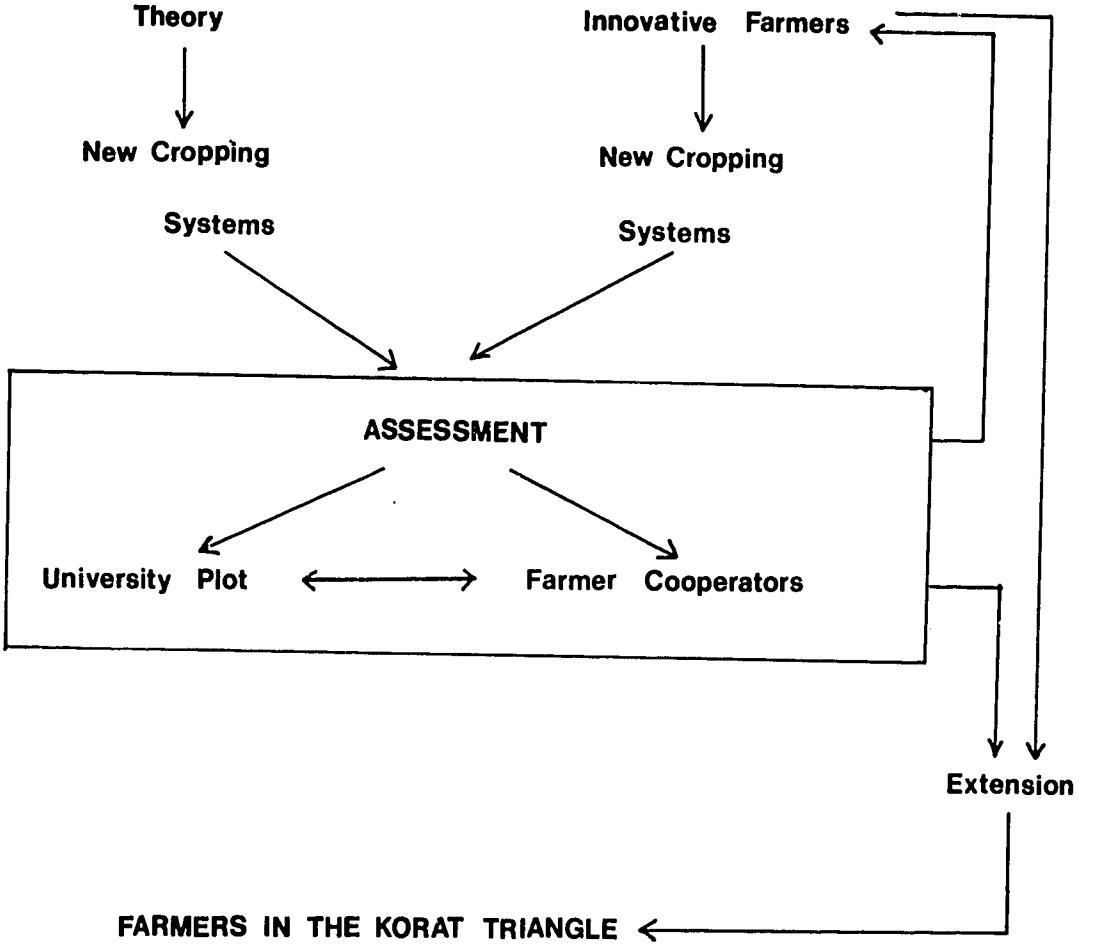

Figure 7.1. Modified testing strategy of the KKU Cropping Systems Project.

We will give high priority to this question since cassava is very important crop in the country and ranking second after rice. Cassava production depends exclusively on the world market, especially the European Economic Community (EEC), and the price of cassava in the past few years has fluctuated very much in response to the demand of the world market. The farmers in the Northeast will suffer most if EEC cuts off its cassava imports from Thailand. It will also have immediate impact on the national economy. Alternative crops, therefore,have to be seeked. In fact, EEC itself in cooperation with Ministry of Agriculture and Cooperatives has set up a research program for crops to replace cassava. Recent data indicated an increase in acreage of sugar cane, peanut, and mungbean in the Northeast. We, therefore, will look for cropping systems which involve these crops.

2. How is the productivity and stability of the Triangle affected by the other systems in the Northeast?

The Northeast region consists of four major agroecosystems - the Korat Triangle, the Mekong Provinces, the Western Hills, and the Southern Hills. Each system interacts with each of the others. A change in one affects the other systems. It is important to know how the other systems will have an effect on the productivity and stability of the Triangle which is our target system.

3. Which major change in government policy will bring about the greatest increases in agricultural productivity?

An increase in agricultural production in the Northeast, especially cassava and corn, depends heavily on the world trade market. However, the productivity of the Triangle, as we have seen in the earlier discussion, is much affected by government policies such as irrigation, fertilizer, agricultural price, and marketing policies. These policies have both negative and positive effects on productivity. For example, the rural work program appears to have a negative effect on dry season cropping and also on the labor-exchange system.

4. Would substitution of non-glutinous rice for part of the glutinous rice acreage increase farm income and its stability, and if so, what measures are required by the government to encourage this ?

5. Would a higher price encourage farmers in the Northeast to switch from glutinous to non-glutinous rice and/or to purchase more inputs, particularly fertilizer and pesticides ?

Rice grown in the Northeast is mainly glutinous type and is for family consumption. Its production is to meet immediate subsistance requirements, with perhaps some surplus sold in the good years. Glutinous rice has a low price and a limited market. Substitution of non-glutinous rice might then increase farm income. The farmers realize this, but it appears that they are not willing to switch their rice crop. What kind of measures will encourage the farmers ? Would a higher price alone do so ?

Mesolevel

1. How can the miniwatershed be best managed as a system ?

2. What is pattern of distribution of land types on individual farms ?

3. How can the upper paddy area be best managed ?

4. What is the precise nature of the interactions between the various land uses in the watershed ? For example, how does the use of the upland areas affect the water supply to the paddy areas, and can improved systems of water management be designed which optimise the performance of the watershed in all years ?

5. Would contouring and reconstruction of the bunds improve the overall performance of the typical watershed ?

6. What role have small tanks to play in improving the performance of the watershed ?

We cassified the rainfed cultivated land of the Northeast region into miniwatershed, non-flood plain, and flood plain. Miniwatershed is further

divided into upland, upper paddy,and lower paddy areas. The success of our rainfed cropping systems depends entirely on soil moisture.

Any management practices of soil and water that can keep sufficiant soil moisture to meet the crop growth requirement would be highly desirable. For example,farmers try to grow rice in the upper paddy areas which is more suitable to field crops by putting up bunds to keep water in the field. Most of the years,they cannot transplant their rice,or if they can,the crop often times fails, due mainly to inadequate rainwater. If the water supply in the soil, especially during the dry season, is used to grow crops in the upland areas,it may cut down the moisture supply in the adjacent upper paddy fields. We,therefore,have to find ways to improve management in these land types to suit our cropping systems.

Microlevel

1. How can the climatic pattern be most appropriately classified for agronomic purposes,and what extra parameters and analysis are required to do this ?

The mean annual rainfall of 1,200 mm seems to be adequate for any crop species grown in the Triangle. However, crops in the region are always damaged by drought and flood. The distribution of rainfall on a weekly or daily basis is far more important to the farmers as it varies from year to year and location to location. This kind of microclimatic pattern will have significant impact on cropping systems. The early and late monsoon rainfall is also important and affect crop plantings.

2. What is the moisture storage potential under the Khon Kaen and Roi-et rainfall regimes,and how can it be best exploited for more intensive cropping ?

For our cropping systems where two crops are grown in sequence, the cropping season will last longer than the rainy season. It requires

the first crop to be planted early and the second crop to be harvested late. Crop growth, therefore, depends entirely on stored soil moisture. Soil moisture potential is affected by topographic position, soil types, water table, and techniques of land preparation. Intensive studies should be carried out to gain better understanding and solve this problem.

3. What are the principal causes of microvariability in the Northeast soil, and can cropping practices and systems be devised which will overcome the instability of yields this creates ?

Soil microvariability refers to land areas which produce uneven crop growth. It is common for tropical soils. Certain crops like maize and sorghum respond significantly to this, while others do not. Some experiments have already been set up to investigate this problem, but solutions are not yet available.

4. What is labor availability and distribution for existing cropping systems?

Recently, labor availability for farm activities has become a problem, although the average family size is seven, and four persons are of working age. It appears that non-farm activities have drawn away the labor force. It is very important to know the actual availability of labor for farming, especially during the peak period of growing season.

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