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An Interdisciplinary Perspective of Cropping Systems in the Chiang Mai Valley : Key Questions for Research

by

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PREFACE

The work described in this document was initiated early in 1979, and although still continuing, this report outlines the progress made up to February, 1980. The objective of the work was to develop and then use a methodology for planning future multiple cropping research in the Chiang Mai Valley.

At the outset publishing a document of this nature was not seen as a primary objective of the study. It has now become apparent, however, that publishing this report could have a number of beneficial uses to a variety of individuals and institutions. First, it serves as a benchmark for the MCP group to assess the progress made and to refocus attention on the critical problems impinging on multiple cropping research in the Chiang Mai Valley. Second, by presenting the work to other interested parties and institutions it enables the methodology so far developed to be further refined and improved through criticism and discussion with a wider range of people. Furthermore, although this report focusses specifically on multiple cropping in the Chiang Mai Valley, the methodology developed remains sufficiently general and flexible to be of potential use in a wide variety of other situations where cropping systems research is being undertaken or planned.

In addition to the potential uses already mentioned, by presenting the large and varied amount of data and information analysed by the group while conducting the study, this report may be of value to a wide range of individuals or groups either currently conducting or planning to initiate research in the Chiang Mai area.

Because of the interdisciplinary nature of the work and the need for a large number of people from very different disciplines to be able to communicate in common terms, it has been essential throughout the period of study to present results in simple terms, in such a way that they focus on the main objectives of the study and are readily understandable by all members of the group. For these reasons it is hoped that the information presented in this document will be useful to and readily assimilable by all groups of individuals whether they be government agents such as extension workers, research personnel or administrators.

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Drafts of the manuscript have been read by Dr. Sam Johnson of the Ford Foundation and Dr. Earl Kellog of Illinois University and we are grateful to them for their comments.

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We are very grateful to all officers of the Royal Irrigation Department and the District Agricultural Offices who supplied information and gave us their time to discuss the specific characteristics of agriculture in their areas.

We thank Jaturong Puangmanee for his painstaking preparation of the many figures and Sritai Boonprohm for the typing of the several drafts of the manuscript.

Most importantly we wish to thank the farmers of the Chiang Mai Valley who readily and cheerfully gave their time to answer our questions and also contributed their own ideas many of which have been incorporated into this report and which, we believe, added greatly to the relevance of the study and to the value of this report.

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CONTENTS

PREFACE ii

CHAPTER ONE INTRODUCTION

1. Objectives of the report
2. Multiple cropping in the Chiang Mai Valley
3. The Multiple Cropping Project (MCP)
4. Procedure of analysis

CHAPTER TWO PATTERN AND PROCESSESS : STRUCTURE

1. The system boundary
2. Soils
3. Water supply
4. Cropping intensity
5. Population
6. Land holding
7. Infrastructure
8. Village and farm

CHAPTER THREE DYNAMICS

1. The seasons
2. Cropping patterns
3. Prices, credit and labour
4. Long term changes
5. Stress and perturbation

IAPTER FOUR DECISION MAKING 116

1. National policy objectives
2. Patterns of decision making
3. Farmers' goals and values
4. Perceptions, attitudes and constraints
5. Farmers' strategies and tactics

HAPTER FIVE THE EVALUATION OF CROPPING SYSTEMS 149

1. Cropping systems on the University experimental plots
2. Experience from the village programme
3. A portrait of the Valley systems and the constraints to increasing intensity

CHAPTER SIX SYSTEM PROPERTIES 172

1. Introduction
2. The properties of agro-ecosystems
3. The Chiang Mai Valley agro-ecosystem
4. Multiple cropping systems

CHAPTER SEVEN KEY QUESTIONS 194

1. Introduction
2. Context questions
3. Valley system questions
4. Valley sub system questions
5. Village system questions
6. Farm family system questions
7. Cropping system questions
8. Component questions

CHAPTER EIGHT CONCLUSION 212

1. An assessment

2. Priorities

3. Comparative advantage of the MCP

REFERENCES 219

GLOSSARY 227

THAI LANGUAGE GLOSSARY 235

LIST OF FIGURES

		PAGE
1.1	Map of the Northern Region of Thailand.	2
1.2	Map showing the paddy land of the Chiang Mai Valley.	3
1.3	Outline of the procedure of the study.	6
2.1	Map showing the boundary of the system.	9
2.2	Map showing Changwat boundaries and major road networks within the system.	10
2.3	Diagramatic cross section of the Valley.	11
2.4	Map showing major soil-types in the Valley.	12
2.5	Map showing major irrigation systems in the Valley.	16
2.6	Map showing traditional irrigation systems in the Valley.	17
2.7	Map showing Royal Irrigation Department projects in the Valley.	19
2.8	Map showing cropping intensity in the Valley.	22
2.9	Map showing population, by amphur.	24
2.10	Map showing population density, by amphur.	25
2.11	Map showing total agricultural households, by amphur.	26
2.12	Map showing agricultural households as percentage of total households, by amphur.	27
2.13	Map showing size of agricultural holdings, by amphur.	28
2.14	Map showing land tenure patterns, by amphur.	30
2.15	Typical village land profile.	34
3.1	Annual climatic patterns in the Valley.	41
3.2	Major cropping patterns in the Valley.	48
3.3	Seasonal price movements of selected crops in the Valley.	53

3.4	Cash expenditure profiles of selected cropping systems in the Valley.	57
3.5	Labour requirement profiles of selected cropping systems in the Valley.	61
3.6	Trends in cropping intensity, 1970-78.	66
3.7	Trends in the relative importance of the major dry season crops grown in the RID systems.	67
3.8	Crude birth rates in Chiang Mai Province, 1950-73.	69
3.9	Age and sex structure of the population, Chiang Mai Province.	72
3.10	Age and sex structure of selected villages in the Valley.	73
3.11	Trends in age - specific fertility in Chiang Mai Province.	75
3.12	Price indices for fertilizer in Thailand, 1967-76.	80
3.13	Average annual local retail prices of fertilizer, 1963-77.	81
3.14	Trends in the controlled price of fuel, Chiang Mai City, 1971-80.	82
3.15	Trends in annual prices of major selected crops in the Valley.	85
3.16	The effect of planting date on the yield of peanut and sunflower.	90
3.17	Trends in rainy season rice yield, MCP plots, 1969-79.	93
3.18	Changes over time in soil pH associated with cropping intensity and cultural practices.	94
3.19	Changes over time in soil pH associated with the use of chemical fertilizers.	95
3.20	The effect of planting date on the incidence of and damage due to beanfly in soybean.	97
3.21	The effect of planting method and weeding treatment on rice yields.	98
3.22	The effect of weed competition on the yield of mungbean.	107

3.23	The effect of plant spacing in peanuts on yield levels and the incidence of weeds.	108
3.24	Fatalities due to malaria, 1937-78.	110
3.25	Calendar of traditional festivals and ceremonies in Northern Thailand.	111
3.26	Potential sources of climatic perturbation.	114
4.1	Spheres of decision making: use of the national water resource.	128
4.2	Decision making structure within the RID irrigation projects.	130
4.3	Operational structure of traditional irrigation systems.	132
4.4	Spheres of decision making: traditional irrigation systems.	133
4.5	Spheres of decision making: agricultural credit.	135
4.6	Spheres of decision making: agricultural marketing.	137
4.7	Spheres of decision making: agricultural production technology and marketing information.	139
4.8	Decision tree for farmer's choice of cropping strategy.	145
6.1	Map showing the Valley subsystems.	178
6.2	The combined cash expenditure profiles for 3 multiple cropping systems.	184
6.3	Major elements of a sequential multiple cropping system.	185
6.4	Hypothetical destabilizing effect in the second crop due to a perturbation in the first crop.	189
6.5	Hypothetical compensatory effect in second crop due to a perturbation in the first crop.	189
8.1	Models of cropping systems research.	214

LIST OF TABLES

		PAGE
2.1	Comparison of major soil types in the Chiang Mai Valley.	13
2.2	Traditional irrigation systems with permanent head regulators.	18
2.3	Royal Irrigation Department projects in the Chiang Mai Valley.	18
2.4	Irrigable and planted area in R.I.D. systems in the Chiang Mai Valley.	20
2.5	Some processors of agricultural produce in Chiang Mai Province.	31
2.6	Percentage of farmers using seed stored from a previous crop.	36
2.7	Percentage of farmers using fertilizer, by type.	37
2.8	Percentage of farmers using mechanised power.	38
2.9	Percentage of farmers using pesticides.	38
3.1	Credit demand and maximum credit given.	56
3.2	Demographic statistics for Northern Thailand (1970-74).	68
3.3	Annual population growth rate of Amphurs in the Chiang Mai Valley.	70
3.4	Changes in agricultural households in the Chiang Mai Valley.	71
3.5	Long term changes in average holding size and cropped area, by Amphur.	76
3.6	Production costs and returns from the application of chemical fertilizers.	78
3.7	Utilization of chemical fertilizer in Thai agriculture, 1967-76.	83
3.8	Linear trends fitted to monthly nominal prices of selected crops.	84

3.9	Proportion of rainy season rice lost due to major perturbations in the Chiang Mai Valley.	88
GE 3.10	Optimal fertilizer levels for the Chiang Mai Valley.	91
3 3.11	Optimal levels of micronutrient application at the M.C.P. plots.	91
8 3.12	Crop damage due to pests, diseases and weeds and their control recommendations.	99
3 3.13	Effects of cultural weed control on grain yields in rice.	106
) 3.14	Harvesting losses in rice.	109
3.15	Changes in human disease incidence in the Chiang Mai Valley, 1970-78.	112
4.1	Abstract of Thailands agricultural policy : targets and development aims, 1961-81.	118
4.2	Water users' associations in the Chiang Mai Valley.	131
4.3	Farmers' strategies and tactics.	146
5.1	Cropping system budgets for the M.C.P. experimental plots.	150
5.2	Crops ranked by selected criteria, M.C.P. plots.	154
5.3	Systems ranked by selected criteria, M.C.P. plots.	155
5.4	Cropping systems tested by the M.C.P. in the test villages.	158
5.5	Costs and returns to the systems operated in the test villages, 1975-76.	159
5.6	Costs and returns to the systems operated in the test villages, 1976-77.	161
5.7	Crops ranked by selected criteria in the village programme.	162
5.8	Systems ranked by selected criteria in the village programme.	163
.1	The major elements of a system.	173
.2	Characteristics of the Valley subsystems.	179

6.3 Distinction between system and component properties and their effects on productivity, stability and durability. 18

CHAPTER ONE

INTRODUCTION

Objectives of the report

In 1969, the Faculty of Agriculture of Chiang Mai University began ı programme of research aimed at developing multiple cropping systems ıdapted to the irrigated areas of Northern Thailand and especially of the :hiang Mai Valley. Over the past ten years a variety of cropping systems ınd techniques have been designed and experimented upon in research plots ›n the University campus and subsequently tested in farmers' fields. On ›ccasion, farmers, observing the trials, have adopted the new practices, ıt least in part. Yet, in reviewing our experience it is evident that all :oo frequently our cropping systems and techniques have not been as suit- ıble in meeting the needs of the farmers as those they have developed for :hemselves. If we are to realize our initial purpose we need, at this juncture, a very critical assessment of our research programme and it's ›elevance to the broader context of development in the Valley.

The purpose of this report is (1) to review the state of multiple :ropping in the Chiang Mai Valley; (2) to identify problem areas where more ›esearch effort is needed; and (3) to establish research priorities and lirections for the multiple cropping programme.

2. Multiple cropping in the Chiang Mai Valley

The Chiang Mai Valley, covering an area of about 150,000 hectares of :ultivated fertile flood plain, is situated along the Ping River between .8°20' and 19°10' north latitude and 98°50' and 99°10' east longtitude in :he northern part of Thailand (Figure 1.1). The average altitude is about 300 meters above sea level. Paddy land occupies about 75 percent of the ırea, the rest is in diversified crops and fruit trees (Figure 1.2).

The average annual rainfall (1951-1976) is 1218 mm., but it varies ıidely from year to year. There are several distinct seasons within a year ıhich enable a wide range of crops, tropical as well as temperate, to be ;rown in the Valley.

The Chiang Mai Valley is the most intensively cropped area in North- ›rn Thailand. The most common cropping pattern in the Valley is two crops ›er year: rice followed by an upland crop or rice; but in some areas, three :rops are grown: rice followed by two upland crops or an upland crop and ›ice. The Valley is a net exporter of agricultural produce, although in ıome years has to import rice from other areas.

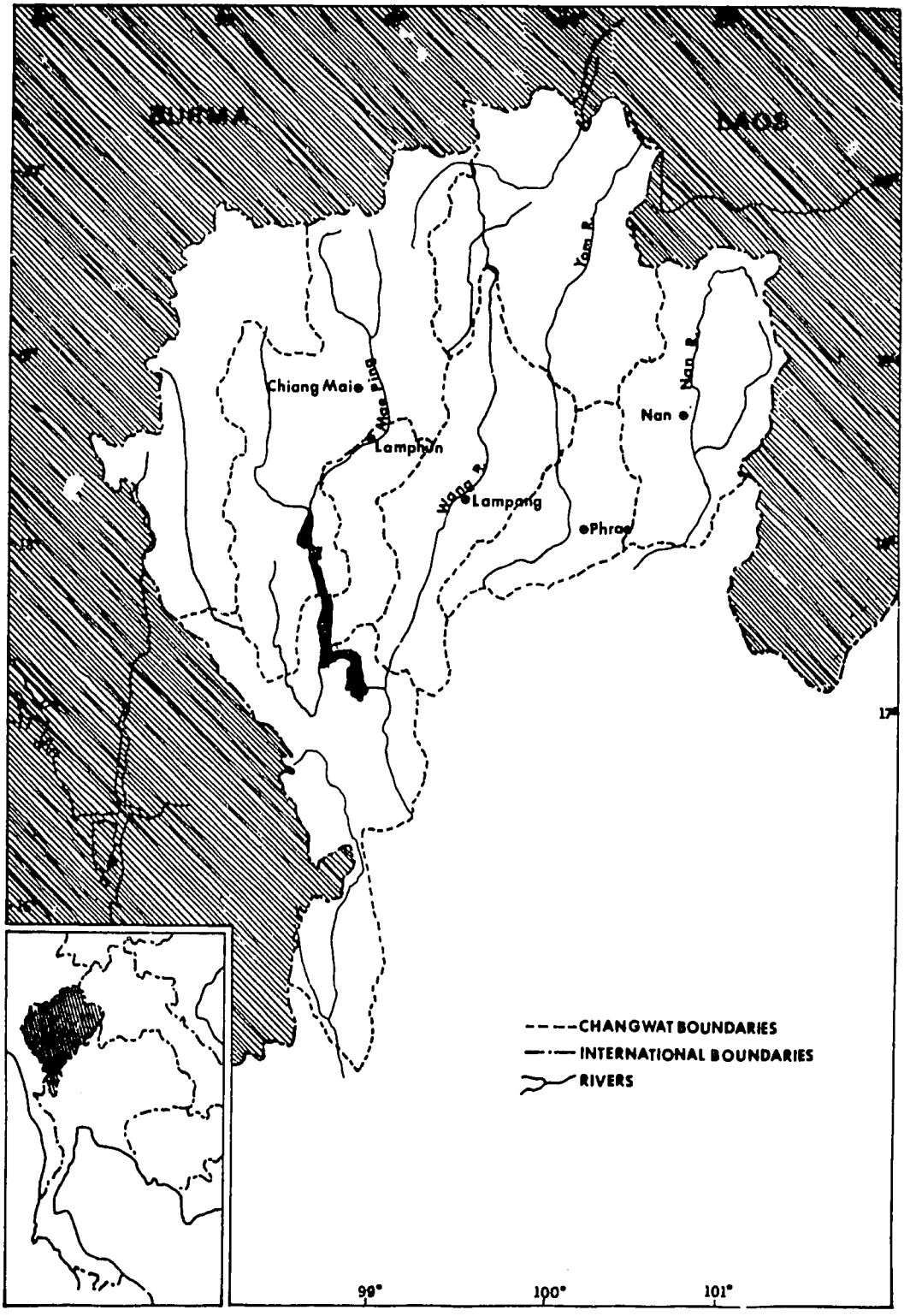

Figure 1.1 Map of the Northern Region of Thailand

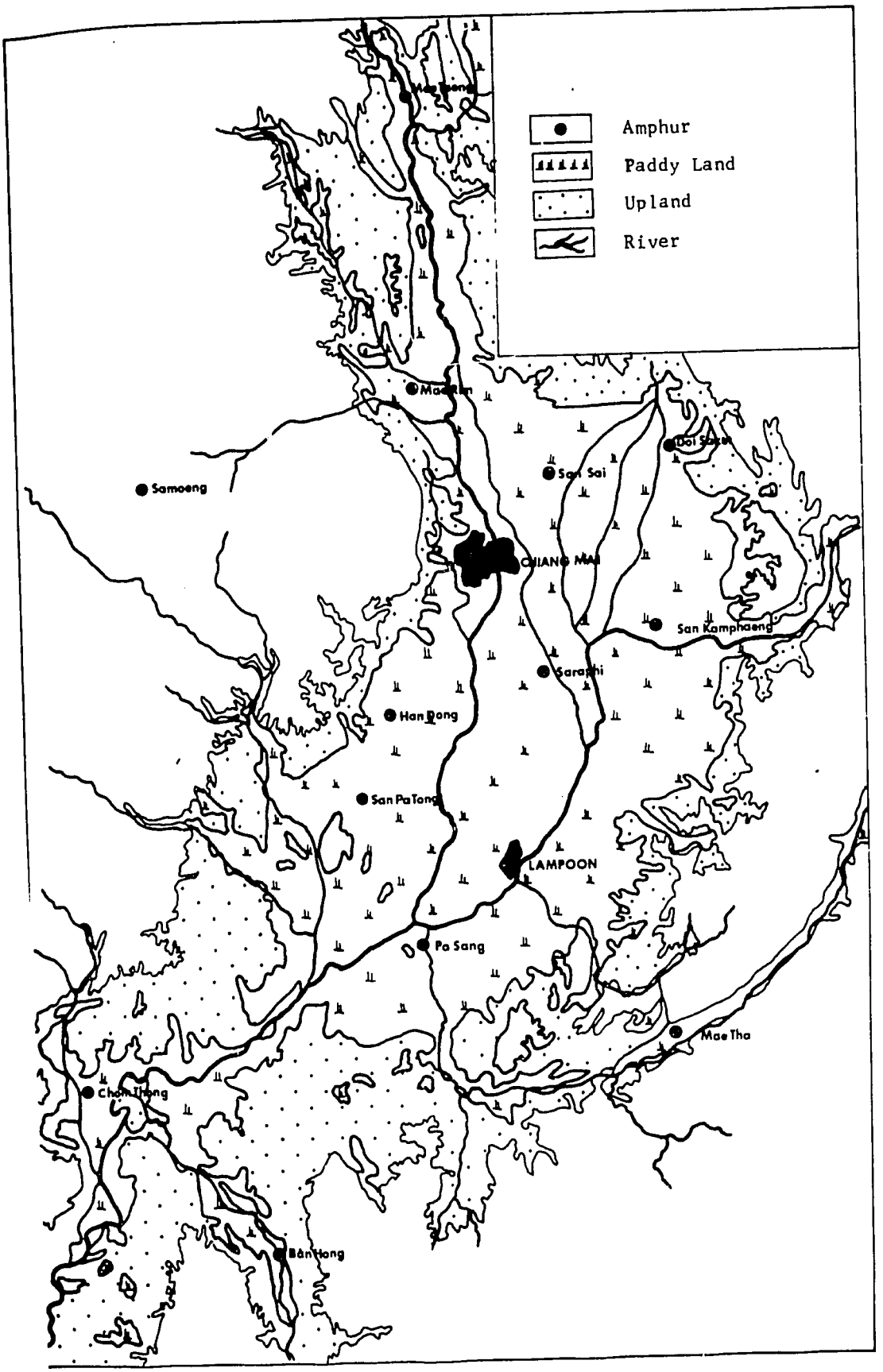

Figure 1.2 Map showing the paddy land of the Chiang Mai Valley

3. The Multiple Cropping Project (MCP)

The MCP is an interdisciplinary research project of the Faculty of Agriculture, Chiang Mai University. It was established in 1969, with support from the Ford Foundation who have provided consultants, equipment, supplies, fellowships and research assistance. During the first two and a half years much effort was directed towards developing laboratories, an experimental site and office for the project and in planning the research. Subsequently two main programmes have evolved, namely agronomy and social science. Village testing also forms an integral part of the MCP research and it is intended that the Project will also participate in the training and extension of multiple cropping.

The agronomy programme has focussed on the design and testing of various cropping systems, while the social science programme has set about identifying the economic and social constraints to increasing cropping intensity. In the past, however, insufficient interaction has occurred between the two programmes. As a consequence the agronomists have tended to concentrate on developing systems which have maximum production potential, but employ a package of practices designed for optimal conditions of water supply, labour, etc. The resulting systems have not been particularly suited to the needs of farmers faced with social, economic and physical constraints different from those in the experimental plots. It is primarily for this reason that we now need to critically examine our research programme, focussing on the system aspects and identifying those areas where integration of ideas and effort is most urgently required.

4. Procedure of analysis

The team which prepared this report consists of 12 staff members of the MCP and one consultant, who collectively represent the disciplines of agronomy, soil physics, crop breeding, crop physiology, weed science, entomology, plant pathology, agricultural extension, agricultural economics and systems ecology. It was recognised at the outset that a systematic, yet flexible and rapid procedure of work was required if the different disciplines were to interact productively with each other in the preparation of the report. Such a procedure had been developed for ecosystem studies elsewhere (Walker *et al.*, 1978) and it was decided to modify and improve on this so as to provide an analytical approach appropriate to a large scale agro-ecological study.

The critical assumption underlying the approach 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. Thus at the heart of an efficient systems analysis lies the successful identification and formulation of a set of key questions which relate to these processes and decisions.

The next three Chapters in the report respectively describe the patterns of structure, dynamics and decision making in the Chiang Mai Valley. Chapters 5 and 6 deal explicitly with the system characteristics. Chapter 5 evaluates the performance and constraints of the multiple cropping systems in the Valley while Chapter 6 discusses the system properties of productivity, stability and durability. The key questions are listed and discussed in Chapter 7. In the final Chapter the questions are assessed in terms of their appropriateness for research by the MCP.

The procedure is designed to ensure that agricultural, ecological, socio-economic and management issues are raised simultaneously in the investigation, 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 groups of two or three individuals.

Figure 1.3 outlines the procedure. It begins with an agreement on the system to be studied and an identification of the system boundary. The seminars then concentrate on analysing patterns and processes in the system. This involves explicit examination of (1) the structure of the system, its spatial relations, (2) the dynamic processes that characterise the relationships in time, and (3) the pattern of utilisation and decision making present in the system. Existing knowledge is reviewed by the group, making extensive use of dioristic models (Southwood, 1978), 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. Firstly it serves to uncover gaps in existing knowledge, secondly, out of the discussions and arguments generated by the seminars there emerge the first outlines of the key questions and finally it serves to establish a holistic framework ensuring, as far as possible, that the cropping systems analysed in Chapter 5 are evaluated in terms of all relevant factors and also helps to identify the important interactions that arise due to the system properties discussed in Chapter 6, enabling the group to evaluate the overall performance of the entire valley system. The key processes and decisions become progressively clearer and the group is able to reformulate and refine the key questions. Initially the questions tend to be framed in purely agricultural, ecological, socio-economic or management terms. The agricultural questions focus on productivity, on the optimal utilisation of resources and the overcoming of constraints; the ecological questions focus on stability and particularly on how the system and its components respond to stress and perturbation; the socio-economic questions focus on the choices facing decision makers, at all levels; while the key management questions focus on the design of the policies, strategies and tactics required to improve both productivity and stability. However, through discussion and the process of reformulation and refinement there eventually emerges a limited number of very powerful key questions which combine elements of each of the foregoing.

Once the questions have been determined the procedure then requires the group to analyse itself, as a research team in terms of its capacity to answer each of the questions. The exercise is essentially one of

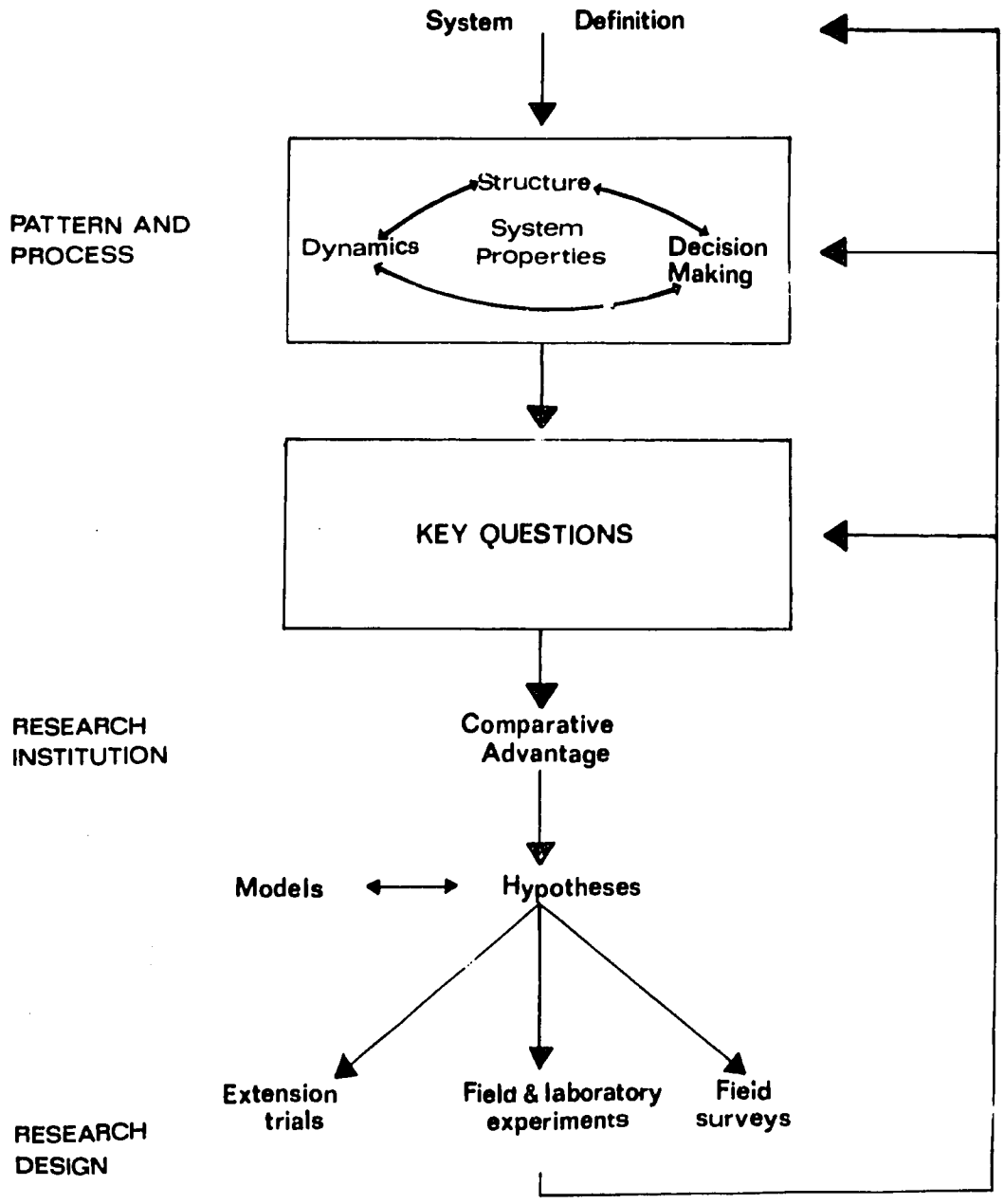

Figure 1.3 Outline of the procedure of the study

assessing the comparative advantage of the group with respect to other research groups with an existing or potential interest in the system. This results in a screening of the questions leaving a limited set for the group to consider further. The penultimate phase of the procedure is to turn these surviving questions into testable hypotheses. These hypotheses may then be refined or even partially tested by the use of mathematical and computer models.

The report thus finishes just prior to the hypothesis generating stage. The final phase of the procedure involves carrying out laboratory and field experiments, extension trials and field surveys to test the hypotheses. The results from these modify what has gone before, new key questions emerge and the process repeats itself.

CHAPTER TWO

PATTERN AND PROCESSES : STRUCTURE

1. The system boundary

We chose as our system boundary the limit of contiguous paddy land in the Chiang Mai and Lampoon *Changwats** (Provinces) in the Chiang Mai Valley (Figures 2.1 and 2.2). Paddy land is here defined as land on which wet season rice is usually grown in bunded fields where the soil is submerged for most of the growing season. All of this land is potentially irrigable; at present water is derived from Royal Irrigation Department and traditional irrigation systems and from tube wells and shallow dug wells.

This limit follows approximately the 330 metre contour line (Figure 2.3). Most of the RID main canals follow this contour. The boundary also encompasses the flat recent alluvial land together with most of the semi-recent and low terraces in the Valley. Outside the boundary, between the 330 and 400 metre levels lies a zone of high terraces and upland in which there are some broken areas of paddy land, but these are excluded from the study system.

The agro-ecosystem, so defined, includes all land in the Valley that is capable, given sufficient water supply, of continuous cropping throughout the year.

2. Soils

The soils in the Chiang Mai Valley are derived from alluvial deposit and may be classed as old, semi-recent and recent alluvials (Figure 2.4). Old alluvial soils are found on the edges of the Valley, while the recent alluvials are scattered along the main rivers. The semi-recent alluvials, which lie in between, are the most extensive. In the three groups a total of 66 soil series have been identified (Min. Agric. Coop., 1976) but only a few of these occur widely. Indeed only two, Lampang and Hang Dong, dominate the old and semi-recent alluvials respectively. Outside the boundary are old alluvial soils, predominantly of the San Sai series.

The soils of the Valley are very similar in many of their detailed characteristics (Table 2.1). In general they vary from loam to silty loam and silty clay loam to clay, with a few sandy loam and sandy clay loam soils. The clay mineral is predominantly kaolinite. Surface drainage is slow, with poor to moderate permeability and internal drainage. For an

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* A number of Thai words are used throughout this report in their romanise form because no direct translation is possible. The first time each wor is used in the text it appears in italics to indicate that its meaning can be found by reference to the Thai glossary at the end of the report.

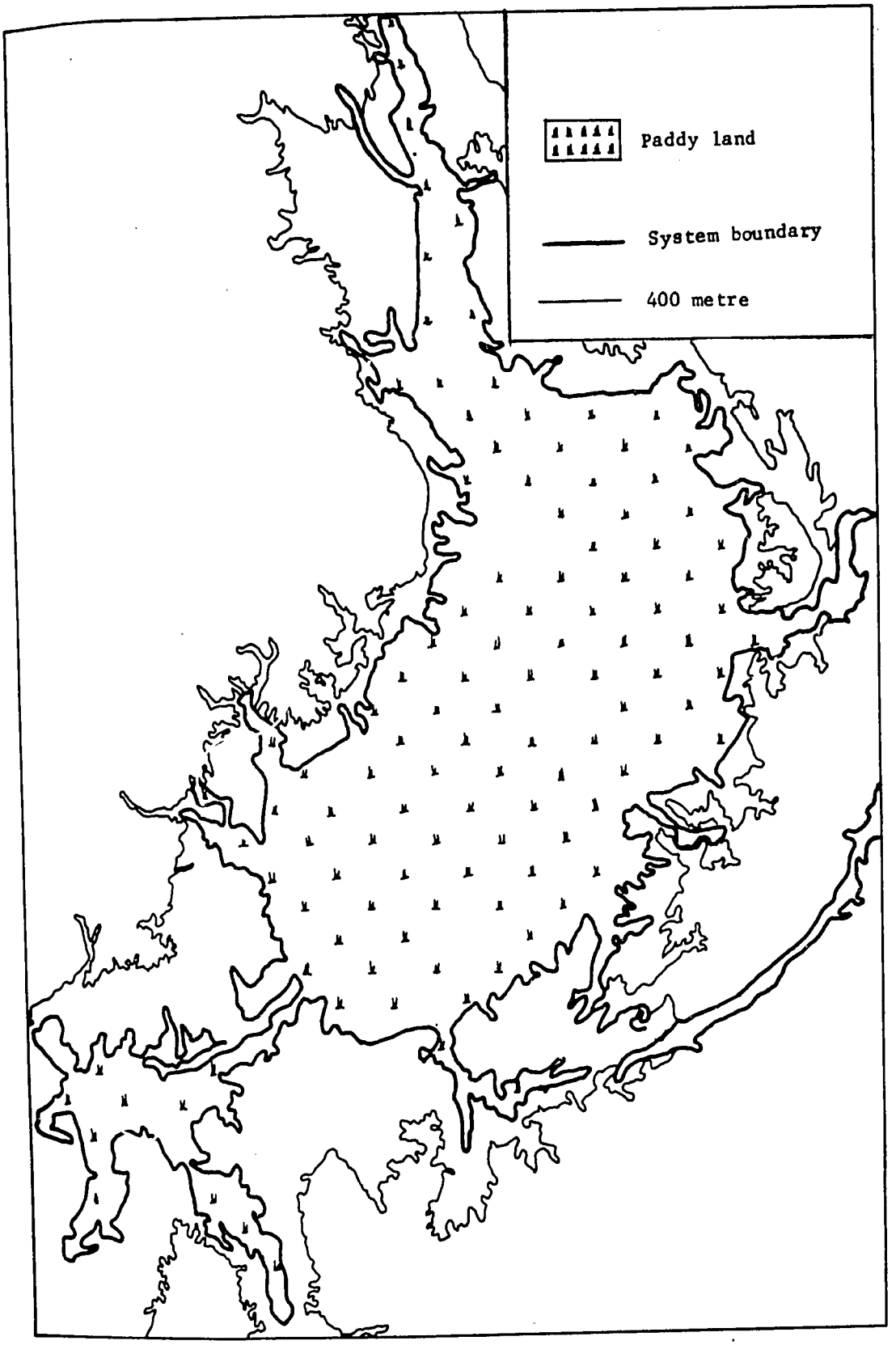

Figure 2.1 Map showing the system boundary

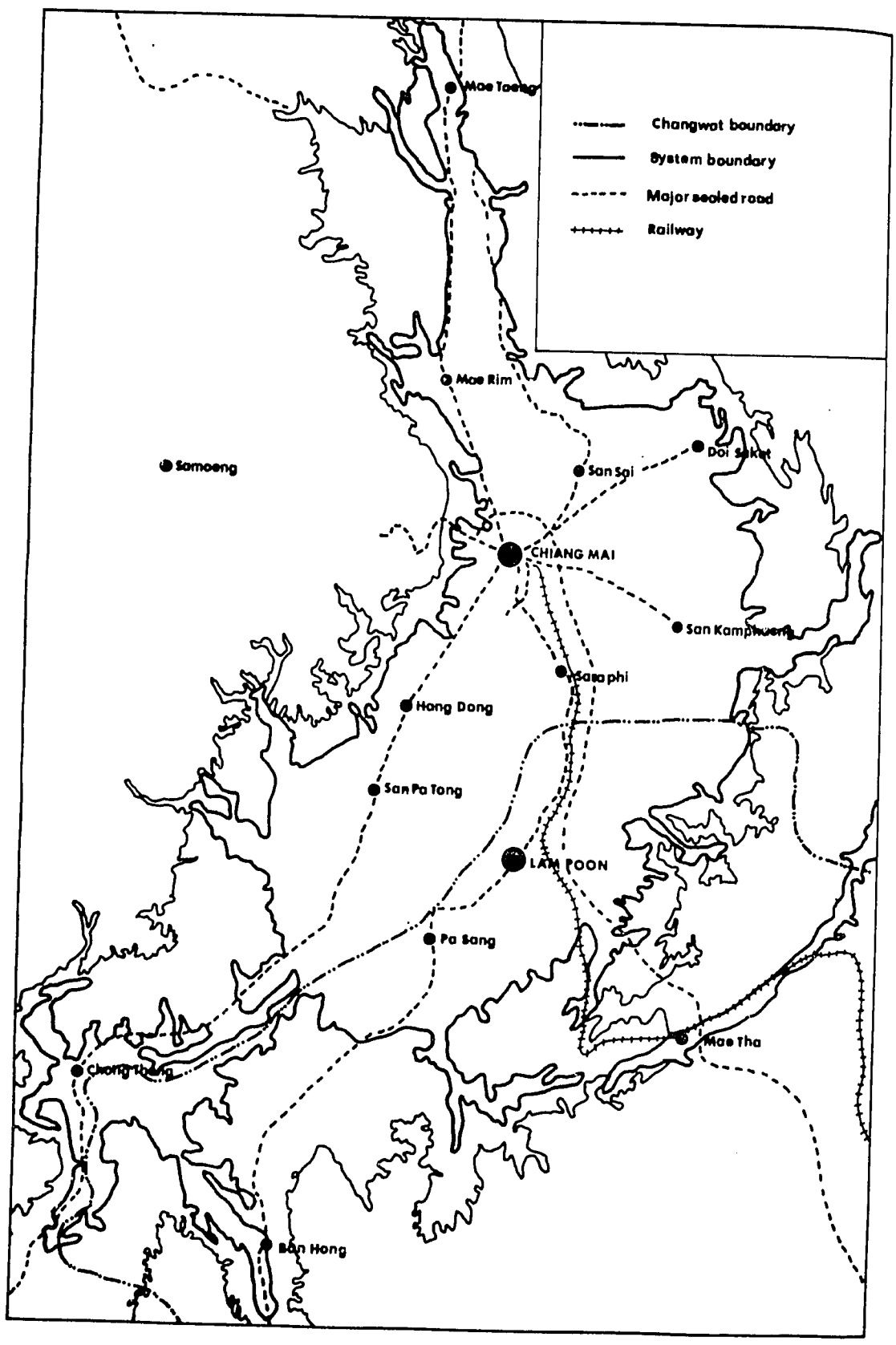

Figure 2.2 Map of Chiang Mai Valley - Changwats and Roads

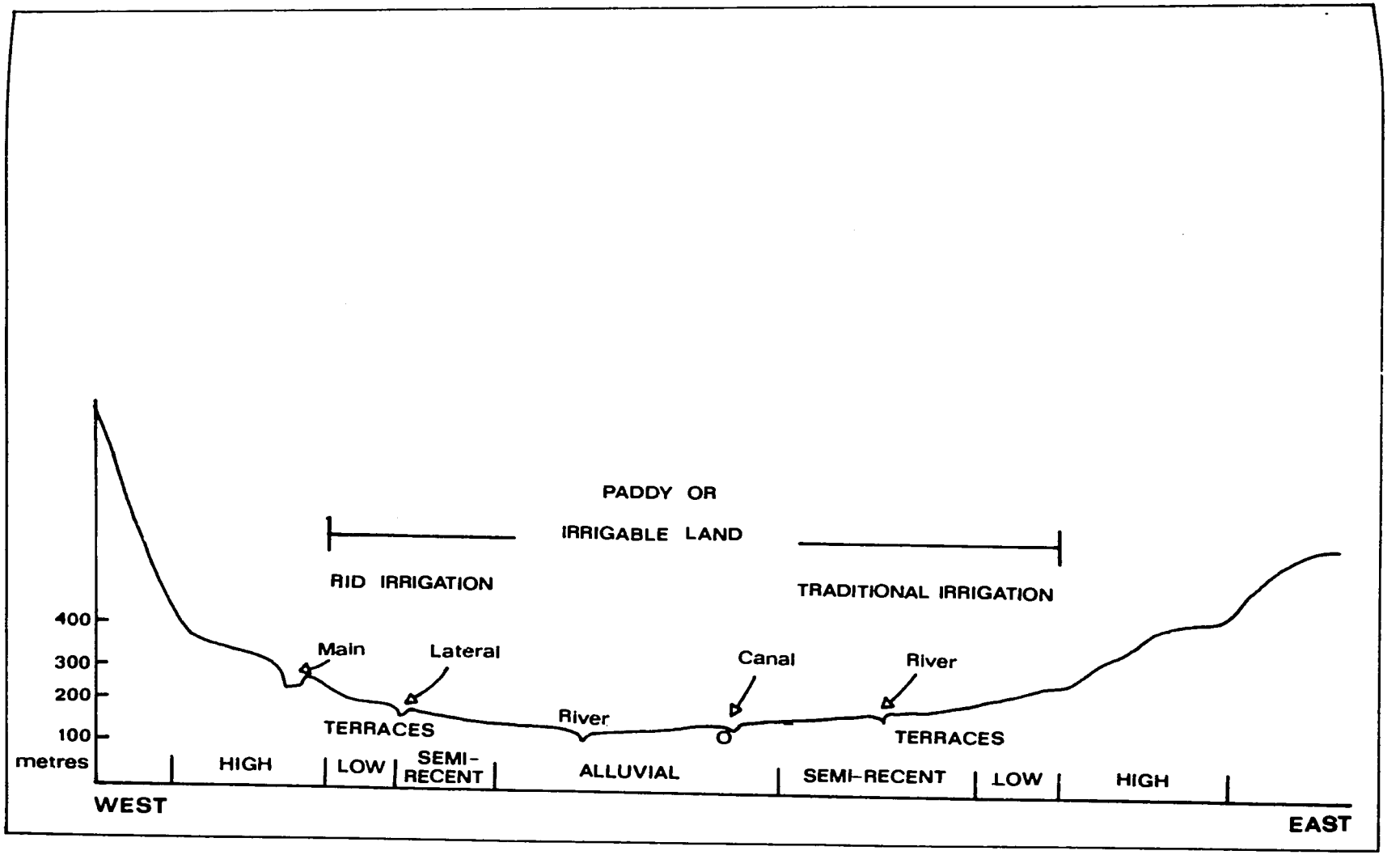

Figure 2.3 Map of Chiang Mai Valley - Valley profile

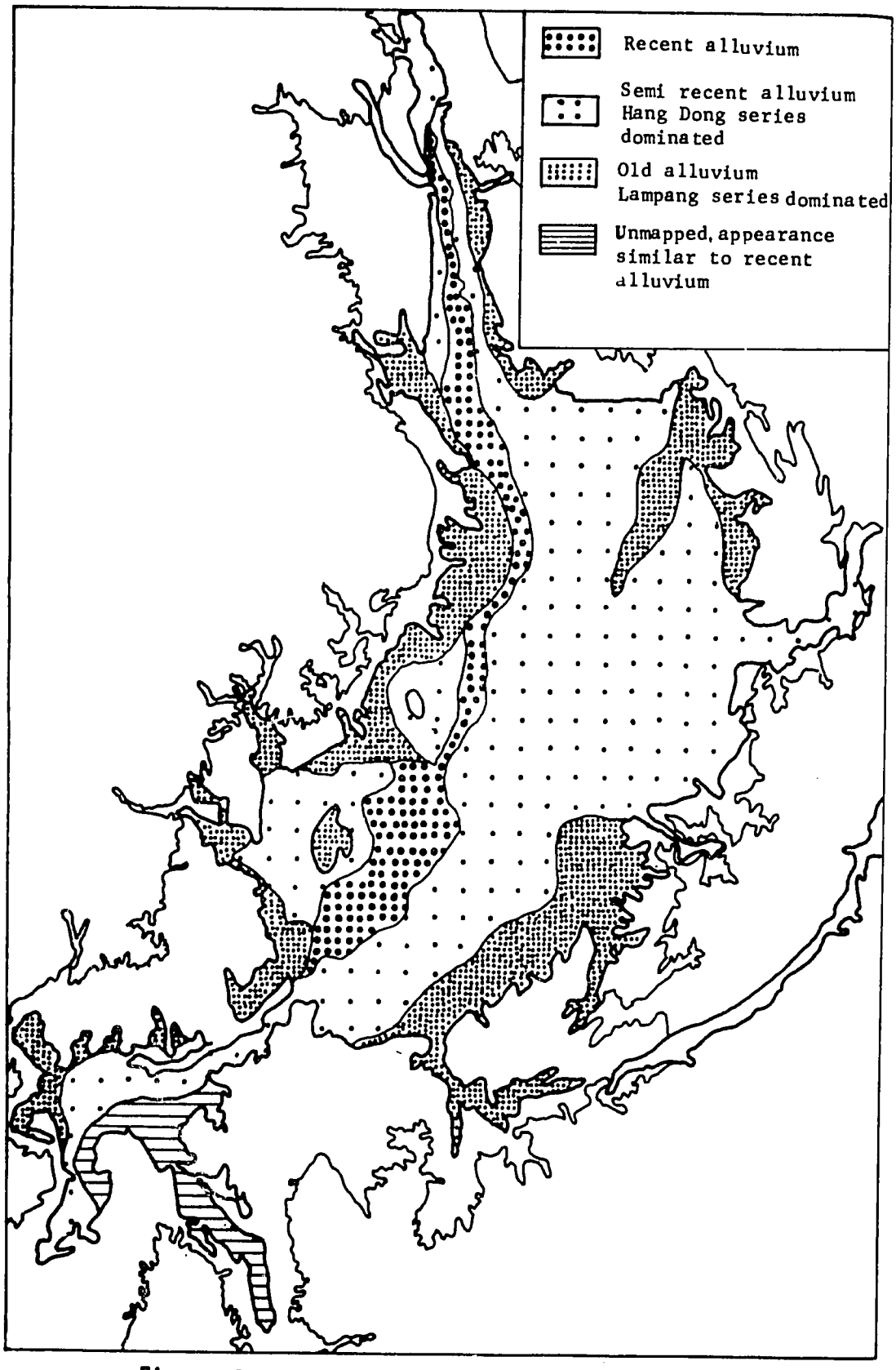

Figure 2.4 Map of Chiang Mai Valley - Soil types

Table 2.1 Comparison of major soil types in the Chiang Mai Valley (Simplified from Min. Ag. Coop., 1976)

	(Old alluvials) Lampang	(Semi-recent alluvials) Hang Dong	(Recent alluvials)
1. Classification a) National d) USDA	Low-Humic-Gley Typic Paleaquults	Typic Tropaqualfs	Alluvials Ustifluvents and Tropaquepts
2. Soil depth	Very deep		
3. Slope	0 - 2%		2%
4. Texture	Silt loam to clay	Silty clay to loam	Fine loam to clay
5. Colour	Pinkish grey, greyish brown to light grey with brownish mottles	Dark grey to light grey with brownish mottles	Dark grey to dark brown
6. Structure a) Upper A-horizon b) Subsoil	Weak to coarse subangular blocky Moderate to coarse		Weak to coarse
7. Drainage	Poor		Poor to moderate
8. Permeability	Slow		Slow to moderate
9. Surface runoff	Slow		
10. Period of water saturation a) Surface b) Subsurface	4-5 months 5-6 months		0.5-5 months 0.5-7 months
11. Organic matter (% carbon x 1.724)	Low 0.5-1.0%	Medium 1.5-2.5%	Medium to moderately high 1.5-3.5%

Table 2.1 ... (cont'd)

	(Old alluvials) Lampang	(Semi-recent alluvials) Hang Dong	(Recent alluvials)
12. Base saturation 0-30+ cm	Medium 35-37%		Medium to high 35-75+%
13. Cation exchange capacity (me/100g soil)	Low, 3-5	Medium, 10-15	Medium to very high, 10-30+
14. Available phosphorus (ppm)			
0-30 cm	Moderately low, 6-10	Low, 3-6	Low to very high, 3-45+
30+ cm	Moderately low, 6-10	Moderately low, 6-10	Low to high, 3-45
15. Available potassium (ppm)			
0-30 cm	Low, 30-60	High, 90-120	Medium to very high, 60-120+
30+ cm	Low, 30-60	Medium, 60-90	Low to medium, 30-90
16. Reaction (pH 1:1 H_2O)			
0-30 cm	5.5-6.5		5.5-7.0
30+ cm	4.5-5.5	6.0-8.0	5.5-8.0

old alluvium of the San Sai series, which occurs in association with the Lampang series, the bulk density of the surface soil was estimated at 1.65 g/cm^3 with water holding capacity at 16% (w/w) at field capacity and 8% at permanent wilting point (MCP, 1975).

Except for the recent alluvials, which are annually flooded and thus have fresh deposits added, the soils are highly weathered. In general fertility decreases with age. Organic matter content, available phosphorus and potassium, cation exchange capacity and the combined percentage of exchangeable calcium, magnesium, potassium and sodium are higher in the recent alluvials than in the semi-recent alluvials and are lowest in the old alluvials (Table 2.1).

Since most are bunded for paddy rice cultivation, soils in the Valley are subjected to continuous water logging for 3-4 months a year, and up to 8 months a year in areas double cropped with rice.

3. Water supply

Over 80% of the paddy land in the Chiang Mai Valley is irrigated (Figure 2.5). Irrigation is essential for cropping in the Valley during the dry season and in the wet season is used to supplement rainfall. The irrigation systems in the Valley fall under 2 main categories: first, diversion systems which use diverted river water and ground water systems which use underground water. Diversion systems include both traditional and Royal Irrigation Department (RID) systems and the ground water systems consist of communal or privately owned dug wells and tube wells.

Traditional Irrigation

Traditional irrigation systems (Figure 2.6) are the most extensive, with over 2000 such systems in changwats Chiang Mai and Lampoon (RID, 1962). They are typically developed communally by groups of farmers and some are over 1000 years old. In the wet season, the systems cover about two thirds of the Valley (Sektheera and Thodey, 1975). However, most of the traditional systems are rather small, some covering areas under 100 rai, and water may not be available in the dry season. A typical traditional system is based on a wier, made from local materials such as bamboo stakes, logs and stones, which is built across a stream or river and serves to raise the water level to a height sufficient for diversion into irrigation canals. In some cases the weirs have been reinforced, in recent years, by concrete structures and a number of the large traditional systems, particularly in the south of the Valley, have permanent head regulators. Sektheera and Thodey (1975) list the number of these operating in the wet season as shown in Table 2.2.

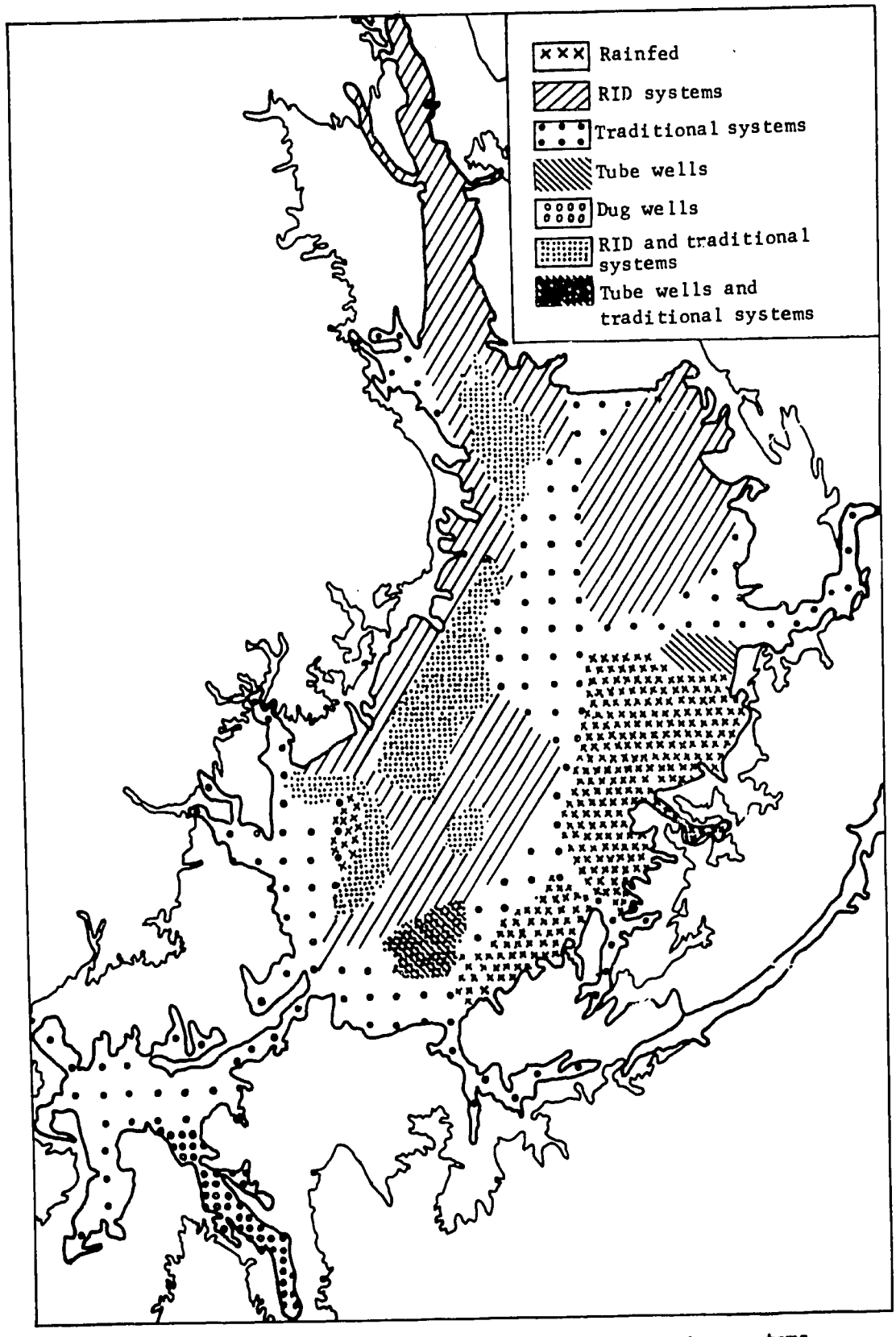

Figure 2.5 Map of Chiang Mai Valley - Irrigation systems

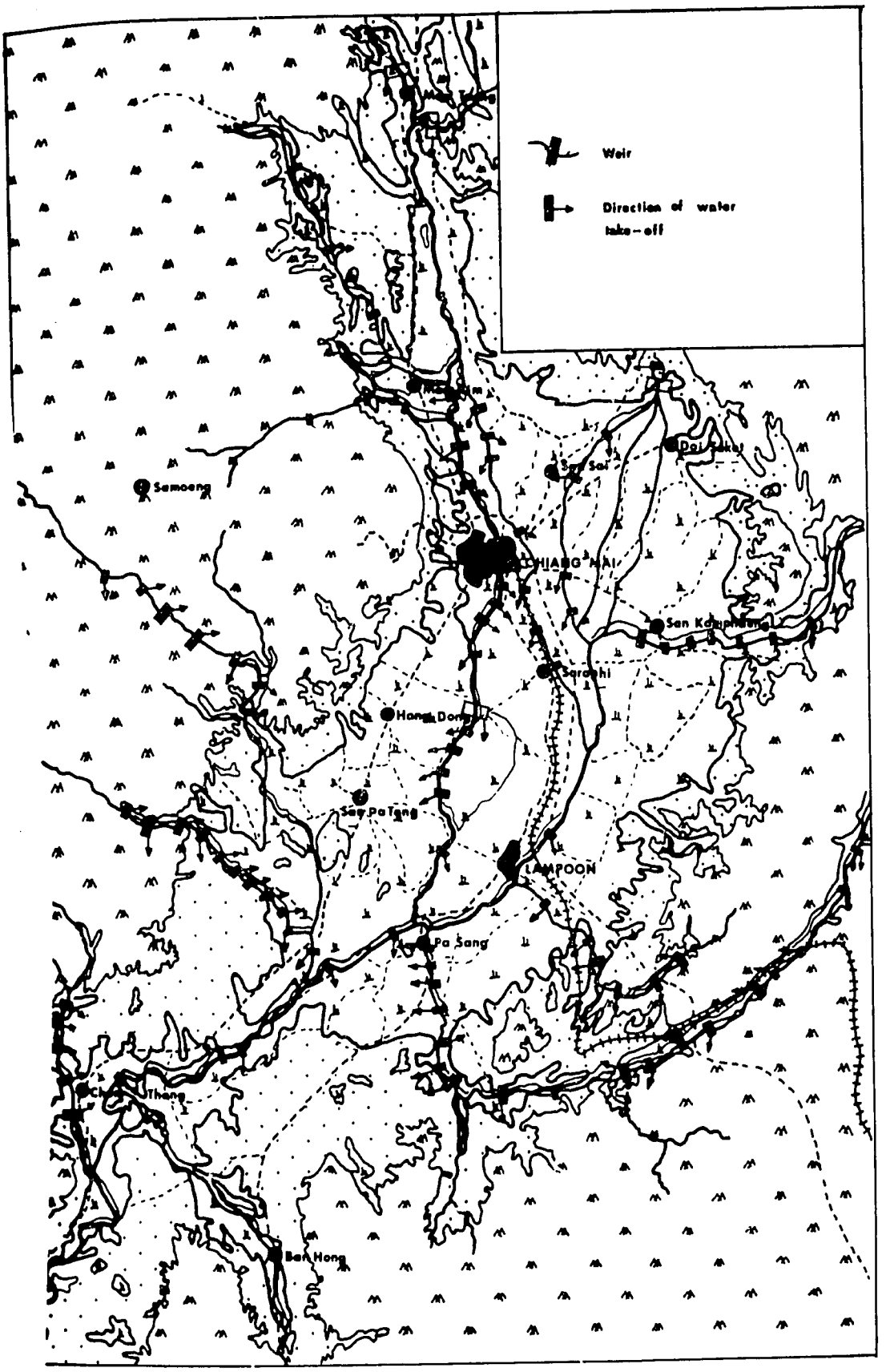

Figure 2.6 Map of Chiang Mai Valley - Traditional irrigation systems

Table 2.2 Traditional irrigation systems with permanent head regulators (Sektheera and Thodey, 1975)

	Area serviced in wet season (rai)		
	< 1,000	1,000 to 5,000	> 5,000
Number of systems with permanent head regulators	563	125	18

Some of the large systems have recently been improved by the RID.

There are no comparable figures for the dry season, but as an example the Tha Sala project in *amphur* Saraphi serves nearly 16,000 rai in the wet season and about 9,000 rai in the dry season (Kung, 1974).

Royal Irrigation Department

There are four RID systems in the Chiang Mai Valley which have been completed, serving about half of the paddy land (Figures 2.5 and 2.7). In these systems water is diverted from the rivers by permanent wiers into main canals, then into laterals and sublaterals before reaching the fields The length of the main irrigation canals and length and number of laterals and sublaterals are shown in Table 2.3.

Table 2.3. Royal Irrigation Department (RID) projects in the Chiang Mai Valley (Sektheera and Thodey, 1975)

Project	Source of water (River)	Year completed	Length (Km)		Number of laterals
			Main canals	Laterals and sublaterals	
Mae Taeng	Mae Taeng	1971	74.5	258.6	23
Mae Fack	Mae Ping	1935	36.0	55.0	17
Mae Kuang	Mae Kuang	1954	27.7	140.3	13
Mae Ping Kao	Mae Ping	1941	13.8	82.0	11

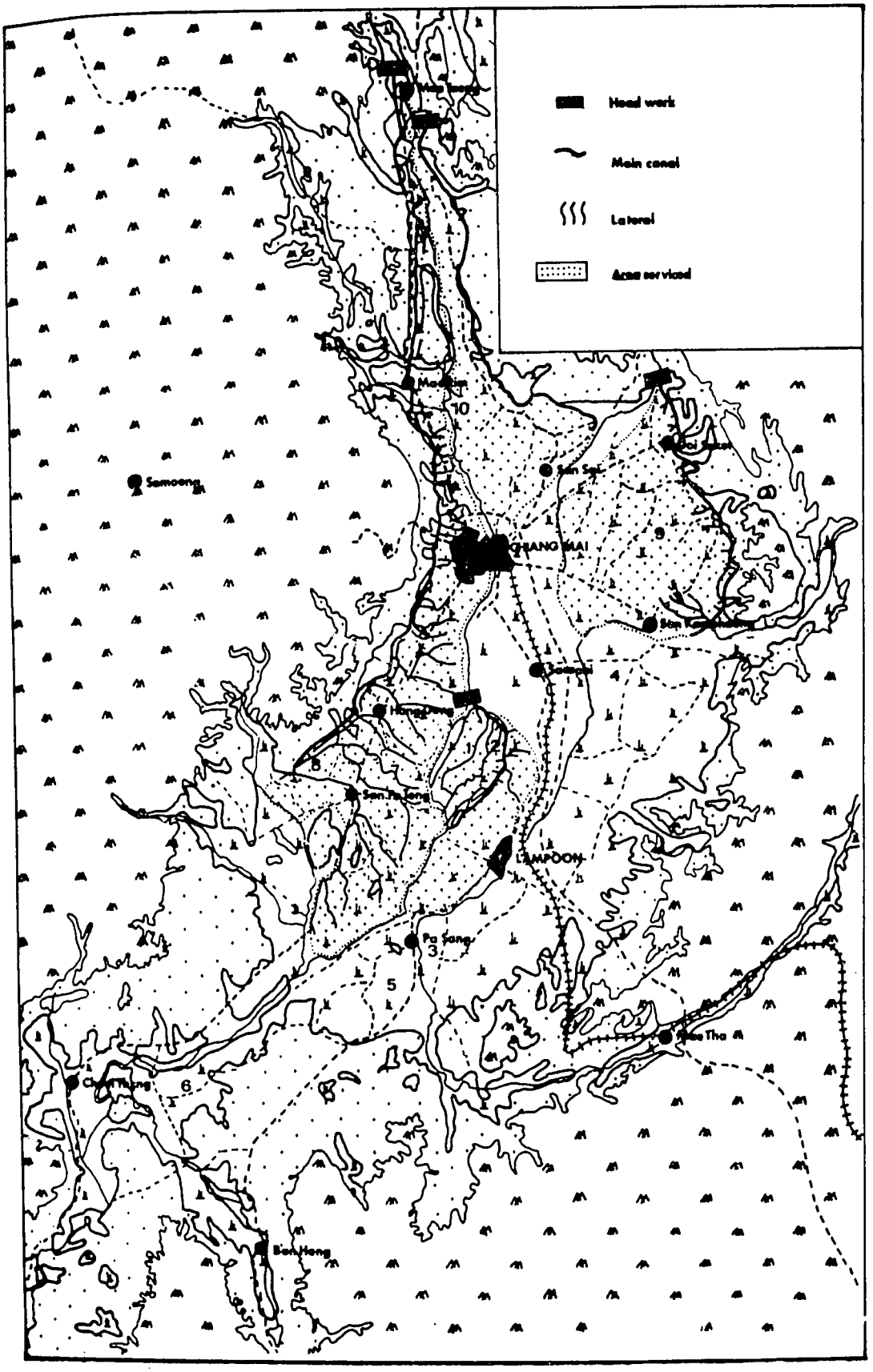

Figure 2.7 Map of Chiang Mai Valley - RID irrigation systems

At full capacity, the four RID systems, supplementing the rain, can irrigate 325,000 rai in the wet season (Table 2.4). However, the actual area planted varies from year to year depending on rain fall and the river flow that can be diverted. There are also some flood prone areas which cannot be planted in particularly wet years. On the average 95% of the irrigable paddy land is cropped each year.

Table 2.4 Irrigable and planted area in RID systems in the Chiang Mai Valley (Kung, 1974 and Sektheera and Thodey, 1975)

Project	Districts (Amphur) served	Irrigable area (rai)		Planted area (rai)*	
		Wet season	Dry season	Wet season	Dry season
Mae Taeng	Mae Taeng, Mae Rim, *Muang* Chiang Mai, Hang Dong and San Pa Tong	150,000	60,000	143,898	80,184
Mae Fack	San Sai, Mae Rim and Muang Chiang Mai	70,000	30,000	65,003	30,549
Mae Kuang	Doi Saket and San Kamphaeng	60,000	20,000	59,280	16,652
Mae Ping Kao	Saraphi and Muang Lampoon	45,000	30,000	40,261	30,599
Total		325,000	140,000	308,442	157,984

* Figures for planted area are means from 2 years data for Mae Taeng, and 12 years for Mae Kuang, Mae Ping Kao and Mae Fack.

In the dry season, with very little rain, only 140,000 rai can be irrigated, but the number of rai planted exceeds this on average by 13% (17,984). This is partly due to the extensive area of overlap between the RID and traditional systems (Figure 2.5); nevertheless water deficit does occur and is a growing problem.

Wells

Underground water is currently being used for irrigation in a small number of locations in the Valley (Figure 2.5). Tube wells are found in two locations, San Kamphaeng and Pasang districts. In the Ban Buak Kang area, for example, farmers have installed 20 tube wells which supply 150

rai in the warm and hot seasons. However there is evidence of increasing depth of the water table in these areas, now as much as 20 metres and farmers are progressively lowering their pumps. In the Ban Hong area, traditional shallow dug wells supply water for intensive cropping of vegetables in the dry season. Previously the crop area there had been small, water being drawn and carried by hand but with the introduction of small pumps dry season cropping has become extensive, so far apparently without any noticeable effect on the water table. At the height of the dry season, in March 1979, water levels in these open wells were never lower than 4 metres.

4. Cropping Intensity

The measure of cropping intensity, the 'cropping index' is traditionally defined as the number of crops grown on the same piece of land in one year x 100.

A large proportion of the agricultural land in the Valley is cropped more than once a year (Figure 2.8) and the average cropping index over the whole Valley was estimated to be 163% in 1978 (Nippanutiyan, 1979). Rice in the wet season is the main crop in the Valley and almost all of the cropping patterns are built around this crop (Kung, 1974; Tongsiri *et al.*, 1975 and Seetisarn, 1977). As can be seen from a comparison of Figures 2.5 and 2.8 cropping intensity is closely related to water supply.

Single cropping, usually with wet season rice is found in areas with no water supply during the dry season. This includes the rainfed area, part of the RID serviced area, particularly in the Mae Kuang, and areas served by very small traditional systems. Double cropping is found in most of the area served by the RID systems, in some of the medium size traditional systems and in the tube well systems.

Throughout the Valley farmers often devote a very small fraction of their land, 0.1 to 0.2 rai, to continuous cropping of vegetables, mainly for personal consumption. However, triple cropping on a large scale is restricted to the large traditional irrigation systems, as in Chomthong and Saraphi; to Pasang and Ban Hong where underground water is plentiful throughout the year; and to some areas where RID and traditional systems overlap.

Multiple cropping has greatly increased since the completion of the RID systems (Thodey and Seetisarn, 1974; Seetisarn, 1975 and 1977). However, it is significant that while much of the double cropping occurs within the RID systems most of the triple cropped land lies outside, in traditional or tube well systems. It would thus appear that there is only sufficient security of water supply for the third hot season crop when the farmer has a high degree of control over the irrigation system. RID water cannot be relied upon in the hot season and thus the only triple cropping in the RID systems occurs when there is a strong complementary traditional irrigation system present.

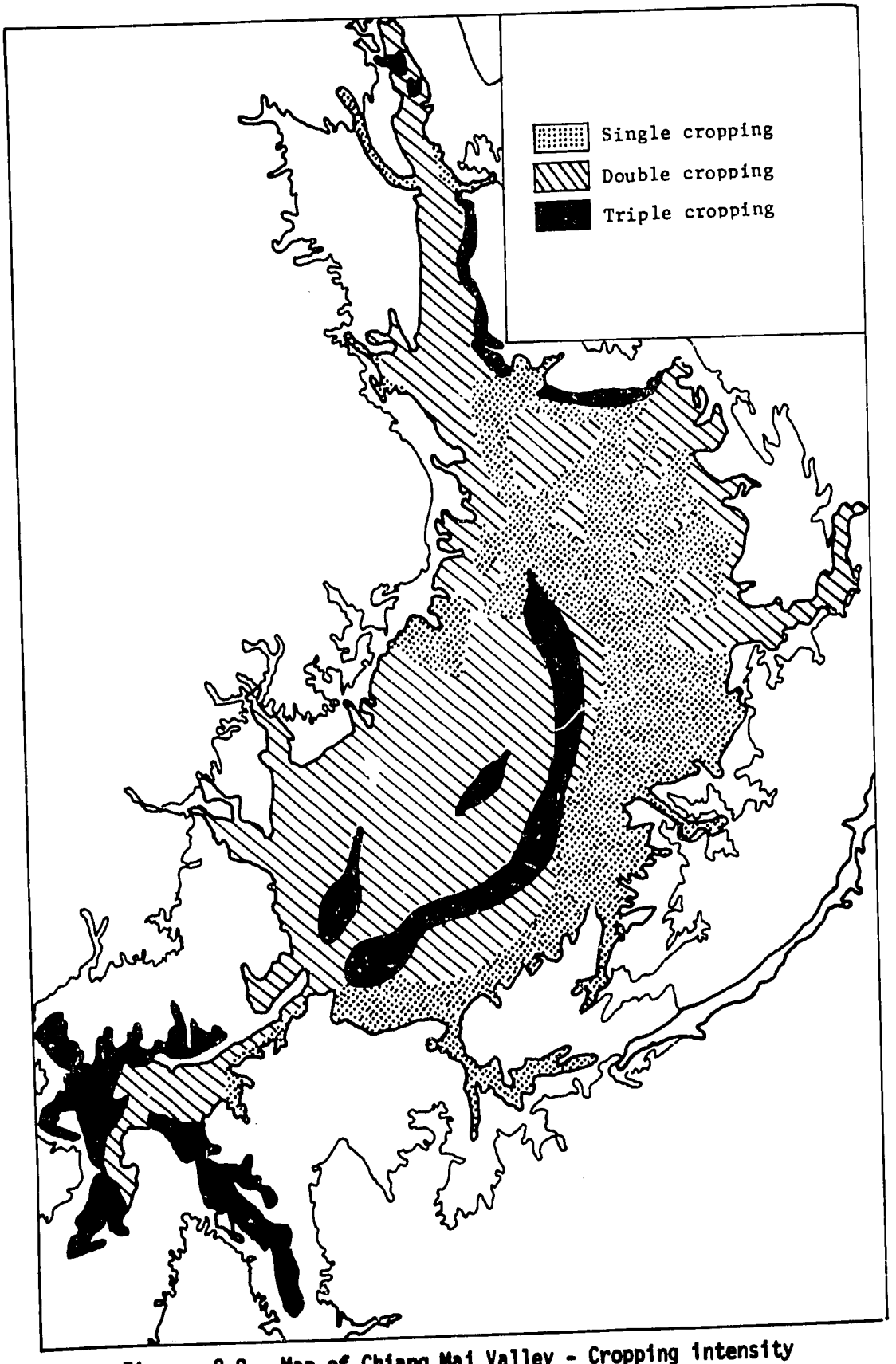

Figure 2.8 Map of Chiang Mai Valley - Cropping intensity

Comparison of Figures 2.4 and 2.8 suggests that soil type is less important in determining cropping intensity. Most of the triple cropping occurs on the semi-recent rather than recent alluvials, possibly because the latter, although more fertile, are prone to flooding and poorer water control. Double cropping occurs on both recent and semi-recent alluvials. However, much of the old alluvium is monocropped, but this probably is more a function of its position and hence lack of water supply than its soil properties.

5. Population

The total population of all the administrative units, amphurs, which lie partly or wholly in the Chiang Mai Valley, was estimated at 1,004,150 in 1974. Although this includes people living outside the Valley, the majority of the estimated population lies within the system, since the areas outside the system boundary are mostly highlands and uplands, and are sparsely populated.

The population and population density by amphur is shown in Figures 2.9 and 2.10.

Muang Chiang Mai (city district) has the biggest population, at 163,745. It is also the most densely populated with a density of 952 persons per square km. Muang Chiang Mai is the biggest urban centre in the area but its agricultural population is small (Figures 2.11 and 2.12). In 1970 the number of agricultural households was 2,781, less than 10% of the total households. The other amphurs are much less densely populated, with 50-75% of the households engaged in agriculture in 1970. Muang Lampoon, the second urban centre, has a population of 137,990, a little less than muang Chiang Mai, but in terms of density and proportion of households engaged in agriculture it is similar to the rest of the Valley. In general the population density appears to be related to the proportion of the total land in the amphur which is paddy land. The amphurs with a population density greater than 200/sq km lie mainly in the Valley while those with a density less than 100/sq km are predominantly upland amphurs.

6. Land holding

Farm size

The average farm size in the Chiang Mai Valley in 1975 was estimated at 8.8 rai (Tongsiri *et al.*, 1975). In many cases the holding is made up of several parcels of land, scattered quite far apart, one of these being the farmer's homestead. The average holding size by amphur in the Valley is shown in Figure 2.13. The smallest holdings, 4.5 to 5.5 rai, are in amphurs which lie across the middle of the Valley - San Pa Tong, Hang Dong, Saraphi, San Sai and Doi Saket, and also in Ban Hong in the southernmost part of the Valley. The biggest holdings, averaging considerably more than 6 rai are found in the south eastern amphurs - Pasang, Lampoon and San Kamphaeng. Chomthong in the south with Mae Taeng and Mae Rim which are in

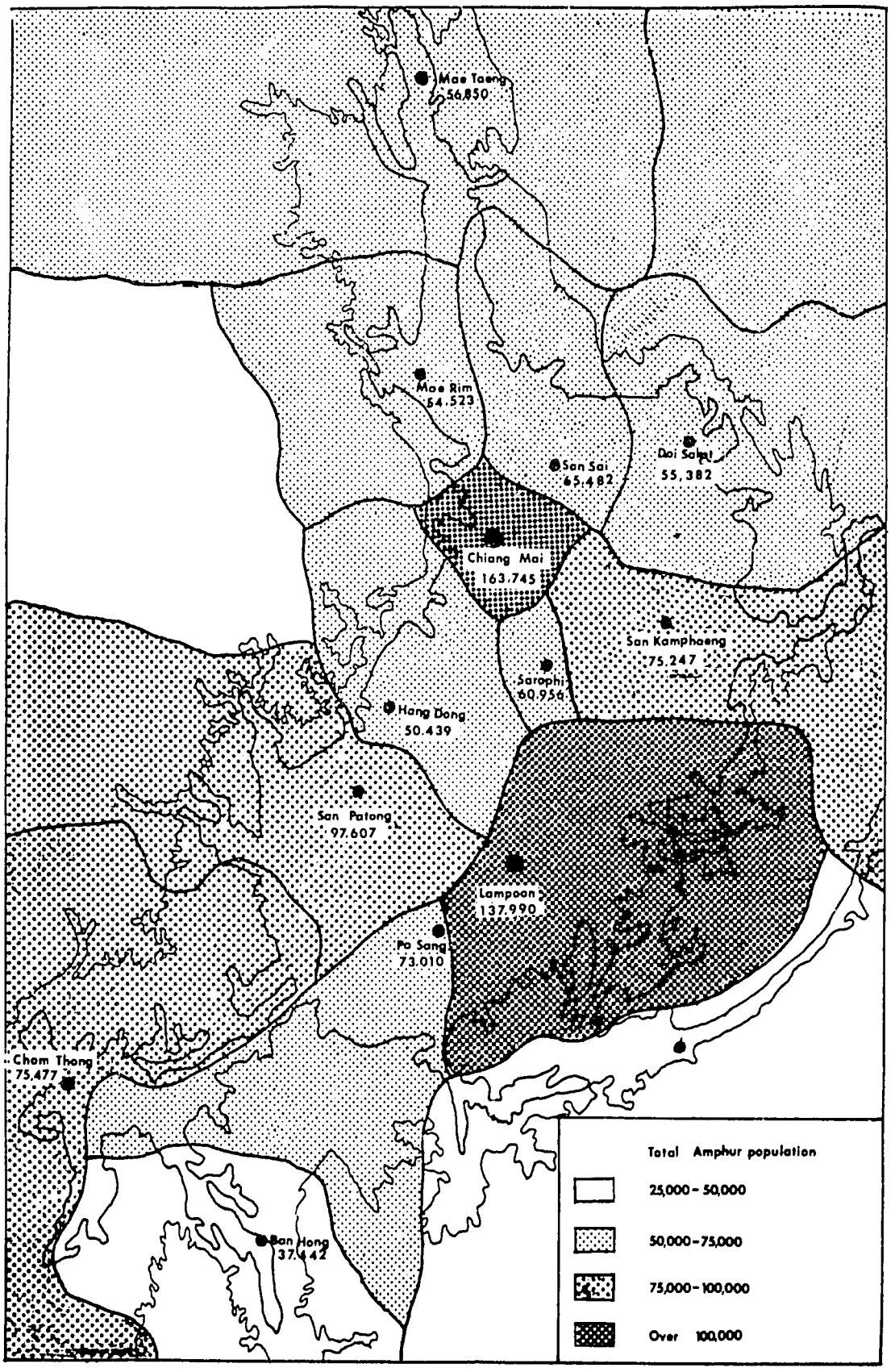

Figure 2.9 Map of Chiang Mai Valley - Amphur population (1974)

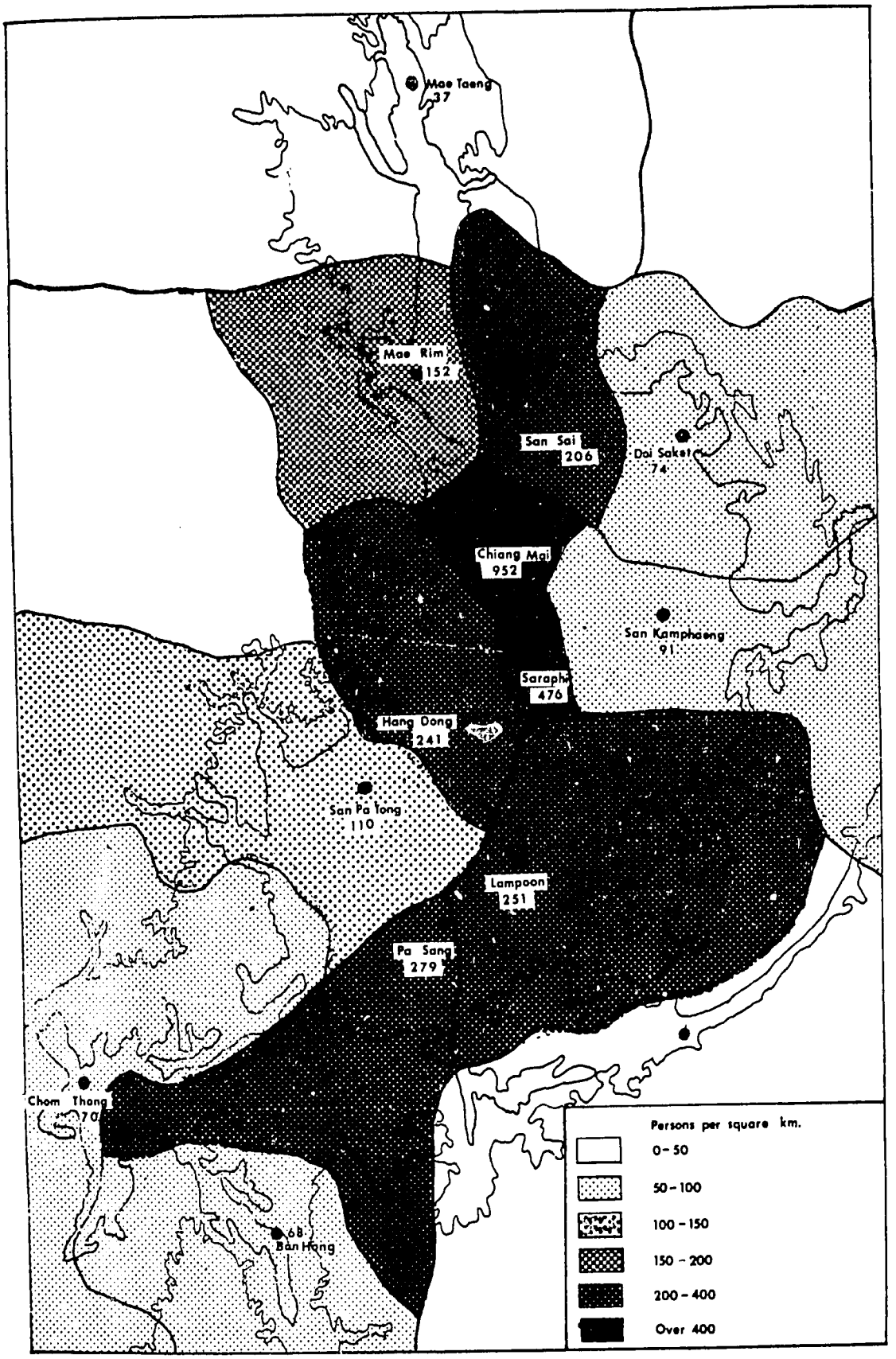

Figure 2.10 Map of Chiang Mai Valley - Amphur population density (1974

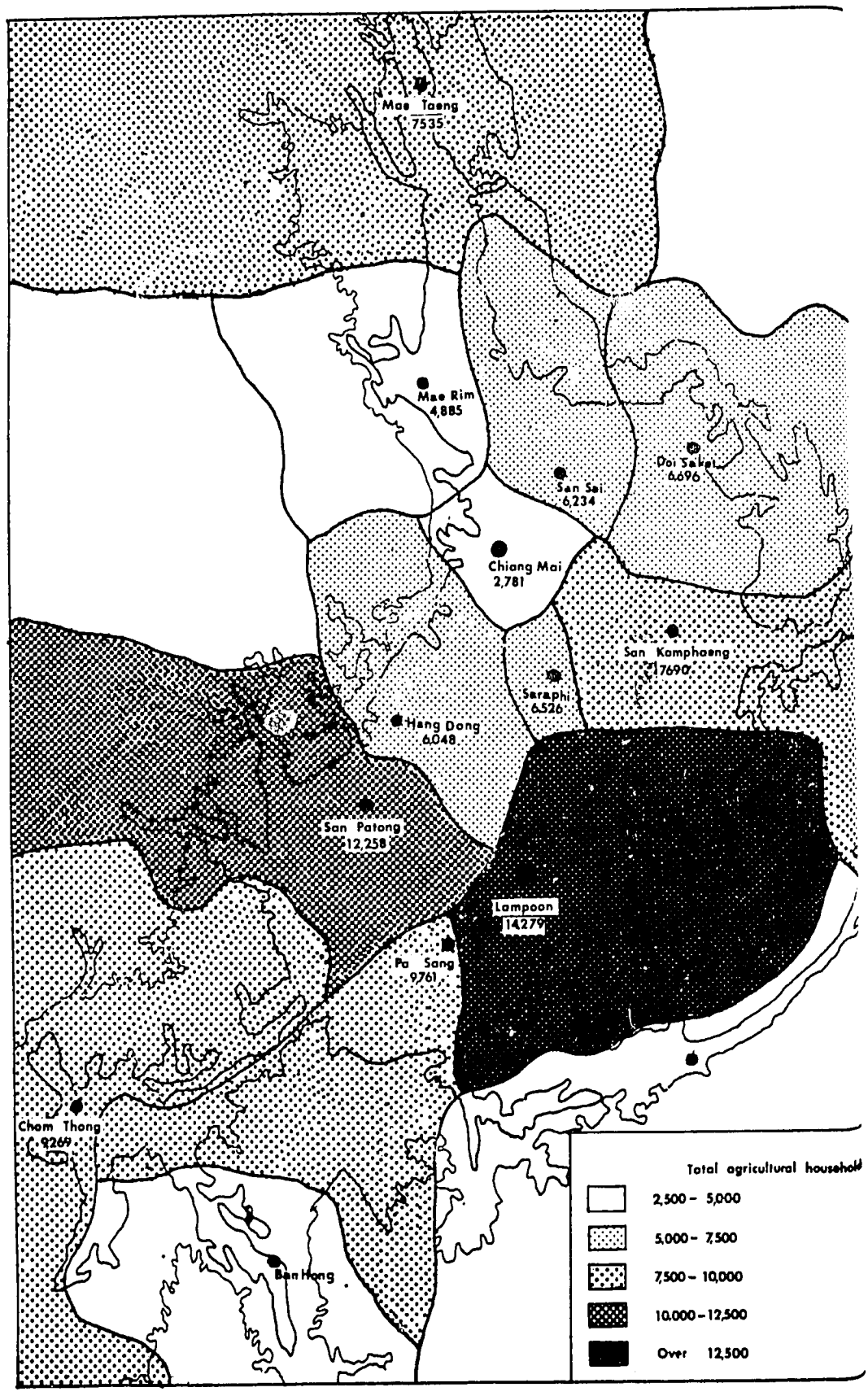

Figure 2.11 Map of Chiang Mai Valley - Agricultural households (

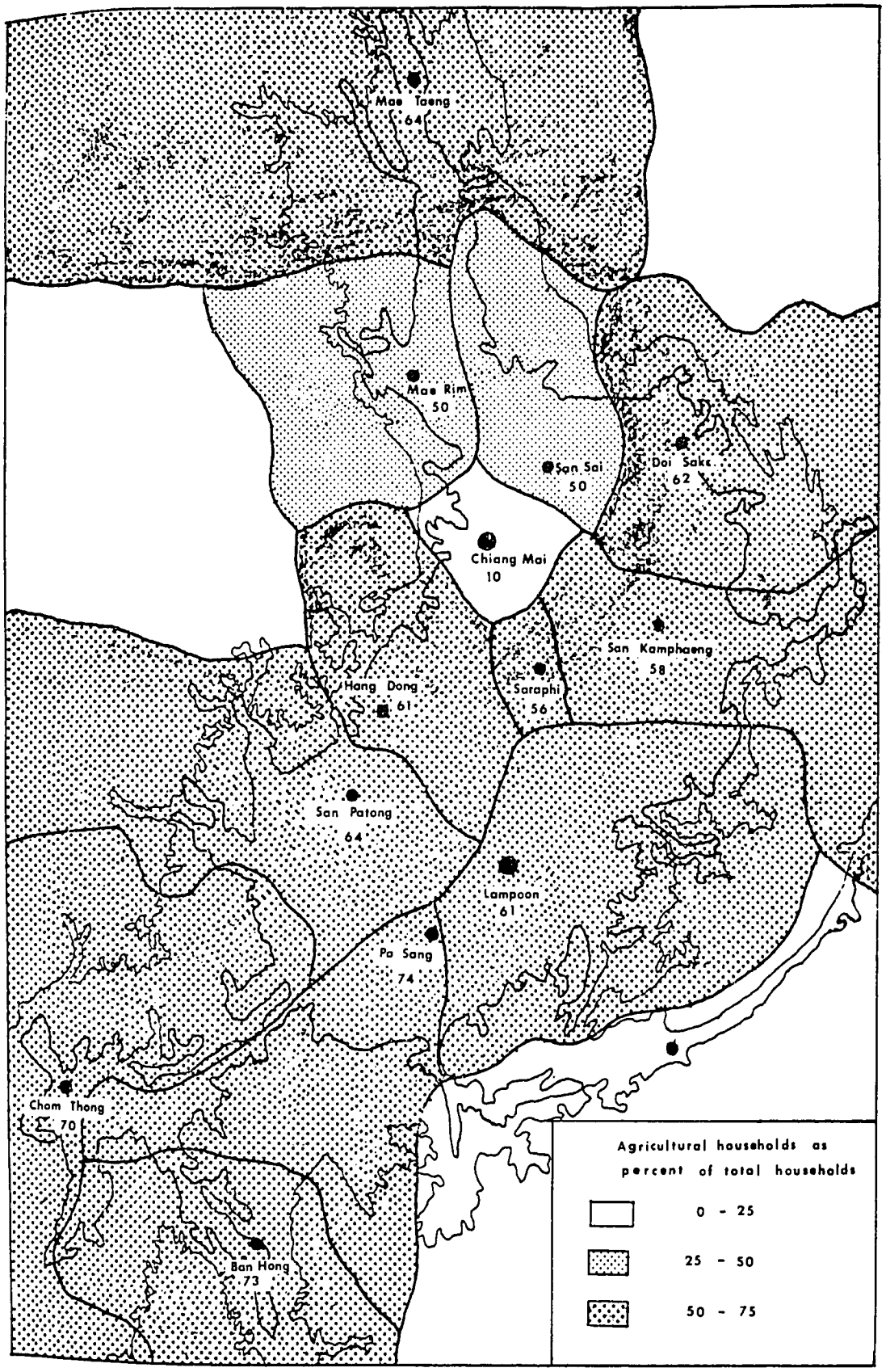

Figure 2.12 Map of Chiang Mai Valley - Agricultural households(percentage) (1970)

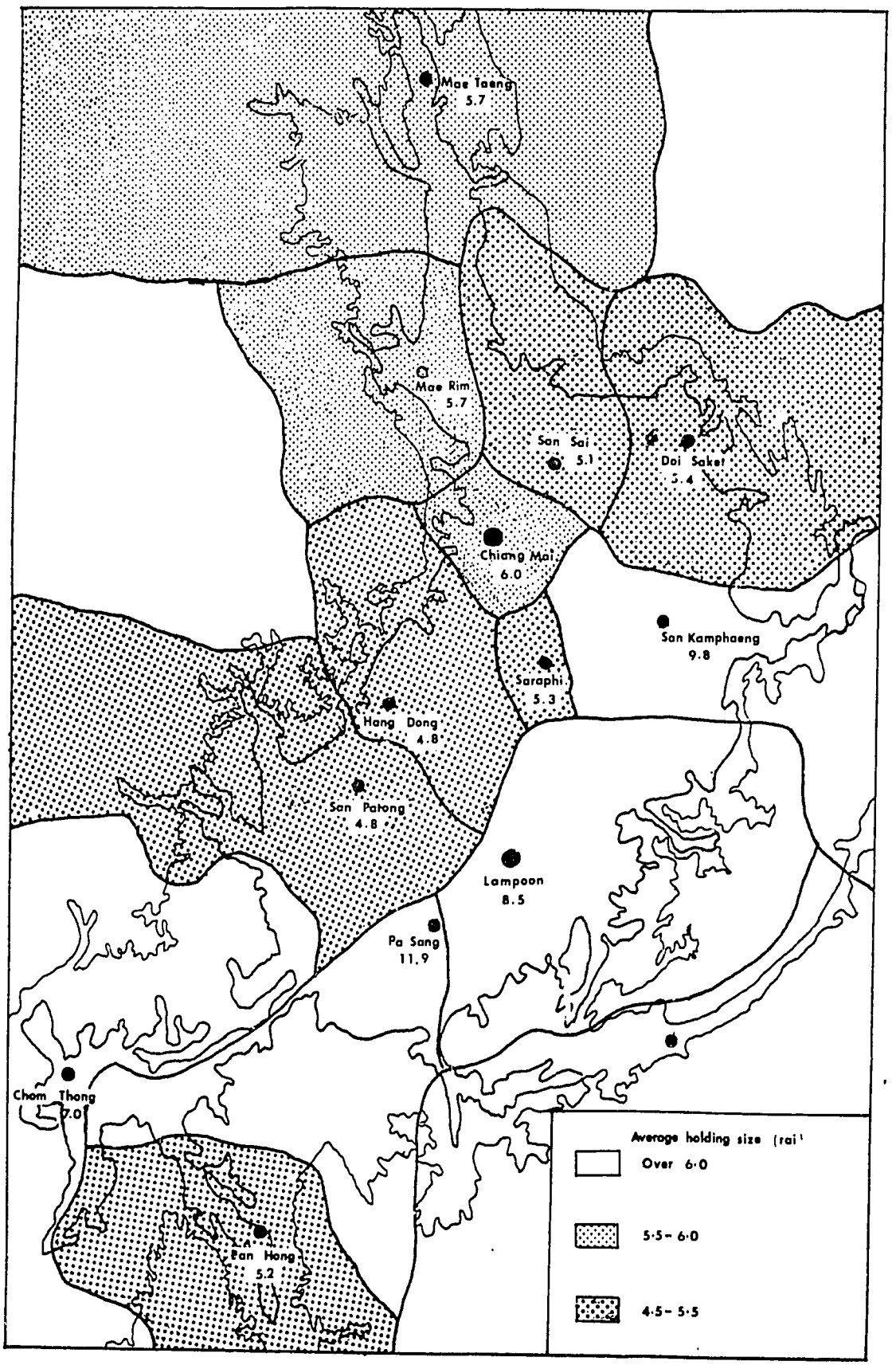

Figure 2.13 Map of Chiang Mai Valley - Amphure holding size (1977)

the northern part of the Valley and Muang Chiang Mai have an average holding of 5.6 to 6.0 rai.

Significantly most of the double and triple cropping occurs in the amphurs with average farm sizes of under 6 rai (see Figure 2.8).

Land tenure

About half of farmers in the Chiang Mai Valley own all of the land they farm and this group accounts for 47.4% of the total land area. 27% of the farmers own part of the land they farm and rent the rest (31.6% on an area basis) and 23% are solely tenant farmers (21% on an area basis) (Nippanutiyan, 1979).

The pattern of land tenure in the Chiang Mai Valley in 1979 is shown in Figure 2.14. In Muang Chiang Mai the tenancy rate is the highest in the Valley at 65%, but this is atypical. In three amphurs close to Muang Chiang Mai: San Sai, Saraphi and Doi Saket, the ratio of full owner operators to part owners, part tenants to full tenants is about 1:1:1. However, in the rest of the Valley the tenancy rate averages less than 18%, with the majority of farmers farming their own land.

There is no clear relationship from these figures between land tenure and cropping intensity but in general double and triple cropping occurs where there is a high proportion of owner operators.

7. Infrastructure

Transportation

Transportation and communication facilities in the Chiang Mai Valley are rather well developed. Most villages are not more than 5 to 10 km. from an amphur centre and no more than 50 km. from Muang Chiang Mai (Thodey, 1975). Sealed roads link amphur centres with most neighbouring amphurs and with Muang Chiang Mai. A good highway system, a rail service and an air service connect Chiang Mai with other Northern provincial centres and with Bangkok. A direct air service between Chiang Mai and Hong Kong has just recently been initiated.

Small, 1,000-1,600 cc, pick-up trucks are generally used for local transportation of people and goods. They are converted for passenger use and operate partly as mini-buses on fixed routes and partly as variable route group-taxis. Bicycles and motorcycles are very common in the villages they are quite often used for transportation of fertilizer, rice seedlings, vegetables, small livestock and so on.

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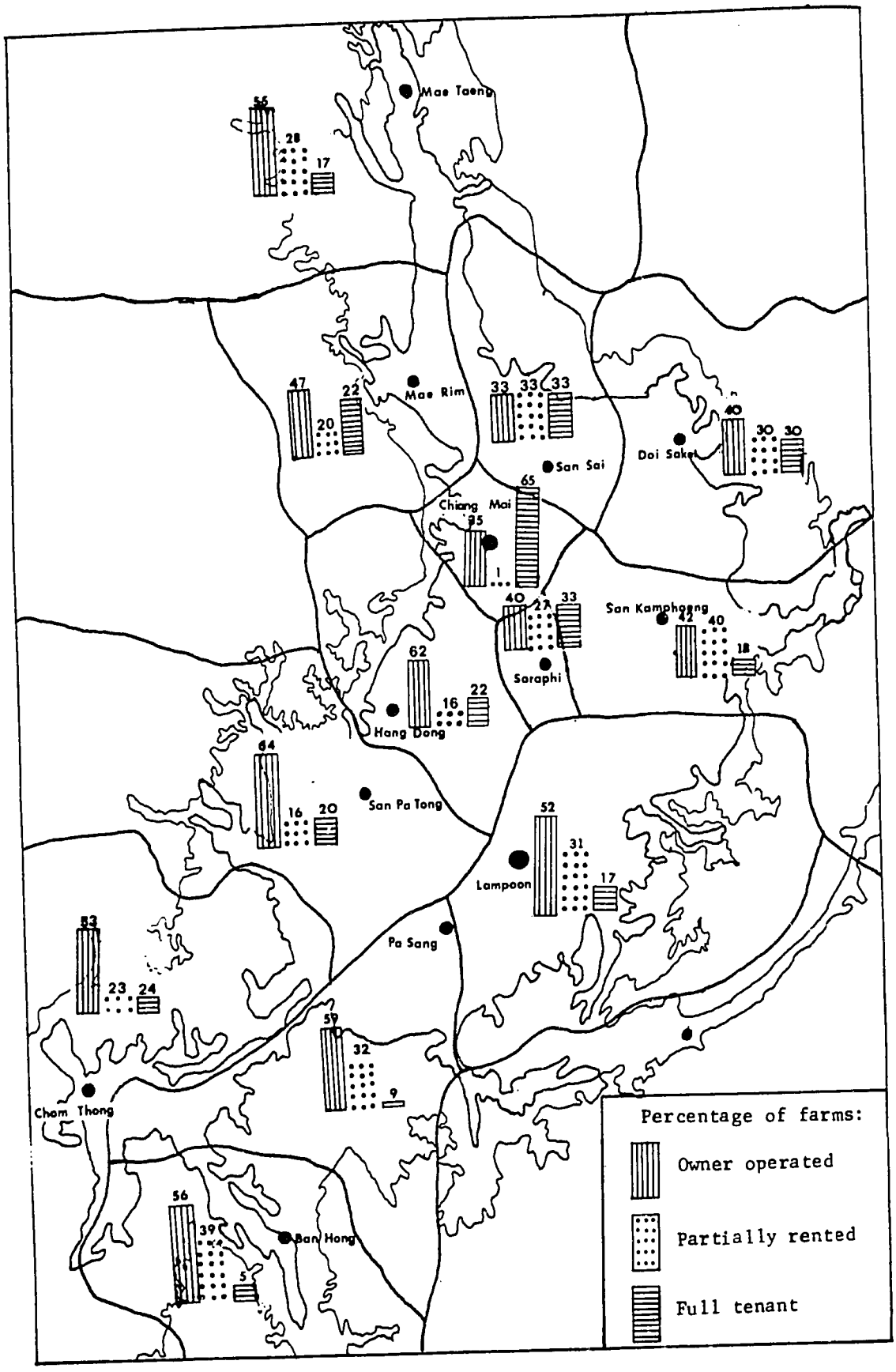

Figure 2.14 Map of Chiang Mai Valley - Land tenure systems (1979)

Markets

Retailing of agricultural inputs and consumer products spreads well into the villages. Most agricultural inputs can also be obtained through cooperatives and farmer associations. Prices of both agricultural inputs; e.g. fertilizers, hoes, plough shares and consumer goods; e.g. washing powder and soap, differ very little between the urban centres of Chiang Mai and Lampoon and in the villages. A fixed price is often set by the producers to prevent competition between retailers and wholesalers.

In addition farmers have adequate access to markets for their produce. In areas where a crop is grown to a significant scale visits by traders can be expected during the harvest season. This is true for grain legumes, rice, chili pepper and other vegetables. There are also several markets, retail and wholesale, in Chiang Mai and Lampoon where farmers often bring vegetables to sell. In the pick-up trucks converted for carrying passengers, a farmer can take two baskets of produce, 20-30 kg in weight, without additional charge. Roving markets also operate in the Valley, mostly in the amphurs around Chiang Mai. These are held in the morning at a different location each day. Farmers buy and sell livestock, village-made household and farm utensils, bicycles and motorcycles. The markets are also well attended by vendors selling factory made consumer goods, clothing etc.

Table 2.5 shows the number of tobacco curing and processing plants, rice mills and other processors by amphur in the Chiang Mai province. There is some unevenness in the distribution of processors, particularly rice mills, among amphurs but given the good transport facilities this may not be a significant constraint to production. A very big processing complex, capable of canning, dehydrating and freezing vegetables for the export market, operates in Chiang Mai but very much below capacity.

Table 2.5 Some processors of agricultural produce in Chiang Mai province (1979).

	Tobacco curing plants	Tobacco drying & processing factories	Rice mills	Vegetable oil extractors	Peanut shellers
Muang Chiang Mai	1	1	10	2	7
Chomthong	6	1	54	-	-
Doi Saket	4	1	40	-	-
Mae Taeng	5	-	-	-	-
Mae Rim	5	-	14	-	-
San Kamphaeng	7	-	3	-	1
San Sai	13	-	1	-	-
San Pa Tong	5	-	61	-	-
Saraphi	2	3	2	-	-
Hang Dong	5	1	38	-	-

Source: Industry Directory, Chiang Mai

In Chiang Mai and Lampoon there are also many smaller processors of fruit, vegetables and grain legumes for local consumption and the national market.

Non-farm employment

Small scale retailing of farm produce and processing factories provi significant off farm employment. During the off season many villagers wor on construction sites in the towns. There is also a steady movement away from farm employment of farmers' children. Some become drivers of pick-up trucks if their fathers are sufficiently well off to provide the initial investment. Many girls migrate to the towns to work as waitresses, shop attendants, maids and in other tourist related employment. Traditional home based crafts, for the tourist trade such as weaving, woodcarving, pottery, basketry and bamboo work, silk and cotton and carpentry, are also important, particularly in San Kamphaeng and other amphurs near to Chiang Mai, both in the off season and throughout the year between farm tasks. The forest, just outside the Valley boundary, may also provide employment in the gathering of saleable or consumable products such as bamboo, bees, mushrooms, etc.

Social services

Primary education is readily available throughout the Valley. Tuiti is free, but there is a cost for books and uniforms. Secondary education is available at each amphur centre. In addition to Chiang Mai University, major tertiary institutions in the Valley include an Agricultural Institut of Technology, a Teachers Training College and a College for Technology an Vocational Training.

Basic health service is available in most areas. A unit which inclu a public health officer and a midwife is responsible for one *Tambon*, makin regular visits to all villages in the Tambon. Most amphur centres have a public hospital, 10-30 beds, with a resident doctor. *Nakorn* Chiang Mai hospital, a teaching hospital attached to the Faculty of Medicine at the Chiang Mai University with 900 beds capacity, provides a very comprehensiv free service to those who qualify on the grounds of low-income. There are also 10 private hospitals in Muang Chiang Mai providing a wide range of services.

Like the rest of Thailand the population in the Valley is predomina ly Buddhist and the *Wat* (temple) and monks play a very important social r They form an institution to which farmers and villages have easy access, act as an important source of information, including that of an agricultu nature.

8. Village and farm

So far we have looked at structure in terms of the entire Valley or its major agro-ecological or agro-economic regions. The Valley, however,

is strongly heterogeneous both at the macro- and micro- level. In this section we describe the variation that occurs at the level of village and farm. As well as being components of the regional system they are themselves also systems and can thus be expected to exhibit important system properties (see Chapter 6, Section 1) which will have repercussions at the level of the Valley as a whole. This is discussed in greater detail in Chapter 6, Section 3.

The information in this section is largely derived from surveys of the Valley begun in 1975 (Tongsiri *et al.*, 1975 and Nippanutiyan, 1979).

Village Characteristics

A village is considered as the smallest more or less natural collection of houses that make up an administrative hamlet (*muban*), under a headman. Literally translated, a muban means a congregation of houses and a typical village in the Valley consists of a fairly tight cluster of houses surrounded by crop fields.

There are 804 villages in the Chiang Mai Valley and of those surveyed to date (Tongsiri *et al.*, 1975), the size varies from 48 to 328 households, with an average of 140 households. This variation depends on soil fertility, the encompassed cultivated area, the settlement period, the location plus other socio-economic factors. For the Valley as a whole, 68.3% of the villagers have agriculture as the major source of income. The average agricultural household size is 5.5 people, giving an average village population of 770 individuals.

In most villages the houses are clustered on the high land, along one or both sides of the road. Each compound has up to five houses with usually no fence between the home plots. Many trees grow around the edge of the compound, giving a cooling shade.

The village is surrounded by crop land usually of 3 fairly distinct elevations as shown in Figure 2.15. The major characteristics of the 3 elevations are outlined in the Figure and a fuller discussion follows in Chapter 5, Section 3.

Villages are usually self-sufficient in terms of agricultural-allied services such as blacksmiths and carpenters for agricultural implement repairs and a small shop can usually provide agricultural supplies of a day to day nature. The owners of these small businesses are often farmers themselves.

Farms in the Valley are usually run as a family business (92%) with the head of the household as the major decision-maker. The average farm size is 8.8 rai of actual crop land but one third of the households also have a small vegetable and/or orchard area on the higher land near to the house adding, on average, a further 0.41 and 0.25 rai respectively to farm size (Tongsiri *et al.*, 1975).

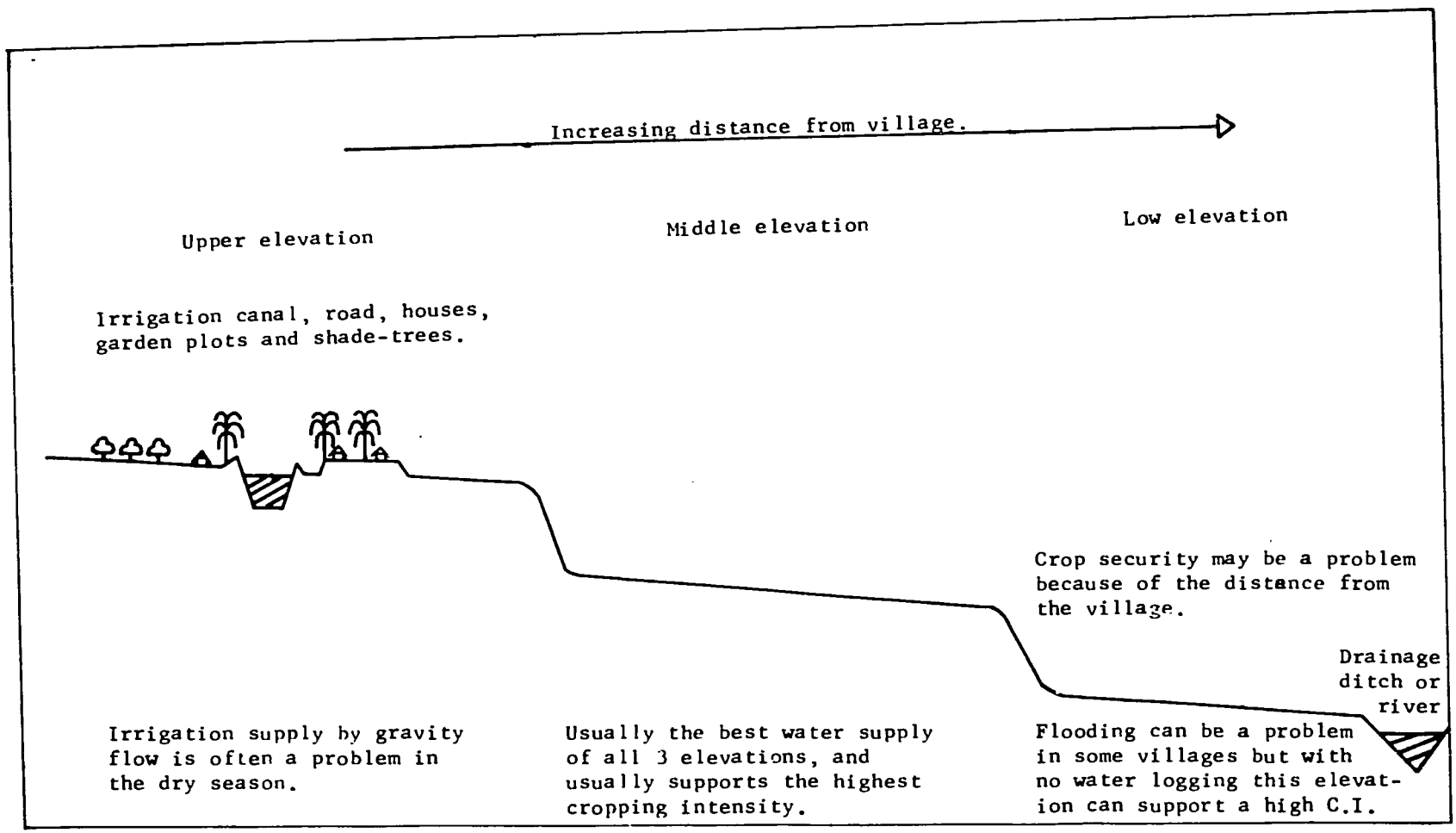

Figure 2.15 Typical land profile of villages in the Chiang Mai Valley

Each household is generally composed of a house, a rice-barn, a pig-pen, a buffalo shed and perhaps a small kitchen-plot. The houses are generally uniform in construction, although variable in material used and size, with bamboo or wood flooring raised about 6 feet off the ground and with a leaf, tin or tile roof. The open area under the house is used for carpentry, handicrafts manufacture, cleaning and sorting crops, resting and as a gathering place for friends and neighbours. The rice-storage barns, which are of a similar design to the houses, vary in size according to household rice and other production and are thus an indication of family wealth and income. Most of the families raise a few pigs in the adjacent pen and some raise chickens and ducks which are allowed to run freely about the compound. Buffalo and oxen are usually tied under a tree in the compound. Some households have their own wells from which water is drawn for drinking and domestic use. Some households have kitchens, bath rooms and lavatories separate from the house.

Land fragmentation is common, largely as a result of the inheritance custom whereby parents divided land equally among children, male or female. The number of separate land parcels operated by a family and their location have a bearing on the efficiency with which resources, particularly labour, is utilized and determine which crops will be grown and where. The typical extent of fragmentation can be gauged from Figure 2.16 which shows the location of fields farmed for a number of households in Ban Pa Mark and close by villages in Amphur Hang Dong in the wet season of 1973. Note for example that while household 25 has a single, large planted area, household 3 has a similar total area but in widely scattered holdings. In fact 17% of all households own 3 or more parcels of land and although the average distance from the house to the farmers' fields is 0.6 kms. some farmers have fields over 3 kms. away.

The individual plot, within the field,is the basic unit of water and crop management. It tends to be smaller in the Valley than in the Central Plain. In Ban Pa Mark, the average size of plot per household ranged from .22 to .49 rai, but a safe generalization is that there will be about 3 plots to a rai, regardless of the size of farm overall.

As shown in Figure 2.14, a large proportion of the area farmed is rented land. The 1974 Land Rent Act (see Chapter 6) lays down laws regarding land-tenure; but it is rarely observed and the rent is generally a 50:50 share for the rainy season rice crop, inputs being supplied by the tenant, who is sometimes compensated for these before the share is made. In some cases the landlord is responsible for harvesting his own share of the crop. The rent for dry season cropping, with the exception of dry season rice, is usually on a cash basis, the actual rent paid being variable, with the landowner often specifying certain crops which may not be grown. In some cases the landowner may demand very little or even no payment for dry season cropping, being willing to settle for the perceived residual benefit of added nutrients, etc. in his own wet season rice crop. (See Chapter 6).

In very few instances does the farmer follow the same cropping pat tern on all of his land. This diversification of cropping patterns has numerous potential advantages which are discussed more fully in Chapter

Farm Management

Glutinous rice is almost exclusively grown as the wet season crop. The major dry season crops include non-glutinous rice, soybean, garlic, tobacco, peanuts and vegetables in approximate descending order of impor tance. The predominant rainy season glutinous rice varieties planted in the Valley are photosensitive, traditional or locally selected, but stil basically low nitrogen responsive, varieties such as *Niaw* San Pa Tong. Very little effort has been put into breeding improved varieties of glut nous rice with acceptable eating quality for the people of the Northern Provinces. However this is now a priority in the current National Devel ment Plan. Improved non-glutinous rice varieties such as RD 1 and RD 7 readily accepted for a cash crop in the dry season.

Improved soybean varieties are predominantly used in the Valley, whilst the use of improved peanut varieties is now also increasing. In contrast the garlic and chili pepper varieties grown are mainly local un- improved ones. In the case of tobacco, seedlings are generally supplied by the processing companies but only a few of these conduct any form of breeding programme.

Table 2.6 shows that a large proportion of the farmers retain a par of their crop as a source of seed for future planting, and selection un- doubtedly occurs to a certain degree especially in rice (Thodey *et al.*, 1974).

Table 2.6 Percentage of farmers using seed stored from a previous crop (Tongsiri *et al.*, 1975)

Source of seed	Glutinous rice	Non-glutinous rice	Soybean	Peanut	Mungbean	Garlic	Tobacco	Chili pepper	Vegetables
Own farm	96.3	72.9	38.2	26.4	52.1	85.7	4.3	60.0	29.0

The level of all fertilizers applied in Thailand is very low (Table 3.9) and the Chiang Mai Valley is no exception to this. As can be seen from Table 2.7, less than 30% of all farmers apply fertilizer of any kind to their rice crop. For traditional glutinous rice varieties this is in keeping with recent findings that there are no or only localised responses to nitrogen up to 50 kg per hectare.

Table 2.7 Percentage of farmers using fertilizer, by type (Tongsiri *et al.*, 1975)

Type	Glutinous rice	Non-glutinous rice	Soybean	Peanut	Mungbean	Garlic	Tobacco	Pepper	Vegetables
Animal or other natural	13.2	13.2	20.5	18.1	-	2.1	-	5.0	2.6
Artificial	13.8	14.6	2.5	3.2	2.2	90.0	97.9	85.0	76.9
Total	27.0	27.8	23.0	21.3	2.2	92.1	97.9	90.0	79.5

The very high incidence of artificial fertilizer application in tobacco is probably in part due to the fact that the curing barns will supply all inputs to the growers, the costs of which are deducted from the buying price at harvest. This, coupled with the fact that a guaranteed buying price is given at the beginning of the season, greatly reduced the risk involved in fertilizer application.

Land preparation is predominantly by animal and human power. 62% of all households have working buffalo or oxen which are used to draw traditional hand-made ploughs and harrows and are also used in the transport of farm materials and produce in ox carts. Less than 10% of the farmers use mechanised power for any part of land preparation for rice, including the dry season crop where turn around time may often be short. Land preparation for rice usually consists of a single ploughing followed by puddling the soil, sometimes once but usually twice, and land levelling is also sometimes crudely performed. Thirty to forty day old seedlings are then transplanted into the puddled soil, most commonly at a spacing of 30 cms. x 30 cms. or 25 cms. x 25 cms. with about 3 to 5 plants per hill.

Soybean is usually sown directly into the rice stubble after burning the rice straw and thus involves no cultivation. Other upland crops are commonly grown on beds of various sizes usually raised by hand after sometimes ploughing the field. Tractors fitted with rotary hoes are used to a larger extent in land preparation for upland crops especially in peanut and tobacco (Table 2.8).

Table 2.8 Percentage of farmers using mechanised power (Tongsiri *et al.*, 1975)

Type	Glutinous rice	Non-glutinous rice	Soybean	Peanut	Mungbean	Garlic	Tobacco	Pepper	Vegetable
Animal and human only	96.7	93.0	86.6	63.9	93.2	89.3	75.0	100.0	85.
Tractor with some animal and human	3.3	7.0	13.4	36.1	6.8	10.7	25.0	-	15.(

Care of the crop, apart from irrigation, is often minimal especiall for soybean and third season peanuts which are often virtually abandoned until harvest. In all crops weeding is often the only post planting mana ment activity performed apart from irrigation. Although pest, weed and disease losses can be considerable, (see Chapter 3) pesticide application is generally low and of poor quality and weeding is usually performed by hand or by treading into the mud (Table 2.9).

Table 2.9 Percentage of farmers using pesticides (Tongsiri *et al.*, 1975)

Type	Glutinous rice	Non-glutinous rice	Soybean	Peanut	Mungbean	Garlic	Tobacco	Pepper	Vegetables
Insecticide	5.1	3.2	3.1	9.0	2.2	16.7	85.6	35.0	51.3
Herbicide	5.0	7.7	-	0.8	-	0.7	-	5.0	2.7

Irrigation is usually of the ditch and furrow type with splashing th water onto the beds in the case of garlic. For rice most farmers attempt to maintain a depth of 5 to 15 cms. of water in the field. In the diversion systems the frequency of irrigation in the dry season is often more

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dependant on water availability than on the crops' requirement as perceived by the farmers.

By far the greatest proportion of farm labour is supplied by members of the farm household and includes even the young children. However, labour peaks, when they occur, are sometimes overcome by the use of hired labour which must be arranged in advance and is normally supplied by small farmers who have labour in excess of their own farm requirements. Exchange labour is traditionally practiced in almost all villages for wet season rice-transplanting and harvesting. Under this system a number of people will work together, helping on each other's farms and receiving an equivalent amount of help on their own farms in return. For a further discussion of exchange labour see Chapter 6.

CHAPTER THREE

PATTERN AND PROCESSES : DYNAMICS

The seasons in the Chiang Mai Valley are clearly defined by the pattern of temperature and rainfall. Other changes in the hydrological cycle, in solar radiation and other climatic factors during the year add further to the distinction between each season.

1. The seasons

The Hydrological Cycle

The Valley receives an average annual rainfall of 1218 mm. but, as can be seen in Figure 3.1a, most of this, about 95 percent, falls in the 5 months from May to September, the heaviest rain, about 250 mm. per month, coming in August and September. The early rain in April and the end-of-season rain in October virtually make up the remainder; the 5 months from November to March are almost completely dry. Potential evapotranspiration fluctuates much less sharply than rainfall. The highest potential evapotranspiration (150 mm. per month) is at the beginning of the rains in May. It decreases gradually with time to its lowest value (about 100 mm. per month) in December. A crude description of water balance can be obtained from the difference between average monthly rainfall and potential evapotranspiration and, as Figure 3.1a shows, the Valley has 6 months a year in which rainfall exceeds potential evapotranspiration.

Water balance has also been defined in terms of the probability that in each week the ratio of rainfall to evapotranspiration will be greater than 0.33, which represents the minimum requirement for crop growth (Hargreaves, 1975 and Virmani, 1978). Data from 1968 to 1978 was used to estimate this probability for the Valley. For the most part the probability follows the same pattern as the difference between rainfall and evapotranspiration (Figure 3.1b), but with one critical difference: from October right through to early May the probability that there will be enough rain in each week for crop growth is very low, not more than 0.5% and often not more than 0.3%. In the 4 week period in May and June the likelihood of sufficient rain increases to above 70%, but it decreases sharply again to remain below 70% for 5 weeks in June and July. This 5 week trough is highly critical; it indicates the very unreliable nature of the opening rains of the wet season. For August and September the rain is very much more reliable. This analysis indicates that the period of sufficient rainfall for crop growth in the Chiang Mai Valley is less than 5 months and the Valley can thus be classified as a semi-arid area (Troll, 1965).

Additional water in the form of irrigation is thus required during the prolonged dry period from mid October to mid May and also in the five week trough from the middle of June to the last week of July.

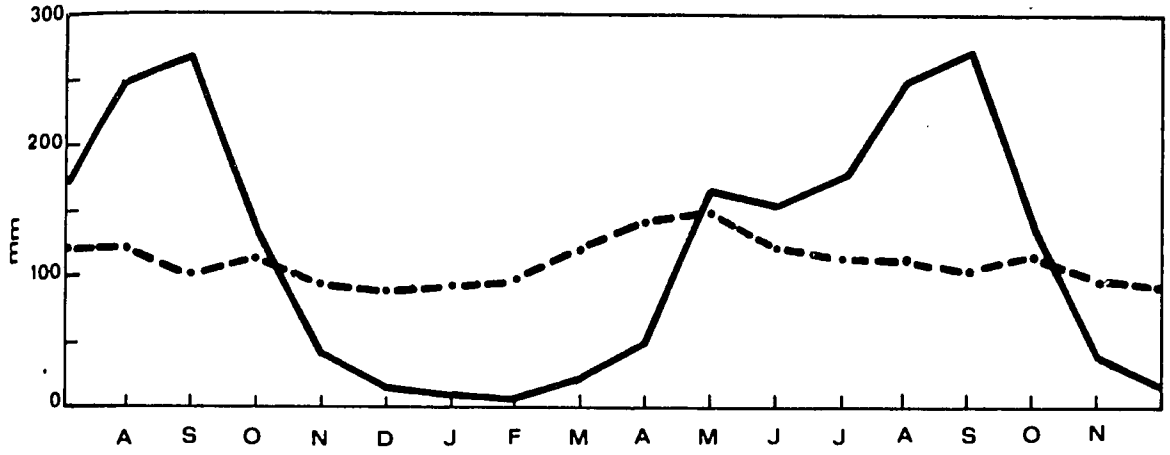

Figure 3.1a Rainfall (———) and potential evapotranspiration (·— — ·—)

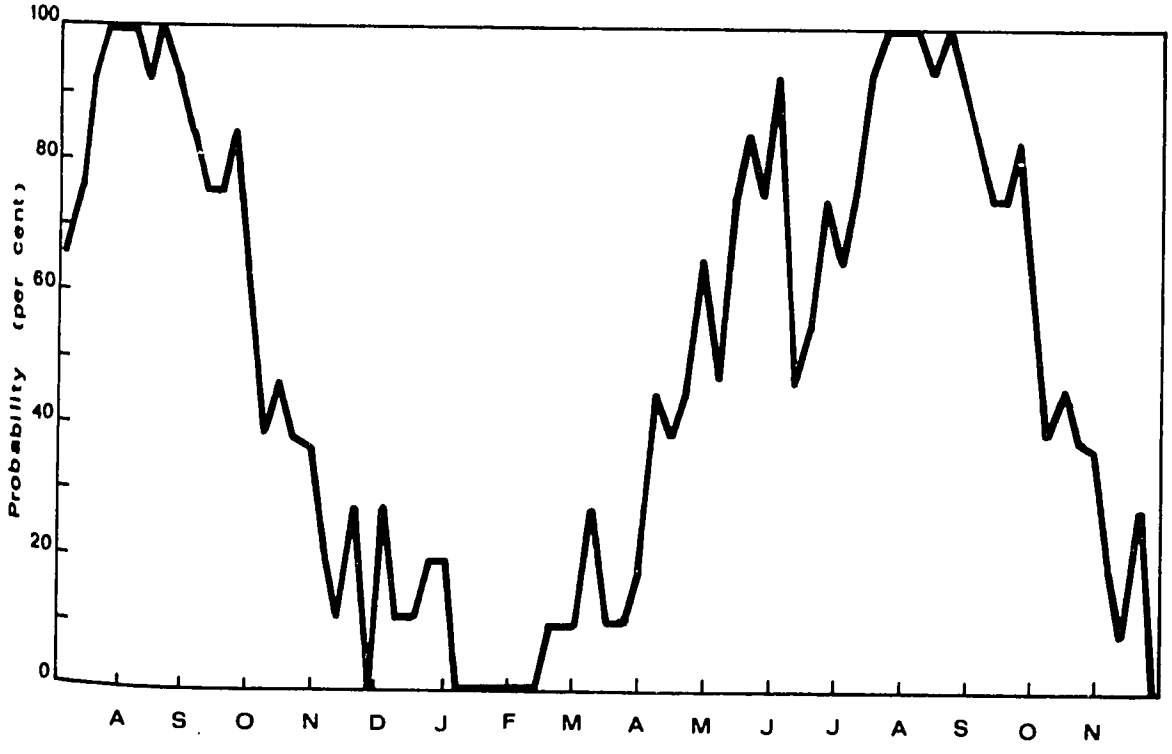

Figure 3.1b Weekly initial probability of rainfall/potential evapotranspiration exceeding 0.33 (Dum-ampai, Unpubl. data)

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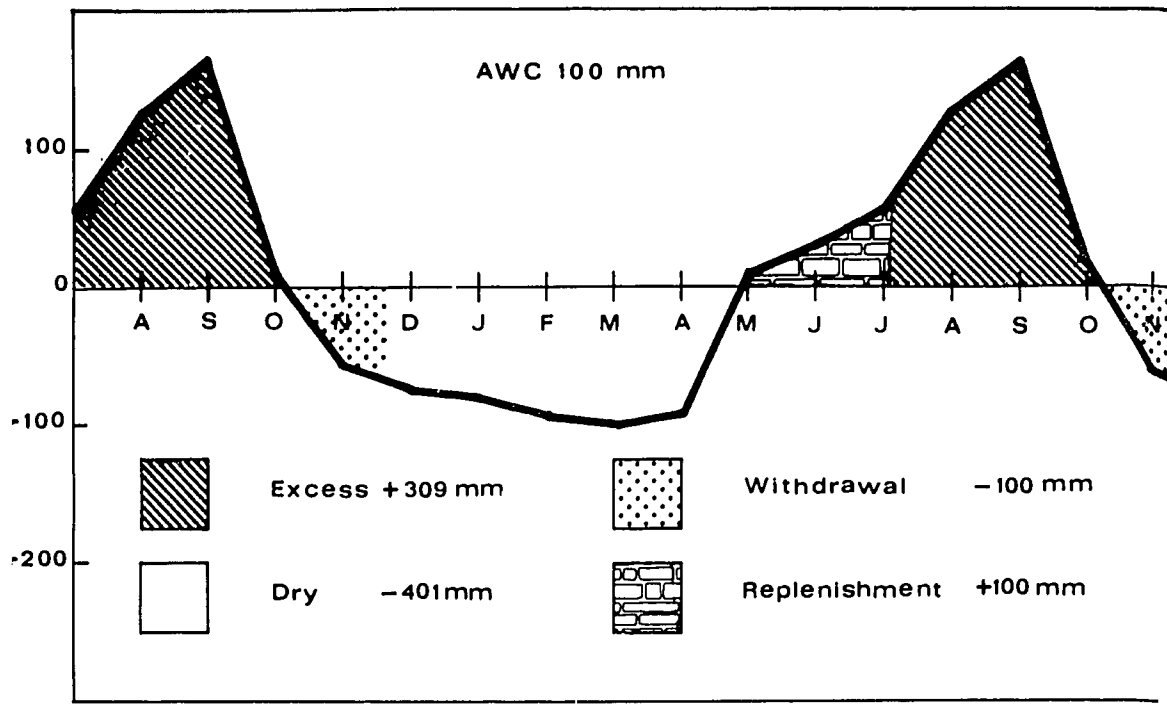

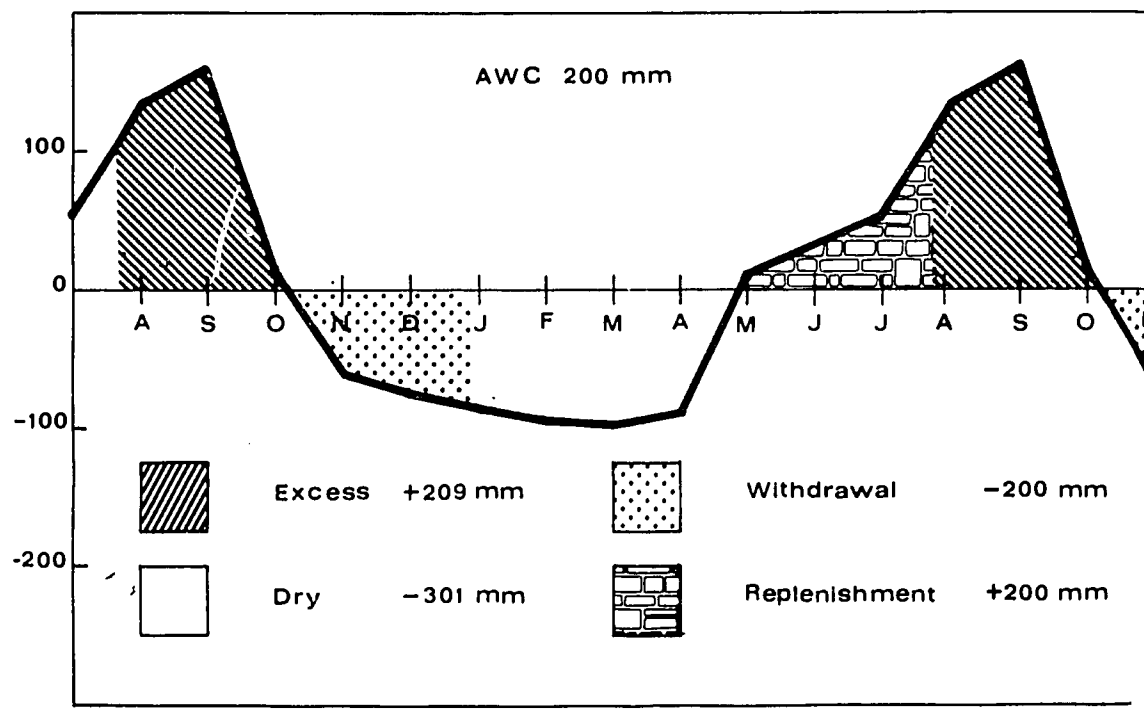

Figure 3.1c Moisture balance, R-ETP ± SM
(R = rainfall, ETP = potential evapotranspiration, SM = soil moisture, AWC = available water holding capacity)
(Kibreab, Unpubl. data)

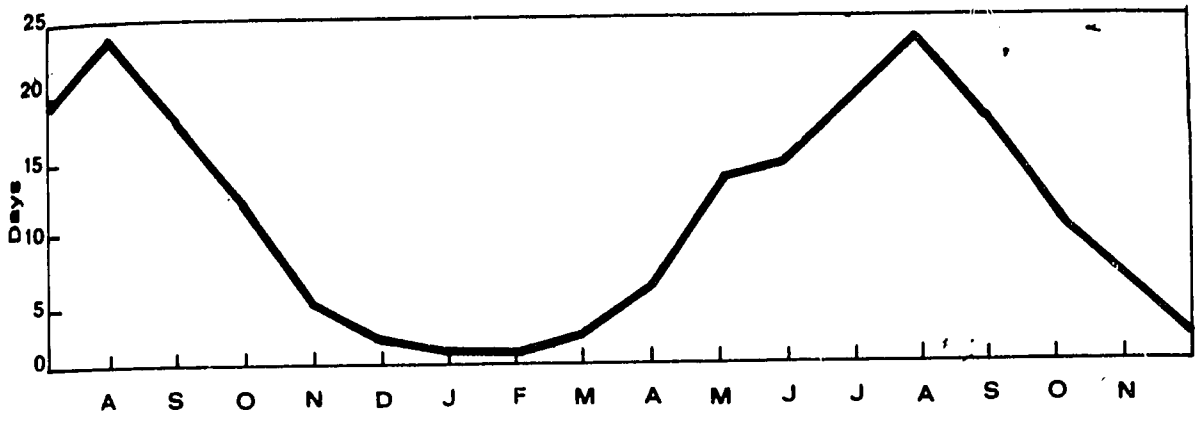

Figure 3.1d Rainy days

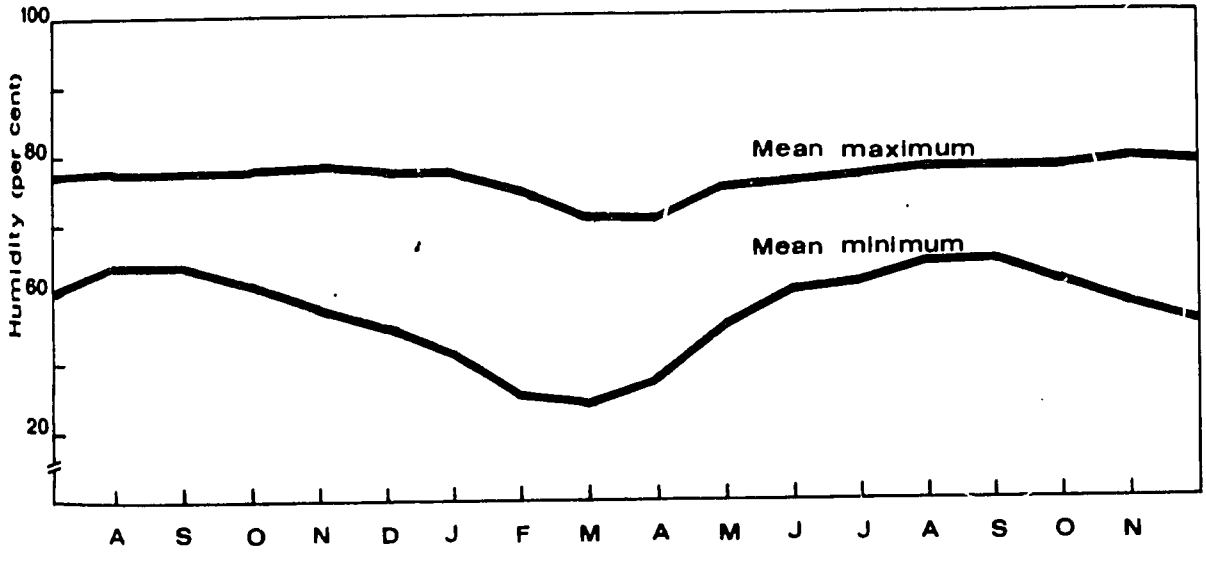

Figure 3.1e Relative humidity

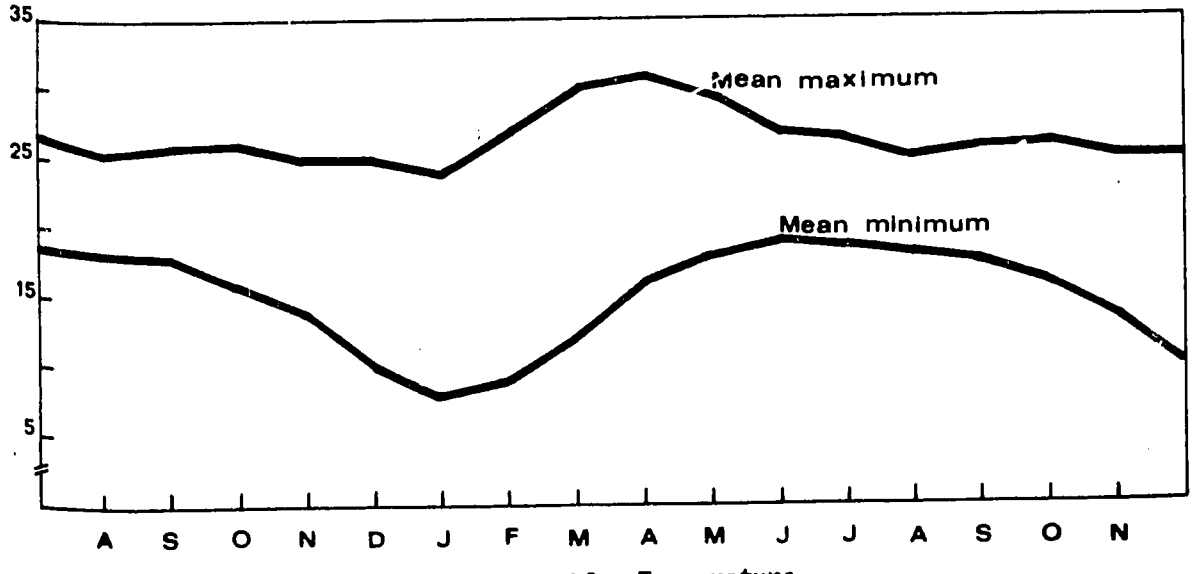

Figure 3.1f Temperature

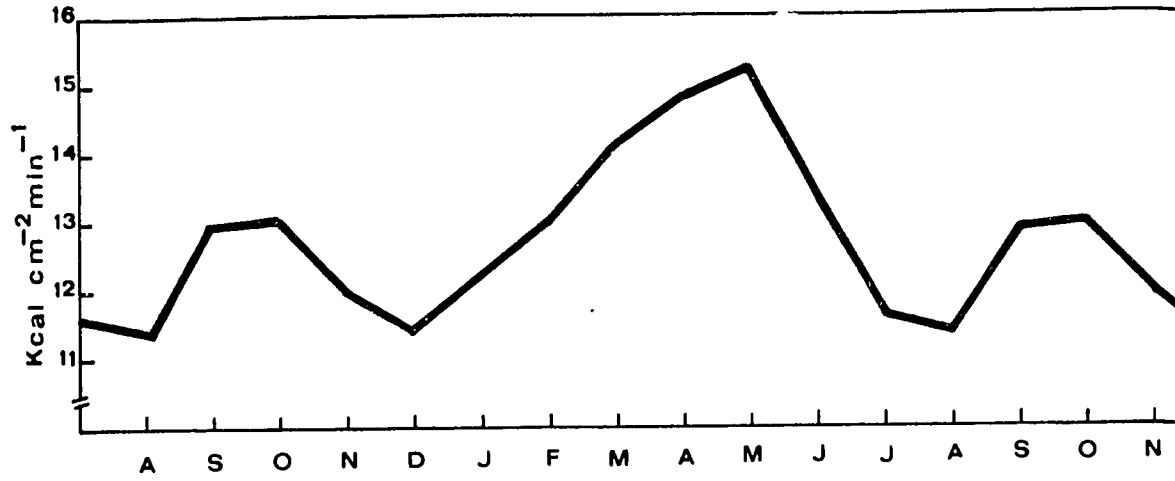

Figure 3.1g Solar radiation

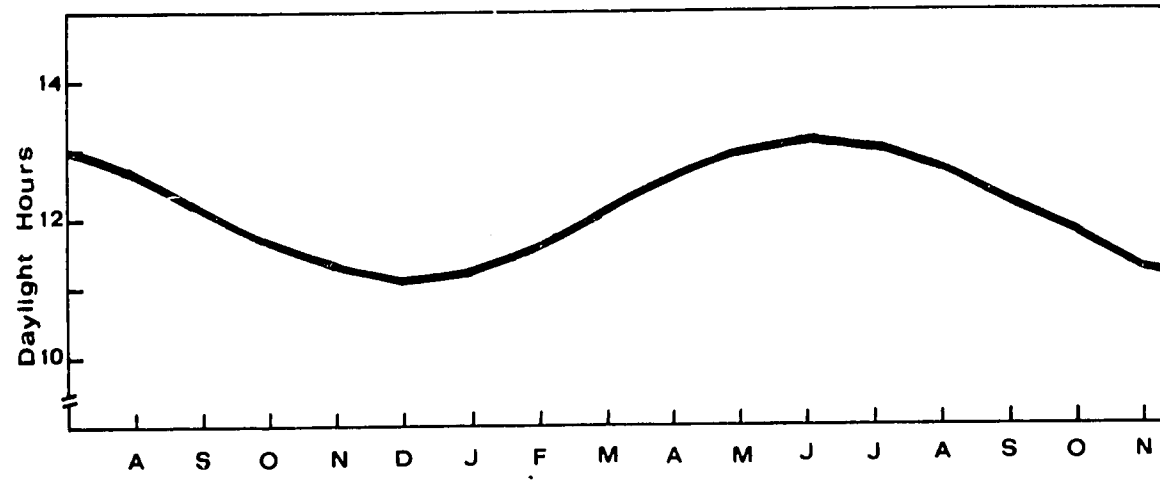

Figure 3.1h Daylength

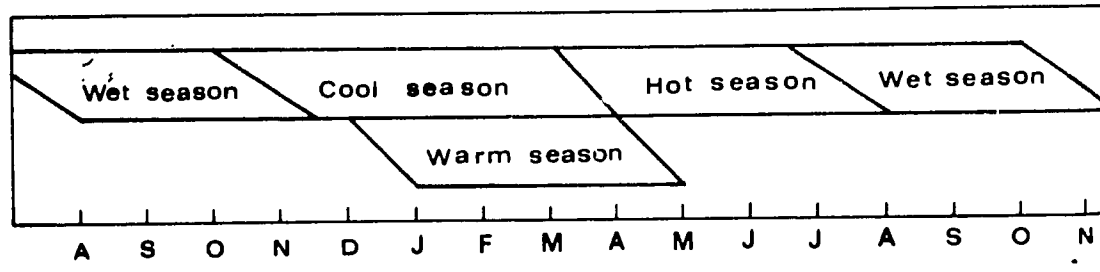

Figure 3.1i Seasons

In some years supplemental irrigation will also be required at other times during the wet season, because of the relatively high variability in rainfall. However, during the peak wet period, from mid July to mid September, there is likely to be a need for artificial drainage in areas where natural drainage is restricted.

Proper water management is thus critical for intensive cropping in the Valley. Finding crops adapted to excess or deficit moisture, augmenting sources of water supply, by wells or by tapping shallow ground-water-tables with deep-rooted plants, and developing practices that increase yield per unit input of water are all required.

Soil Moisture

Soil type will of course modify moisture availability. In Figure 3.1c we have assumed idealized soil profiles with homogenous texture throughout, a deep ground-water-table (greater than 10 m.), no restriction on water intake capacity and a moisture extracting depth for the plant root of 80 cm. The theoretical available water holding capacity (AWC) for sandy and clay soils is then 100 mm and 200 mm respectively.

For the sandy soil there is an excess of 309 mm. of water which may be lost to deep percolation, runoff or alternatively may cause water-logging. The period of plant growth then becomes extended by about 5 weeks, from mid October to late November. For the clay soil, however, the excess water amounts to only 209 mm. and the period of available moisture is extended by 10 weeks, from mid October to early January. These calculations give some indication of the potentiality in the Valley for growing an extra crop after rice, in the absence of irrigation or groundwater supply, given improved soil structure.

Rainy Days

The number of rainy days in each month follows the pattern of average monthly rainfall rather closely (Figure 3.1d). The period from June to September, which receives most of the annual rain, also has the highest number of wet days, totalling over 80 days which are evenly distributed among the 4 months. In contrast, there are only 16 wet days in the six month period from November to March.

Relative Humidity

Relative humidity is usually very high in the Chiang Mai Valley (Figure 3.1e). The average monthly maximum value ranges between 90-96% for most of the year, except in March and April when it drops to around 83%. The average monthly minimum relative humidity follows a slightly different trend. There is a definite peak of minimum relative humidity at 67% in August and a low point of 29% in March with gradual changes in the months in between.

Temperature and Solar Radiation

The annual average temperature over the whole year in the Chiang Ma Valley is 25.8°C but there are well defined hot and cool periods (Figure 3.1f).

The cool season in the Valley is characterised by low night tempera ture. For the five months from November to March the mean monthly minimu temperature is never higher than 19°C or lower than 13°C. The lowest tem perature of 6°C was recorded for December and January. For the rest of t year average minimum temperatures are between 21°C and 23°C. During the the temperature is high throughout the year. Average maximum temperature is close to 30°C for most months, with a peak of 35° and 36°C in March, April and May. Diurnal ranges of temperature (maximum temperature-minimu temperature) are largest (over 18°C) in the months of July to September.

Solar radiation in the Valley is rather high throughout the year (Figure 3.1g). It is lowest, at about 11 K cal/cm^2/min, in December whic is in the middle of winter and also in July and August due to cloud cover during the rainy period. The radiation peak of 15 K cal/cm^2/min is in March. Daylength fluctuates from 11 hours in December to 13 hours in Jun (Figure 3.1h).

The Agronomic Seasons

In practice, as our survey of the cropping patterns of the Valley shows, farmers recognize essentially four distinct seasons for cropping (Figure 3.1i). They may be characterised as follows:

The wet season (July/August to October/November)

This is the typical paddy rice season. Rainfall exceeds pan evapor tion by over 300 mm for the whole period. There is water surplus in each month except in November and the probability of sufficient rain for crop production over the season is over 80%. Most of the traditional rice cul tivars are sensitive to the daylength shortening from 13 hours at the beginning to 11 hours at the end of the season. Maximum temperature is close to 30°C throughout the season, with a minimum temperature of 24°C July declining steadily to just under 19°C in November. Thus the maturi and ripening of the rice crop coincides with diminishing rainfall, lower night temperatures and shortening days.

The cool season (October/November to March/April)

The unique characteristic of this season is the relatively low tem perature, particularly at night. While the daily maximum temperature is maintained around 30°C, the minimum temperature for the season begins at 21.5°C in October and decreases steadily to a low of 13°C in January bef

a gradual rise to 21°C in April. This is the season with the largest diurnal range of temperature, with over 18°C difference between the average maximum and minimum in both February and March. The probability of sufficient rain in each week rarely exceeds 0.2% and irrigation is thus essential. The rise in evaporation towards the end of the season, to 200 mm in March and April, together with the sharp rise in temperature probably determine the length of growing season for cool season crops. Crops grown in this season are subject to daylength shortening to 11 hours in December, but then the days become longer, to 12.5 hours in April.

Cool season crops typically grown in this period are garlic, chilis, tomato, onion and cool season vegetables e.g. cauliflower, broccoli, lettuce and peas. Tobacco, although not restricted to this season, is widely grown as a cool season crop. Temperate crops such as wheat, potatoes and beans (*Phaseolus vulgaris*) have also shown promising agronomic potential (MCP, 1974, 1975 and 1976).

The warm season (December/January to April/May)

Crops grown in this season are subject to low night temperature for the first few months. The temperature, however, rises rapidly after January, and is maintained around 35°C from March to May. These last 3 months of the season also have the highest rate of evaporation in the year, at 180-200 mm per month. Over the whole season there is a net water deficit of 668 mm and irrigation is essential. Virtually all of the rain falls in May, and this is a major constraint to the harvesting of most grain crops. Rice, peanut and soybean are grown in this season following a late harvested rice.

The hot season (March/April to June/July)

This season is characterized by uniformly high temperatures, with maximum temperatures of 32° to 35°C and minimum temperatures rarely under 20°C. There is a net water deficit in the first half of the season and a surplus in the second half. The rainfall, however, is highly variable and the probability of sufficient rain in each week exceeds 75% for only 4 weeks in May and June. Though crops grown in this season are highly dependent on irrigation water, the opening rains are also essential, since they come at the time when irrigation water from most sources has become exhausted for the year. Crops for this season include mungbean, rice, corn shallots and vegetables. They are usually grown as a third crop in a sequence following a wet season rice crop and a cool season crop.

2. Cropping patterns

Within our system boundary we have identified over 20 different cropping systems, having one, two or three crops a year matching the agronomic seasons (Figure 3.2). Generally the systems are specific to a particular

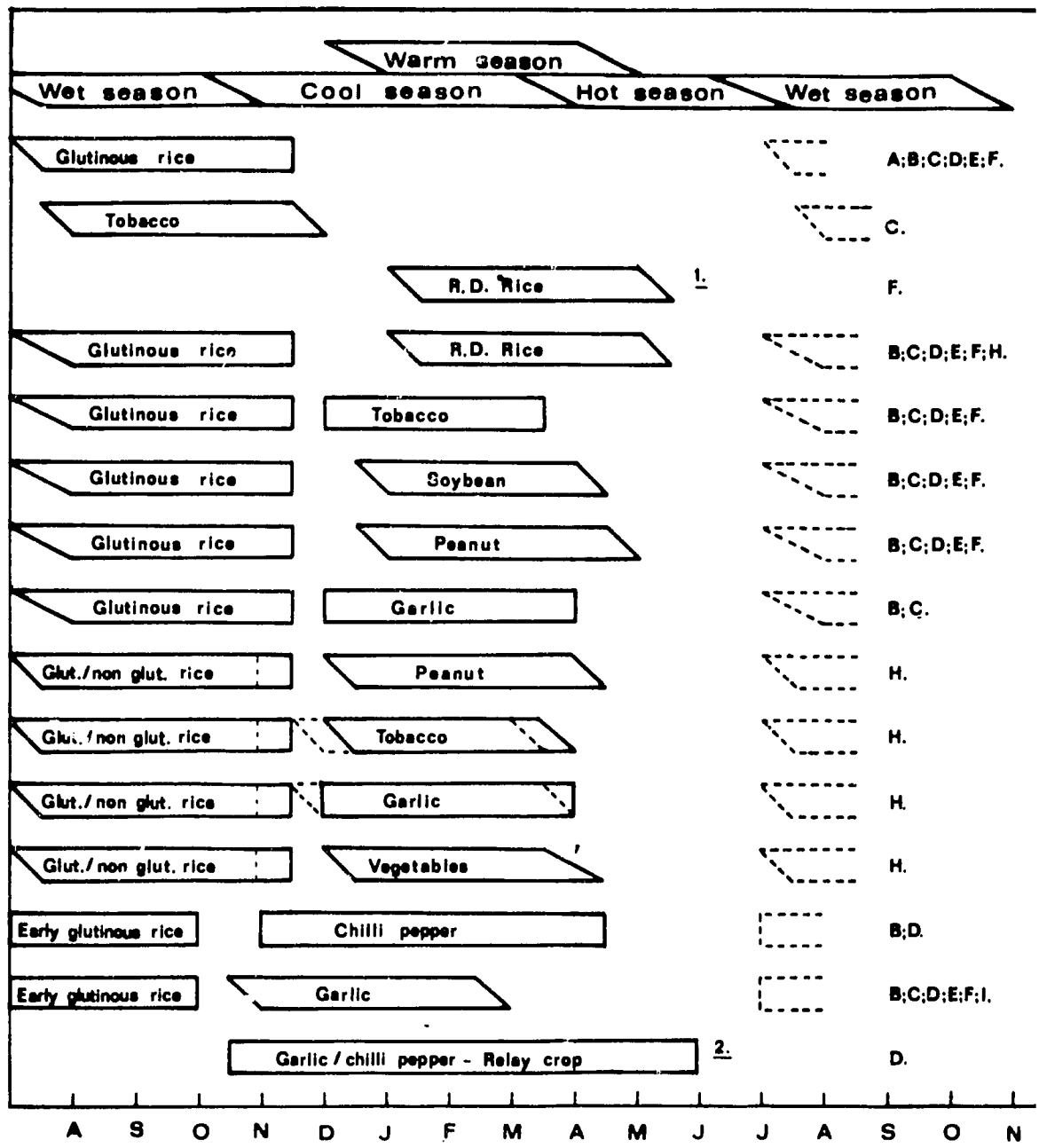

Figure 3.2 Common cropping sequences in the Chiang Mai Valley

1. Wet season rice crop is not possible due to annual floods. R.I. guarantees water for these areas in dry season.

2. Grown on permanent raised beds.

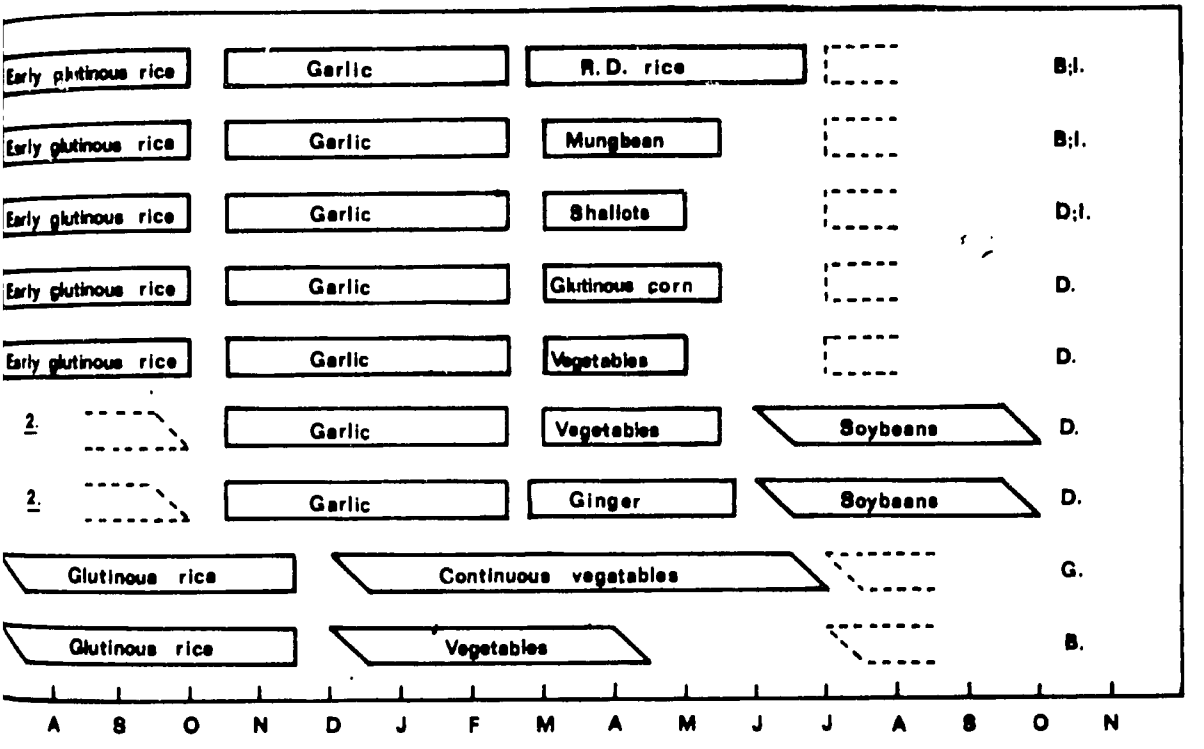

Figure 3.2 (cont.)

a. Rainfed
b. Traditional schemes
c. Mae Kuang
d. Mae Ping Kao
e. Mae Fack
f. Mae Taeng
g. Dug well area
h. Tube well, San Kamphang
i. Tube well, Pa Sang.

N.B. In this and all other time series diagrams a standard procedure has been adopted to aid in comparisons and to facilitate understanding. Within-year mean time-series data have been graphed on a standardised 18 month cycle, this means that data for the months of July - December is repeated once at the beginning and once at the end of the scale. This enables a complete 12 month cycle to be analysed and compared from a number of different starting points and in the case of cropping pattern diagrams also shows turn-around time at the beginning and the end of the year as well as within the year.

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location and presumably have evolved to suit particular combinations of topographic, soil, water supply and socio-economic factors. Each farmer is likely, however, to utilise a number of cropping patterns on his farm each year in an effort to more evenly spread his resources and risk, so that considerable variety exists even in regions dominated by one or two major crop sequences.

Rice is the subsistence crop in the Valley. It may be grown as the only crop or it may be the base around which the cropping patterns are built. Glutinous rice is generally grown for subsistence, the main cultivar being Niaw San Pa Tong. However, other rice cultivars, both glutinous and non-glutinous, are extensively used to fit the various goals of different cropping systems. For example, Dor Prao is a short duration traditional glutinous cultivar which matures in about 3 months and is widely used by farmers planning to plant an early cool season crop. *Kao Dawk Mali* is a high quality traditional non-glutinous variety grown mainly for cash. The new non photosensitive cultivars from the Rice Division - RD 1 and RD 7 - are used mainly for the warm or hot season when the photoperiodism of traditional cultivars causes difficulties. The potential for this use of genetic diversity to cope with ecological patterns in time and space is present not only in rice and indeed the rich variety of cropping systems in the Valley reflects a highly sophisticated utilisation of genetic diversity.

Monocropping

Where monocropping is practised, primarily on the non-irrigated land, the predominant crop is glutinous rice grown solely for subsistence in the wet season. In flood prone areas along the Ping River rice is also monocropped, but in the cool season after the water has receded. In areas where water holding capacity is poor, as in parts of the Mae Kuang Project, tobacco may be found as a single cropping system in the wet season. Tobacco in this season has a higher quality than when grown in the cool season and demand is higher. Yields, however, are relatively low.

Double cropping

The double cropping patterns which are confined to irrigated land in the Valley consist either of a cool or warm season crop following the wet season rice crop. Tobacco, garlic or chili-pepper, which establish better under low temperature, are planted immediately after the rice harvest in early November while soybean, peanuts, water melon and some chili are delayed until the warm season, being planted after a December harvest from late December to early January when the temperature is relatively higher. Non-photosensitive rice varieties RD 1, and RD 7 may be planted as a second rice crop, for cash. Transplanting of this crop occurs from mid January to early March.

The rice-tobacco sequence is common in the upper section of Mae Taeng, Mae Fack and Mae Kuang irrigation projects. Most curing barns are located

in this area (see Table 2.4) and the tobacco varieties, mostly various Coker lines from the USA, are provided by the curing barns although some farmers grow their own local varieties.

The rice-garlic sequence is most common in the Mae Ping Kao area, farmers utilising an early 90 day glutinous rice variety such as Dor Prao. Rice is harvested in mid to late October and garlic is planted one month earlier than elsewhere. A local garlic variety is normally grown but farmers seldom keep their own seed for more than a few seasons, preferring to regularly renew their seed stock from other areas often outside the Valley.

The rice-soybean sequence is practiced extensively in the lower section of Mae Taeng irrigation project, i.e. in Hang Dong and San Pa Tong districts, and in the Mae Fack irrigation project, i.e. in the San Sai district. Soybean has become an important cash crop mainly due to high demand and government policy (see Chapter 4, Section 1). Recent releases of SJ 1, SJ 2 and SJ 4 from the Department of Agriculture, have replaced most of the local indeterminate types.

The rice-peanut sequence occurs most extensively in the Mae Kuang area. However peanut is also an important cash crop in the Mae Ping Kao area on land adjacent to the main canal. The highest yield in the Valley, about 4.4 ton/ha, is found in the Pra Tu Pa area.

Rice vegetable sequences are localised in the lower parts of the Mae Fack Project where recent alluvial soils predominate. Some large scale vegetable cultivation is also incorporated in young orchard nurseries, cabbages, lettuce, broccoli, melons and chili-pepper are the main vegetable crops.

Double cropping in the San Kamphaeng tube-well area consists of rice-peanut, tobacco, garlic, chili-pepper and vegetables such as cabbages. Two rice cultivars may be grown in the wet season, depending on farm size; farmers may allocate 5-8 rai to the glutinous Niaw San Pa Tong variety, while the remaining plots are planted to non-glutinous, good eating quality Kao Dawk Mali 105 variety.

In the Pa Sang tube well area double cropping of rice-garlic, rice-peanut is practiced. The wet season rice crop is not planted entirely to the Niaw San Pa Tong cultivar, some indigenous local varieties such as Dor Rai and Dor Leuang, which are early to medium maturity types are still being cultivated. The peanut variety is now mostly Tainan 9, the cultivar recommended by the Department of Agricultural Extension.

Triple Cropping

Most triple cropping systems arise simply by adding a third crop to one of the double cropping sequences described above. For example in the Pa Sang tube well area mungbean (utilising the local "Golden Podded" mungbean variety which requires 6 to 7 pickings), or rice or shallots are added

to a rice-garlic sequence. In the Chomthong area, where traditional irrigation systems are the only source of water supply, rice or mungbean is added to a rice-garlic sequence or mungbean to a rice-soybean sequence. Farmers here grow various glutinous rice cultivars in the wet season; for instance, Niaw San Pa Tong, Meuy Nong and Leuang Yai, all of which are photosensitive late varieties. Harvest for these cultivars does not begin until late November, no matter how early in the wet season they are transplanted (Rerkesem, Unpub. data). Garlic bulbils for planting in December are obtained mainly from Mae Hong Sorn Province, while the hot season rice crop is planted to RD 1, RD 7 and glutinous RD 2 varieties.

Triple cropping in the Ban Hong area, based on shallow dug wells, is mainly rice-vegetables where vegetables are grown continously after the wet season rice crop. There is also some triple cropping adjacent to the main canal in the Mae Ping Kao Project, based on soybean which is planted on permanent 3-metre beds in the wet season. The crop is harvested in October and is immediately followed by an early garlic crop. The third crop is either vegetables, ginger or chili-pepper which is relay-cropped into the garlic plot when the latter is about two months old.

3. Prices, credit and labour

Seasonal Price Movements

Prices of most agricultural products in the Chiang Mai Valley vary with the season, some more markedly than others (Figure 3.3).

Because of the good transport network, there is ready movement of agricultural products between Chiang Mai and adjacent provinces and large towns in the north and Bangkok. This means that supplies of crops such as paddy, peanuts, soybean, mungbean, garlic and some vegetables can be absorbed very rapidly and in the case of paddy and vegetables importation can often occur quickly enough to meet changes in supply and demand. For most crops, with the notable exception of garlic and vegetables, prices in Chiang Mai are thus closely tied to a country-wide market and in particular to Bangkok prices.

For most storable crops, the prices are lowest shortly after harvest and highest during the growing season. For example the price of paddy (traditional or "yellow" varieties) is highest in September and October and starts to decline in November when paddy begins to be harvested in some parts of the Valley. The minimum price of yellow paddy occurs around March (Figure 3.3a) and the minimum price for RD rice varieties is in June or July (no RD variety price data is available for January to March since only a few farmers grow these varieties in the wet season).

Prices for unshelled peanuts are highest in April and start to decline when peanuts are harvested in June and July. The price begins to rise again in September but the increase is not maintained (Figure 3.3b) because wet season peanuts come onto the Chiang Mai market in November and peanuts from a number of provinces begin to enter the Bangkok market during this period.

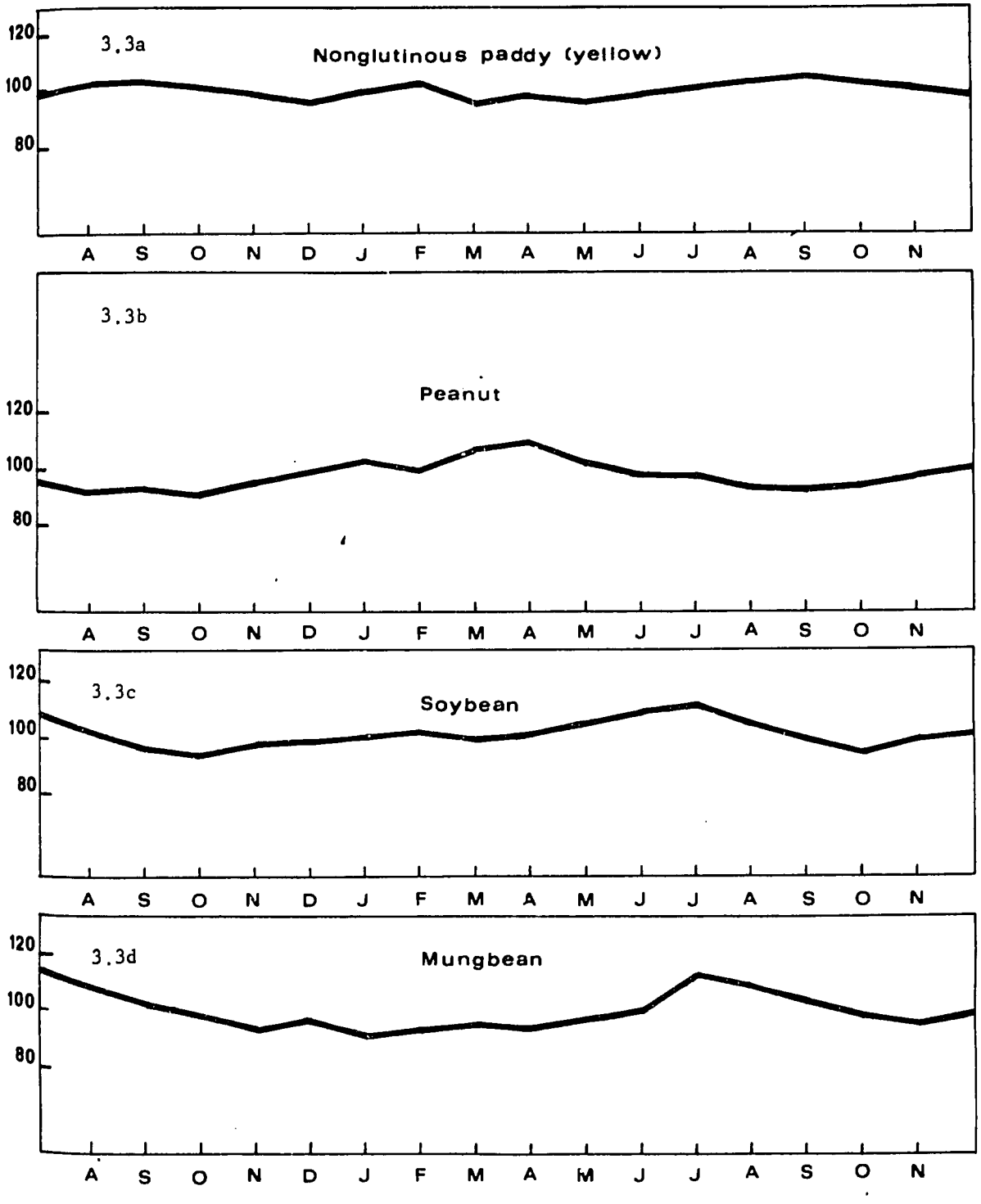


Figure 3.3 Seasonal price indices of selected crops in Chiang Mai, based on the average price. Mungbean prices are for Bangkok (Wiboonpongse, 1979)

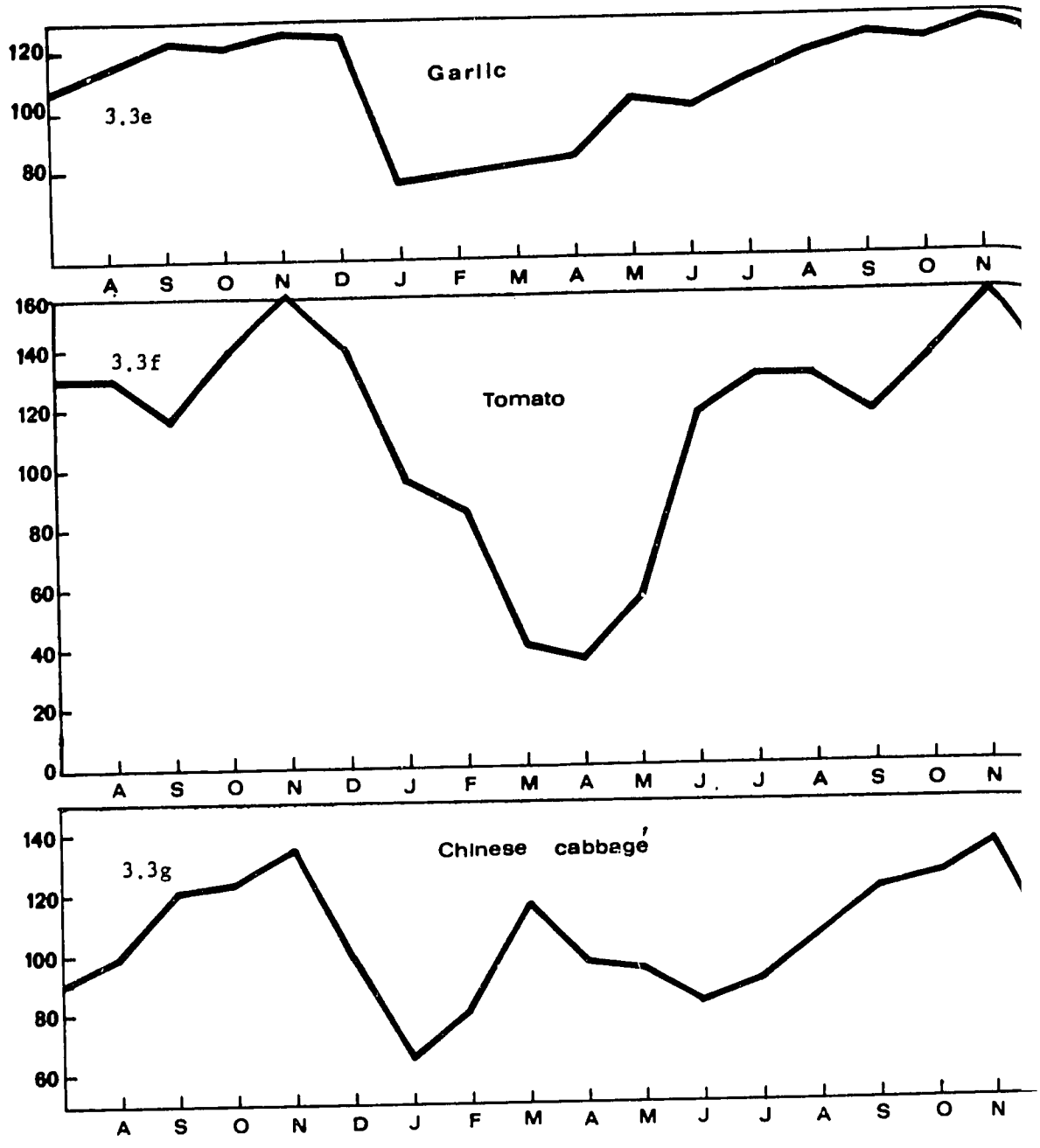


Figure 3.3 (cont.)

Farmers market their dry season soybean in April. The price then tarts to rise in May and hits its peak at the beginning of July (Figure .3c). The low prices in October occur because this is the time when soy-ean is harvested in nearby Sukothai Province where it is grown as a wet eason crop.

The seasonal movement of mungbean prices is described for Bangkok Figure 3.3d) which in turn is the basis of Chiang Mai wholesale prices Wiboonponse and Thodey, 1974). The lowest price is in January while the ighest is in September.

The seasonal pattern for garlic (Figure 3.3e) is, however, very pro-ounced largely because Chiang Mai and Lampoon are the main garlic produc-ng areas of the country and the market is unaffected by production else-here, unlike the situation for other crops. The minimum price is in ebruary when the new crop starts coming on to the market and the maximum s in November and December when there is an additional demand for seed.

Vegetable prices also show very marked seasonality because of their igh dependance on local demand (Figures 3.3f-g). Vegetables are produced ll the year round but in general the weather is more favourable for egetables grown in the cool season, and the market thus tends to be flood-d in late February and March, suppressing the price. High prices tend to ccur from July to November.

easonal Cash Demand

In the Valley, cash is required for such production expenditures as ired-labour, seed, fertilizer, chemicals, insecticides and farm equipment. This requirement is either met by the farmer's own savings or by borrowing from local money lenders or from institutions such as the state owned Bank of Agriculture and Agricultural Cooperatives, commercial banks and farmers' cooperatives. For tobacco growers, credit is also available through their contract with the processing factories, both in cash and in the form of inputs.

Institutional credit is available at any time during the year to farmers upon a security pledge or group guarantee basis, and upon the bank's evaluation of a farmer's repayment ability. The demand for cash and hence the provision of production credit varies with the crop and is generally higher for cool season crops (Table 3.1).

Table 3.1 also indicates that the maximum credit for some crops (e.g. garlic, peanut and tomatoes) may be lower than the actual requirement level. Garlic is highly labour intensive, requires fertilizer and insecticide and garlic seed is expensive. Peanut growers have to hire labour to prepare the beds and need to purchase seed and fertilizer. Tomato cash requirements are mostly for fertilizer and insecticide. The difference may be made up by farmers' own funds, additional borrowing, or cash and credit management.

Table 3.1 Credit demand and maximum credit given by the Krung Thai Bank.

Crops	Maximum credit available (Baht per rai)	Actual cash expenditures* (Baht per rai
Wet season rice	500	220
Dry season rice	500	196
Garlic	1,500	2,217
Soybean	400	412
Peanut	500	802
Tobacco (own fertilizer)	1,000	1,000
Tomatoes	500	595
Chili green pepper	400	202
Cabbage	500	212

* Calculated from cash expenditures of farmers in Ban Mae Kuang and Ban Harn Kaew villages by the MCP.

Although credit is given on a component crop basis and is to be repaid after harvest, credit can be extended to cover several crop seasc with up to a one year repayment term. In multiple cropping, cash and credit demands are largely determined by the second and third crops; farmers may choose to borrow the total annual requirement or may manage their farms in such a way that cash sales from one crop can be used, totally or partially for production expenditure on the following crop or crops.

Figure 3.4 shows that the major peaks in cash demand occur around November/December due to the high-input, high-return nature of most cool season crops. Also apparent from the Figure is the way in which increas cropping intensity tends to increase cash requirement peaks. This is du to the inverse relationship between cropping intensity and turn-around t which causes harvesting costs of one crop to be incurred at the same tim as input costs of the following crop. This factor strongly influences t cool season peak because, as was shown in Figure 3.2, it is at this time when the shortest turn-around period generally occurs.

For these reasons the tightest time for cash for farmers in the Valley could be expected from late in the rice crop to early in the cool season. Indeed the large number of second-hand consumer durables appear for sale in the village markets at this time of the year lends additiona support to this conclusion.

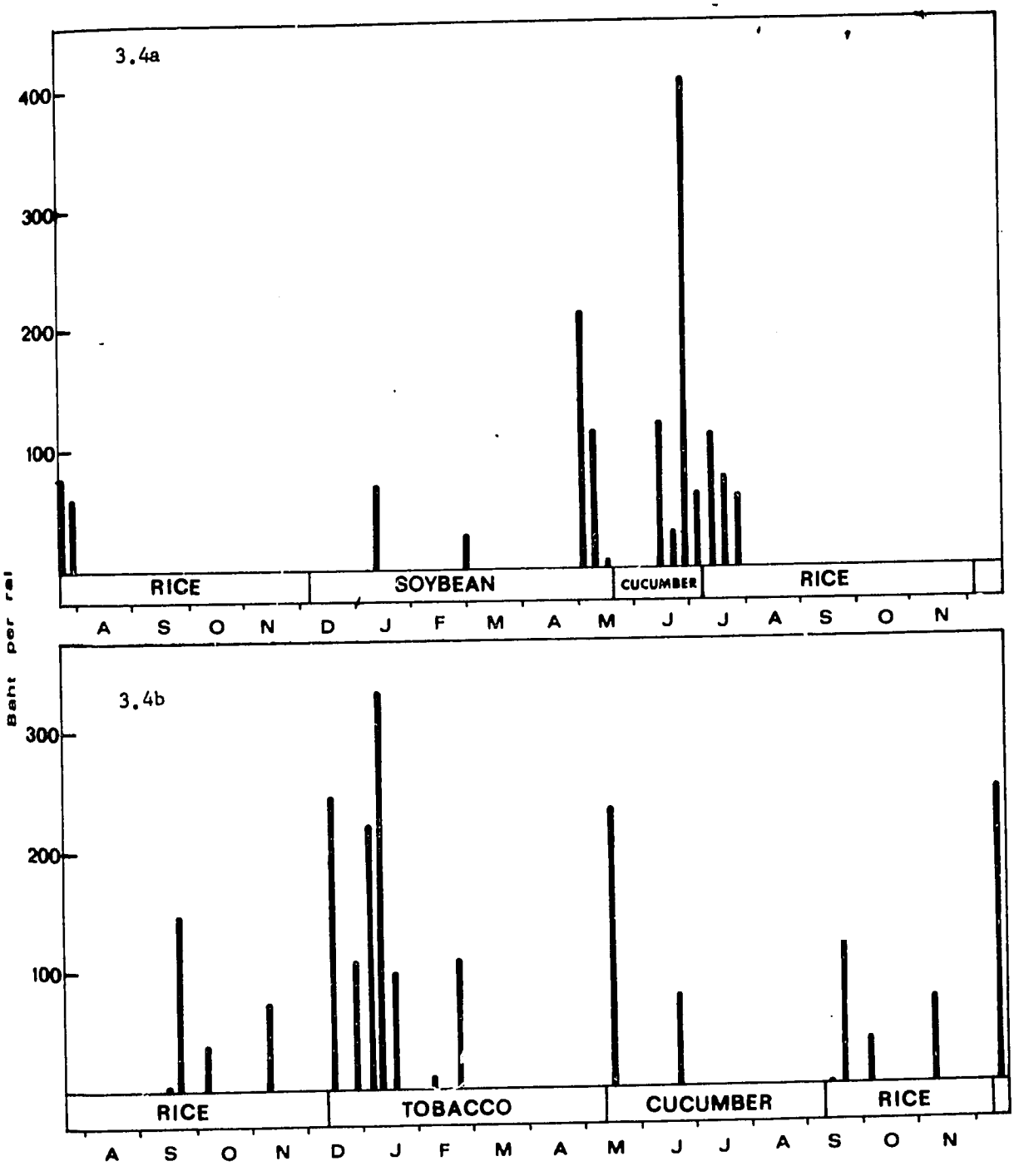


Figure 3.4 Cash expenditure profiles for some cropping systems in Ban Han Keaw and Ban Mae Kung for 1976-1977

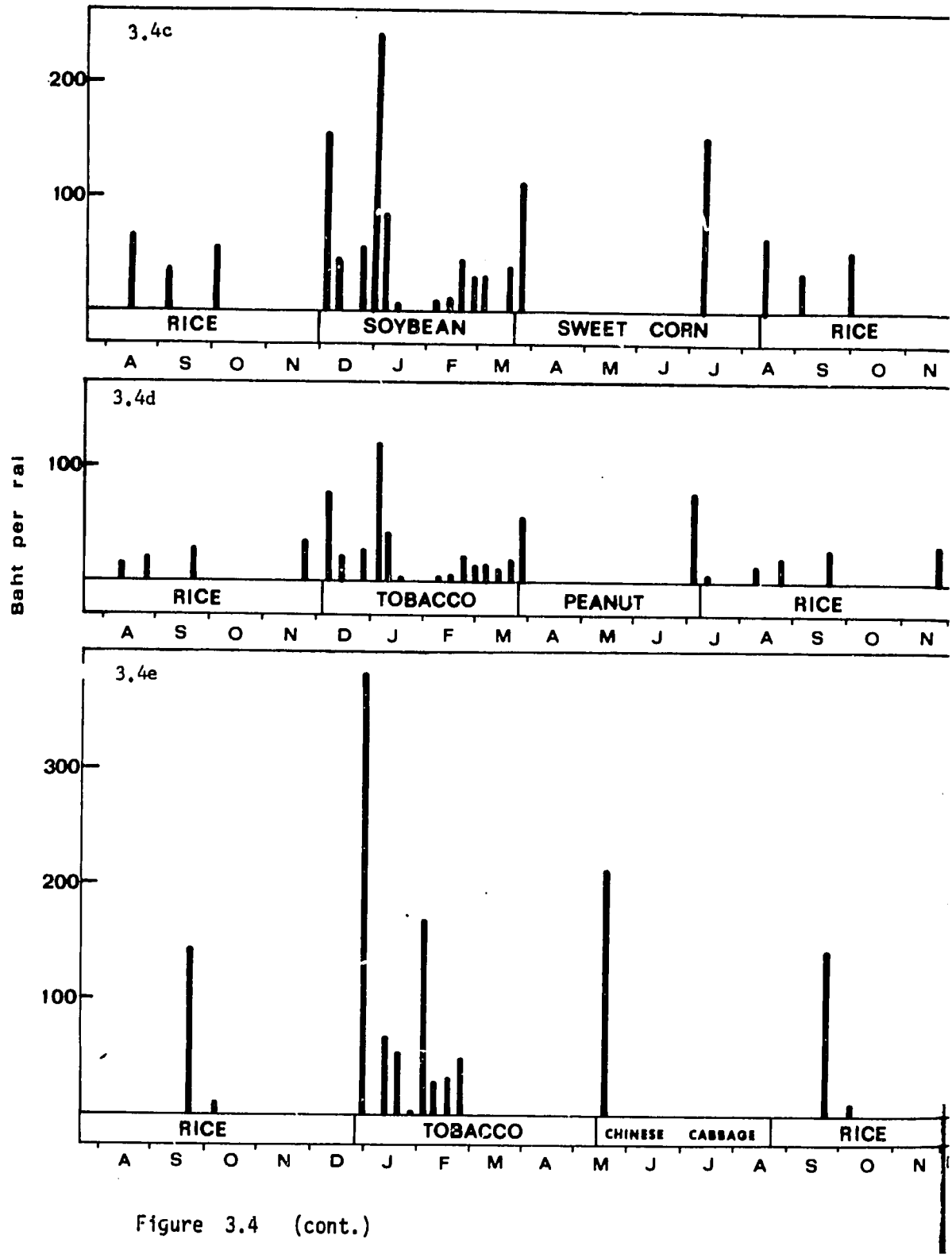


Figure 3.4 (cont.)

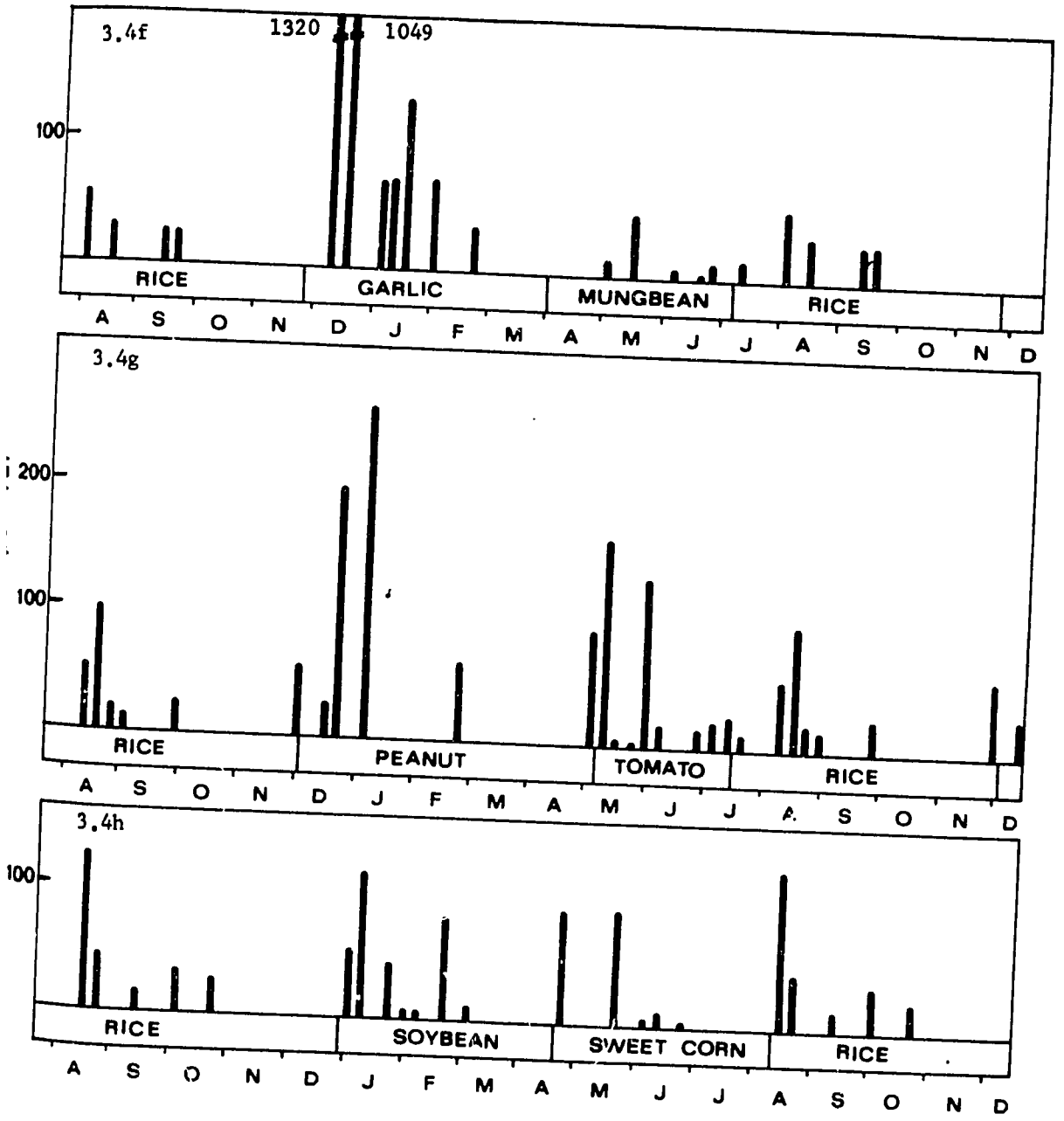


Figure 3.4 (cont.)

Seasonal labour demand.

Labour utilisation varies by crops and level of management. Figure 3.5 shows the labour profiles of eight multiple cropping systems developed by the MCP and six traditional systems.

Of the eight introduced systems, the rice-peanut-tomato sequence has the highest peak labour demand (180 man hours per rai) when farmers prepar the land and plant tomatoes. High peaks also occur in sequences with garlic (140 man hours per rai for land preparation and planting) and in sequences with peanuts where 90 man hours per rai are required for harvesting. Less dramatic are the labour fluctuations for the rice-soybean-sweet corn and the rice-soybean-chinese cabbage systems which have peak demands of only about one third of the rice-peanut-tomato system.

In the traditional systems the highest peak is 145 man hours per rai (rice-tobacco-chinese cabbage) which is still 23% lower than the peak labour demand in the MCP systems. In general the introduced systems require more labour in the peak periods than traditional cropping systems. Some of the introduced crops (e.g. tobacco and peanut) also have peak labour requirements at times different from those of traditionally grown crops and the question is whether farmers can reallocate their labour to meet the new peak demand and whether there is enough hired and/or exchange labour to help in the operations. Farmers may be able to meet peak labour requirements but often at a substantial cost. Intensive multiple cropping systems are only possible when there is fast turn around between one crop and the next. As can be seen from the Figure, the critical bottle-neck lies between rice harvesting and the second crop planting, and is generally more pronounced in the more intensive and the potentially more profitable systems.

4. Long term changes

Cropping Patterns.

Over the past eight years there has been considerable increase in cropping intensity in the Valley as a whole (Figure 3.6). This has undoubtedly been due, at least in part, to the opening of the Mae Taeng irrigation scheme in 1971 and thus changes in cropping intensity will var greatly between the different sub regions within the Valley.

Figure 3.7 shows trends in the relative importance of the major cro grown in the RID irrigation areas. The major changes occur post 1970 and may also be influenced by the opening of the Mae Taeng irrigation system. Indeed the crops showing the most dramatic increases, rice and soybean , could be expected to be natural choices for farmers adopting multiple-cropping for the first time as both can be merely 'tacked' on to the traditional rainy season rice crop without necessitating any change in practices in that crop. In addition neither crop is likely to cause severe management problems for a new multiple cropper as the management of soybeans is very simple and all farmers are familiar with the rice crop. In the case of peanuts which shows the most dramatic decline in relative

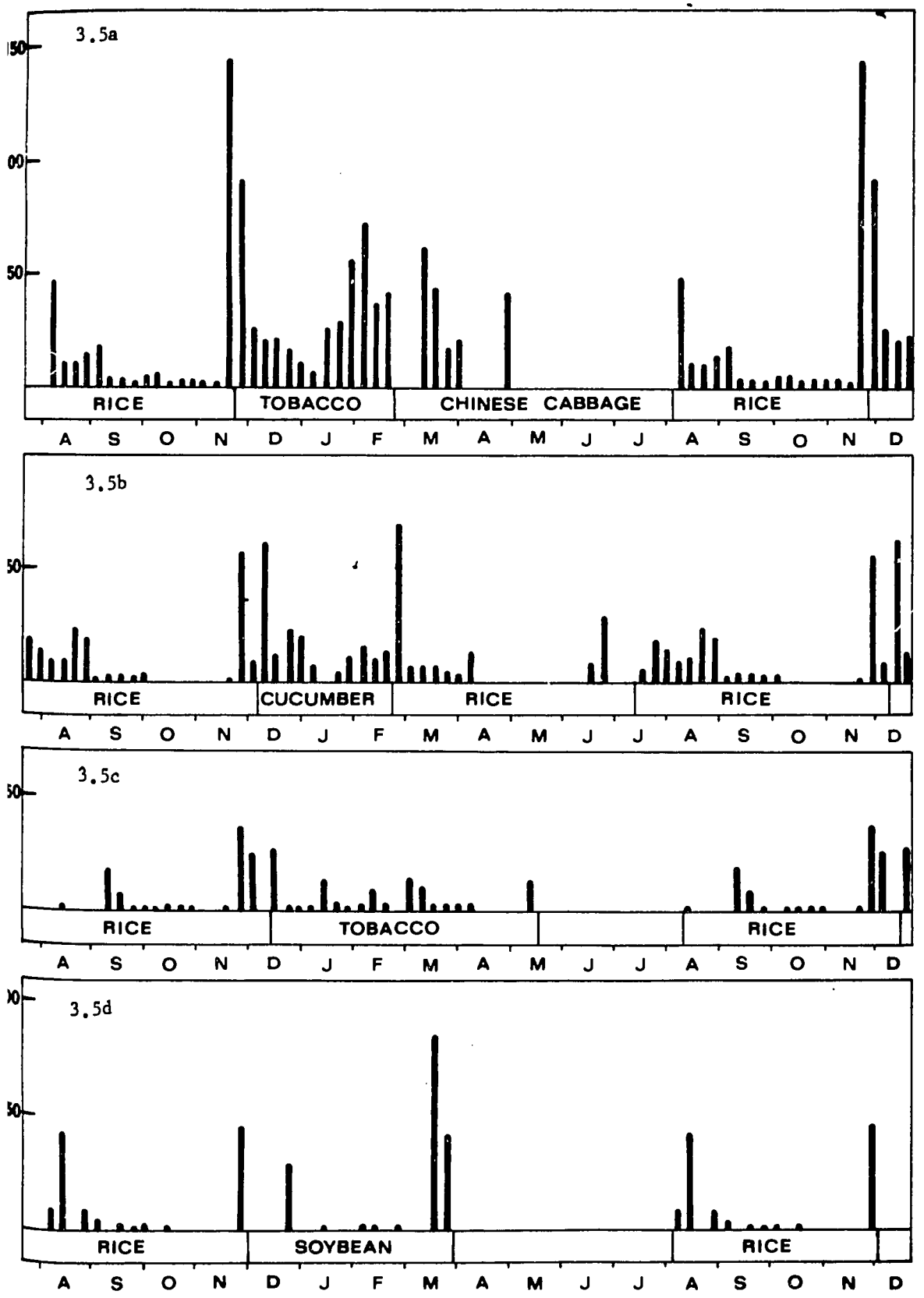


Figure 3.5 Labour requirement profiles for some cropping systems in Ban Harn Keaw and Ban Mae Kung for 1976-1977

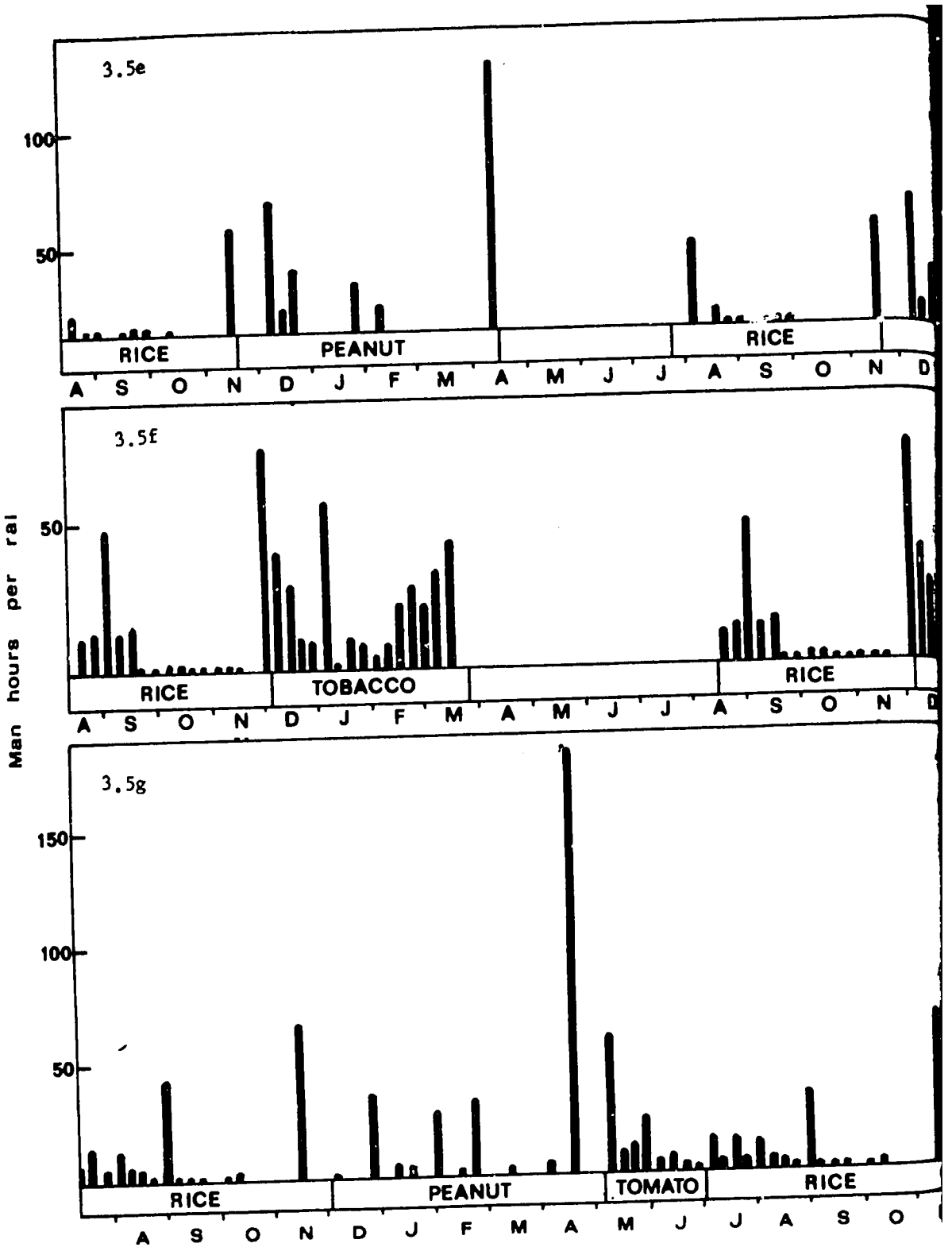
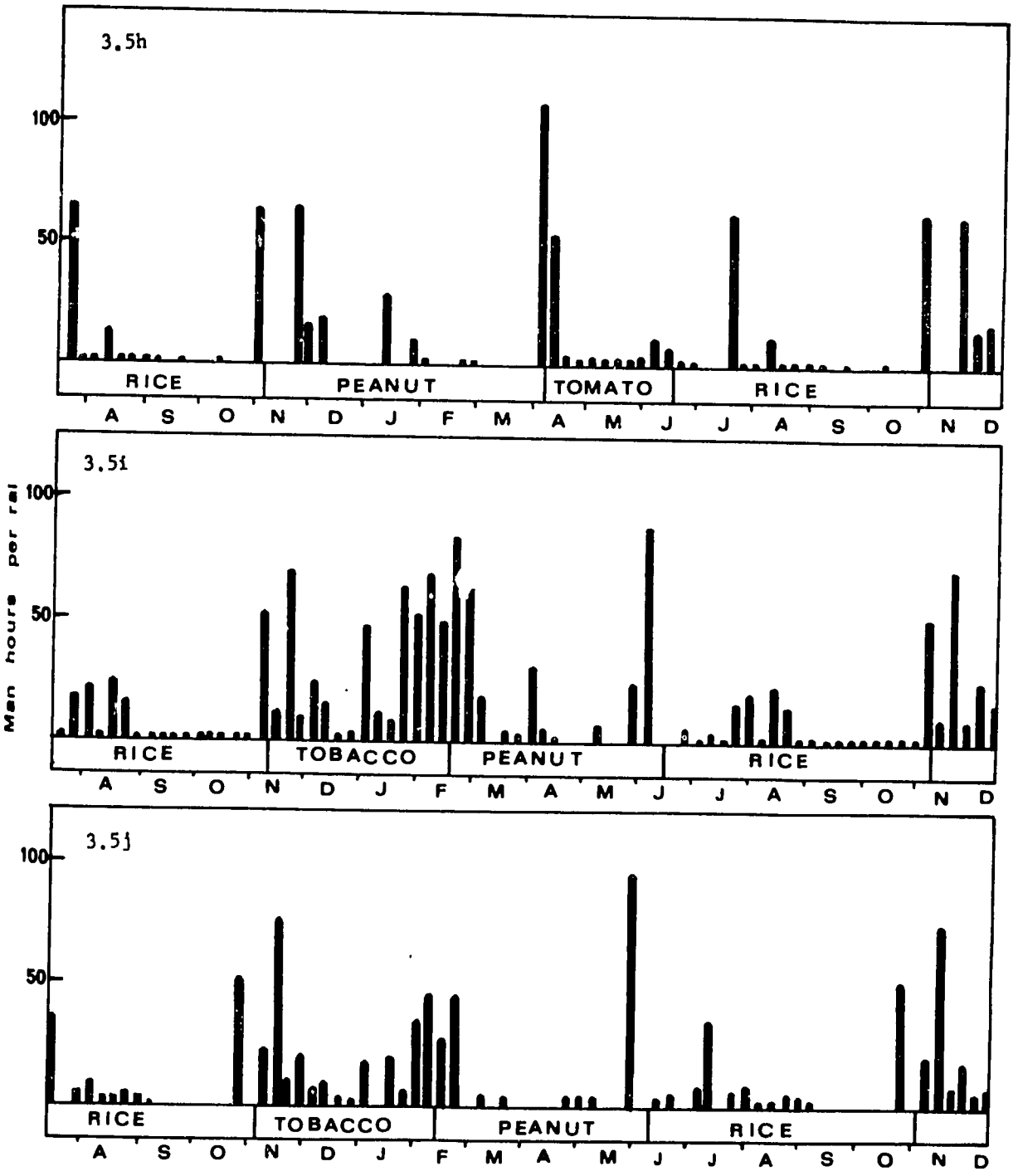


Figure 3.5 (cont.)



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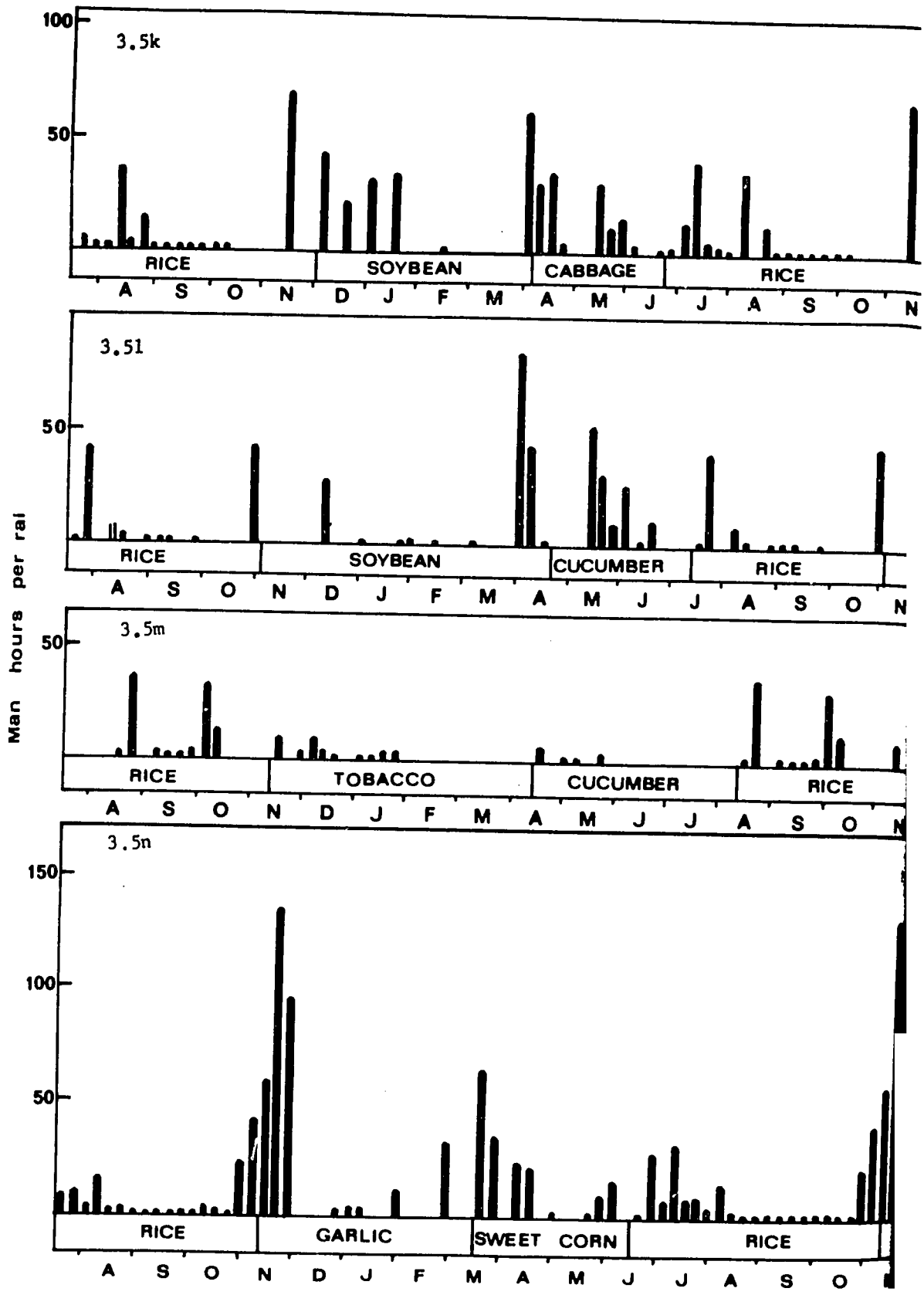

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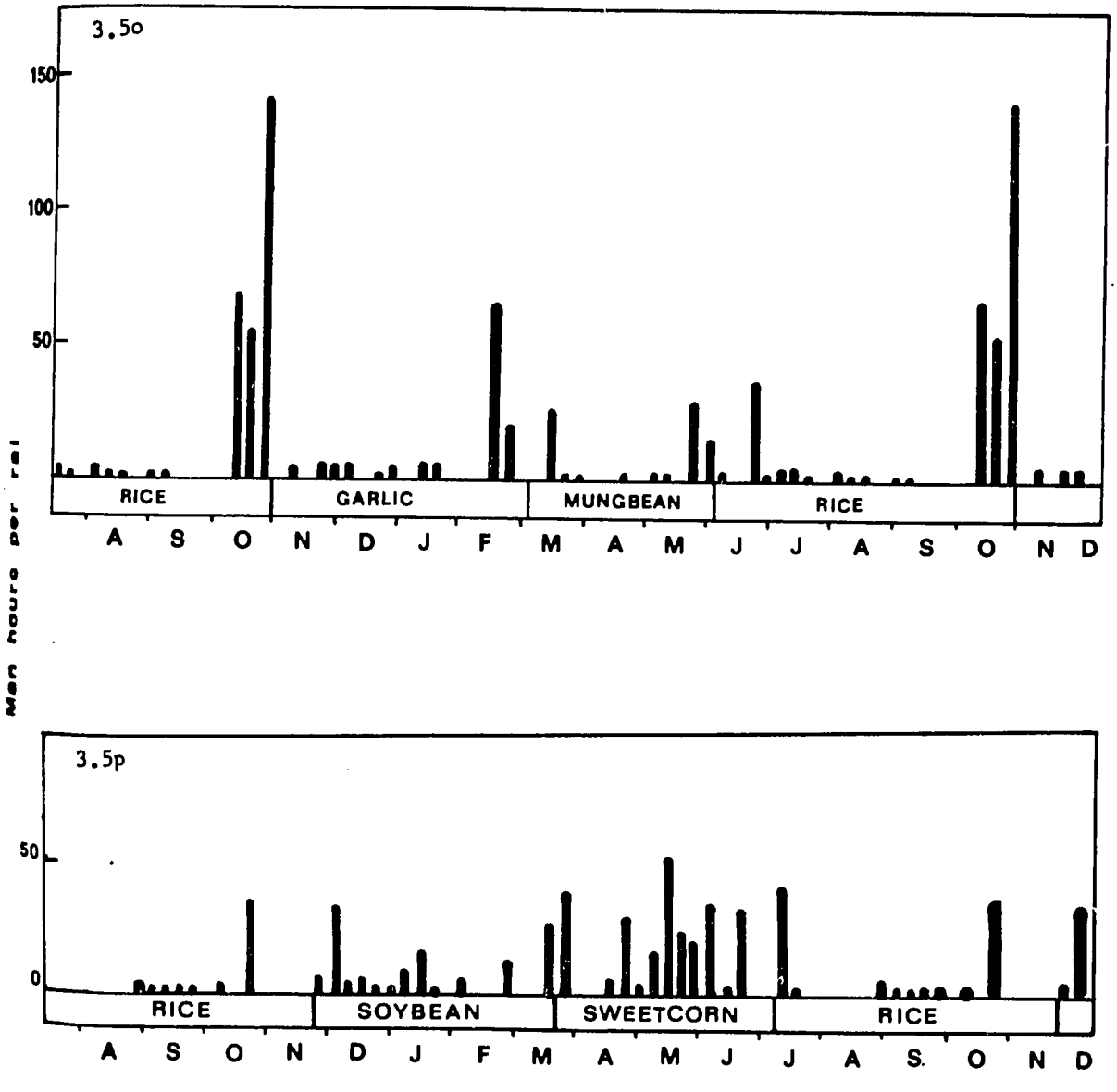

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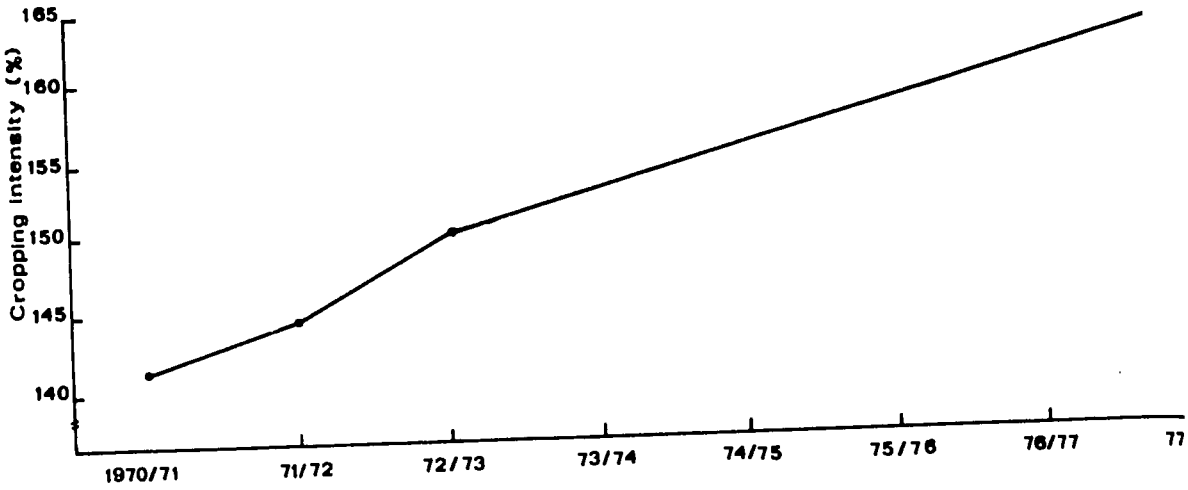
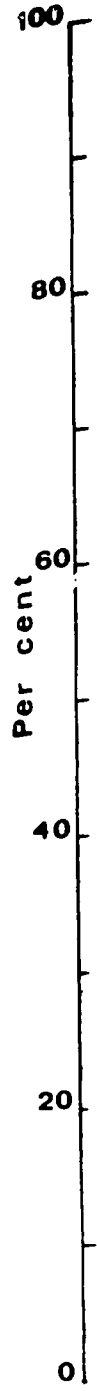


Figure 3.6 Trends in cropping intensity in the Chiang Mai Valley 1970 to 1978. After Tongsiri et al 1975 and Nippanutiyan, 1979.



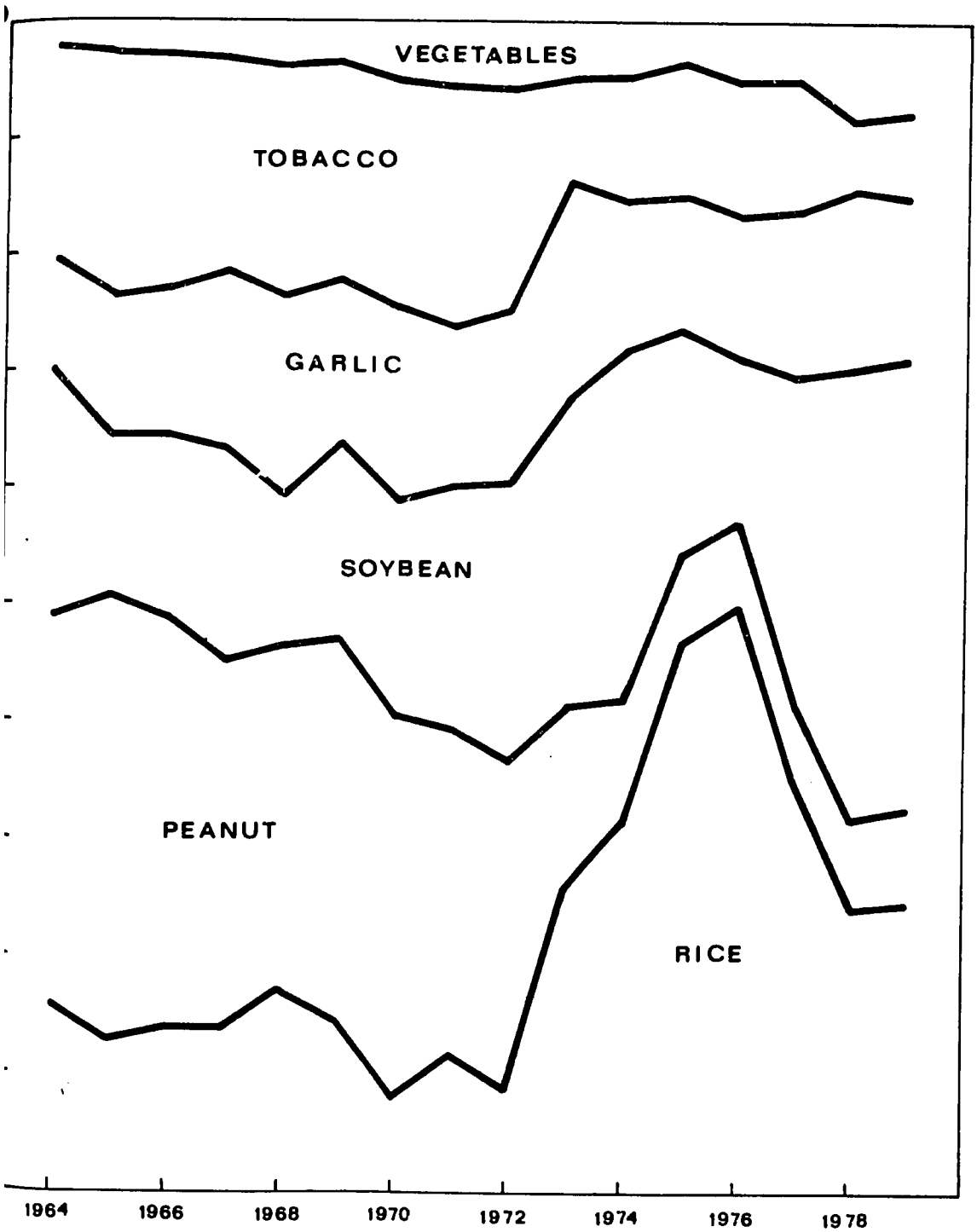


Figure 3.7 Relative importance of major dry season crops (% of total area planted) in RID project areas in the Chiang Mai Valley

proportions the actual area planted, although also declining, is not nea so dramatic. Thus the decline in relative proportion of peanuts may be part due to the increase in other crops.

Population

The national population growth rate was greater than 3% per year, prior to the 3rd National Development Plan (1972 - 1976) when a populati policy was first officially accepted. The rate effectively reduced to 2 per year during the period 1970 - 1974. The population in Chiang Mai an Lamphun Provinces, however, has expanded at a rate much slower than the national average, as a result of rapidly declining birth rates (Figure 3 Death rates in these two provinces have also been low but birth rates ha been about half the national average (Table 3.2). The population in Chiang Mai is expected to rise at a faster rate than in the past 15 year from 1976, however, not because of a high natural growth rate but becaus of anticipated in-migration.

Table 3.2: Demographic statistics for Northern Thailand (1970-74).

	1/ Whole Country	1/ Northern Region	2/ Chiang Mai	3/ Lamphun
Birth rate (%)	3.76	3.74	1.99	1.79
Death rate (%)	0.91	1.18	0.70	0.71
Growth rate (%)	2.85	2.56	1.29	1.08

Sources: 1/ Population and Manpower Planning Division, National Economic and Social Development Board.

2/ Statistical Division, Ministry of Public Health.

3/ Statistical Year Book, Lamphun Province, National Statistical Office.

The low birth rate during 1970-74 partly explains the sudden drop dependency ratio of the Chiang Mai population, from 100 : 107 in 1970 to 100 : 61 in 1978 (Population Census, National Statistical Office 1970; Labor Force Survey, Chiang Mai Provincial Labor Office, December 1978). However, the move into the Province of adult labour may be a contributor factor (The dependency ratio here is defined as the proportion of the population in the working group (11-60 years of age) to the rest).

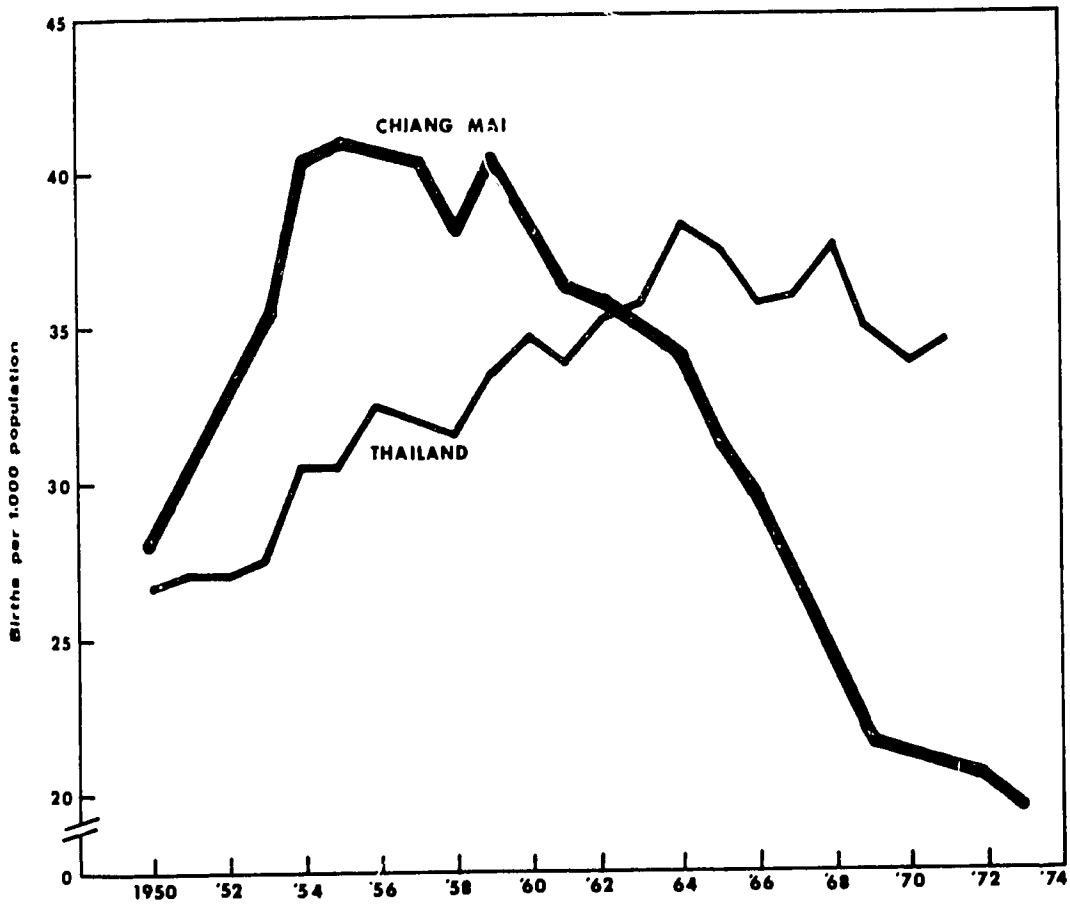


Figure 3.8 Unadjusted crude birth rate based on vital registration for Chiang Mai Province and Thailand (Pardthaisong 1978)

The growth rate has also varied greatly between different amphur the Valley and there have been marked year to year fluctuations in the growth rate within amphurs. This suggests an unsystematic migratory m ment within the Valley, since birth and death rates generally change e ly from year to year.

During 1970 - 1974 the population expanded most rapidly in Muang Chiang Mai, Mae Rim, and Chomthong, at average annual rates of 4.79, 3, and 3.08 respectively. In Mae Taeng, however, there was a negative gr rate of 0.41 percent per year. Saraphi and Hang Dong had growth rates less than 1% a year, whereas all other amphurs had growth rates in the neighborhood of the valley's average (Table 3.3).

Table 3.3: Annual population growth rate of Amphurs in the Chiang Mai Valley.

Amphur average	1960-1970	1970-1972	1972-1974	1970-1974
Muang Chiang Mai	3.718	6.429	2.801	4.795
Chomthong	2.414	-1.532	7.947	3.086
Doi Saket	2.057	1.747	1.085	1.435
Mae Taeng	2.497	-0.694	-0.131	-0.411
Mae Rim	3.372	6.380	0.938	3.719
San Khamphaeng	2.324	2.662	0.736	1.719
San Sai	2.310	4.035	0.242	2.148
San Patong	1.966	0.593	2.061	1.339
Saraphi	1.466	0.999	0.019	0.490
Hang Dong	3.035	0.515	0.836	0.680
Muang Lamphun	-	0.245	4.659	2.196
Ban Hong	-	0.687	2.094	1.405
Pasang	-	1.526	1.896	1.740

In general the total number of agricultural households has decreas in the Valley with the exception of 4 Amphurs, the most notable increase being in Chomthong. In terms of percentage of total households however decrease occurred in all Amphurs with the notable exception of 4% incre once again in Chomthong (Table 3.4). The most dramatic decreases have been in Amphurs Muang Chiang Mai, Mae Rim and San Khamphaeng where there has been a drop of 20% in 7 years (Table 3.4).

Table 3.4: Changes in agricultural households in the Chiang Mai Valley.

Amphur	Agricultural households			
	Total Number		As percentage of total households	
	1963	1970	1963	1970
Muang Chiang Mai	4,543	2,781	23.72	9.84
Chomthong	7,186	9,269	66.07	70.48
Doi Saket	7,009	6,696	76.84	62.09
Mae Taeng	6,487	7,565	66.06	63.57
Mae Rim	5,772	4,885	72.74	49.64
San Khamphaeng	8,434	7,690	73.46	58.09
San Sai	7,137	6,234	71.37	49.86
San Patong	11,858	12,258	71.59	64.17
Saraphi	7,343	6,526	66.25	55.86
Hang Dong	5,502	6,048	66.41	60.92
Muang Lamphun	-	14,279	-	60.75
Ban Hong	-	48,930	-	73.43
Pasang	-	9,761	-	74.46

Source: National Statistical Office.

Projections of future population trends in the Valley depend on the analysis and interpretation of the dramatic demographic changes that have occurred over the past 5 to 10 years. Figure 3.9 shows the age and sex structure as censused in the population of the Chiang Mai Changwat in 1970. As can be seen the largest proportional age classes are the 10-14 and 5-7 year age classes. The smaller proportional size of the 0-4 age class is evidence of the declining birth rate reported in Table 3.2. This percentage dropped from 17% in 1960 to 12.1% in 1970.

A more up to date picture can be obtained from Figure 3.10 which shows the age pyramid for the villages of Ban Han Kaew and Ban Mae Kung in 1976. These are only small sample sizes and so the data should be treated with caution. Nevertheless they show a continuing dramatic decline in birth rate, with the 15-19 year age class occupying the largest proportion of the population and subsequent age classes each smaller than the preceding one. The natural growth rate of the population of the villages is only 0.37% (Social Science Research Centre, 1979).

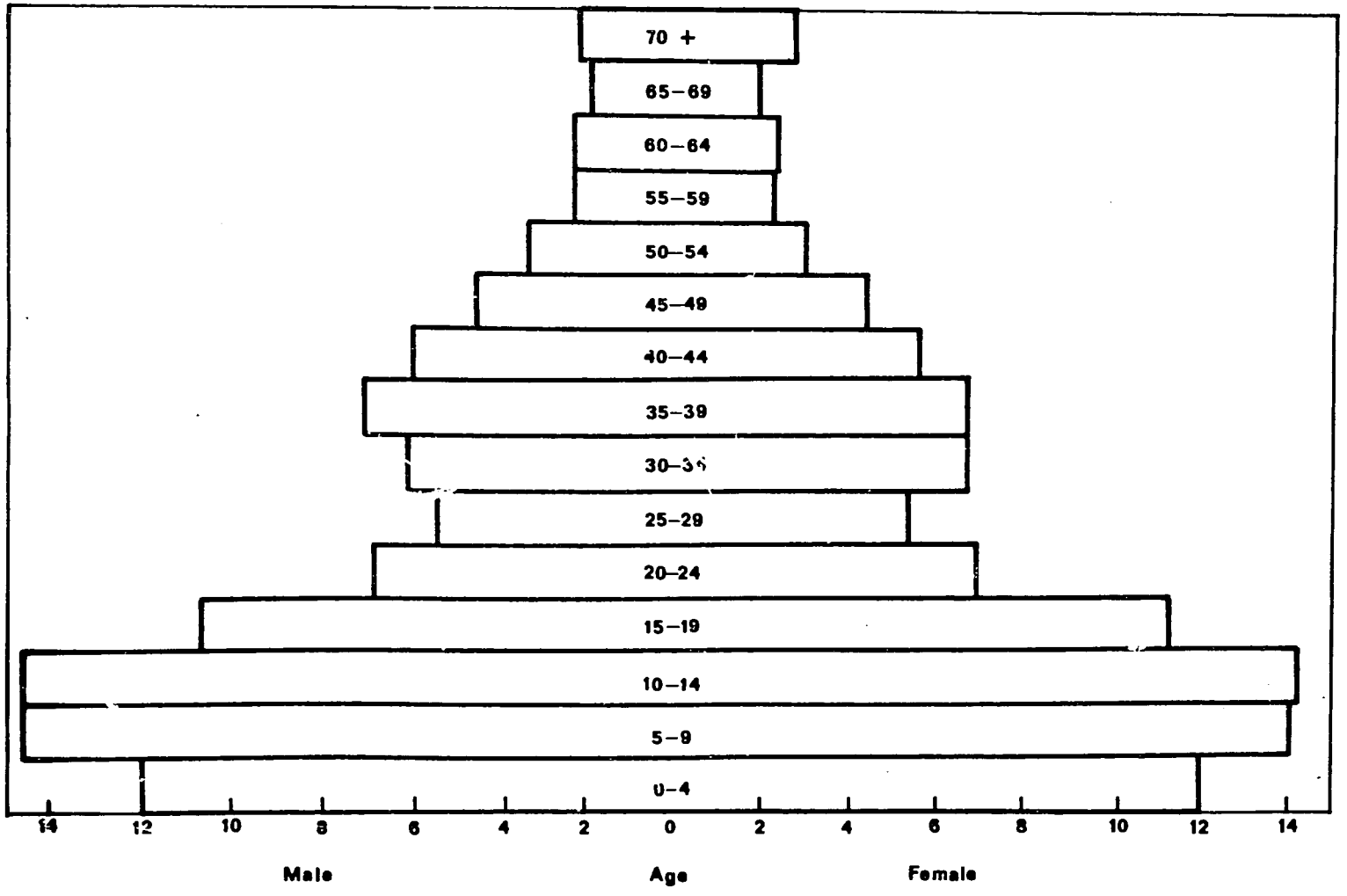
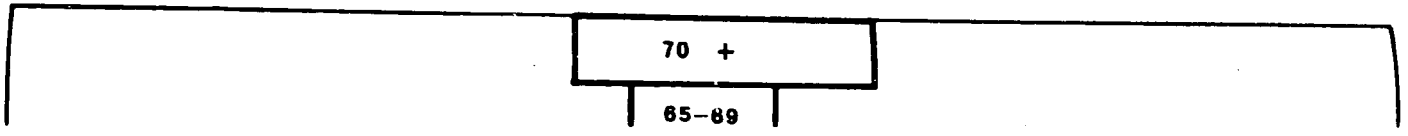


Figure 3.9 Age and sex structure of Chiang Mai population in 1970 (Prasith-rathsint et al 1978)



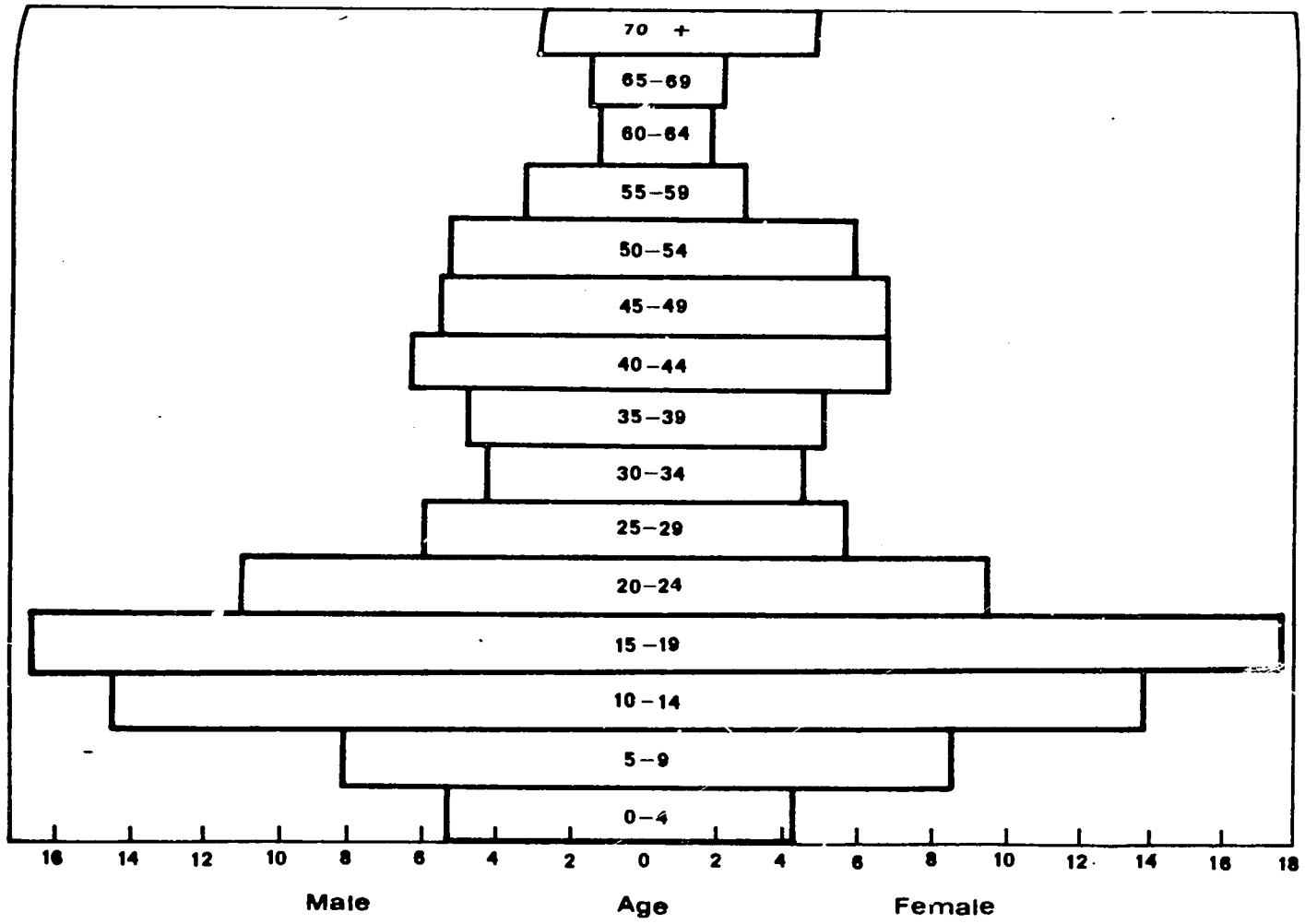


Figure 3.10 Age and sex structure of Ban Harn Keaw, Ban Mae Kung and Ban villages in the Chiang Mai Valley

(Soc. Sci. Res. Coun. Unpubl. data)

It is generally considered that the decline in birth rate is due t a real decline in the fertility rate in the Chiang Mai Province (Pardthaisong, 1978). Supporting evidence comes from the decline in the proportion of third and higher order births, with an increasing number o women in the 25 to 29 age group having families of only one or two children. The total fertility rate in the Province is estimated to have fall by 40% between 1960 and 1975 (Figure 3.11). The pattern is similar for Lamphun Province.

There is little evidence of changing nuptial patterns to account fo this dramatic decline and it appears to be most likely a function of increased acceptance of family planning, particularly injectable contraceptives. Family planning programmes have spread widely throughout the Vall and surveys show that the proportion of new acceptors in the highest-fertility age-group (20-29) increased from 51% in 1970 to 67% in 1975.

For the future if the fertility rate remains at its present level w may nevertheless expect a sharp rise in birth rate over the next 5-10 yea because of the large number of 10-19 year olds reaching child bearing age (see Figures 3.9 and 3.10). However, the birth rate will then once again drop as the current 0-10 year olds also mature and is likely to continue do so, with mild fluctuations, at a rate which depends on the continued decline in fertility.

The implications for multiple cropping may be considerable. While the labour force may remain relatively large, primarily due to the maturing of the current 10-19 year old group, there will be a sharp decline in rural labour, probably accelerated by urbanization, toward the end of the century. This shortage may become a serious inhibiting factor to the intensification of the, necessarily labour-demanding, cropping systems.

Farm Size

Since data on average farm size at Amphur level are not available, land holding size is taken as representative of farm size. This by definition comprises the farm land and the homestead occupied by a farm fami In rural Northern Thailand farm fields are typically separated from the homestead area and houses are clustered in the centre of the village, sur rounded by the farm land (see Figure 2.15). Houses and farm are usually within walking distance, however. New houses for new families are normally built on the parents' homestead rather than on the farm land and thus change in land holding size is a good indicator of change in farm size.

In the period of 14 years between 1963 and 1977 average land holdin size per farm family in most Amphurs of the Chiang Mai Valley declined, except for Chomthong. However although there has been a reduction in far size, cropped area generally increased during this same period (Table 3.5

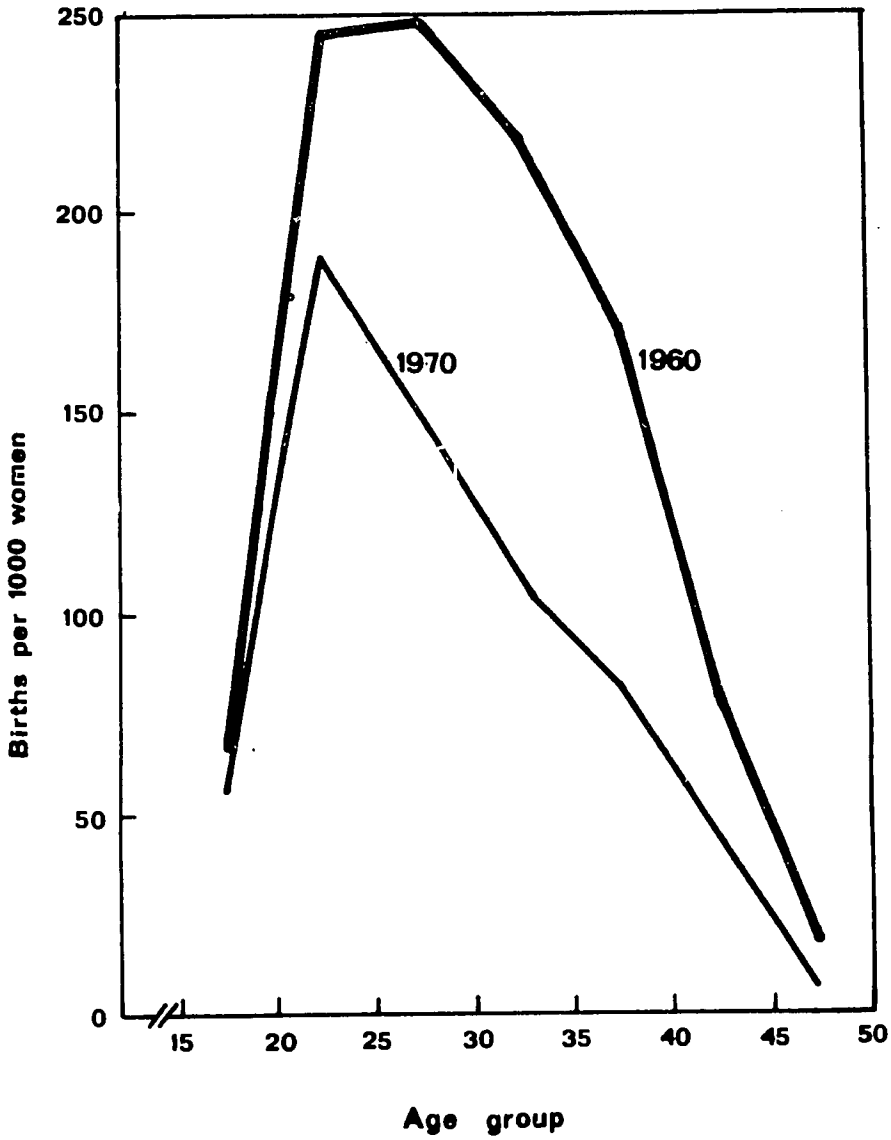


Figure 3.11 Age-specific fertility: Chiang Mai Province for 1960 and 1970 (Pardthaisong, 1978)

Table 3.5: Long term changes in average holding size and cropped area by Amphur.

	Holding size (rai/family)		Cropped area (rai/family)	
	1963	1977	1963	1977
Muang Chiang Mai	7.27	6.00	6.30	12.62
Chomthong	6.22	7.04	5.10	8.70
Doi Saket	8.47	5.40	7.00	8.22
Mae Taeng	6.80	5.70	5.10	7.27
Mae Rim	6.55	5.70	5.90	5.85
San Khamphaeng	10.18	9.83	9.40	15.49
San Sai	8.84	5.12	7.40	12.24
San Patong	6.26	4.74	5.40	7.84
Saraphi	7.06	5.25	6.50	6.06
Hang Dong	7.40	4.79	6.40	7.25
Muang Lamphun	9.66	8.47	8.70	10.74
Ban Hong	7.35	5.20	5.90	5.94
Pasang	7.59	na	5.90	8.45
overall	6.83	6.70	6.60	8.97

Source: National Statistical Office.

Farm Size and Urbanization.

Urban growth can either maintain or decrease farm size. The flow o poor migrants to the towns may reduce rural populati density and henc maintain farm size since there will be less fragmentation and fewer in- habitants remaining. However, the territorial growth of urban centres ma reduce farm size as the price of land near the outskirts of the cities increases, causing farmers to sell their la d and purchase new land in mo remote areas.

Although at the present time there is no study available of the gro of the principal cities of Chiang Mai and Lamphun Provinces, it is evidem that in the past few years many new housing projects as well as small sca industrial factories have been erected on the outskirts of Muang Chiang M and on the Chiang Mai-Lamphun Highway. A substantial amount of farm land along the roads connecting Muang Chiang Mai-Hang Dong, Muang Chiang Mai- Mae Rim, and Muang Chiang Mai-Saraphi is now converted into residential areas and factory sites. Amphur Doi Saket, where a new highway passes

through, may soon lose farm land in the same way. The expansion of Muang Chiang Mai thus, has an impact on farm size in all the neighboring Amphurs.

Farm Size and Migration.

Knowledge of migration movement is almost equally inadequate. In the 1970 population census Chiang Mai Province is reported to have had, in 1965-1970, a net migration of about 36,000 persons from other provinces and about 500 from foreign countries, while its internal migration figure was about 36,000 persons. The census however gave no information on origins and destination nor the professional status of the migrants. When looking at the sectoral growth of the Chiang Mai economy where the value added has been increased most rapidly in trade, banking business, transportation and services since 1970 (National Income Statistics, various issues) it appears that in-migration, both inter-and intraprovincial, is a function of the expansion in trade and service-related industries in the city, and the migrants are thus likely to be composed more of professional and skilled labor than farmers seeking new jobs.

The result of a recent study on labour movement into Muang Chiang Mai gives partial support to the above assertion (Tongchai and Chiwat, 1978). This study reveals that of workers from upcountry, 50% are presently employed in the service sector, 25%, in production and 24%, in the trade sectors. Most of the labourers come from Amphur Mae Rim, San Khamphaeng, and Saraphi. There are more male workers than female, mostly *prathom* 4-7 graduates, in the 20-24 age group and they have been working for about 4 years.

Prices

(a) Chemical Fertilizers. The average amount of chemical-fertilizer-use in Thai agriculture is very low. It was about 3.8 kg per rai, averaged for Thailand's total planted area, in 1972; in other Asian countries the rate is 9 kg per rai (FAO Annual Fertilizer Review, 1975).

The use of fertilizer is dependent almost exclusively upon the value/cost ratio of crop production, providing that other factors such as the availability of money, input supply and water are not constraints. A value/cost ratio of 2.00 is suggested by the FAO as a minimum level that will induce farmers to apply chemical fertilizer. This high value arises because profit alone is not sufficient an incentive for the farmers; they have to look at total income, stability of product prices, as well as other risk factors before making the investment. From a study by the Rice Division and Agricultural Economic Division on fertilizer response and value/cost ratio for various crops, the result indicates that no single crop has a ratio higher than 2.00 (Table 3.6).

Table 3.6: Production costs and returns from the application of chemical fertilizers.

Crops	Incremental yield per kg. of fertilizer use (kg.)	Price received by farmers (Baht/kg.)	Cost of fertilizer (Baht/kg.) (1977)	Incremental value/cost ratio	Cost of production (Baht/kg.)	Value/ cost ratio
Rice (wet season)						
Central	8.45	2.40	3.70	5.51	1.90	1.26
North	4.37	2.40	3.70	2.83	1.24	1.94
Northeast	3.48	2.40	3.70	2.26	2.15	1.12
South	2.64	2.40	3.72	1.71	2.20	1.09
Rice (dry season)	6.54	2.40	12.50	5.81	1.65	1.45
Maize	37.59	1.95	12.50	5.86	1.38	1.41
Sugarcane	0.09	275.00 1/	2.50	10.38	147.00 1/	1.87
Soybean	4.0	5.00	17.50	1.14	3.65	1.37

1/ Unit : Baht/ton

Source : Facts and Recommendation on Fertilizer, Ag. Econ. Div., Ministry of Agriculture and Cooperatives. April 1978.

It is also clear from Figure 3.12 that as the product-price/fertilizer-price ratio becomes unfavourable the use of fertilizer in agriculture declines.

The supply of chemical fertilizer for agricultural use comes from two sources, imports constituting about 80-90% and local production about 10-20% of the total annual utilization (Table 3.7). Overall there has been no increase in fertilizer use over the past ten years and there is even evidence of a decline from 1974 to 1976.

Long term price movements of fertilizers in Thailand have followed world market price trends. Prior to 1972 prices changed very little from year to year, but after the worldwide energy crisis in 1972-73 prices of fertilizers increased steeply. Prices in Thailand are also determined by government policy and intervention regarding production and trade. Figure 3.13 shows average annual retail prices of major fertilizers in Chiang Mai, Lamphun, Chiangrai and Mae Hongson markets and also indicates the periods during which the government exercised various fertilizer policies. A significant proportion of fertilizer applied either directly or indirectly is in the form of animal manure (see Table 2.7). Thus any trends in increasing farm mechanisation at the expense of animal power may well affect the demand for artificial fertilizer.

(b) Fuel

Fuel oil prices, although fixed by the Government, are closely related to world prices. There has been an average increase of about 10% per year since 1970 (Figure 3.14) with a major jump of over 30% in 1979 and a jump of similar magnitude early in 1980.

(c) Commodity prices

The wide fluctuations in the prices of agricultural commodities are probably due to the fact that supply and demand for agricultural products are both relatively inelastic in the Valley. The supply of agricultural commodities changes over seasons and over years but demand for these commodities is relatively stable. These price changes can be characterized into four components: seasonal, trend, cyclical and irregular changes. Seasonal changes have been referred to earlier in the Chapter. The analysis is based on the monthly wholsesale prices at Chiang Mai and Bangkok.

Data are available to analyse the long-run price movements only for paddy, peanuts, mungbean, soybean and garlic but even these are inadequate to fully illustrate trend and cyclical changes. Given this limitation, the results show that there were slight increases in nominal prices for all of these commodities over a period of 10 years or more (Table 3.8). The average annual increase in Chiang Mai, approximated from a linear trend function for 1975-76, for paddy was 102.72 baht per ton (10.27 baht per quintal) or 12.6%. The average annual increase during 1974-76 was 22.08 baht/quintal (10.6%) for peanuts, 25.68 baht (25.68%) for soybean and 30.5 baht (8.16%) for garlic. The average annual increase during 1967-76 in the Bangkok price

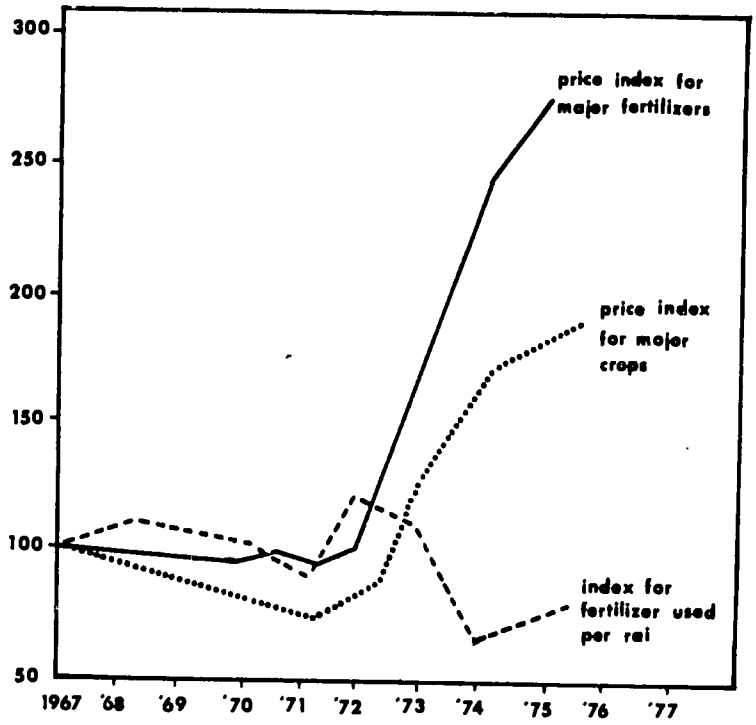


Figure 3.12 Indices for fertilizer use and prices of major crops and fertilizers (Div. of Ag. Econ., Min. of Ag. and Co-op.)

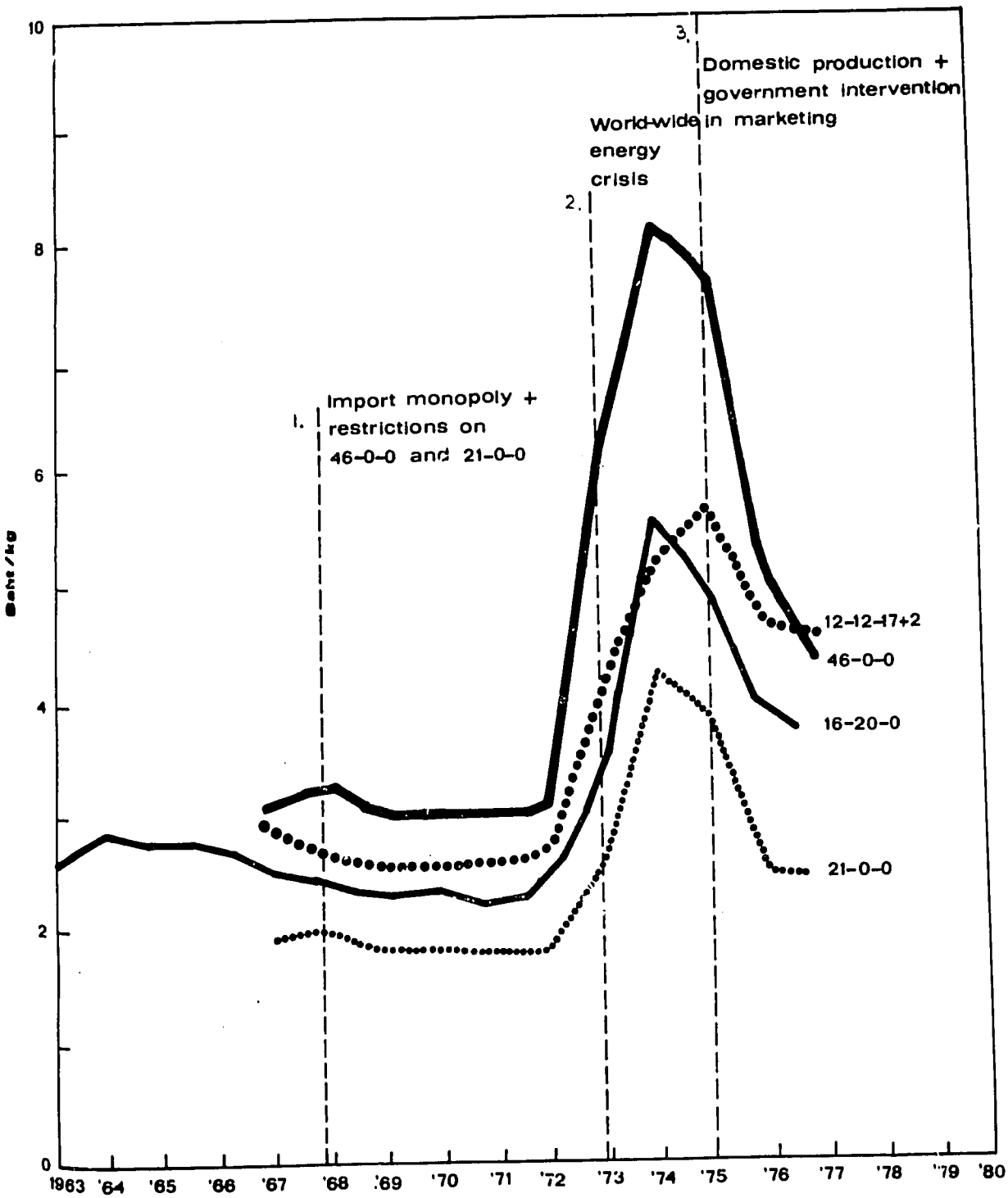


Figure 3.13 Average annual retail prices of fertilizers (Div. of Ag. Econs., Min. of Ag. and Co-op.)

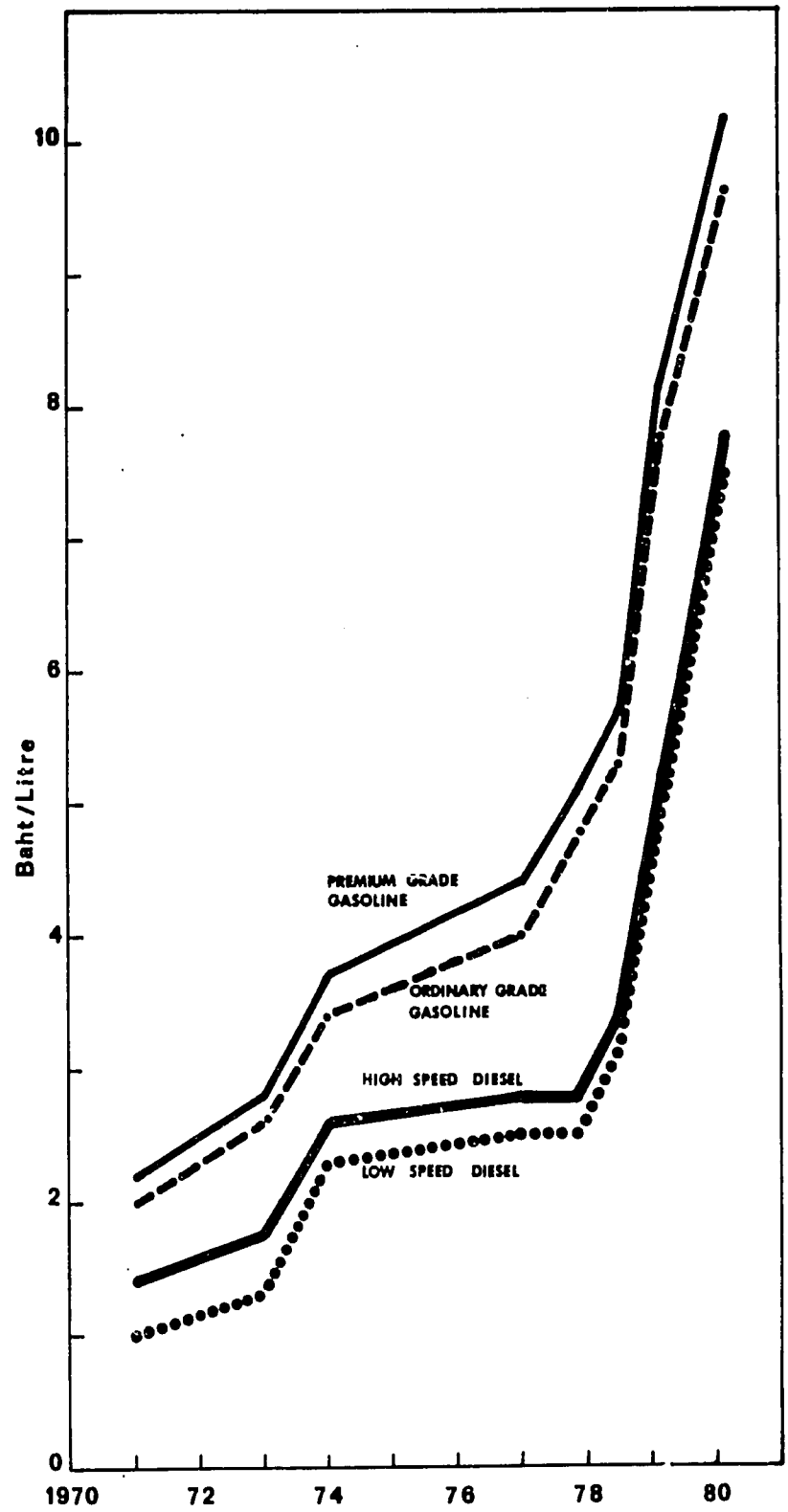


Figure 3.14 Controlled prices of fuel oil in Chiang Mai (Provincial Office for Commerce)

Table 3.7 Utilization of chemical fertilizer in Thai agriculture, 1967-76.

Year	Imported fertilizer (tons)[a/]					Locally manufactured[b/] fertilizer (tons)	Fertilizer[b/] used (tons)	Farm holding[b/] area (rai)	Rate of fertilizer use (kg/rai
	Nitro-gen	Phos-phate	Potas-sium	Others	Total				
1967	57,485	89,303	3,259	67,897	217,944	36,561	252,470	82,963,561	3.04
1968	46,576	134,294	3,858	80,760	265,488	28,867	291,729	85,782,143	3.40
1969	25,781	125,752	2,750	11,346	265,629	20,449	282,775	89,064,859	3.17
1970	11,812	79,991	3,963	153,848	249,614	45,648	290,155	92,833,110	3.13
1971	53,414	53,262	4,781	121,836	233,293	53,289	280,681	98,563,072	2.85
1972	39,250	116,356	6,403	225,313	387,322	43,384	400,527	104,499,403	3.83
1973	37,655	70,224	13,224	272,612	393,715	38,248	381,032	113,094,931	3.37
1974	51,614	36,009	10,920	240,044	338,587	26,315	230,000	114,546,693	2.01
1975	86,068	900	25,980	312,287	425,235	97,000	261,324	116,281,999	2.25

Sources: a/ Division of Agricultural Economics, Agricultural Statistics of Thailand Crop year 1975/76, Agricultural Statistics No. 54, 1976, p. 131 (From January to November).

b/ Division of Agricultural Economics, Agricultural Economic paper, No, 84, 1978.

for mungbean was 10.92 baht per quintal(3.52%).

Table 3.8: Linear trends fitted to monthly nominal prices of selected crops.

Dependent variable	Constant	Trend Coefficient (month)	t	R^2	Time Period	No. of Observations
Paddy Price	788.99	8.56 (0.70)	13.43	0.51	1965-76	120
Peanuts	132.52	1.84 (0.11)	16.69	0.64	1964-76	156
Mungbean	189.10	0.91 (0.09)	12.52	0.40	1967-76	240
Soybean	129.60	2.14 (0.13)	17.05	0.65	1964-76	156
Garlic	564.77	2.54 (1.24)	2.05	0.15	1964-76	156

Note : Figures in the parenthesis are standard errors.

Source : Wipoobongse *et al.*, 1979.

When weighted by the consumer price index for food in order to give trends in the levels of real prices over the period (Table 3.8) the low values of 't' and 'R^2' indicate that no significant trends have taken plac

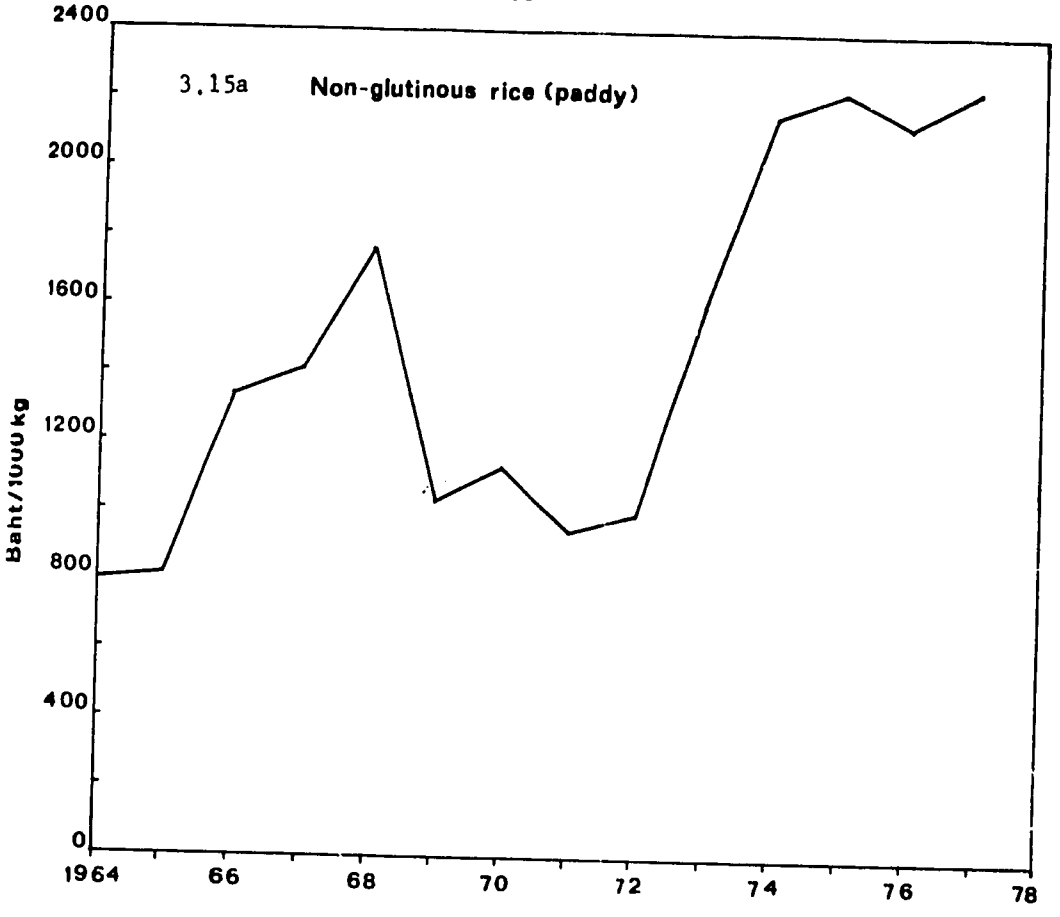
The long term price changes of some crops are illustrated in Figure 3.15. Each crop has a quite distinctive pattern with high irregularity in peanuts and chinese cabbage and greater regularity in soybean and mungbean Garlic and tomato fluctuate widely, but with reasonable seasonal regularit

5. Stress and perturbation

Factors which adversely affect agricultural production may behave in one of two ways. Stress factors typically act with low to moderate intensity and act either continuously or with frequent regularity. Examples of stress factors include:

1) low pH, nutrient deficiencies and toxicities

2) regular, predictable flooding



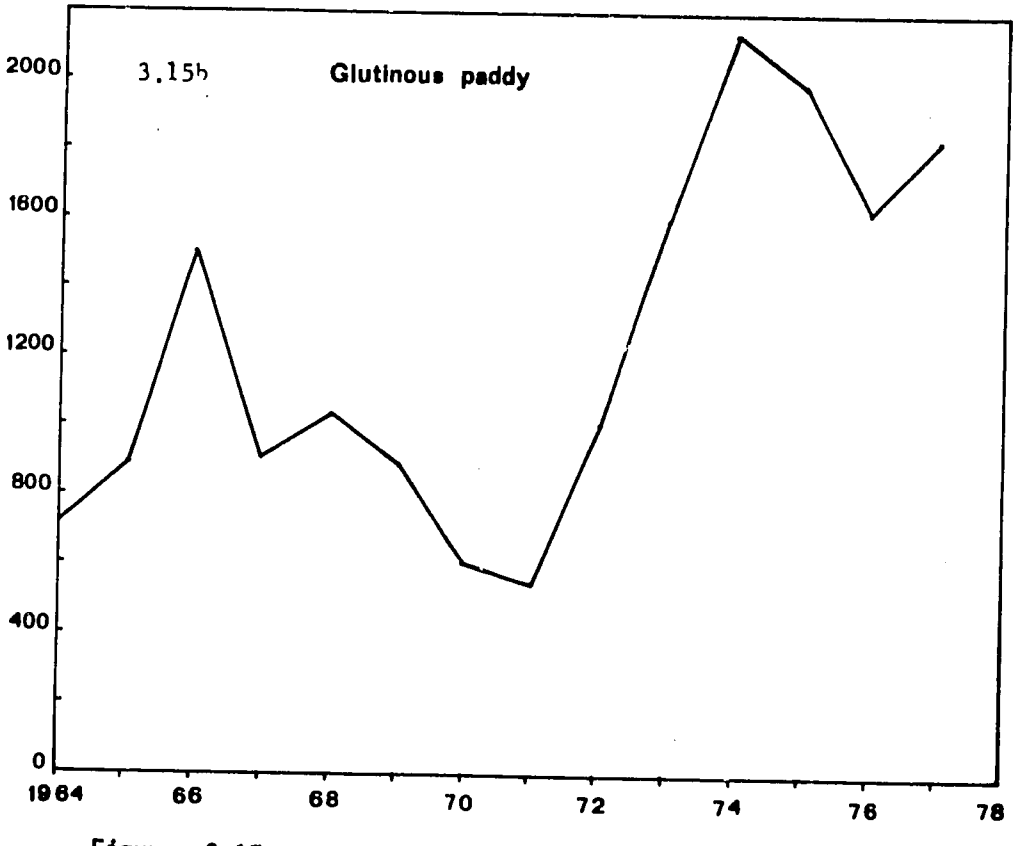
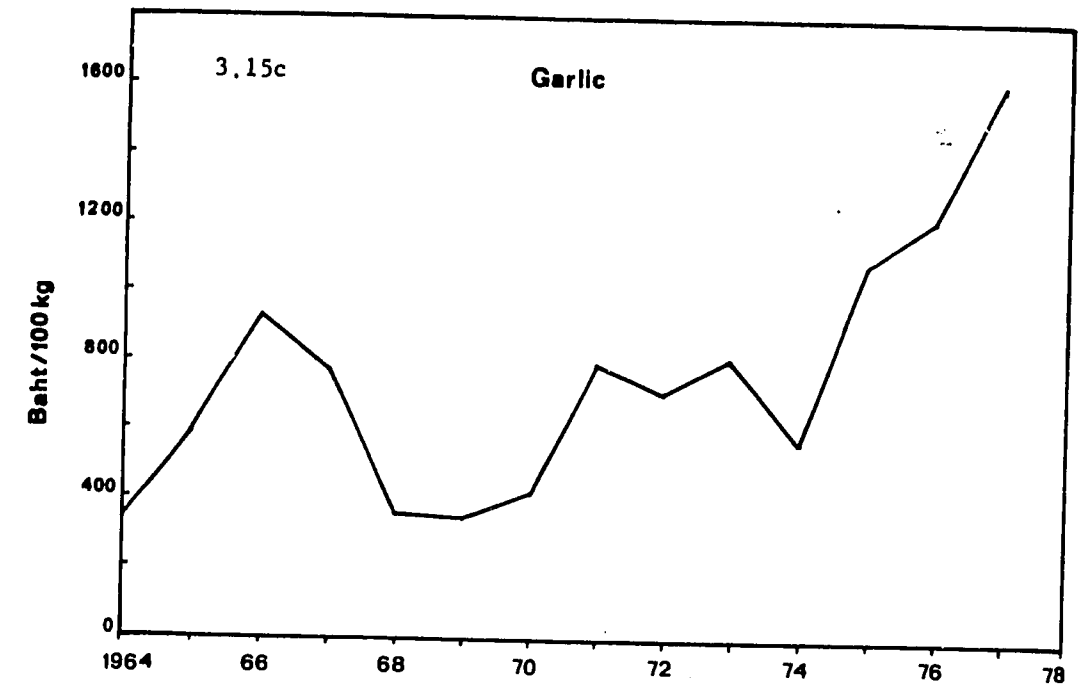
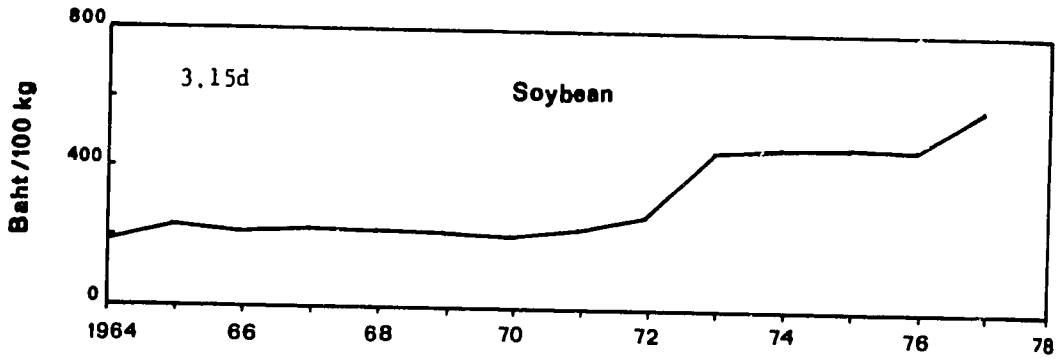


Figure 3.15 Longterm price movement of selected crops





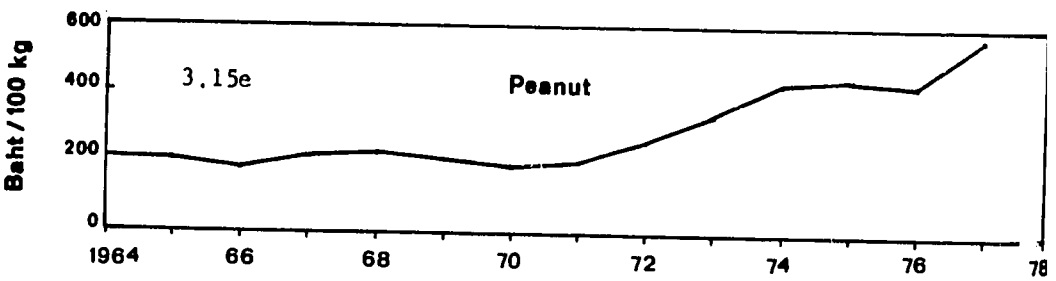
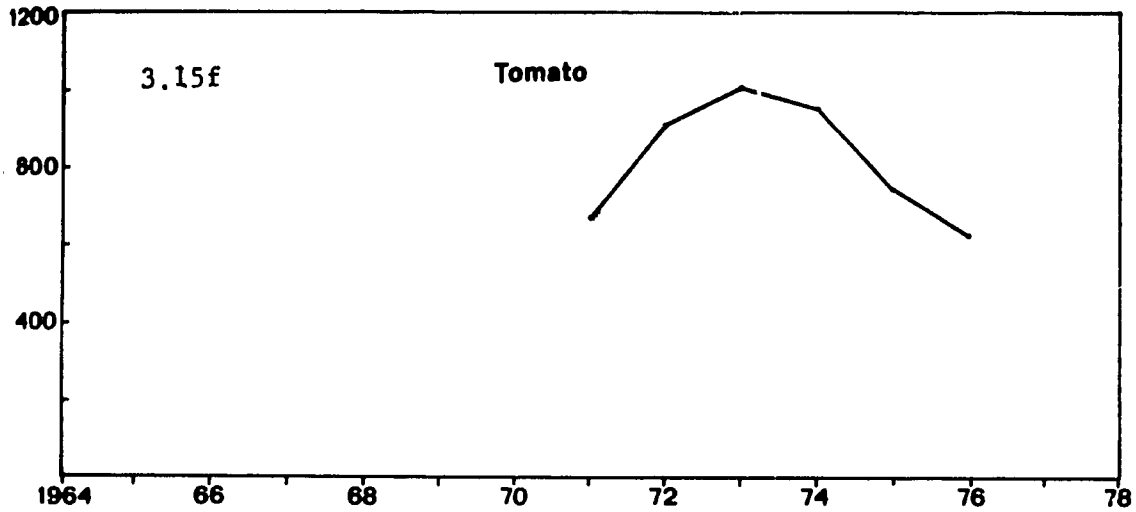
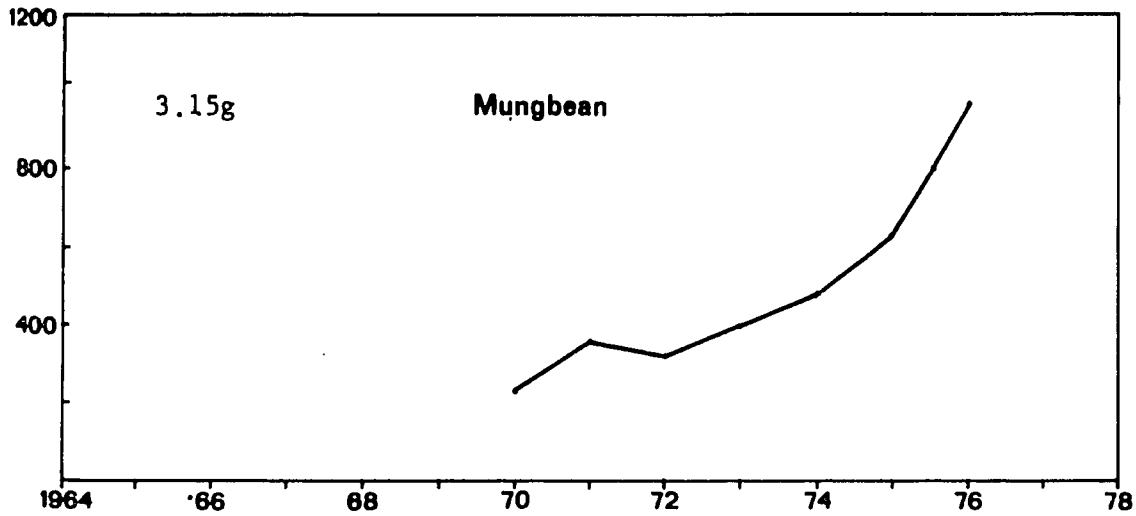
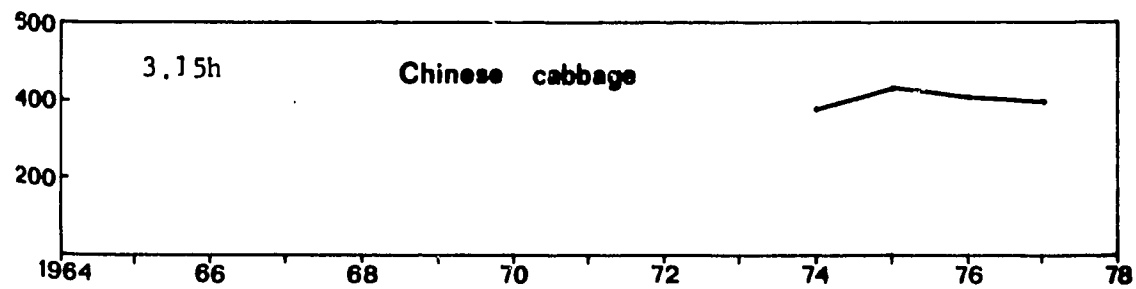


Figure 3.15 (cont.)







gure 3.15 (cont.)

3) uneven water supply from irrigation canals

4) variable seasonal market price fluctuations for certain crops

5) annual, expected pest disease and weed damage in a crop.

By contrast a perturbation factor is one which operates with high intensity or considerable force and occurs infrequently or largely unpredictably. Examples include the following examples:

1) major unpredictable flooding

2) major, unpredictable drought

3) major, infrequent pest and disease outbreaks

4) sudden dramatic price changes e.g. in oil price

5) serious illness of a farmer or his family

Stress is a common, accepted fact of agricultural life and farmers evolve ways of coping with stress factors. For example, in Amphur San Patong along the banks of the Ping river a double rice cropping system has been developed which fits between the flood periods (see Figure 3.2). By contrast major perturbations are usually so infrequent or so unpredictable that the farmers have only partially adapted to them or have no defense at all. The consequence of a major perturbation is thus often a major disaster for the farmer in terms of crop loss. Table 3.9 shows the percentage of wet season rice lost as a result of such major perturbations.

Table 3.9: Proportion of rainy season crop (rice) lost due to flood, droughts and insect outbreaks* in the RID projects (Sektheera and Thodey, 1975).

Year	Total area planted (rai)	Area lost (rai)	Percentage	Cause
1963	170,460	4,534	2.66	Flood
1964	170,460	0	0	-
1965	170,460	1,962	1.15	Flood
1966	241,450	541	0.22	Insect
1967	314,376	21,360	6.79	Floods
1968	309,351	850	0.27	Drought
1969	305,925	12,139	3.97	Floods + Insects
1970	298,917	10,212	3.42	Floods
1971	306,339	3,505	1.14	Floods
1972	303,504	0	0	-
1973	308,742	38,140	12.35	Floods

* The damage due to insects is probably attributable to climbing cutworm

Seasonal Stress

The seasons in the Valley are very sharply defined and crop yields are thus often highly sensitive to date of planting. The yield of rice, both traditional and new improved Rice Department varieties, decreases sharply when planted after mid-August (Rerkasem, unpublished data). It is suspected that low night temperatures during reproductive development and flowering may be responsible for these yield reductions. Garlic also yields poorly when planted late in the cool season (MCP, 1976) but here preliminary studies indicate that increasing evapotranspiration may be as important as the rising temperatures in reducing yields. Extensive studies have also been made on the effects of planting date on the yield of sunflower and peanuts; the former is much more sensitive to planting date than the latter (Figure 3.16).

Climatic fluctuations at the beginning and end of each season also often contribute to reductions in crop yield in the Valley. Since the water used for irrigation has to be replenished each year by the actual rainfall, virtually the entire Valley is affected by a late start to the wet season. At this stage the rice crop is still in the nursery. When the season finally breaks, about the time of transplanting, there is often then too much water. Farmers have learnt to cope with this by transplanting rather old seedlings, up to 35-40 days old. This becomes an important constraint to the adoption of new, improved semi-dwarf rice varieties which are recommended for transplanting at 20 days.

Irrigation systems in the Valley currently operate with no storage reservoir and the pressure for increasing cropping intensity causes farmers to grow more crops in the dry season than there is water for irrigation (see Table 2.4). Water stress thus becomes acute even before the end of the cool season in some areas. For the warm season many farmers insist on growing another crop of rice, which adds to the strain on water supply. Water disputes increasingly constitute a serious social problem in the Valley, more especially in the RID systems.

Soil Stress

As indicated earlier (see Table 2.1) the major soils of the area, the Hang Dong and Lampang series, are old tropical soils. They are low in organic matter and in stable aggregate content and are thus very hard when dry. They have moderately-good to poor internal drainage and fair to good water infiltration. They are low in macro and micronutrients.

Multiple cropping in the past has been on the recent river alluvials which are better structured and more fertile, partly as a result of rainy season flooding and partly from the addition of animal manure. However on the Hang Dong and Lampang soils good yields depend on frequent fertilization. Experiments at the MCP plots and in farmers' fields suggest applications of 50-150 kg/ha of nitrogen as optimal for non-legume crops (Table 3.10). However only cabbage and soybean responded to phosphorus and only

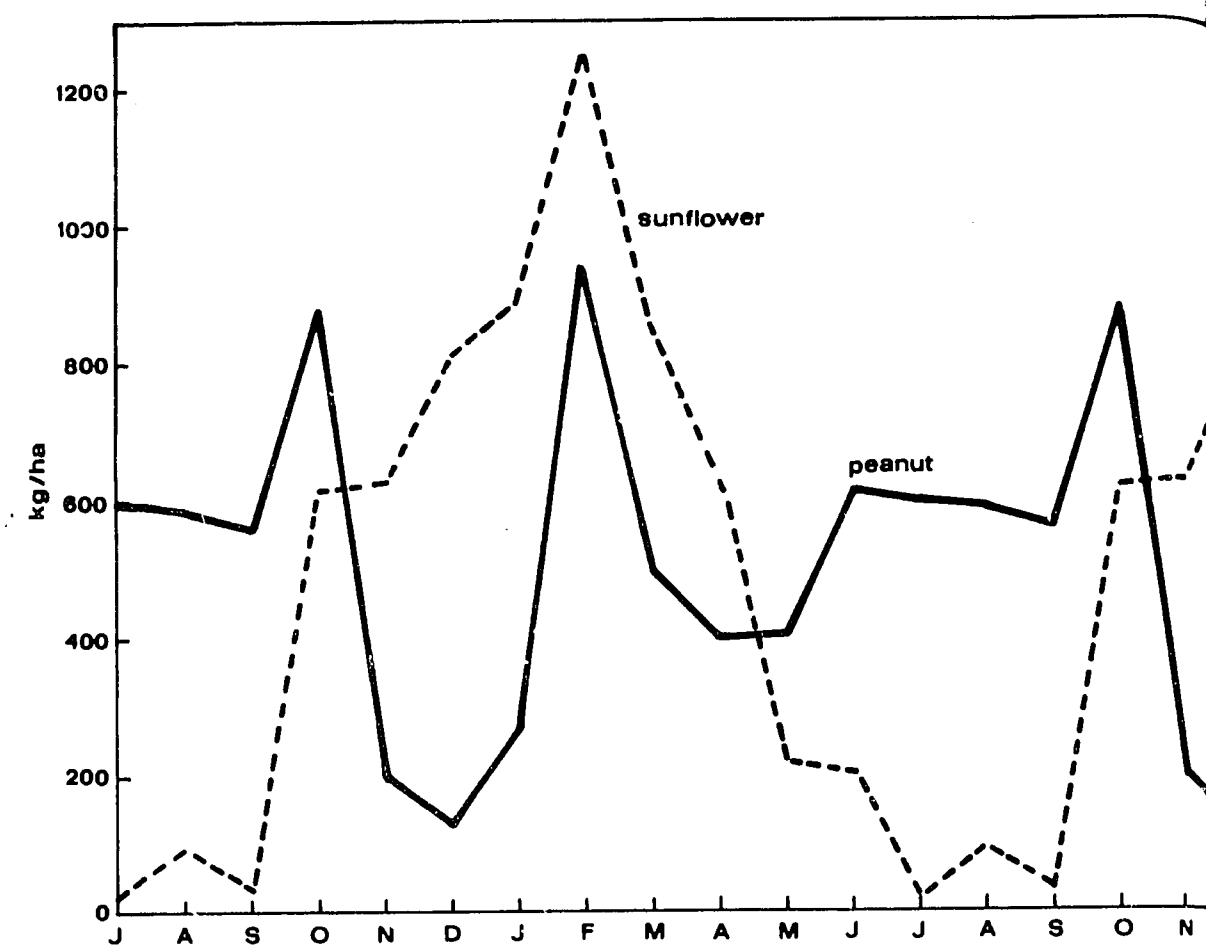


Figure 3.16 Effects of planting date on grain yield of sunflower and peanut

the latter to potassium (Table 3.10). Micronutrient studies show responses of peanuts to boron, copper and calcium but not to other micronutrients (Table 3.11).

Table 3.10: Optimal fertilizer levels obtained by experiments on farmers' fields and at MCP experimental plots (San Sai Soil).

Crop	Soil type	Fertilizer kg/ha			Reference
		N	P	K	
Rice RD1	Hang Dong	120	0	0	Sanmaneechai, 1974 Boonduang, 1974
	San Sai	120		0	Senthong, 1974
Corn	San Sai	50	0	0	Wivutvongvana, 1974a
Cabbage	San Sai	60	60	0	
Garlic	San Sai	150			Wivutvongvana, 1974b
	San Sai	120			Wivutvongvana *et al*, 1975
Soybean SJ 2	San Sai	20	120	30	Nalampang, 1974
Sesame	San Sai	30-60			Julsrigival, 1975

Table 3.11: Optimal levels of micronutrient application obtained at the MCP experimental plots (San Sai Soil Series).

Crop	Grams/ha						Reference
	Boron	Copper	Manganese	Calcium	Zinc	Sulphur	
Peanuts (Chiang Mai Red)	300	300	0	10,000	0	0	Hobbs, 1974

In the Ban Pa Mark study (Thodey *et al.*, 1974) it was shown that most farmers use some form of fertilizer on their crops. Animal manure is most commonly used on wet season rice, soybean and peanut and chemical fertilizer on dry season rice and garlic (Thodey *et al.*, 1974). Recent experiment in farmers' fields, however, suggest no, or only localised, responses to nitrogen up to 50 kg/ha for glutinous rice.

On the MCP experimental plots, which have been subject to continuous cultivation for nearly ten years, severe soil acidity has developed, the pH dropping from 6.5 to less than 4 within 3 years. Plant analysis has also shown more than 2,000 ppm manganese in peanut and mungbean leaves. However, since 1971, yearly liming to lime requirement, although bringing pH back to normal levels, does not appear to have solved the problem. From the peak of up to 7 ton/ha of paddy in 1971 the rice yield has been decreasing to around 4 ton/ha in 1977-1978 (Figure 3.17). Other crops have also suffered badly. Wheat, mungbean and soybean now seldom yield more than 1 ton/ha and French bean has failed completely in the past 2 years. Previously these crops had shown considerable potential. It is suspected that the problem is a very complex one, the decline in soil stability being related to the increased cropping intensity under high input "improved" management.

The main factors appear to be:

1. Depletion of nutrient elements at unprecedented rates due to large harvests in the first few years.

2. Heavy use of ammonium fertilizer, inevitable in rice production, which causes loss of calcium and a lowering of soil pH.

3. In the acid soil the inhibition of the reversion of potentially toxic divalent manganese ions to insoluble tetravalent manganese.

4. Other nutritional imbalances caused by liming.

Alarmingly the problem is now beginning to appear in farmers' fields in the Valley. Farmers are complaining that their soils are becoming "lifeless" and "need to be limed". Plant symptoms similar to those observed in the MCP station can be seen on peanut and mungbean crops throughout the Valley. In some areas farmers have stopped growing mungbean as a third crop because the yield has become too low. Of the many crops observed at the MCP, mungbean appeared to be the one most sensitive to this particular soil problem.

Recent experiments at the MCP have shed light on some aspects of soil chemistry in our particular environment. We have found for example that in some cropping systems soil pH can fluctuate over 2 pH units in one year (Figure 3.18). A drop of one pH unit is associated with a crop of paddy rice, completely independent of nitrogen fertilizer used (Figure 3.19). For upland crops, a further decline in soil pH appears to be related to the use of ammonium fertilizer (Figures 3.18 and 3.19).

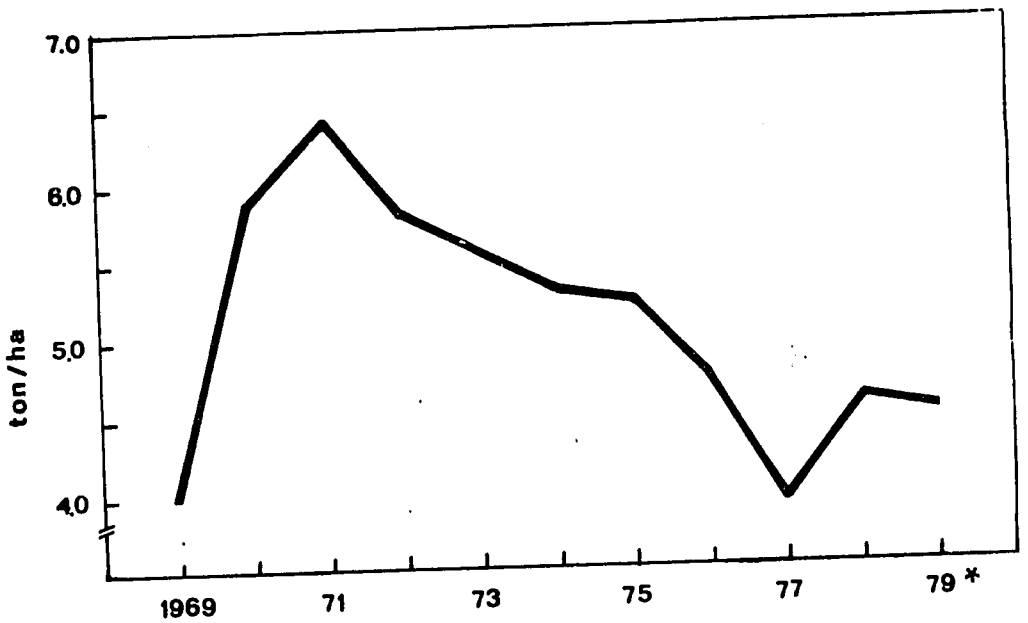


Figure 3.17 A declining trend in rice yield under high inputs and intensive cropping (3 crop/year) at MCP experiment station. Means of 16 half rai plots, * mean of 4 plots

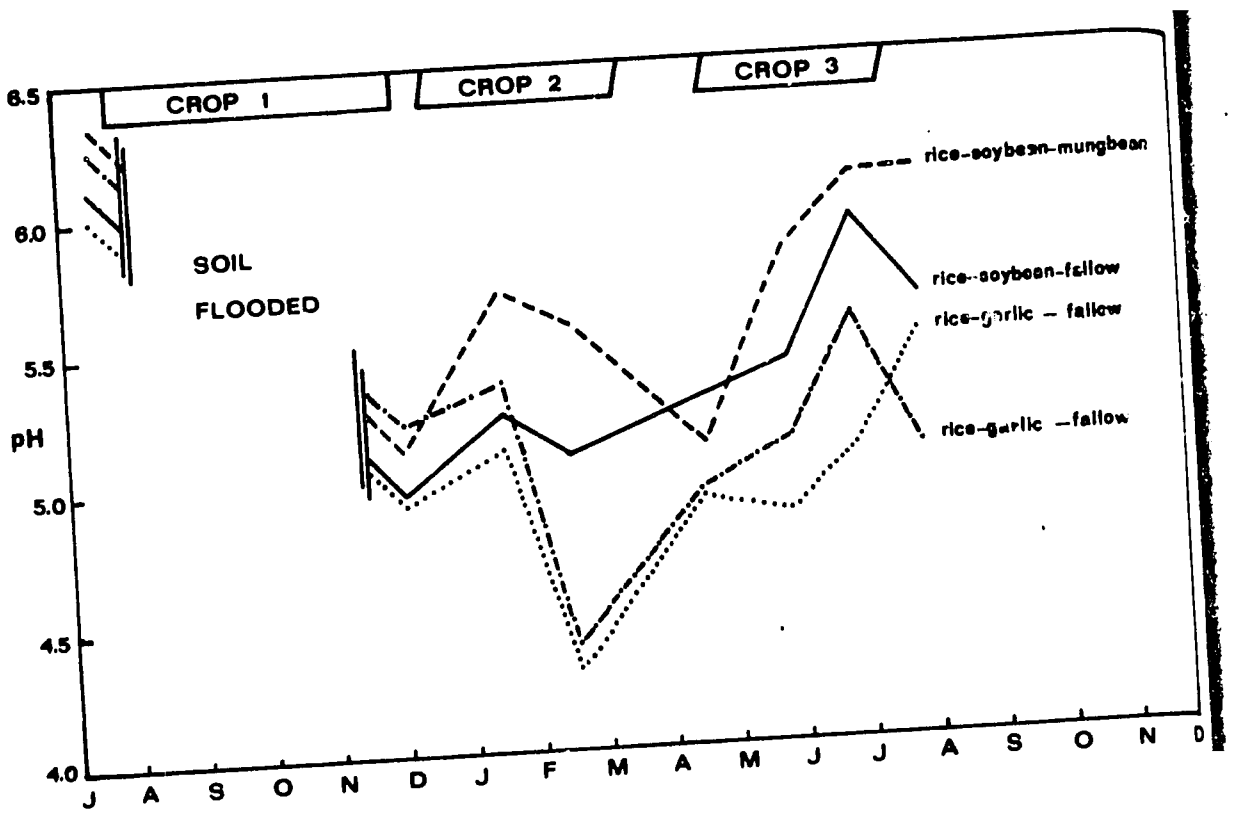


Figure 3.18 Fluctuation in soil acidity under four cropping systems pH measured in 0.01 M $CaCL_2$ (1/5; w/v) (Penchan and Rerkasem, Unpubl. data)

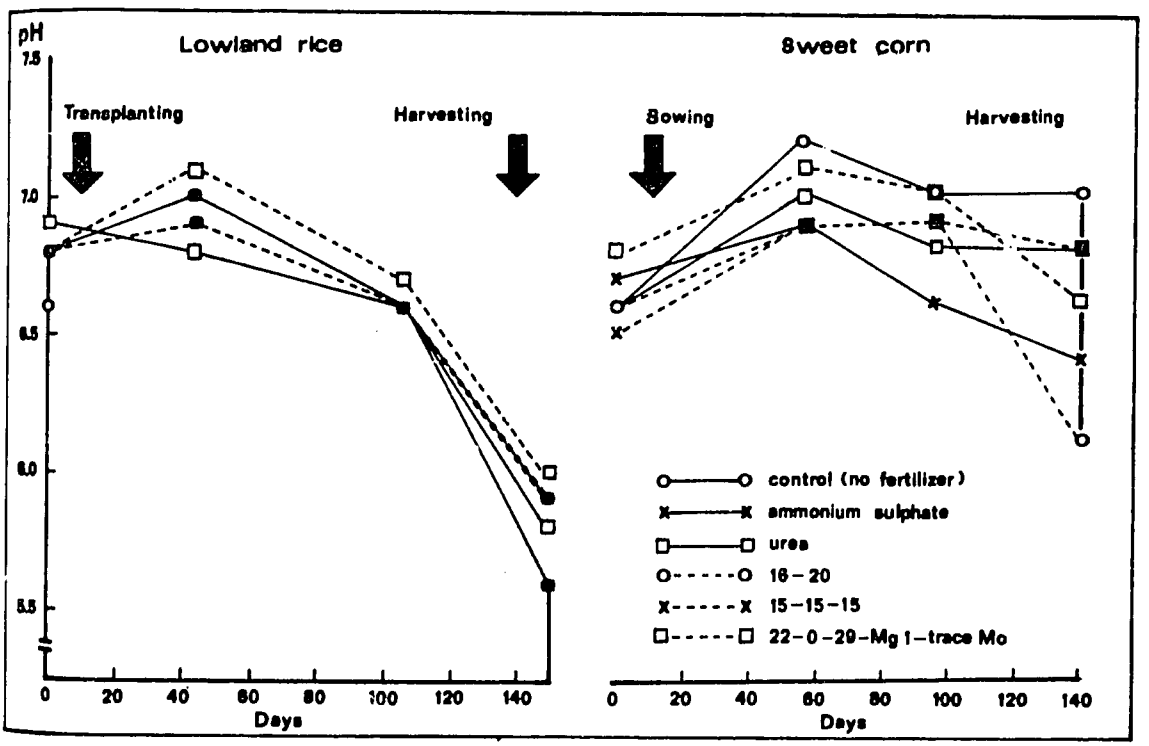
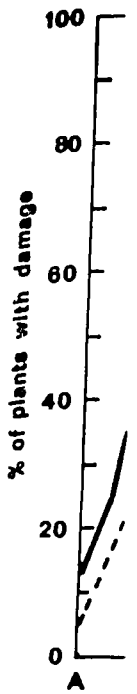


Figure 3.19 Fluctuations in soil acidity under rice (flooded) and corn (upland) with various chemical fertilizers. pH measured in paddy water (1/5; w/v) (Lerssupavithnapa and Rerkasem, Unpubl. data)

Pests, diseases and weeds.

Although there is no precise estimation of loss in crop production due to insects, diseases and weeds in the Chiang Mai Valley, information from various sources is compiled in Table 3.12 to give approximate estimates of damage. The degree of damage due to pests and diseases generally ranges from 10-30% but occasionally there are outbreaks of insects which cause a total loss in yield (for example the outbreak of thrips(*Thrips oryzae*) in both wet and dry season rice. (Table 3.12).



One study has been made of the seasonal fluctuations in an insect population. In soybean, the bean fly (*Melanagromyza soja*) can reduce yield by as much as 85% (Table 3.12) and Visithpanitch (unpublished data) has shown the coincidence between the numbers of bean flies and damage to soybean (Figure 3.20). In general, bean flies are more numberous in the seasons most favoured for soybean planting.

There have also been attempts to screen varieties for resistance to insect pests. Titayawan (unpublished data) grew 15 cultivars of sweet potato (*Ipomoea batatas*) in a field infested by weevil (*Cylas farmiearius*). The degree of damage ranged from 6.6 to 44.6% with Mae Jo being the most resistant cultivar in this experiment. Among the introduced cultivars, AVRDC 035-2 and Tainung 57-1 showed a high degree of resistance to weevil (about 10% damage).

A number of storage pests are frequently found in the Valley. The major pests of paddy are the Angoumois grain moth (*Sitotroga cerealella*) and the lesser grain borers (*Rhizopertha doiminacae*) (Table 3.12). The Southern cowpea weevil appears to be the only significant storage pest of grain legumes. Although there are no data on losses due to storage pests in the Valley, Aritachat (pers. com.) estimates losses as high as 10-20% in paddy stored over a 1 year period i.e. subsistence requirement and seed requirement. Almost total loss of stored-mungbean was reported in the Village of Ban Han Kao when farmers adopted the rice-garlic-mungbean cropping pattern (Gypmantasiri, pers. com.).

Apart from the above no basic information on the insects and diseases in the Valley, e.g. their life cycle, host-parasite relations, etc., exist and hence no basic strategy of pest and disease control, particularly in terms of cropping systems has been developed. The currently recommended control measures, largely chemical, for particular insects or disease are given in Table 3.12.

There have also been relatively few studies of weeds in the Chiang Mai Valley (Table 3.12); however, farmers have recognised significant yield loss due to weeds especially in rice, peanut and tobacco crops. The current control measures comprise hand weeding, mainly by hoeing in the case of upland crops and burying the weeds into the mud under lowland paddy. Sen Thom (1973) showed that grain yield of transplanted rice could be increased significantly even if hand weeding occurred only once at 35 days from transplanting (Figure 3.21). The results also show that the effect of weed com-

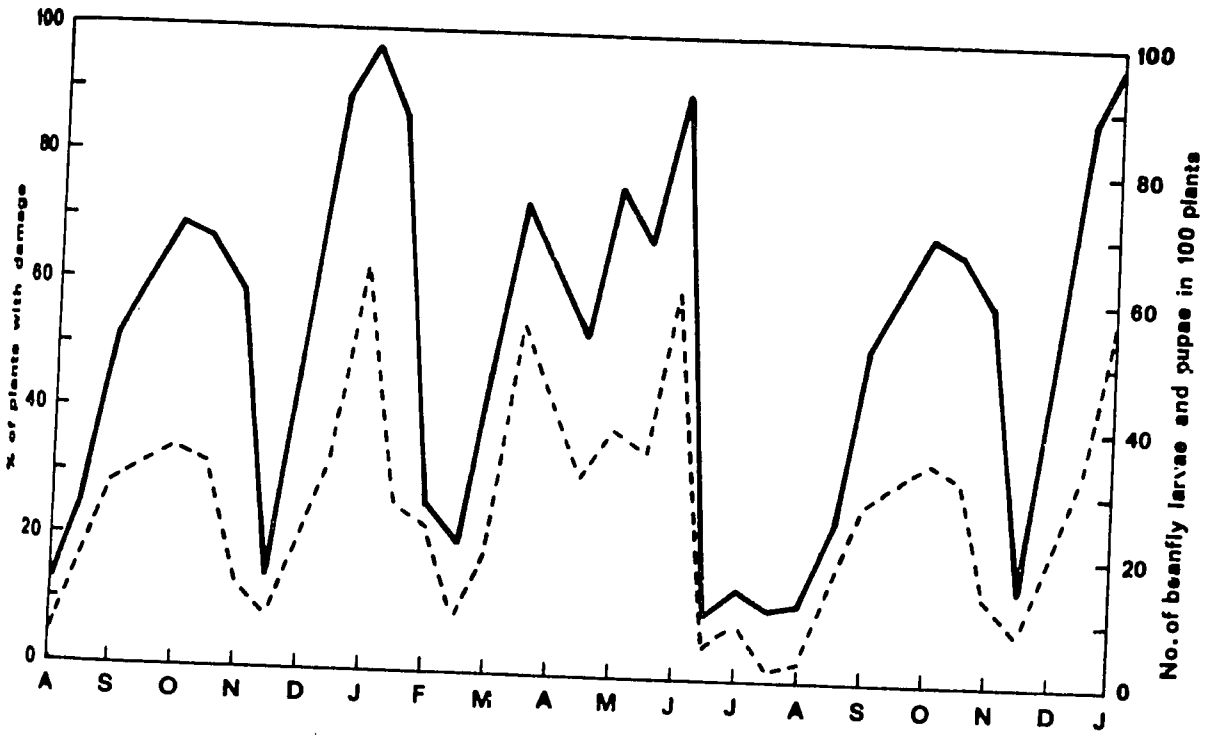


Figure 3.20 A profile of infestation (-------) and damage (———) by beanfly on 4 weeks old soybean recorded at MCP research station in 1978-1979 (Visithpanich, Unpubl. data)

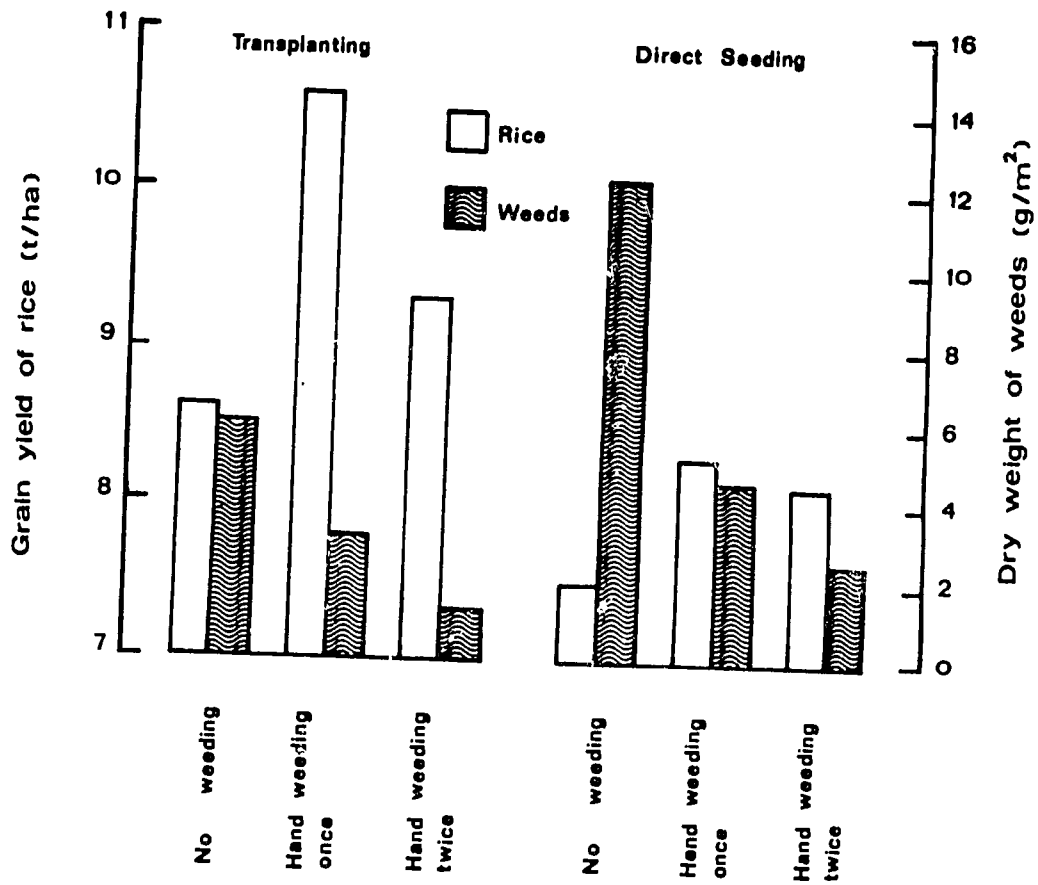


Figure 3.21 Effects of weed control measures on direct seeded an transplanted RD1 rice (Senthong 1973)

Table 3.12 Percent damage of crops due to pest, diseases and weeds and their control recommendations.

Crop		Agent	Damage %	Control recommendation
Rice (Wet season)	Pest	A. Insect		
		1. Stem borer: *Tryporyza incertulas*	10-25	Furadan 3 G
		2. Green leafhopper: *Nephotetti spp.*	20-50	Carbaryl
		3. Rice thrips: *Thrips oryzae*	Na	Carbaryl Malathion
		4. White back Planthopper: *Sogatella furcifera*	Na	Carbaryl
		5. Rice bug: *Leptocorisa acuta*	25-50	Carbaryl, Malathion
		6. Rice gall midge: *Pachydiplosis oryzae*	15-100	Furadan 3 G
		7. Angoumois grain moth: *Sitotroga cerealella*	10-20	Drying seeds before storing
		8. Lesser grain borer: *Rhizopertha dominica*		
		B. Bird		
		1. Sharp-tailed munia: *Lonchura striata*	Na	Mechanical
		2. Spotted munia: *Lonchura punctulata*	Na	Mechanical
		C. Rat		
		1. Root rat: *Rattus argentiventer*	5-10	Poison bait
		2. Black rat: *Rattus losea exiguus*	5-10	Poison bait
		D. Crab		
		1. *Somaniathelphusa sinensis dugasti*	50	Sumithion and cultural practice
	Disease			
		1. Leaf blight: *Xanthomonas oryzae*	Na	Resistant variety Low nitrogen app.
		2. Smut: *Ustilaginoidea virens*	20-30	Resistant variety
		3. Elongation disease: *Gibberella fujikuroi*	13-31	Seed treatment

Table 3.12 ... (cont'd)

Crop		Agent	Damage %	Control recommendation
Rice ... (cont'd)	Weed	1. Tian Na: *Jussiaea linifolia*	Na	Hand weeding
		2. Umbrella sedge: *Cyperus iria*	Na	Hand weeding
Rice (Dry season)	Pest	A. Insect		
		1. Stem borer: *Tryporyza incertulas*	10-25	Furadan 3 G
		2. Green leafhopper: *Nephotettix* spp.	20	Carbaryl
		3. Rice thrips: *Thrips oryzae*	Na	Malathion
		4. Rice bug: *Leptocorisa acuta*	25-50	Malathion
		5. Green bug: *Nezara viridula*	Na	Malathion
		B. Bird		
		1. Sharp-tailed munia: *Lonchura striata*	Na	Mechanical
		2. Spotted munia: *Lonchura punctulata*	Na	Mechanical
		C. Rat		
		1. Root rat: *Rattus argentiventer*	Over 10	Poison bait
		2. Black rat: *Rattus losea exiguus*	over 10	Poison bait
	Weed	1. Tian Na: *Jussiaea linifolia*	Na	Hand weeding
		2. Umbrella grass: *Cyperus iria*	Na	Hand weeding
Soybean	Pest	A. Insect		
		1. Bean fly: *Melanagromyza sojae*	85	Furadan 3 G, Dimethoate
		2. Leaf eating caterpilla: *Prodenia litura*	35	Dimethoate
		3. Leaf hopper: *Empoasca* sp.	35	Carbaryl
		4. Aphid: *Aphis glycines*	35	Malathion

Table 3.12

Crop

Soybean .. (cont'd)

Table 3.12 ... (cont'd)

Crop	Agent	Damage %	Control recommendation
Soybean ... (cont'd)	5. Leaf webber: *Cacoecia micaceana*	Na	Dimethoate
	6. Leaf webber: *Lamprosema indica*	Na	Dimethoate
	7. Leaf miner: *Stomopteryx subsecivella*	Na	Furadan 3 G
	8. Pod borer: *Heliothis armigera*	Na	Methomyl, TDM
	9. Southern cowpea weevil: *Callosobruchus chinensis*	Na	Heating or drying seed
	B. Nematode		
	1. Bud and leaf nematode: *Aphelenchus* sp.	20-25	Temik
	2. Ring nematode: *Criconemoidea* sp.	20-25	D-D, EDB, DBCP
	3. Root knot nematode: *Meloidogyne* sp.	50	Methyl bromide, D-D, EDB
Disease	1. Septoria leafspot: *Septoria glycines*	Na	Seed treatment
	2. Bacterial pustule: *Xanthomonas phaseoli var. sojensis*	Na	Seed treatment
	3. Mosaic and yellow mottle: Virus	30-75	Mechanical
	4. Purple blotch: *Cercospora kikuchii*	0.25-19	Seed treatment
	5. Stem rot: *Cephalosporium* sp.	0.25-2	Seed treatment
	6. Seedling blight: *Colletotrichum dematium*	1-12	Seed treatment
	7. Pod & stem blight: *Phomopsis sojae*	0.5-23	Seed treatment
	8. Rust: *Phakospora pachyrhizi*	Na	Seed treatment and spray with plant wax S-dust

Table 3.12 ... (cont'd)

Crop		Agent	Damage %	Control recommendation
Soybean ... (cont'd)	Weed	1. Pig weed: *Amaranthus viridis*	51	Hand weeding
		2. Puk Pet Dang: *Alternanthera sessilis*	10-30	Hand weeding
		3. Goose berry: *Physalis minima*	10-30	Hand weeding
		4. Goat weed: *Ageratum conyzoides*	10-30	Hand weeding
Wheat	Pest	A. Insect		
		1. Black cut worm: *Agrotis ipsilon*	Na	Furadan 3 G
		2. Aphid: *Toxoptera* sp.	Na	Malathion
		3. Wheat stem borer	Na	Furadan 3 G
		B. Bird		
		1. *Lonchura striata*	Na	Mechanical
		2. *L. punctulata*	Na	Mechanical
		C. Rat		
		1. Root rat: *Rattus argentiventer*	Na	Poison bait
		2. Black rat: *R. losea exiguus*	Na	Poison bait
	Disease	1. Leaf spot: *Helminthosporium oryzae*	Na	High rate P & K+ Low N
		2. Root rot: *Sclerotium rolfsii, Rhizoctonia* sp.	20-70	Seed treatment (Captan) Difolatan or Dithame M 45
	Weed	1. Goat weed: *Ageratum conyzoides*	Na	Pre-emergence herbicide + hand weeding
		2. Crow foot weed: *Dactyloctenium aegyptium*	Na	
		3. Puk Bia Hin: *Trianthema portulacastrum*	Na	
Mungbean	Pest	A. Insect		
		1. Bean fly: *Ophiomyia phaseoli (Melanagromyza phaseoli)*	95	Furadan 3 G, Dimethoate

Table 3.12 ... (cont'd)

Crop		Agent	Damage %	Control recommendation
Mungbean ... (cont'd)		2. Bean jassid: *Empoasca* sp.	73	Furadan 3 G, Carbaryl
	Disease	1. Mosaic: Virus	Na	Mechanical
	Weed	1. Crowfoot grass: *Dactyloctenium aegyptium*	Na	Pre-emergence herbicide + hand weeding
		2. Jungle rice: *Echinochloa colonum*		
		3. Crabgrass: *Digitaria adscendens*	Na	Hand weeding
		4. Goosegrass: *Eleusine indica*	Na	Hand weeding
Vegetable	Pest	A. Insect		
		1. Black cut worm: *Agrotis ipsilon*	30	Furadan 3 G
		2. Cabbage flea beetle: *Phyllotreta* sp.	60	Methomyl
		3. Diamond back moth: *Plutella maculipenis*	80	Methomyl, *Bacillus thurigiensis*
		4. Cabbage looper: *Trichoplusia ni*	20	Mevinfos
		5. Cabbage aphid: *Lipaphis erysimi*	Na	Malathion
		6. Cabbage bug: *Eurydema pulchra*	Na	Mevinfos
		7. Cut worm: *Spodoptera litura*	Na	Mevinfos, Methomyl
		8. Bean pod borer: *Maruca testulalis*	Na	Methomyl
		9. Thrips: *Thrips tabaci*	Na	Malathion
		10. Tomato fruit worm: *Heliothis armigera*	Na	Methomyl, TDM
	Disease	1. Soft rot: *Erwinia caratovara*	Na	Crop management
		2. Damping off: *Phytium derbayanum*	Na	Soil sterilization or soil treatment with DENB

Table 3.12 ... (cont'd)

Crop		Agent	Damage %	Control recommendation
Vegetable (cont'd)	Weed	1. Jungle rice: *Echinochloa colonum*	Na	Pre-emergence herbicide + hand weeding
		2. Teen tid: *Brachiaria reptans*	Na	-"-
		3. Ya-dock-kao: *Leptochloa chinensis*	Na	-"-
		4. Crowfoot grass: *Dactyloctenium aegyptium*	Na	-"-
Peanut	Pest	A. Insect		
		1. Fire ant: *Solenopsis geminata*	Na	Chlordane
		2. Oriental ant: *Dorylas orientalis*	Na	Heptachlore
		3. Greasy cut worm: *Agrotis ipsilon*	Na	Furadan 3 G
		4. Ground nut aphid: *Aphis craccivora*	Na	Malathion
		5. Leaf hopper: *Empoasca flavescens*	Na	Carbaryl
		6. Thrips: *Frankliniella* sp.	Na	Carbaryl, Malathion
		7. Leaf webber: *Cacaecia micaceana*	Na	Dimethoate
		8. Ming moth: *Maruca testulalis*	Na	Methomyl
		9. Bristle beetle: *Mylabris* spp.	Na	Methomyl
		B. Rat		
		1. Bandicoot: *Bandicota indica*	Na	Poison bait
		2. Bandicoot: *Bandicota savilei*	Na	Poison bait
	Disease	1. Cercospora leaf spot: *Cercospora arachidicola*	40-65	Benomyl + Manzate D
		2. Rust: *Puccinia arachidis*	40-65	S-dust, plant Wax

Table 3.12 .. (cont'd)

Crop		Agent	Damage %	Control recommendation
Peanut .. (cont'd)	Weed	1. Ya yang: *Euphorbia geniculata*	60-77	Pre-emergence herbicide + hand weeding
		2. Goosegrass: *Eleusine indica*	60-77	- " -
		3. Crab grass: *Digitaria adscendens*	60-77	- " -
		4. Crowfoot grass: *Dactyloctenium aegyptium*	60-77	- " -
Tobacco	Pest	A. Insect		
		1. Black cut owrm: *Agrotis ipsilon*	30	Furadan 3 G
		2. Green peach aphid: *Myzus persicae*	Na	Malathion
		3. Tobacco bud worm: *Heliothis armigera*	Na	Methomyl, TDM
		4. White fly: *Bemisia tabaci*	Na	Carbaryl Furadan 3 G
		B. Nematode		
		1. Root-knot nematode: *Meloidogyne* sp.	>50	Methyl bromide, D-D, EDB
	Disease	1. Frog eye disease: *Cercospora* sp.	Na	Benomyl
		2. Tobacco Mosaic virus	Na	Mechanical
	Weed	1. Crowfoot grass: *Dacteloctenium aegyptium*	Na	Hand weeding
		2. Spiny pigweed: *Amaranthus spinosus*	Na	Hand weeding
		3. Goat weed: *Ageratum conyzoides*	Na	Hand weeding
Garlic	Pest	A. Insect		
		1. Thrips: *Thrips* sp.	Na	Malathion
		B. Mite		
		1. Red spider mite: *Tetranychus* sp.	Na	Dimethoate
	Disease	1. Purple blotch: *Alternaria* sp.	Na	Daconyl, Dithan M 45
	Weed	Na		

petition is more severe in direct seeding than in transplanted rice thus indicating the importance of the relative time of emergence of the crop (rice) and the weed population. For transplanted rice, Na Lampang *et al.* (1974) again confirmed the effects of weeds on grain yield (Table 3.13).

Table 3.13 Effects of cultural weed control on grain yields in rice, CV. RD 1.

	Method of control		
	Un-weeded	Hand weeded, once	Hand weeded, twice
Grain yield (ton/ha)	3.55	6.29	6.58

Source: Na Lampang *et al.*, 1974.

During the dry season, legumes are the major crop in the rice based cropping systems and the effect of competition from weeds here is usually rather serious. An experiment on the effect of duration of weed competition on mungbean (Somkasame, 1979) showed that biomass and seed yield in mungbean were markedly reduced by weed competition in the period 7 days to 49 days after planting (Figure 3.22). After 49 days the duration of weed competition had little effect. These results indicate the early onset of competition from weeds on mungbean, i.e. about one week after emergence. Thus in order to restore mungbean yields, weed control must be conducted as early as possible. Radanachaless (unpublished data) also found that increasing the density of peanuts could improve seed yield by up to 66% (Figure 3.23). The significant effect of increasing peanut density was to reduce the weed weight from nearly 700 kg/ha to 330 kg/ha. In farmers' fields, a plant to plant spacing of peanut varying from 20 to 30 cm is not unusual.

The predominant methods of rice harvesting and transport may themselves constitute a further form of stress. Rice is cut close to the ground by hand and left to dry before being transferred to the threshing area by attaching small bundles of the plants to carrying poles. Threshing is entirely by hand by beating the heads in large threshing baskets. Winnowing is performed by tossing the grain on trays using the breeze or large, hand-operated fans to separate the chaff. Each process is prone to considerable loss and estimates of these are shown in Table 3.14.

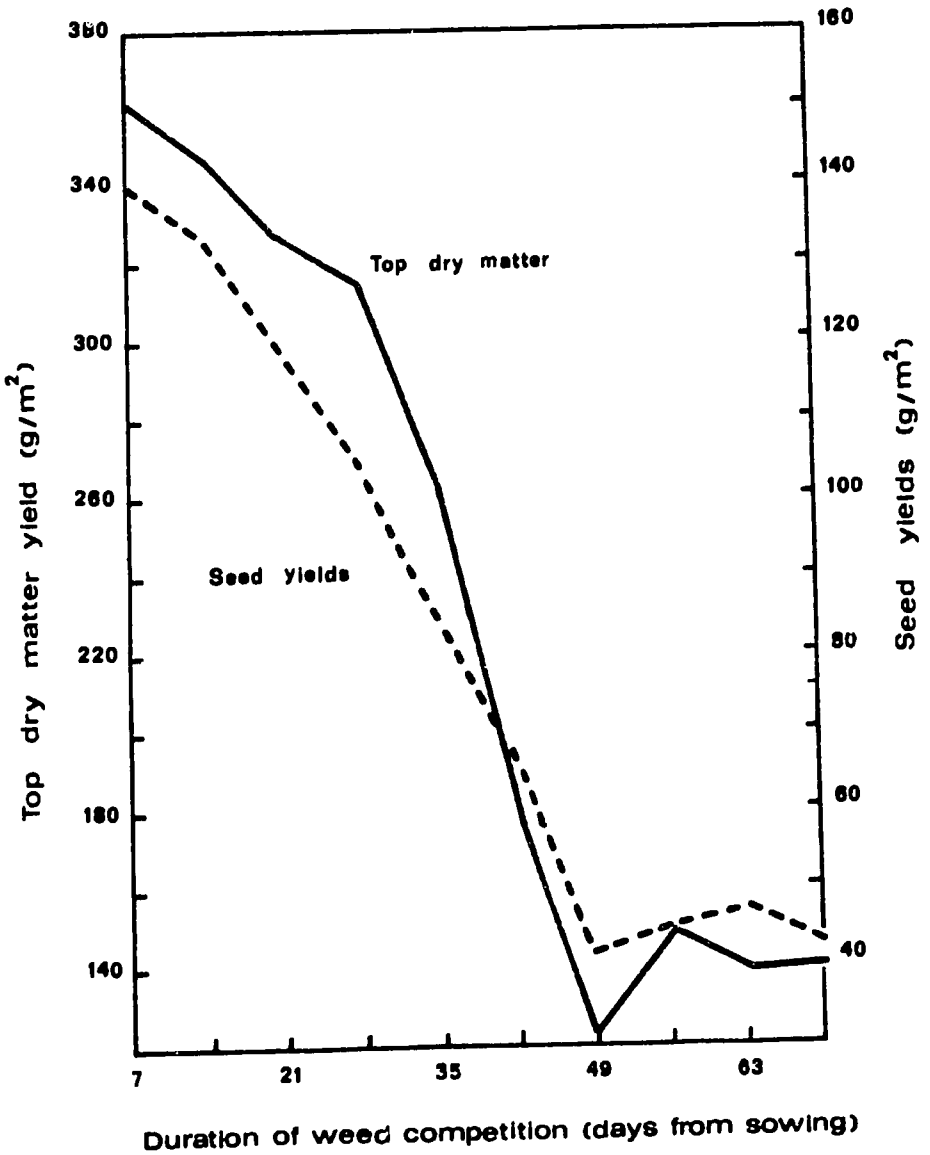


Figure 3.22 Effects of weed infestation on the yield of mungbean, cv. CES 55. For each treatment weeds were removed by hand after a specifice period (days from sowing) and weekly afterwards (Somkasame and Rerkasem, Unpubl. data)

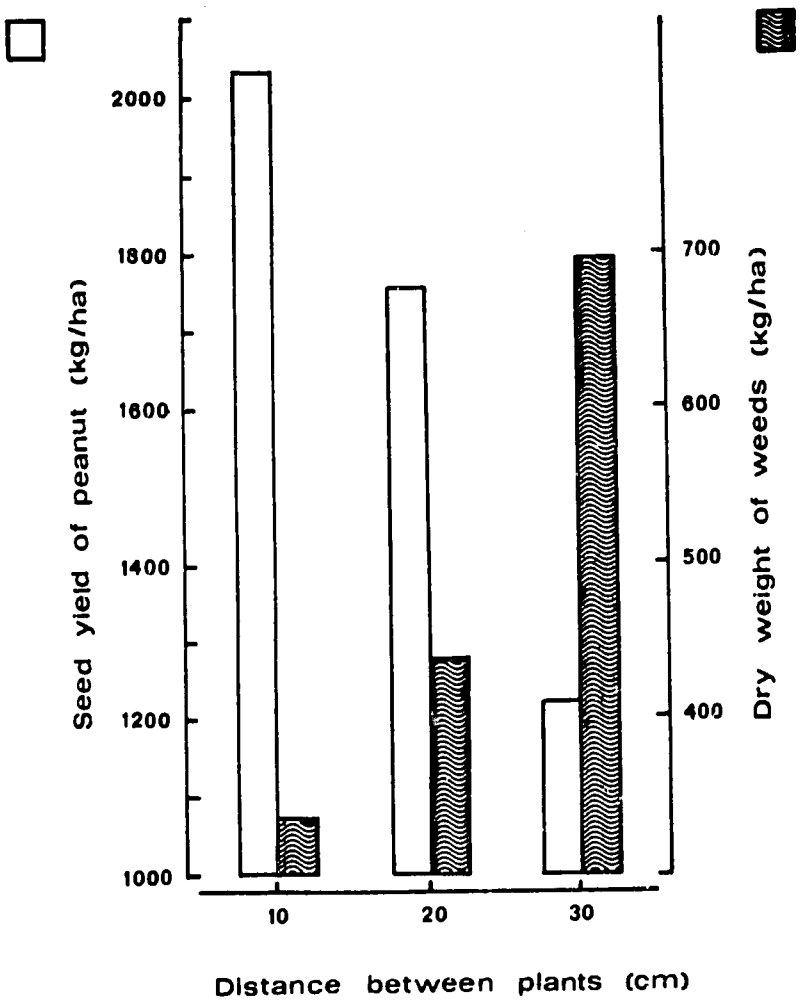


Figure 3.23 Effects of within row spacing on dry weight of weeds a yield of peanut grown on 1.5 m beds at 3 rows/bed (Radanachaless, Unpubl. data)

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Table 3.14 Harvesting losses in paddy.

Place of operation	Operation	loss (%)
Field	Harvesting	5
	Handling and Transport	5
	Threshing	1
	Cleaning	0.5
Mill	Milling	1-2
	Total	13

Source: Department of Agriculture, 1976.

Health and social stress.

(a) Health

The public health service in the Valley has greatly improved in the last 25 years. Data on major illness in the Chiang Mai Valley collected by the Health Department are shown in Table 3.15. Nearly all the major diseases have progressively come under control between 1970 to 1978. A few diseases, such as chicken pox, conjunctivitis and worms had disappeared in the records by 1978. However, a major persistent disease in the Valley is diarrhoea and there is some evidence of an increase in water-related illnesses since 1974 which may be related to the increase in the irrigated area. Malaria, has had a long history of relative seriousness in the Valley (Figure 3.24), but the death rate decreased dramatically following a mosquito control programme based on DDT spraying. A regular programme of spraying by the government has practically eliminated the disease.

Malnutrition is still a serious problem in many areas of the Valley, but the effect of this on agricultural production is unknown.

(b) Social

The Chiang Mai Valley has been settled for more than a thousand years and is steeped in tradition with numerous ceremonies and folk festivals, particularly in the summer months (Figure 3.25). Many farmers still observe the Buddhist temple days, in which there is no work in the fields. These fall on the full moon, half moon and new moon days of the lunar calendar. However, this observance is declining. These

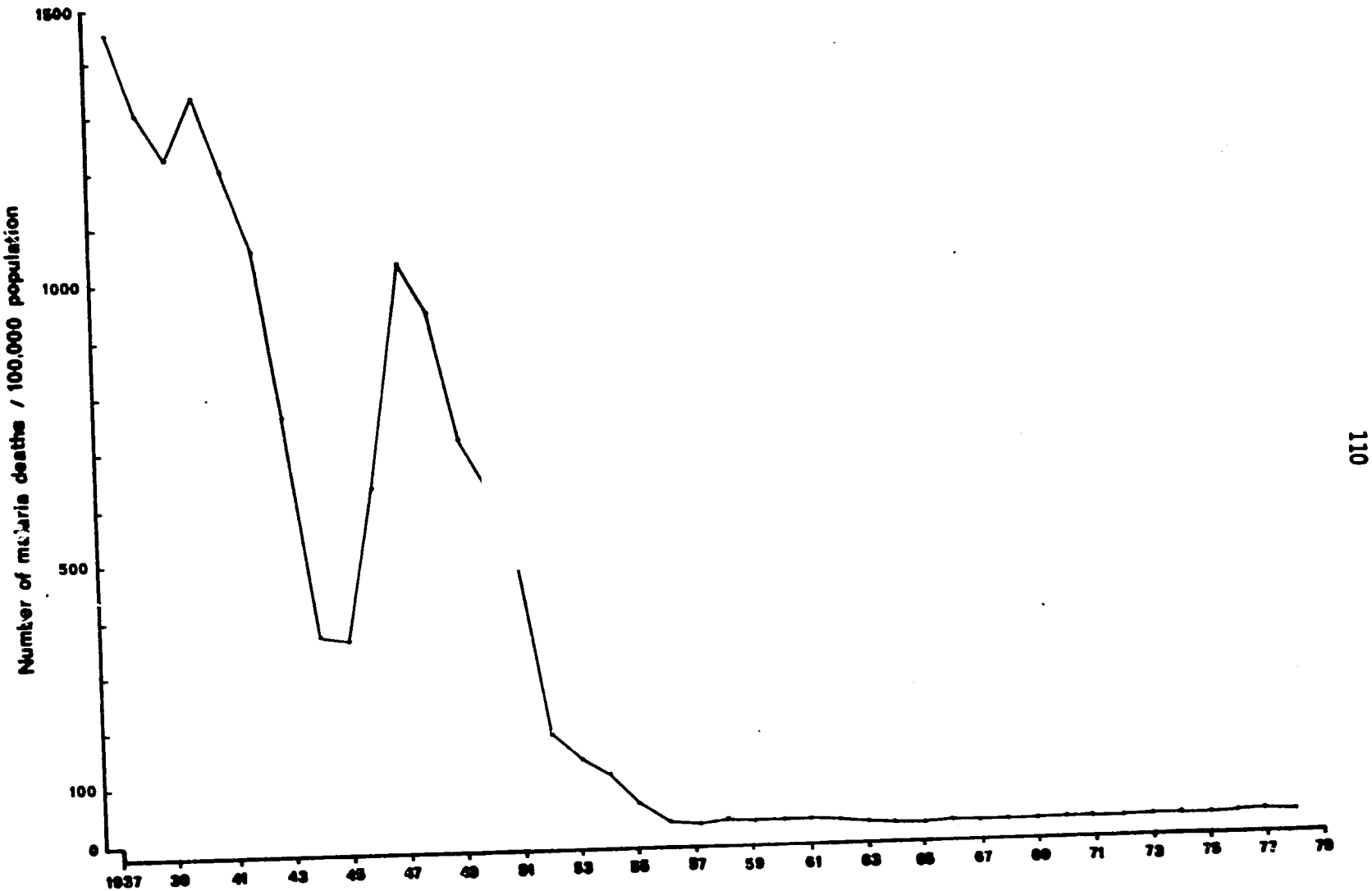

Figure 3.24 The number of deaths per 100,000 persons due to malaria in the Chiang Mai Valley from 1957 to 1978

in the Chiang Mai Valley from 1957 to 1978

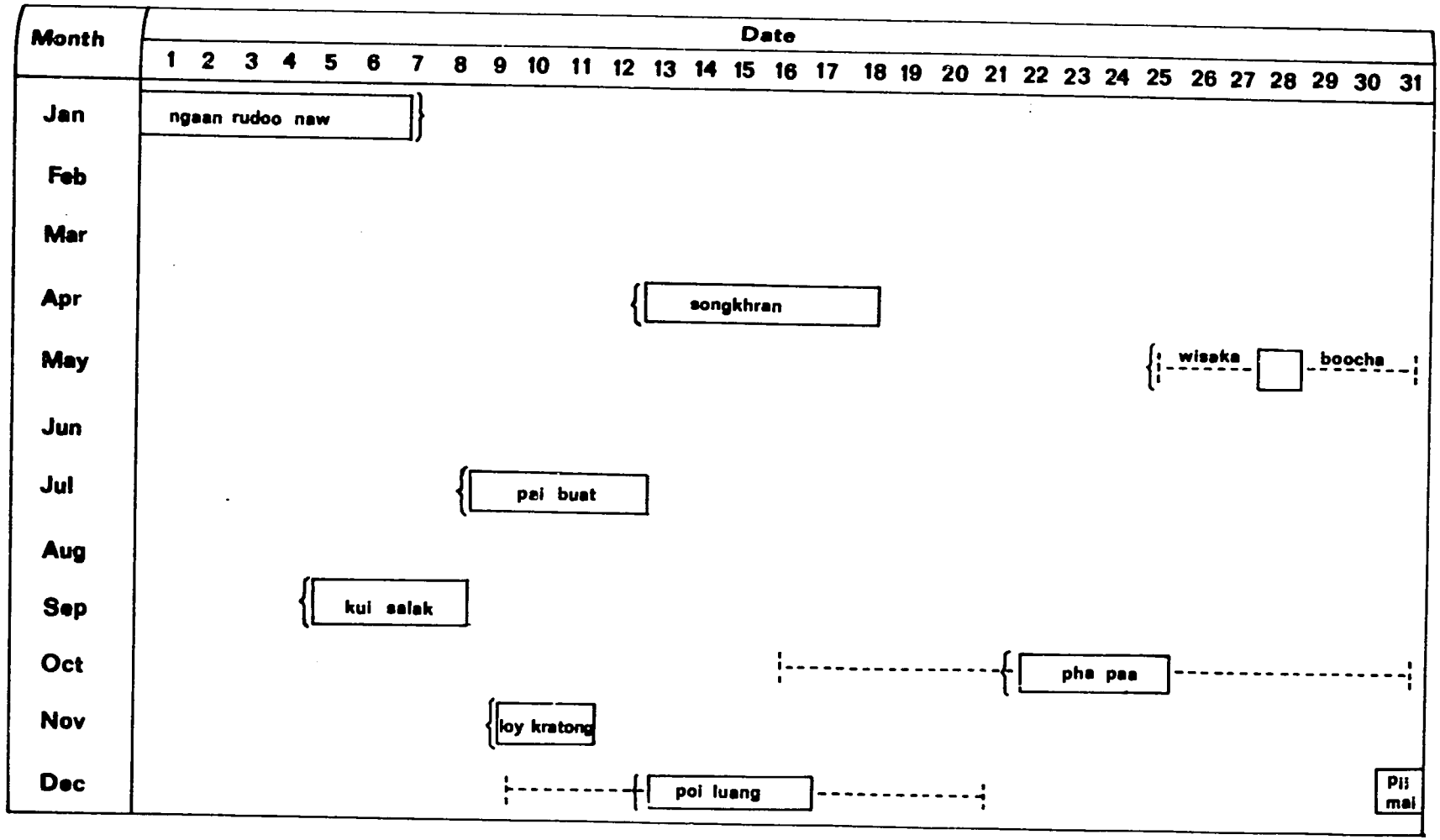

Figure 3.25 A calendar of traditional ceremonies and folk festivals in the Chiang Mai Valley

social activities compete with agricultural activity for time. However, they also provide an incentive for work and the generation of a cash income.

Table 3.15 Changes in human diseases between 1970-78 in the Chiang Mai Valley.

Disease	1970	1971	1972	1973	1974	1975	1976	1977	1978
Influenza	3,800	-	-	-	-	-	1,617	1,617	5
Cholera	-	-	-	-	-	-	-	-	21
Diarrhoea	4,646	-	-	-	1,534	615	821	821	21,34
Dysentery	1,428	-	-	-	52	102	96	96	30
Conjunctivitis	317	-	-	-	1,174	3,546	-	-	-
Worms	1,961	-	-	-	-	-	-	-	-
Encephalitis	146	-	-	-	103	71	55	-	12
Typhoid	-	-	-	-	173	71	106	106	16
Haemorhagic fever	-	-	-	-	74	269	156	156	3
Malaria	-	-	-	-	-	107	61	61	24
Poliomyelitis	-	-	-	-	16	-	13	13	1
Diphtheria	-	-	-	-	29	55	56	56	2
Whooping Cough	-	-	-	-	78	30	5	5	7
Viral hepatitis	-	-	-	-	101	35	105	105	12
Measles	-	-	-	-	-	24	45	25	
Chicken pox	-	-	-	-	-	2	1	1	-
Meningitis	-	-	-	-	-	-	2	2	-
Tuberculosis	-	-	-	-	-	-	-	-	3

Source: Chiang Mai Provincial Hospital.

Perturbation

In general, climatic, biological (pests, diseases and weeds) and economic factors are the major potential perturbing factors that may c a total failure in crop production in multiple cropping systems. Thre

jor climatic perturbations are likely; these are flooding in the wet season ought in the hot season and heavy rains at harvest. Under the present pat- rn of cultivation heavy rains at harvesting time may cause a tremendous ield loss by stimulating the mature seed to germinate, e.g. soybean or anut in the warm season and photo-insensitive rice or mungbean in the hot ason. Farmers harvest their crops and pile them up in the field before reshing. Heavy rains at this time may result in seed germination, because st crop varieties used in the warm or hot seasons have very short or no rmancy periods, e.g. soybean: SJ 2; rice: RD 1 and RD 7 and peanuts.

Farmers usually claim severe crop losses due to major floods and ought, but there have been no detailed records of the effects of these rturbations in the Valley. Flooding recurs regularly along the Ping river, rticularly in Saraphi and San Patong districts, and in many parts of aphum province. Traditional rice cultivars, e.g. Gam Pai and Mae Jo, are ing used in the flooded area since farmers recognise that these cultivars lerate flooding. In practice, 50-60 day old seedlings of Gam Pai or Mae are transplanted requiring double transplanting. When seedlings in the mal nursery bed are about 20 days old, they are transplanted at a very se spacing, i.e. 10 x 10 cm and 4-5 plants per hill. Seedlings are then ft to grow for about 30 days before final transplanting in the field. It uld be noted that the rice cultivars used for this purpose are relatively g maturing; i.e. 150 days or more from transplanting to maturity.

Drought may be experienced in the traditional irrigation systems. In aphi District where irrigation supply is solely dependent upon a tradi- nal irrigation system (the Tha Sala project - one of the biggest projects the Valley), growing rice in the hot season is popular. In April 1979, rice crop here suffered severe drought damage. Some farmers subse- ntly used their fields for grazing while the others waited hoping for ly rain in May, which did not come and a substantial area of rice crop completely lost.

Hailstorms occasionally occur from late in the cool season to the end the warm season (Figure 3.26). Tobacco is the only crop in which heavy es due to hailstorm have been reported. Frost has never been recorded he Valley.

Wind is another perturbation which can reduce crop yields. In the wet on, data shows (Figure 3.26) that the extended maximum wind-speed was km/hr in September. Lodging in rice was recognised but has never been lated to wind as no data were available. In the hot season the figure extended maximum wind-speed was recorded as high as 115.9 kms/hr in l to May. However, lodging in dry season rice has not been reported. may be due to the predominant use of short-stalked, lodging-resistant varieties of RD 1 and RD 7. The perturbating effect of these wind- s on other upland crops could be considerable but no data are available he Valley.

Climatic factors are also major determinants in the outbreaks of in- or diseases. For example, a dry spell in May may cause the outbreak

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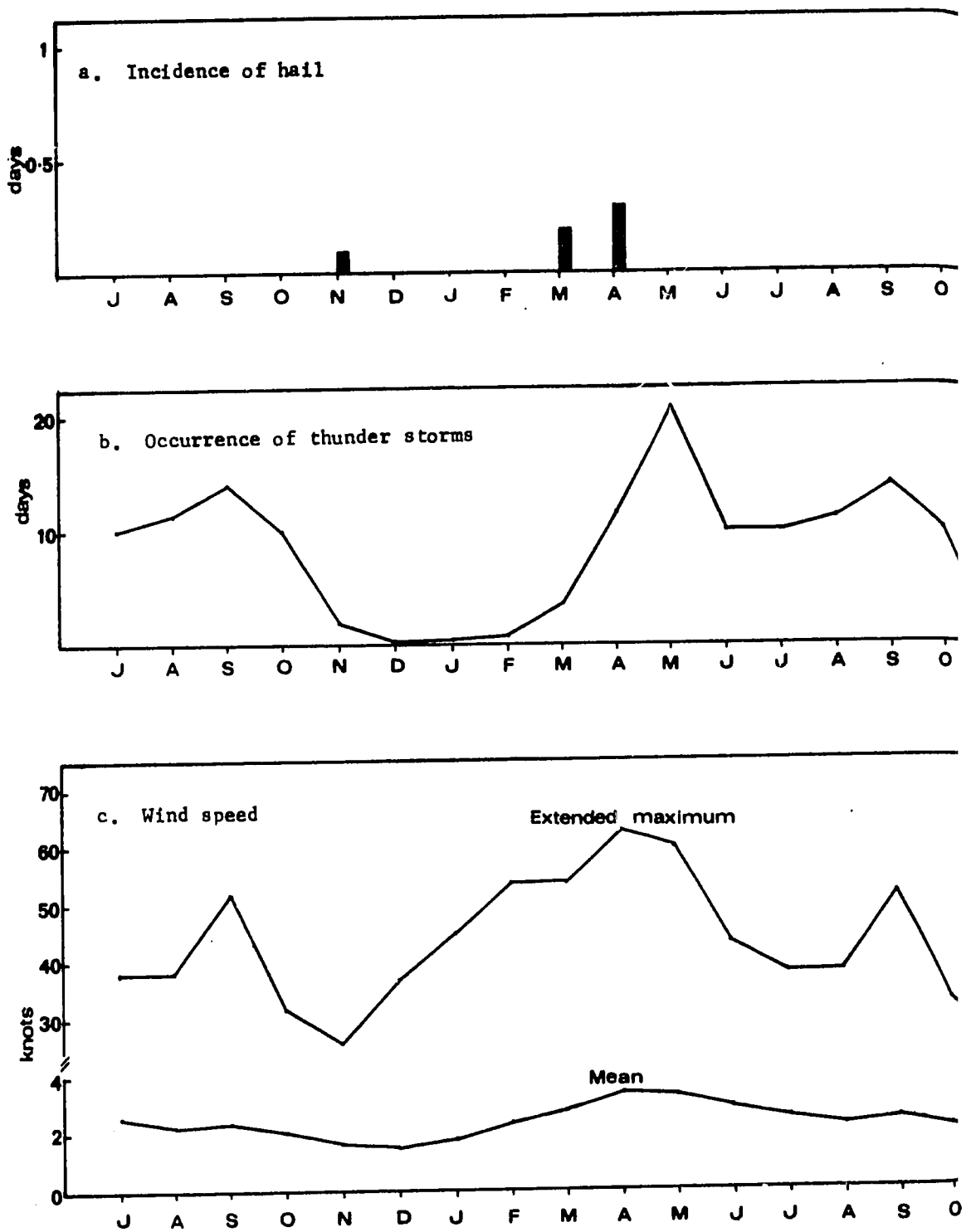

Figure 3.26 Climatic perturbations (data from 1951 to 1970)

armyworms (*Spodoptera* spp.) and thrips (*Baliothrips biformis*) with, in the past, a considerable loss in hot season rice yields in most of northern Thailand (Rasmidatta, 1972). The correlation between low rainfall in June and July and the outbreaks of thrips (*Baliothrips biformis*), jassids (*Nephotettix virescens*) and mealy bugs (*Leptocorisa oratorius*) has been noted. In the case of jassids and mealy bugs, the above correlation was also present in the wet season (i.e. during August and September).

By contrast, heavy rain in the wet season may increase the degree of damage of rice diseases, e.g. blast (*Pyricularia oryzae*), stem rot (*Helminthosporium sigmoideum*) and collar rot (*Ascochyta oryzae*) in rice. Rasmidatta (1972) also observed that in rice, occasional floods in the wet season are usually followed by an attack of cutworms. In addition, severe flooding in September 1977 in the Valley resulted in the outbreaks of climbing cutworm (*Pseudaletia unipuncta* Haworth) (Tikyeven *et al.*, 1978) and this resulted in a heavy yield loss of rice. A disorder called tipburn in garlic which can cause serious damage occurs after heavy rain followed by bright sunshine, but the direct cause is not known (Titayavan, 1976).

Finally, it should be noted that the outbreak of rust disease (*Uromyces fafac*) on sweet peas at the MCP research station varied from year to year (Titayavan *et al.*, 1978). Absence of the disease increases the yield of sweet peas from 0.28 to 1.5 kg/rai. It is possible that variation of climatic factors between years may be a cause of the fluctuations.

Serious perturbation to soil and land caused by land slides or erosion have not been reported in the study area of the Chiang Mai Valley.

Perturbing economic factors, such as the sudden changes in fertilizer or oil prices have already been discussed.

CHAPTER FOUR

PATTERN AND PROCESSES : DECISION MAKING

1. National policy objectives

Economic development planning is a relatively new concept in Thailand. It was not until 1961 that the Government launched its first National Economic Development Plan which was directed mainly at the creation of a basic economic infrastructure and focussed on the structural changes required to encourage private investment. Social aspects of development such as social justice and security were first included in the 2nd plan in 1967. This plan also emphasised the need for maximum resource utilization through the adoption of new technology. The 3rd plan added policies for fairer resource allocation, a balanced regional growth and population planning and employment. The current plan, the 4th, embodies the elements of the previous three and includes policies on the reduction of income disparity.

ESA COLLECTION

Agricultural Development Policy

Although the relative importance of agriculture in Thailand's economy has declined in recent years as a result of the changes in the economic structure of the country brought about by the first National Economic Development Plan, agriculture today is still the mainstay of the country's livelihood.

Agricultural policy as stated in the development plans, and as deduced from Government actions, has been formulated to achieve two major objectives:

1. To raise the income level, living standard and socio-economic status of the farmers and to increase social security and stability in rural areas,

2. to increase agricultural exports so as to rectify the country's unfavourable trade and balance of payments situation.

To these ends, programmes and actions have been designed within the following long range policies:

1. the expansion and development of agricultural infrastructure, such as irrigation, transportation and the extension service,

2. the diversification of crops and farming activities appropriate to the resource base in each area and region,

3. the promotion of farmers' institutions such as farmers' associations and cooperatives, and the improvement of land tenure and credit availability,

4. the improvement in quality of life through family planning, ducation and health services in rural areas,

5. the strengthening of research and experimentation to increase out-ut and modernize agricultural production techniques,

6. the improvement in marketing and prices of farm produce,

7. the reorganization and institutionalisation of government and emi-government agencies to further agricultural development.

Table 4.1 is an abstract of the agricultural components of the first our Plans including the lists of strategic commodities and the target out-uts.

In the following we review those aspects of agricultural or rural olicy which are likely to have a significant impact on multiple cropping n the Chiang Mai Valley.

opulation Policy

A formal population policy was first adopted in the third National evelopment Plan (1972-76) with the aim of reducing the population growth ate, which at that time was over 3%. In the fourth Plan for 1977-81 the cope of the policy was broadened to include the aims of a better popula-tion distribution appropriate to the resource base, improvements of demo-raphic data collection and research and improvements in the coordination f population programmes.

Because of the strong rural focus to the policy government actions re specifically aimed at the reduction of rural family size, improvements n education and proficiency of rural people, the creation of rural employ-ent opportunities, as well as the expansion of public health services and facilities.

The government provides extensive family planning information and birth control services to both rural males and females. Encouragement is also given to private organizations such as the Planned Parenthood Associa-tion, the churches, cooperatives and the Community Family Planning Project, which emphasizes the role local leaders and volunteers can play in family planning services.

The government is also extending compulsory schooling from 4 years to 7 years and building new schools, together with increasing the provision of off-school education, through agriculture extension and demonstration ser-vices and the establishment of 4-H and contract farmer and women groups.

The problem of the migration of the young and often poorly educated from the countryside to the urban centres is being tackled by the establish-ent of regional agricultural development centres, the promotion of local gricultural related industries and the provision of new land settlements.

Table 4.1 Abstract of Thailand's agricultural policy : targets and development aims, since 1961.

Plan/year	Strategic commodities	Selected strategic commodities	Target output at the end of plan year (mt.)	Target quantity exported at the end of plan year (mt.)	Development aims
1st Social and Economic Development Plan. (1961 - 1966)	Rice, rubber, maize, kenaf, cassava, soybean, mungbean, peanut, cotton, castorbean, sesame, tobacco. sugar, coconut, kapok.	Rice	9,500,000	1,000,000	- Improved irrigation
		Maize	750,000	710,000	- Improved seed varieties
		Tobacco	55,000	2,500	- Agricultural extension
					- Increased domestic industrial consumption.

Table 4.1 ... (cont'd)

Plan/year	Strategic commodities	Selected strategic commodities	Target output at the end of plan year (mt.)	Target quantity exported at the end of plan year (mt.)	Development aims
2nd Social and Economic Development Plan (1967 - 1971)	Rice, rubber, maize, kenaf, cassava, soybean, mungbean, peanut, cotton, castorbean, sesame, tobacco, sugar, coconut, kapok, sorghum.	Rice	13,700,000	-	- Better irrigation control & double-cropping - Improved seed varieties - Increased & better application of fertilizer - Improved farming methods (research & extension) - Price support - Extension of ag. credit.

ASIA COLLECTION

Table 4.1 ... (cont'd)

Plan/year	Strategic commodities	Selected strategic commodities	Target output at the end of plan year (mt.)	Target quantity exported at the end of plan year (mt.)	Development aims
2nd Plan ... (cont'd)		Maize	1,500,000	-	- Improved yield
			300,000	-	- Improved product quality
					- Research
					- Increased domestic industrial consumption
					- Expanding foreign market.
		Oil seeds			
		(Peanut, soybean)	185,000	-	
			50,000	-	
		Tobacco	88,000	-	

Table 4.1 ... (cont'd)

Plan/year	Strategic commodities	Selected strategic commodities	Target output at the end of plan year (mt.)	Target quantity exported at the end of plan year (mt.)	Development aims
3rd Social and Economic Development Plan (1971 - 1976)	Vegetables, fruits, silk, coffee bean	Rice	14,467,000		- Continuation of last plan's programme - Demonstration farm (138,500 rai) - Farming method improvements - Double cropping - Seed production - Crop rotation - Increased fertilizer application - Seed improvement.
		Maize	3,500,000		

ASIA COLLECTION

Table 4.1 ... (cont'd)

Plan/year	Strategic commodities	Selected strategic commodities	Target output at the end of plan year (mt.)	Target quantity exported at the end of plan year (mt.)	Development aims
4th Social & Develop- Plan (1977 - 1981) (Plan A)		Soybean	-	400,000	- Extension of improved seed varieties (S.J.1, S.J.2).
		Rice	-	10,190,000	
		Glutinous rice	-	5,796,000	
		Maize	-	3,610,000	

In a number of respects these policies and actions have already proved successful. The population growth had reduced to 2.5% by 1976 and the average size of farm-families had dropped from 6.4 in 1970 to 6.0 in 1975.

Irrigation Policy

Although planned irrigation development began over 70 years ago its rapid growth dates from the first National Development Plan which gave it high priority and provided substantial financial resources. Typically development proceeds in three stages: (1) the infrastructural investments in main facilities, (2) the building of smaller dams and reservoirs, and (3) on-farm irrigation works and land consolidation programmes. In addition to dam and reservoir projects, the government also encourages and develops pump-irrigation and underground-water use. Most irrigation projects are concentrated in the central rice-producing region while the northern region only accounts for about 15% of the total irrigated area.

Despite substantial investment which has increased the total National area under RID irrigation projects from 9.7 million rai in 1961 to 15.5 million rai in 1976, the proportion of total irrigated land to total cultivated land in 1976 has remained at about 15%. This is due to the continuous expansion of the country's agricultural land through deforestation and various new settlement projects. Moreover most modern irrigation facilities also serve such purposes as flood-control and electrification which may, at times, conflict with the irrigation requirement.

In addition to large-scale, costly and long-term irrigation development it is also government policy to promote the efficient use and management of water through advice to farmers, land consolidation programmes and distribution scheduling.

Land Policy

The size of farm holdings has been declining in recent years at the national level. Thailand's average in 1975 was 14.7 rai per family which, it is estimated, will decline to 11.6 rai in 1985. The average holding size is much smaller for farmers in the northern region. In the Chiang Mai area more than 80% of the farmers have a holding size less than the national average but in this area there is evidence to support the beginning of a trend of increasing holding size (Nippanutiyan, 1979).

Farm holding size would already have been much lower if there had been no opening-up of new land.

Through provisions of the 1954 Land Code and the Land Allocation for Occupation Acts of 1942 and 1967, colonization and settlement of cultivable state land was legalised in order to distribute land to land-less farmers. Early efforts centred on the hire-purchase, cooperative land settlement

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schemes; but today the Departments of Land Administration, Public Welfare, of Land Development, the Cooperative Promotion Department and the National Power Generating Authority are all involved in land settlement projects. However, a large portion of the new land has been brought into use through illegal deforestation. This has lowered the proportion of forest land to the total land area from 57% in 1961 to 37% in 1974.

Land expansion essentially accounts for the growth in the country's farm output rather than improvement in yields per acre. Average rice yields in Thailand in fact decreased from 295 kg/rai at the beginning of this century, to about 200 kg/rai during 1950-60 and despite substantial efforts the yield had only improved to 275 kg/rai by 1975/76.

About a fifth of all Thai farmers rent all or part of their land but the proportion is as high as 40% in Chiang Mai Province. Legislation for farm land-rent was made in 1950 and revised in 1974, but is applicable to some provinces only. Rent determination is made by the district rent control committee. Basically rent rates are calculated by determining the maximum production value in each locality which is used to calculate net production value by subtracting production costs (which must represent at least one third of the maximum production value). Rent is then regulated so as not to exceed one half of the net production value. The regulations are also frequently ignored and rent negotiation power remains in the hands of the landlords.

The Agricultural Land Reform Act, passed in 1976, established the Bureau of Agricultural Land Reform. Its stated objectives were to improve the ownership rights and tenurial conditions of agricultural land, to settle residential communities in agriculture, to distribute state land which has been additionally acquired through governmental purchase or expropriation to landless or small farmers, and to allow farmer institutions to rent, acquire by hire-purchase or to otherwise utilize state land. However progress has been slow, mainly consisting of the allocation of poor-quality state and forest land.

Consolidation of land has largely been seen as an adjunct of programmes in rural engineering and irrigation works.

Credit Policy

Agricultural credit in Thailand can be obtained from private money lenders and institutional sources. Public money lenders give loans and accept payments both in cash and in kind but these are usually for farmers non-productive spending. The interest rates vary but are usually exorbitant.

The first proclaimed agricultural credit policy was incorporated in the Farmers Aid Programme, initiated in 1965. In the short run, emphasis was placed on the increases of agricultural production through interest-free loans, both short term (1 year) and medium term (3 years), to farmers

for the purchase of farm inputs and machinery. However, there was no incentive for farmers to pay back the loans when due because interest rates remained unchanged. Therefore, in 1973 operation of the fund was transferred to the Bank for Agriculture and Agricultural Cooperatives (BAAC) and in the following year to a newly established Farmer Aid Fund Office, and a low interest rate (5% annually) was charged. The long run emphasis of the programme is on the improvement of farm production and covers investment in irrigation, education, communication and other social infrastructure, public health and land reform schemes.

Despite the programmes, non-institution lending is still the major source of farm credit, although it's share in the country's total agricultural credit has declined from 95.0% in 1962/63 to 63.7% in 1971/72.

Currently the Bank of Thailand is making an effort to direct capital flow to the agricultural sector by accepting the sales of promisory notes and bills of exchange related to all agricultural activities with the term as long as 60 months, and by having all commercial banks every year release 5% more agricultural credit than in the previous year, which must also account for at least 13% of that year's total deposits.

Fertilizer Policy

The government began to encourage fertilizer use in the establishment of demonstration farms in the 1950's. From 1960 to 1975 no import tax was imposed on fertilizers, except for urea, but in 1963 a domestic fertilizer plan was established with 49.9% of the company's share being held by the government. The operation, however, began by being inefficient technically and administratively, resulting in heavy losses and accumulating fertilizer stocks. From 1970 the government responded by a series of regulations and practices designed to protect the domestic fertilizer industry. These include a monopoly right to the company to import ammonium sulphate and urea and a ban on the import of other nitrogenous fertilizers.

This policy of protecting the domestic fertilizer company however has practically destroyed the competitive structure of the fertilizer market, leaving a single inefficient supplier. The government has attempted to improve the situation by procuring low-cost fertilizers and distributing them to farmers both for cash and on credit terms under the administration of the Ministry of Agriculture and Agricultural Cooperatives, the programmes being implemented by the credit scheme for the Bank for Agriculture and Agricultural Cooperatives. However, in general, profitability from fertilizer-use remains poor and overall usage is low compared with other countries in South East Asia.

Other chemical inputs such as insecticides and herbicides are subject to strict restrictions on import, export, production, marketing, and related services, because of their potential hazards to health and the environment. There is no differential tax rate for imports of raw materials and formulated products and thus the industry is largely based on mixing rather than actual production.

Agricultural Price and Marketing Policy

The agricultural marketing system in this country is based on a private enterprise system with a varying degree of government regulation and intervention. Government policy aimed at improving the farmers' bargaining power and improving marketing efficiency, includes both price and non-price measures.

The government uses price policy to ensure a fair and desirable price level for producers. Direct purchases are made under price guarantee or price support schemes usually administered through farmers' marketing organisations or agricultural cooperatives. Another form of price policy involves the payment of compensation to an industry paying a minimum guaranteed price to farmers but incurring a loss, as for example the sugar industry.

The government has also established a number of marketing agencies to improve marketing efficiency for agricultural products. Among these the most important are Farmers' Marketing Organization (FMO) and the agricultural cooperatives. Their functions are similar in nature but their target farmer groups and management are different. The FMO services all farmers with the working capital being appropriated from government budget and the management decisions coming from the staff. Agricultural cooperatives deal mostly with their farmer members. They obtain working capital from members' shares, retained profits, and by borrowing from commercial institutions and the government, and handle business management along the lines of cooperative principles, while following the supervision and agricultural policy of the government.

Both institutions aim to strengthen the bargaining power of farmers through collective marketing and to increase producers' participation in marketing and processing through the setting up of rice-mills, storage facilities, silos, etc. The government can implement agricultural marketing policy through the FMO and cooperatives by such means as selling cheap fertilizers to farmers, buying farm produce at guaranteed prices, etc. Both the FMO and cooperatives may receive from the government some privileges for exporting farm commodities.

In terms of specific commodities rice price and marketing policy is the most important and controversial. In addition to the present rice price support guarantee programme the government institutes a rice premium and a rice quota and reserve system.

The rice premium is a form of export tax added to the regular export levy, with premium rates fixed by the government and changing periodically depending on market conditions. The rates vary among different grades and types of rice. The objectives are:

1. to stabilize the domestic price for rice and to control export volume, so protecting the domestic consumer from the effect of rising world prices,

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2. the furtherance of international trade strategy i.e. reducing premium rates for purposes of price competition or for releasing domestic surpluses,

3. to re-distribute the gain from price differentials in the world trade for agricultural development programmes.

The rice quota and reserve system is complementary to the rice premium policy. Monthly and total export quotas are allocated to each exporter to control export volume. This system tends to enable only large exporters to share in the rice trade. Each exporter is then also required to deliver rice, at a certain proportion of its total export volume and at a price lower than the market rate, to the government to be used as a rice reserve. The reserve is sold domestically to help urban consumers or is sold internationally for government income.

The effect of the premium is that exporters and traders shift the tax burden back to the farmers by low purchase prices for rice. The quota and reserve system exacerbates the problem by strengthening the close-to monopoly market structure of the rice export sector and creating higher costs which can be shifted to the farmers by the exporters.

Patterns of decision making

The important decisions affecting multiple cropping in the Valley are those concerned with water supply, the availability of land, labour and credit, the provision of physical inputs and technological information and the marketing of products.

The Water Resource

The natural rivers and streams of the Chiang Mai Valley are part of the national water resource. As indicated in Figure 4.1 this resource has a large number of potential users whose interests, in some cases, may conflict. Furthermore because the Ping River and its tributaries are in turn tributaries of the Chao Phya River which flows through the Central Plain and Bangkok and eventually empties into the Gulf of Thailand, the use of the water resource in the Northern Region has repercussions in all other parts of the country (see Chapter 6, Section 3). Figure 4.1 also shows the framework under which all water-use decisions for all pruposes are made.

Government Irrigation Schemes

The Royal Irrigation Department, with its headquarters in Bangkok, has four regional offices one of which is at Lampang. A subregional office at Chiang Mai covers the Chiang Mai, Lampoon and Mae Hong Sorn Changwats.

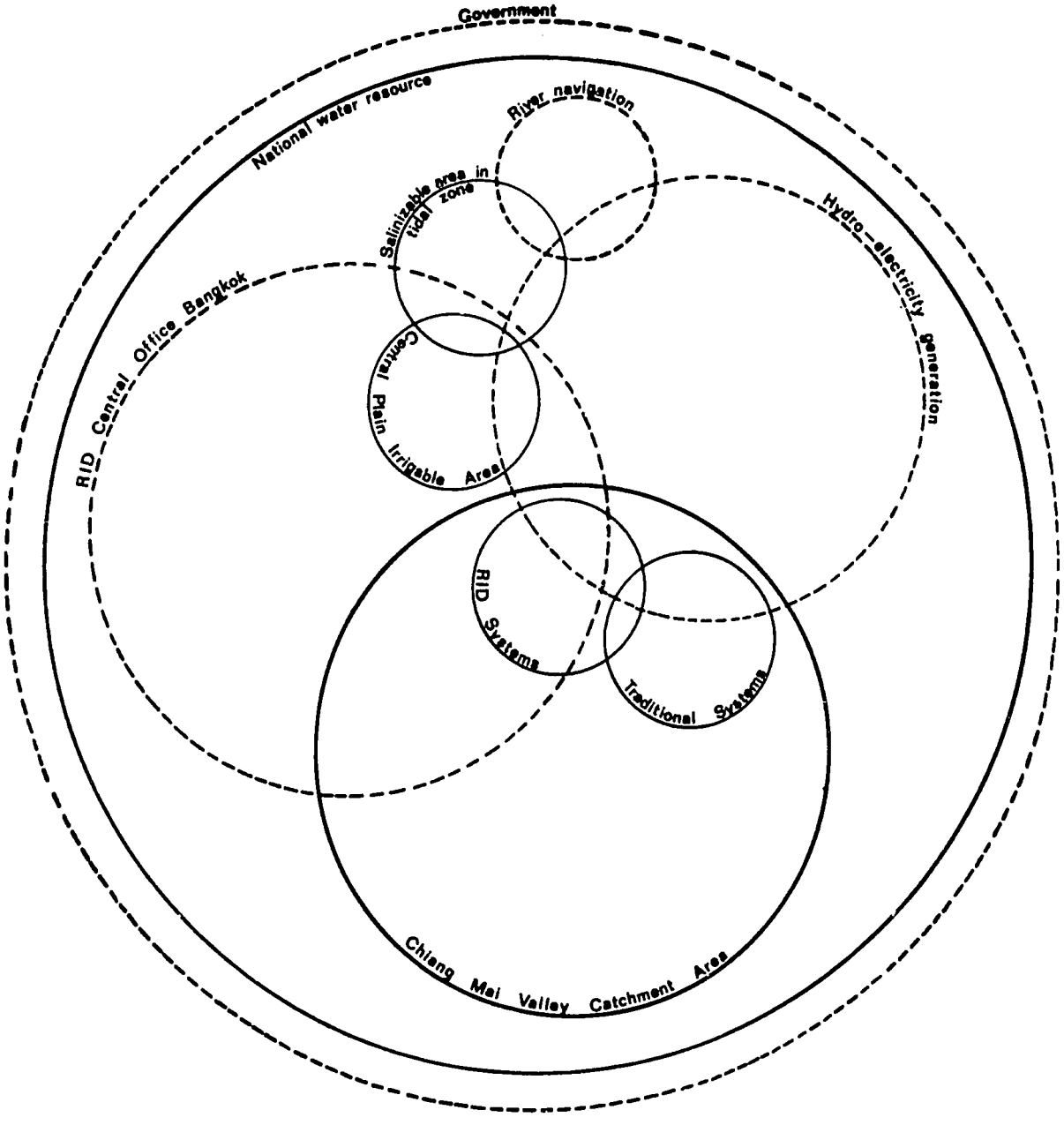

Figure 4.1 Decision making model for water resources of the Chiang M
Valley

N.B. In this and all similar Figures which follow Venn diagrams have been adopted to illustrate physical structures (solid lines) and decision making levels (dotted lines). Areas where different circles intersect are under the jurisdiction of both decision making bodies or within the physical boundaries of both areas.

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The four RID projects in the Valley are each under the control of a project engineer, located in a project office near the headworks. Under the engineer are watermasters, zonemen and gate tenders whose areas of responsibility are shown in Figure 4.2.

Project officials have responsibility for:

1) planning timing and flow in the main canal and laterals,

2) operating the systems as planned,

3) ensuring water distribution to users as intended,

4) maintaining records of water flows, water use, crop areas and production,

5) investigating and measuring water loss,

6) arranging and supervising work of working stations and groups,

7) upholding regulations and settling disputes.

Outside the formal RID structures are five Water Users Associations Table 4.2). They were established under the Civil Commission on Irrigation and their interaction with the formal RID system is shown in Figure .2. Their main purpose (Atthayadhin, 1972) is to:

1) create closer cooperation between water users and RID,

2) provide a channel for the dissemination of modern agricultural nowledge,

3) assist in the organisation and the financing of maintenance of ie irrigation system.

The leaders of the associations are elected by members for a two ear term. The most important employees of the associations are the com- n irrigators. Each has responsibility for about 1000 rai and supervises ie distribution of water from the laterals and sub-laterals through various tches into the farmers' fields. The leaders of the associations, who are paid, in addition to suprvising the common irrigators, also supervise ter allocation, investigate and settle disputes, set fees, levy fines and present the users before the RID and other agencies.

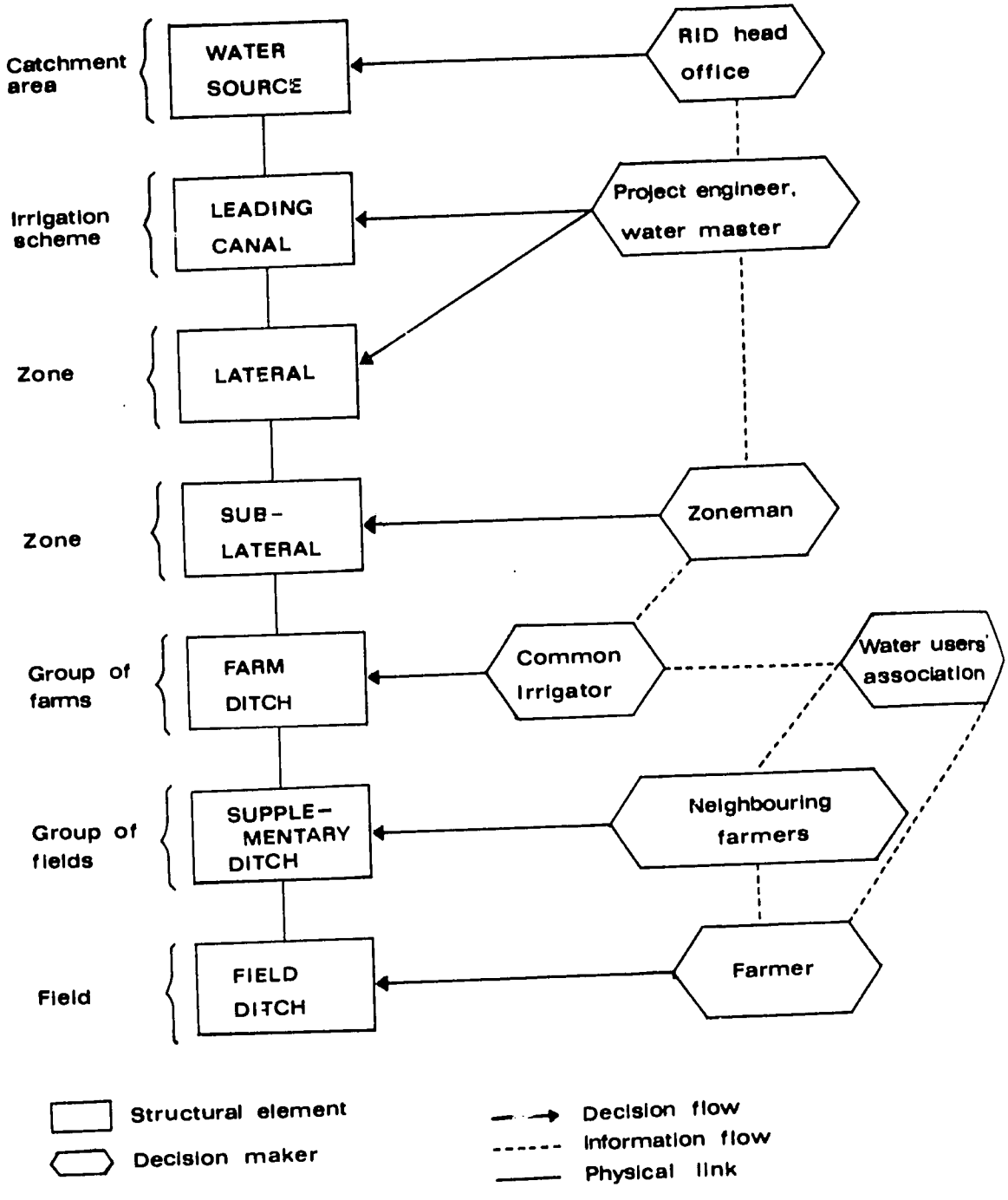

Figure 4.2 A model of decision making within an RID project, showing structure and line of communication

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Table 4.2: Water Users' Associations in the Chiang Mai Valley.

Name of Water Users' Association	Project	Location (Amphur)	Year Formed	Service Area (Rai)	Members
Mae Rim-Mae Taeng	Mae Taeng	Mae Taeng	1969	50,000	3,994
Mengrai Maharaj	Mae Taeng	Mae Taeng	1969	100,000	12,067
Mae Fack	Mae Fack	San Sai	1970	70,000	4,000
Mae Kuang	Mae Kuang	Doi Saket	1969	60,000	3,299
Hareepoonchai-Saraphi	Mae Ping Kao	Saraphi	1970	45,000	1,500

Source: Sektheera *et al.*, 1975.

Maintenance of the main system is undertaken by the RID while the farm level distribution systems are maintained by the farmers and Water Users Associations with the RID providing guidance, surveys and plans as requested.

Traditional Irrigation Systems

A typical traditional system (Figures 4.3 and 4.4) is based on main ditches or *Muang* which carry diverted water from the water source, usually a river or stream. Each Muang is the collective responsibility of the beneficiaries of that system who elect a Muang leader. The duties of the Muang leader, helped by appointed assistants on large systems, are to:

1) supervise the reconstruction of Muang,

2) supervise and set dates for the repair and maintenance of ditches and of their tributaries,

3) supervise a fair and equitable distribution of water,

4) investigate misuse and abuse and assess and collect fines,

5) record the name and size of all land holdings for all farmers in the system,

6) represent the system before the government,

7) represent the system in allocating water between systems,

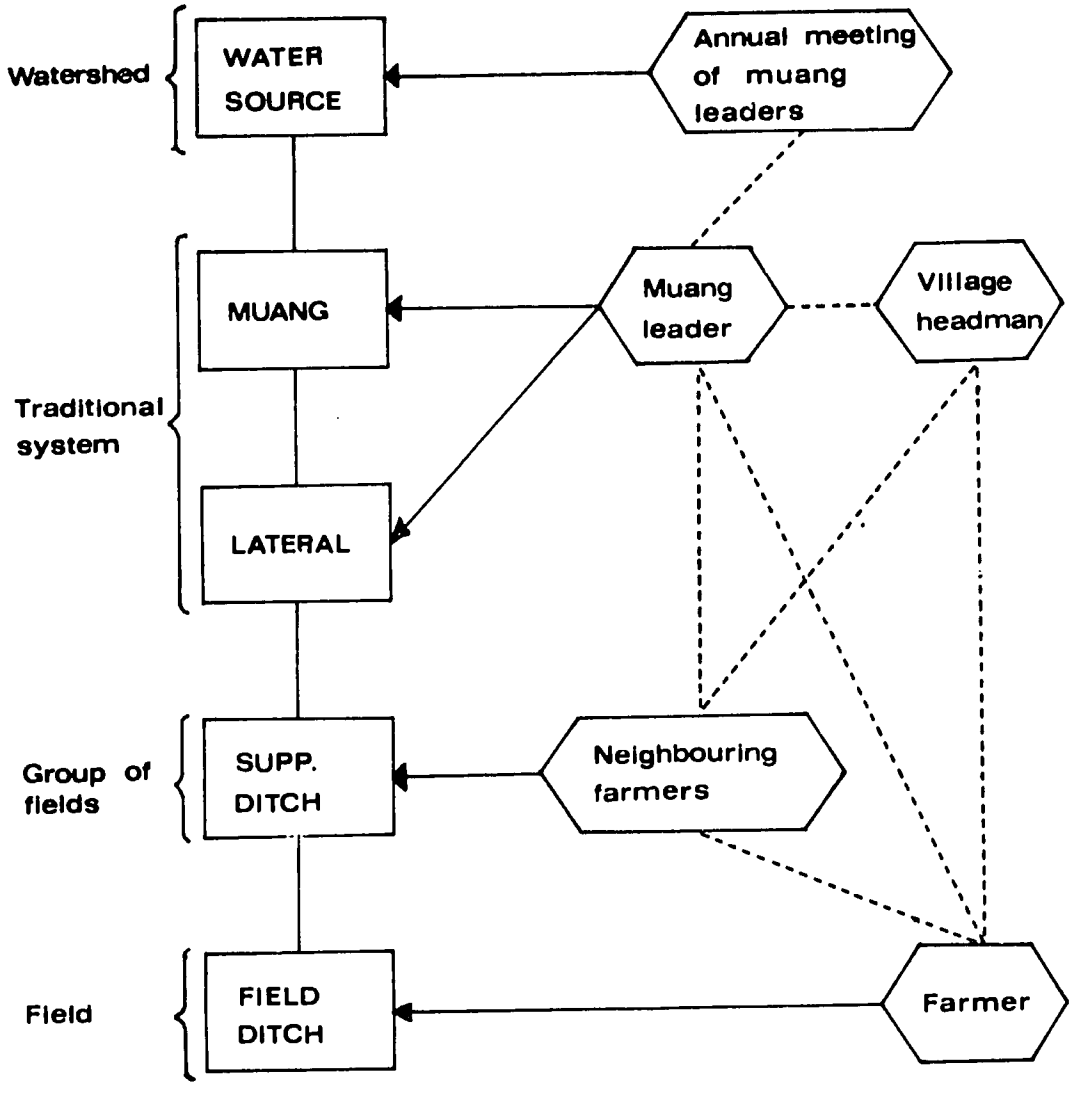

Figure 4.3 Structure and line of communication within a traditional irrigation system

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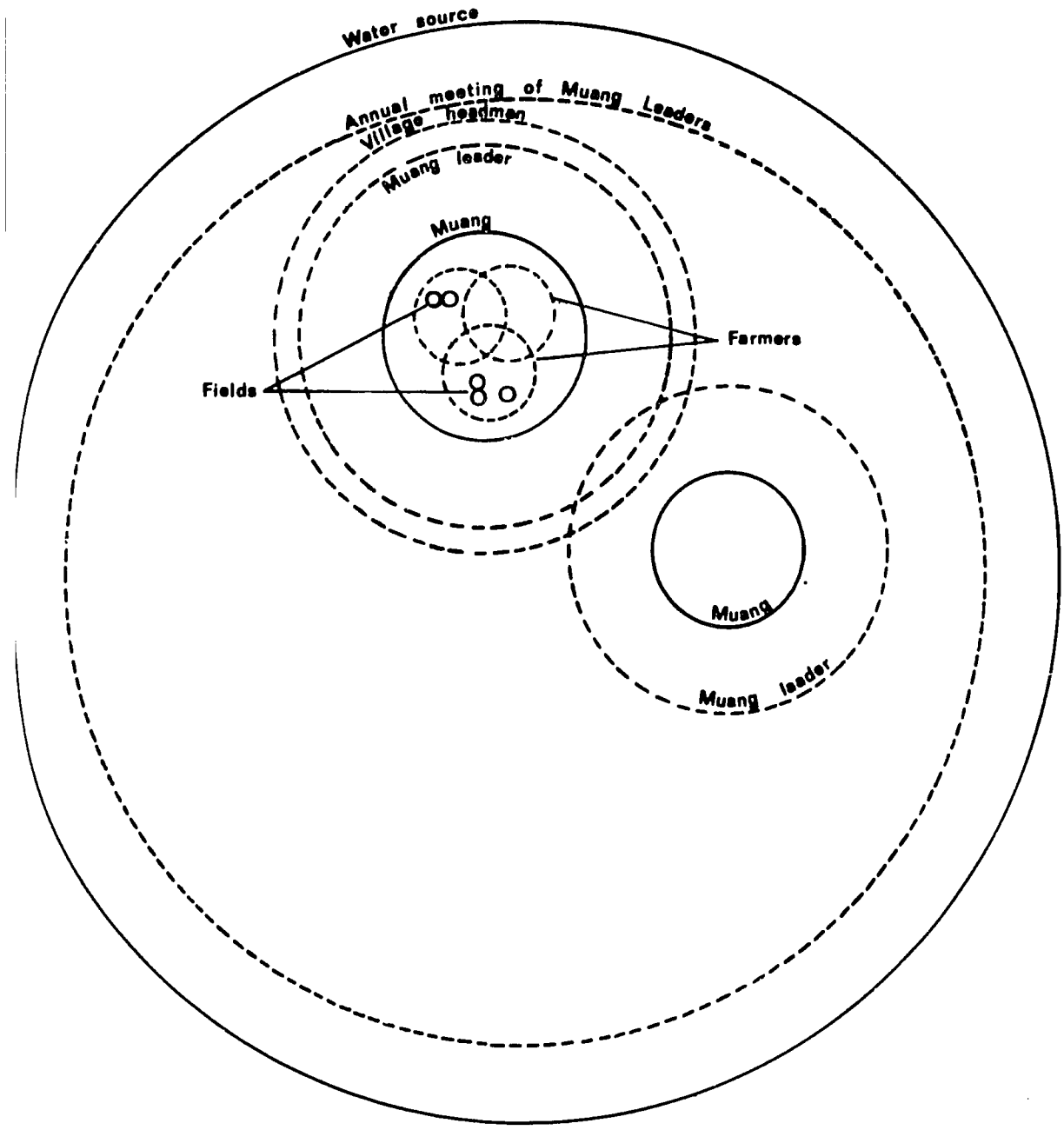


Figure 4.4 A model of decision making in a traditional irrigation system

The village headman is also usually closely involved in running the system, chairing meetings and providing consulting support to the Muang leader.

In the rainy season water is generally allowed to flow freely; however when water becomes insufficient in the latter part of the dry season, its flow is alternated between the laterals of the Muang. The Muang leaders also meet once a year and decide on the allocation of water among the Muang and draw up a schedule with specified water days for each system.

Credit

The major agencies for credit in Thailand are shown in Figure 4.5 and can be summarized as follows:

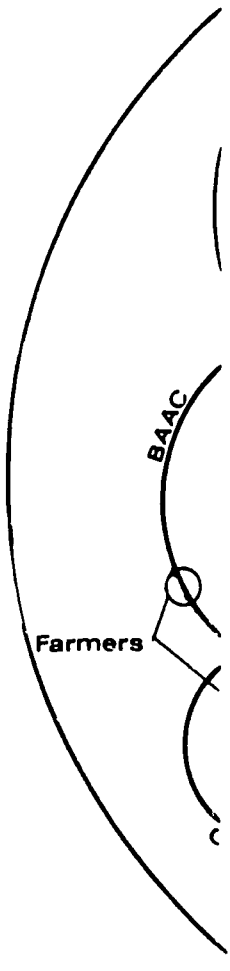
1. Bank for Agriculture and Agricultural Cooperatives (BAAC). This was established in 1966 to take over the functions of the Farmer Bank of Cooperatives and to enlarge the scale of operations to make credit available to farmers who are not cooperative members. The BAAC makes loans directly to individual clients and to agricultural cooperatives and farmers' groups for relending to their members. Apart from loans for production and investment purposes, BAAC also has a policy of helping farmers refinance their old debts with private money-lenders and redeem land lost through mortgages.

BAAC obtains its working capital from the initial fund provided by the Ministry of Finance, deposits from commercial banks, and farmer institutions, and sales of promisory notes to the Bank of Thailand.

2. The Bank of Thailand at the present time accepts the sales of promisory notes and bills of exchange related to all agricultural activities, with the term being extended for as long as 60 months. In 1975, the Bank of Thailand required all commercial banks to release 5% more agricultural credit than the previous year's total, and in 1979, it required all commercial banks to extend at least 13% of the total deposits.

3. The commercial banking system in Thailand has recently played a greater role in farm credit assistance, for instance by making direct loans to individual farmers, depositing 1% of total deposits to BAAC, lending to other farmer institutions and the purchasing of promisory notes and bills of exchange with conditions similar to that of the Bank of Thailand.

4. The Bureau of Accelerated Rural Development (BARD), has promoted the organisation of agri-business groups among farmers in remote barren areas, especially where there is also an insurgency problem, to assist farmers in technical knowledge, credit, and business management. Agricultural credit is the major emphasis of BARD's activities and is financed by commercial banks with the guarantee by BARD against risk in repayment inability associated with crop failure, death or injury and price crises.



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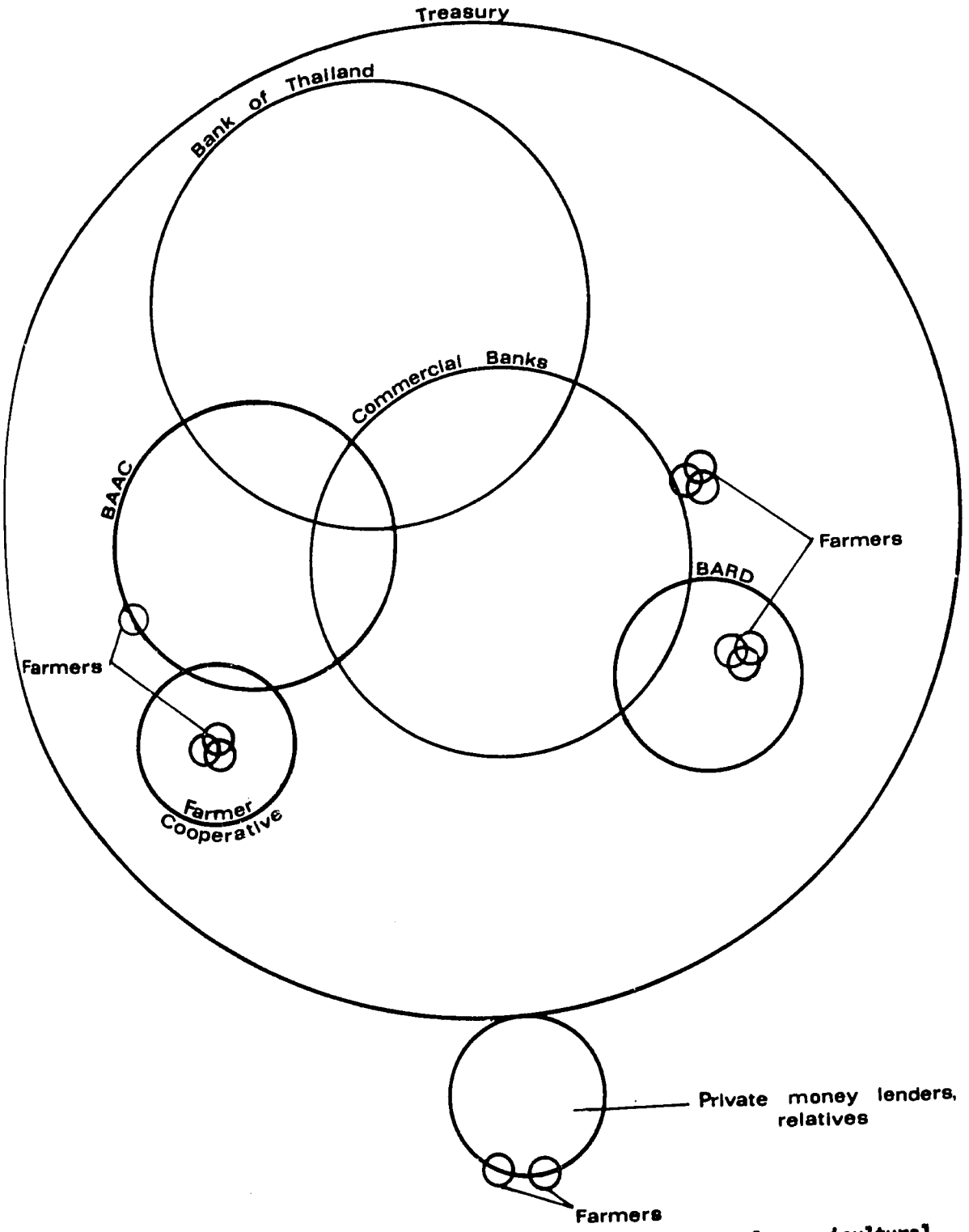

Figure 4.5 A model of decision of decision making for agricultural credit in Thailand

BAAC = Bank for Agriculture and Agricultural Cooperation
BARD = Bureau of Accelerated Rural Development

Marketing

Figure 4.6 outlines the structure of decision making and information flow in the market system.

Surveys show that in general the prices received by farmers for various crops i.e. paddy, peanuts, mungbeans, soybeans, garlic, tomato, chinese cabbage and local glutinous corn are above their total production costs. Some farmers store peanuts, mungbeans and soybeans for up to one month and may store rice and garlic for up to three months, but the majority sell their crops immediately after harvest. Farmers sell their marketable surplus of paddy to merchants who come to the farmers from nearby villages or cities. The local merchants then sell the paddy to local millers or millers in the cities. Other storable crops such as soybean, peanuts, mungbeans and garlic are sold to local merchants and then channelled to either wholesalers in the cities or merchants from other provinces. Some farmers also sell directly to the merchants in the cities.

Vegetables are normally assembled directly by local merchants or merchants from Chiang Mai city and/or adjacent provinces. They buy from farmers in the afternoon and sell to wholesalers in the city that evening. There are also some farmers who sell their own vegetables in the cities or sell to local merchants for local consumption.

The number of garlic buyers at harvesting time is normally greater than that for other crops and some buyers travel long distances, due to the higher profitability of dealing in garlic compared with other storable crops. This well illustrates the fact that the marketing system has no barrier to new entry. A merchant typically deals with any crop that he expects to be profitable. Furthermore, full-time merchants normally handle more than one crop, the actual number depending on the season and the facilities required for handling. Since merchants rarely pay before collecting the produce and farmers do not feel obliged to sell to particular buyers farmers' bargaining power is maintained. Farmers also rarely sell their crops to money lenders, input suppliers or creditors. They are thus rarely taken advantage of in this way and the competitive nature of the output market is not restricted.

Farmers receive a high percentage of the wholesale price for paddy (97.7%) unshelled peanut (86%), mungbean (93%), garlic (64-73%) and lower percentages for tomatoes (63%) and chinese cabbage (56%).

Most farmers seek price information only shortly before each sale. The merchant on the other hand has more interest in and access to price information. However, there appears to be no difficulty for farmers wanting more price information since markets are easily accessible. Surveys have shown that farmers have a more accurate idea of the price of cash crops at selling time than they do for paddy which is usually for their own consumption. They are usually more accurate in their estimation of the price of dry season paddy and common crops such as garlic than they are for mungbeans or vegetables.

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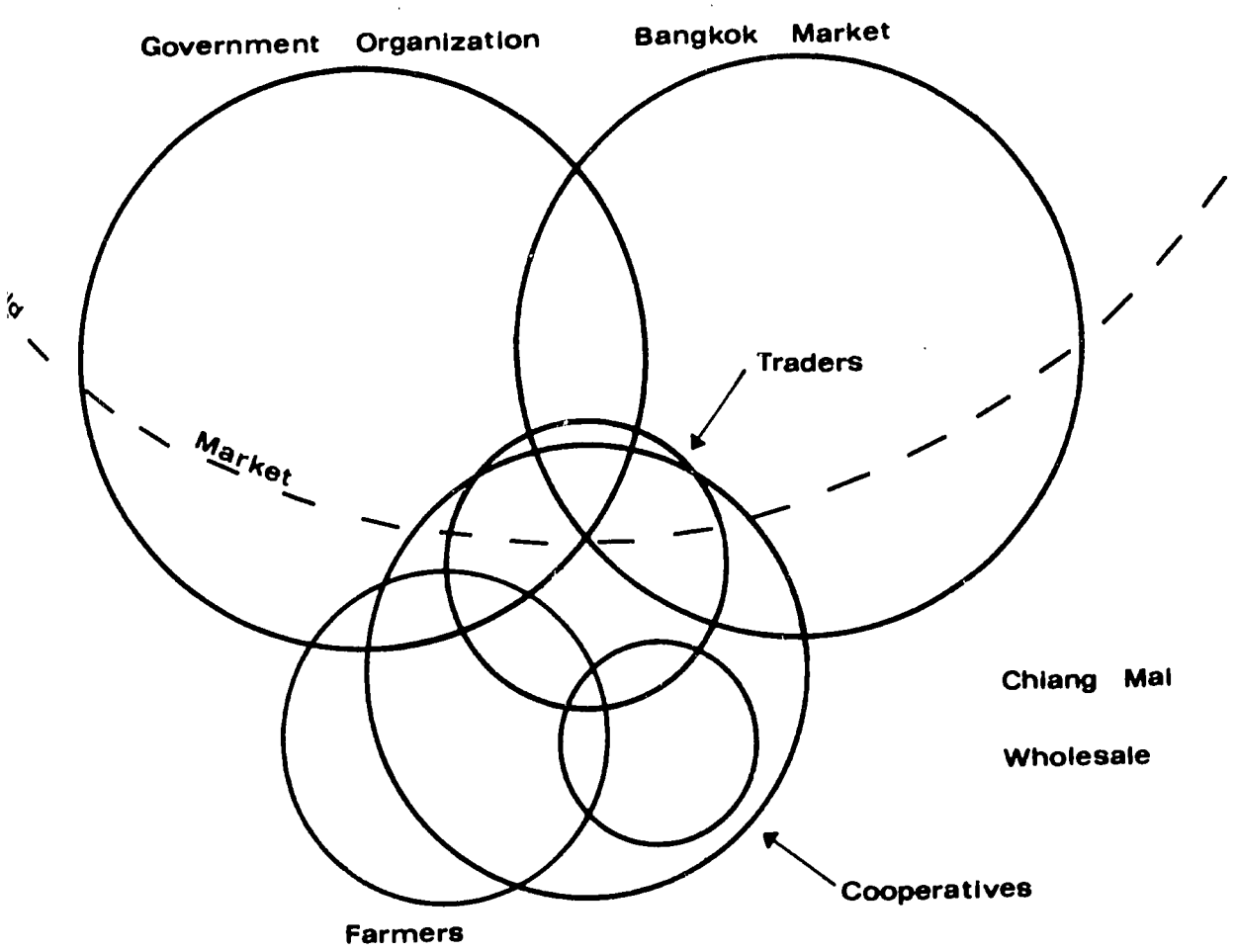

Figure 4.6 A model of decision making within the system of marketing for agricultural inputs and products in Thailand

Very little marketing service for farm products is provided by the agricultural cooperatives as they have difficulty in entering the private business network. For this to come about it would require an integration of the existing organisations from the local through to the national level i.e. from farm cooperatives through to the "Marketing Organization for Agricultural Products" or the "Cooperative Federation of Thailand".

Transfer of Technical Information

The Department of Agricultural Extension is the government organisation primarily responsible for transferring technical information to farmers (see Figure 4.7). It has six regional offices, one of which is at Chiang Mai. The regional office coordinates agricultural extension programmes within the region and also acts as a bridge between the Department of Agricultural Technology and the Changwat officials. It organises training programmes for district extension officers from various Changwats within the regions. The Northern Agricultural Extension Office coordinates the extension programme of all 17 Changwats in the North.

The changwat extension officer, although appointed by the Department of Agricultural Extension, is attached to the Provincial Governor and takes care of the extension programme within the province through district extension officers and also organises the training programmes for village (Tambo extension officers. Farmers obtain information services from the changwat office.

Sources of technical information are obtained from government research institutions e.g. Department of Agricultural Technology, Division of Agricultural Economics, Department of Royal Irrigation, etc. and the Universities These institutes do not provide extension programmes as such but provide a training service for extension officers. In certain instances close collaboration among Universities, provincial extension officers and farmers does occur when research is conducted at the farm level, such as the Multiple Cropping Project village programme.

Private companies engaged in the chemical fertilizer or pesticide business contribute significantly in transferring new information, especially on pest control measures, to the farmers. These companies also conduct trials in the villages primarily for demonstration purposes. In certain intensive cropping areas, such as Mae Ping Kao or vegetable growing areas in the Valley, private agricultural enterprises have greater influence on farmer acceptance than government organisations or the universities.

At the village level, neighbours play a very important role in demonstrating the effect of new technology. For instance, new improved rice cultivars and a heat-tolerant tomato variety in the hot seasons were readily spread through the Hang Dong and San Patong districts by farmer activity.

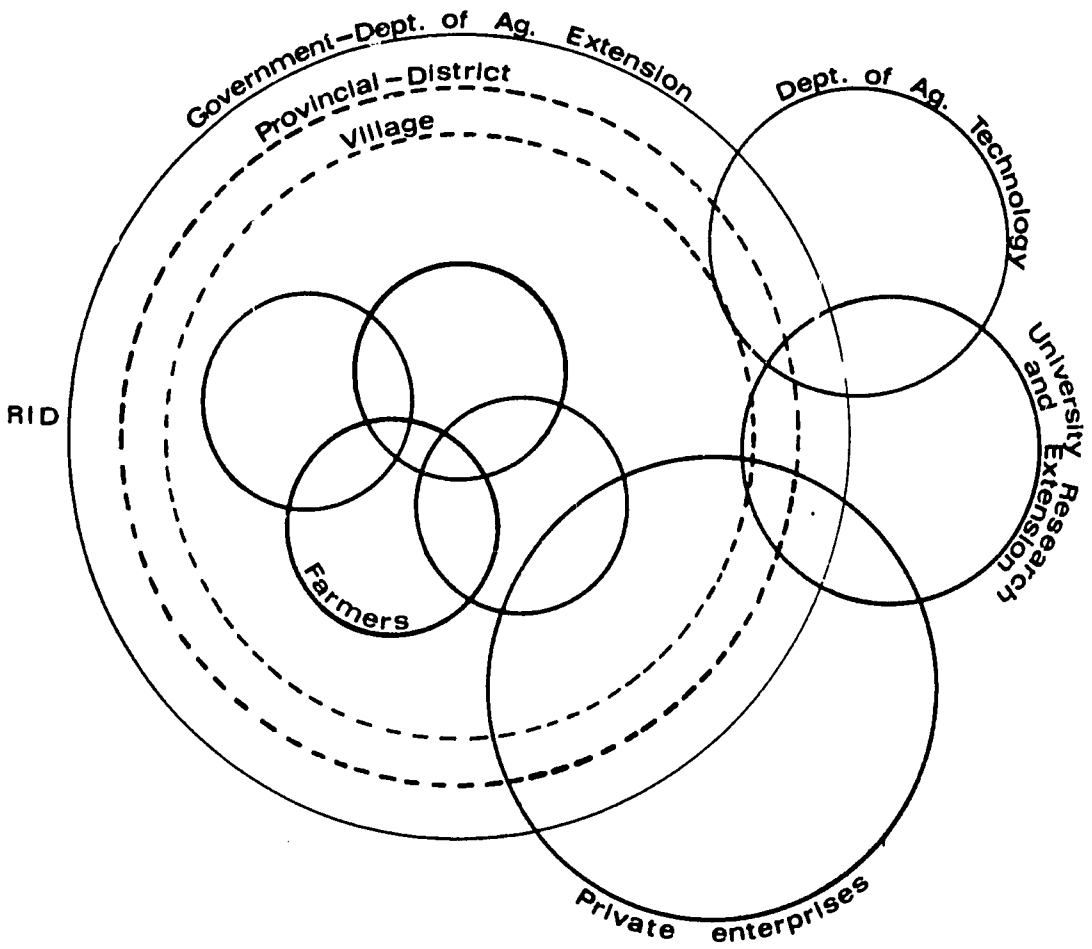

Figure 4.7 The flow of information to farmers

The flow of information and farmer acceptance appears to be more successful with respect to the release of new crop cultivars than for management practices.

3. Farmers' goals and values

There has been no direct research on the nature of farmers' goals and values in the Chiang Mai Valley. However, Ireson (1976) and Suthasupa (1977) have investigated the socio-economic factors associated with cropping intensity, crop choice and cultivation practice, and these studies provide useful indirect evidence. In addition, many members of the MCP group have long experience of working with farmers in the Valley, particularly in villages of the Hang Dong and San Patong amphurs where MCP experimental systems have been tried in farmers' fields under the supervision of the extension team (see Chapter 5).

What follows in this section is based on this experience and on indirect evidence, including the pattern of cropping as now practiced. It should be viewed as collectively arrived at hypotheses about farmers' goals and values rather than established fact.

A goal or objective is an end or state in which an individual farmer desires to be or it is something which he wishes to accomplish (Gasson, 1973). Some goals are ends in themselves. In particular, goals reflecting high or distant ambition, more properly called aspirations, are self-sufficient ends. Other goals are simply intermediate steps in attaining desired ends. For example a farmer in the Chiang Mai Valley may aspire to a better standard of living or a higher social status and to these ends may pursue intermediate goals of acquiring more land or growing more crops a year.

Goals will vary between individual farmers and for the same farmer at different stages of his life. Values by comparison are more permanent properties of the farmer. They are conceptions of what is desirable and serve as a framework within which both goals and the means for attaining goals are chosen. A farmer may thus value honesty or freedom or progress. Values are cultural products, learnt often in childhood, and we can assume that most farmers in the Chiang Mai Valley subscribe for most of the time to the dominant values of the Valley culture and the Thai people. These include freedom, independence, religious merit, etc. Farmers' values can be classified (after Gasson, 1973) as follows:

1. Material values, e.g. security or monetary wealth.

2. Social values, e.g. prestige, social acceptance.

3. Expressive values, e.g. being creative, pride of ownership.

4. Intrinsic values, e.g. having fun, outdoor-life, independence.

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There is no direct evidence as to which kind of value is dominant among Chiang Mai farmers. Villagers in Hang Dong Amphur, however, when asked what they would do with a hypothetical 4000 Baht income increase from multiple cropping, replied as follows (Ireson, 1976):

1. Daily household consumption expenses - 1960 Baht (49%).

2. Construction of new house or rice storage barn, investment in livestock and agriculture - 800 Baht (20%).

3. Religious contributions or making merit - 360 Baht (9%).

4. Others - 880 Baht (22%).

We would hypothesize that material and intrinsic values predominate in shaping farmers' goals in the Valley.

In the rainy season virtually all of the agricultural land is planted to traditional glutinous rice and the bulk of the harvest is consumed by the farmers and their families. The main exceptions appear to be:

1. perennial fruit tree gardens,

2. vegetables on alluvial soils by the Nam Ping River,

3. soybean for seed on elevated plots at Lamphun,

4. tobacco on elevated plots at Lamphun,

5. RD non-glutinous rice at San Khamphaeng.

In at least the last three situations there appears to be land in excess of that required for subsistence rice production and it is this excess land which is cultivated with cash crops. At San Khamphaeng, for example, a farmer interviewed had 13 rai of land. He was using 5 rai for glutinous rice to feed his family of 6 and the remaining 8 rai were for the RD non-glutinous rice which he sold, at a good price, directly off the farm.

This suggests a primary, shared goal of self-sufficiency in the staple rice food which, in turn, probably reflects common dominant values of self-reliance, independence and freedom from uncertainty.

The goals as revealed by the pattern of dry season cropping can be less confidently defined, however. The very rapid and widespread adoption of a second crop in they dry season, following the completion of the RID schemes strongly indicates that second cropping serves one or more major goals of the Chiang Mai farmers. The simplest hypothesis is that they are seeking a maximal cash return.

Ireson (1975) in his study of three villages in the Hang Dong Amphur showed that cropping intensity (essentially the proportion of land in a second crop) increases with:

1. Family cash income.

2. Farmers' commercial orientation, which in turn depends on,

   a. amount of land available
   b. optimising and activism attitudes
   c. support infrastructure
   d. percentage of income earned on-farm.

3. Farmers use of support infrastructure, which in turn depends on,

   a. commercial orientation
   b. optimising and activism attitudes
   c. social status
   d. agricultural support structure.

4. Smallness of amount of land available.

5. Previous years cropping intensity.

Suthasupa (1977) studying the same villages used discriminant analysis to distinguish full multiple croppers (cropping intensity = 2.00) from portional multiple croppers (cropping intensity = 1.04 - 1.90). He showed that full multiple croppers have smaller farms, higher net return per rai and less rainy season rice surplus than portional croppers.

In some cases a farmer may thus plant a dry season rice crop as part of his self-sufficiency goal, but in general these analyses are supportive of the goal of obtaining maximal cash returns for the dry season. Both studies showed a strong correlation between cropping intensity and commercial orientation of the farmer, but they also showed that resources provided no limitation in the adoption of multiple cropping. For example cropping intensity was not correlated with water availability or labour supply. However the villages sampled are atypical in this respect, having an assured dry season water supply and adequate labour.

An analysis of the choice of crop in the dry season by Ireson (1976) showed that, all other things being equal, the preferred crop is prescribed as having:

1. less cash investment requirement

2. more stable yield, and

3. higher net profit

with higher price and higher yield and more stable price as further contributing factors. This again partly supports a profit maximisation goal but also indicates a component of risk aversion. A more accurate reformulation of the goal, on this evidence, would be the attainment of a high cash return per unit of capital.

In the dry season some farmers may rent out their land. Of significance here is that the rental may be nominal, the landlord, however, placing a stipulation that rice is not grown. The accruing benefit to the landlord farmer appears to be in terms of the higher nutrient status in his fields, resulting either from applied fertilizer or a legume crop, which will be of benefit to his next, rainy season, rice planting. The goal here is clearly not one of profit maximisation but includes elements of capital conservation and land improvement.

Triple cropping, as we have seen, is not the norm in the Valley. A third crop is only planted in areas where a water supply in that season is fairly well assured. Such a guarantee is only possible where the farmer has his own tube well or dug well where his land is near a main RID lateral or in a reliable traditional system. Such farmers would be expected to have a strong commercial orientation and their choice of third season crops suggests a high responsiveness to market prices.

Elsewhere triple cropping is seen as too risky a venture. It also coincides with that time of year when festivals are frequent and farmers traditionally devote time to leisure pursuits. In this third season economic goals, as in the rainy season, appear again to be tempered by the influence of intrinsic values.

Perceptions, attitudes and constraints

Values are partly determined by the farmer's perception of the environment in which he lives. For example, self-reliance is especially highly valued in a risky environment. A farmer's perception of his environment, his resources and his own capabilities also determine the feasibility of goals and the routes by which goals may be attained. Of particular importance is the farmers perception of and attitude towards risk.

Experience reveals that farmers often hold strong perceptions as regards the physical and biological environments of their farm although in some instances these perceptions are of questionable scientific validity. For instance one farmer who had problems in cultivating his soil due to large clods applied kitchen salt to his fields each year before the rice crop in the belief that this would improve the situation. Some farmer's perceptions, however, give valuable insight into real problems and their solution, even though the farmer may not be able to articulate the real problem in scientific terms. For example, the practice of farmers renewing their garlic seed-stock every few years from other parts of the valley may help in overcoming trace element deficiency problems although the farmers would not be able to explain the reason for the practice (see Chapter 6).

Whether based on sound scientific fact or not, these perceptions form the basis of decision making as it is the farmer's perception of the situation on which he bases his decisions regardless of its reflection of the true situation.

5. Farmers' strategies and tactics

The analyses in this and the preceding Chapter reveal a very comple pattern of decision making by farmers in the Valley. We have, so far, i sufficient information to unravel this with any degree of precision. Wh follows is a simple working hypothesis of the main choices farmers make each year.

We have made the distinction between strategies and tactics in ord to separate the basic decision which a farmer makes about his whole farm and to which he adheres over a number of years, from decisions which var from year to year or from one plot of his land to another. The former decisions determine the strategy a farmer pursues. They are products pa ly of his constraints of land and water availability but also reflect hi broad goals and values. Strategies will only change slowly perhaps in response to the purchase of new land or the provision of a better water supply. By contrast tactical decisions bear more on immediate objective and reflect, for example, the particular constraints in any year on a pl of land or changing relative prices. Within a particular strategy a far may, for instance, plant mungbean one year and shallots the next because expectation of a better price or the experience of bad disease problems.

The key strategy decision for each farmer concerns the subsistence crop and the cropping pattern for the wet season (Figure 4.8). At the present it would pay an individual farmer not to grow a subsistence crop of glutinous rice in the wet season. The RD non-glutinous varieties pro duce a higher yield. The farmer could choose to treat this as his subsis tence crop and sell the surplus or sell all his harvest using part of th income to buy glutinous rice for subsistence. Alternatively he could pl a commercial crop such as vegetables or tobacco and use part of the incor to purchase his subsistence rice requirement. Either way he would gain higher return than if he planted glutinous rice. In practice very few farmers indeed make this choice in the Valley. Non-glutinous rice is n acceptable for household consumption and the strategy of growing a cash crop and purchasing the subsistence rice goes against traditional value of self-reliance and is regarded as too risky.

In the wet seasons of 1977 and 1978 a number of farmers in the Val devoted some of their land to non-glutinous rice before enough glutinou rice sufficient to meet their subsistence requirement had been planted. However, due to a good national harvest of non-glutinous rice, reducing its price, coupled with a shortage of glutinous rice in the Northern an North Eastern Regions, increasing its price, the majority of these farm were actually worse off, thus emphasising the truly risky nature of go for a cash generating strategy before meeting subsistence requirements full.

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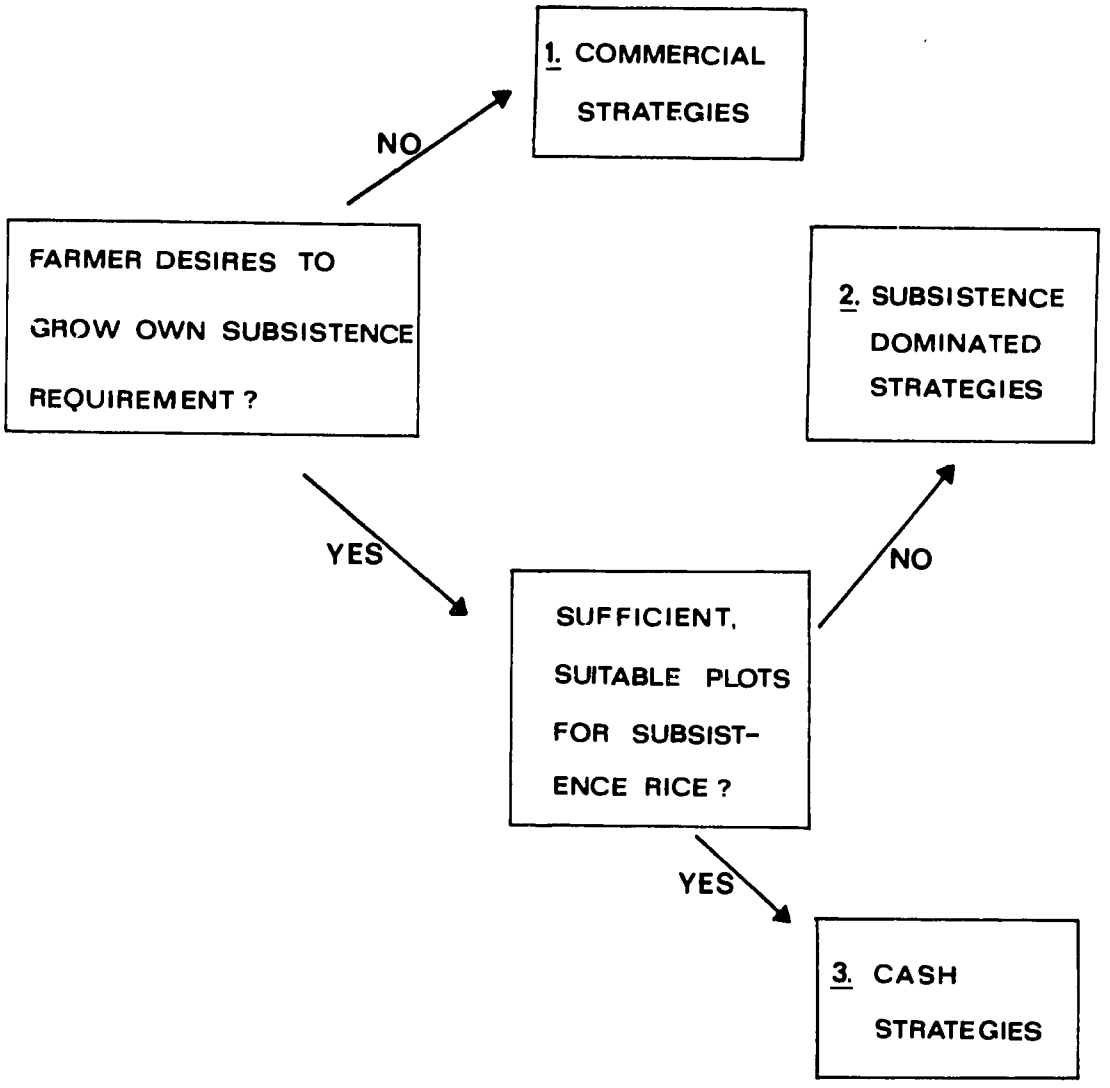

Figure 4.8 A decision tree of farmers' strategies

We have used the term Commercial Strategies to describe strategies which are not based on growing the subsistence glutinous rice crop. There appear to be three such strategies (Table 4.3). The exclusive cultivation of non-glutinous rice in the wet season, the Rice Based Commercial Strategy is very rare and only occurs where large land-owners rent out all their land and insist that the tenants only grow non-glutinous rice. The tenants themselves are likely, however, to grow glutinous rice either on their own land or on other land that they rent. Exclusive growing of vegetables usually in association with fruit is slightly more common, particularly in areas of recent alluvial soil along the Ping River with good access to the Chiang Mai markets where prices for vegetables are high. There is probably also some exclusive growing of tobacco or soybean for seed in the wet season. The field crops commercial strategy occurs along the boundary of the Valley System on the higher elevation land which is not suitable for paddy cultivation.

Table 4.3: Strategies and tactics : Commercial Strategies

	Conditions	Strategy	Tactics
a)	Well irrigated paddy land.	Rice based	Non-glutinous rice followed by same or high input, high return upland crops e.g. garlic, cabbage, etc.
b)	Well irrigated recent alluvial soil, good markets available.	Vegetables/Fruit	Rotations of high input high return vegetables e.g. cabbage, onions, green peppers, broccoli, carrots, watermelons, peas, tomatoes, etc. usually in association with citrus or lamyai.
c)	Higher elevation soils, local processors or markets available.	Field crops	Tobacco, soybean for seed, followed if possible by vegetables.
	Subsistence Dominated Strategies		
a)	Insufficient land for subsistence crop	Exchange subsistence	Glutinous rice where possible in wet season plus on remaining land, or in dry season if possible, upland crops such as soybean, peanut or chilli pepper readily saleable or exchangeable for glutinous rice.

Table 4.3... (cont'd)

Conditions	Strategy	Tactics
b) Land marginally sufficient for subsistence crop.	Subsistence plus	Glutinous rice in wet season plus, if possible, glutinous rice or upland crops as in exchange subsistence in dry season.
	Cash Strategies	
a) Low input availability, water for one or two crops.	Income, risk minimizing	Glutinous rice, plus non-glutinous rice, soybean for seed or tobacco in wet season. Rice followed, if possible, by peanuts, soybean or tobacco followed by vegetables.
b) High input availability, water for two or three crops.	Profit maximizing, high risk	Early maturing glutinous rice, plus non-glutinous rice in wet season, followed by garlic, chili pepper, vegetables or non-glutinous rice as second crop and if possible third crop of mungbean, shallots, non-glutinous rice, tomatoes, sweet corn, ginger, etc.

If the farmer, as is most likely, chooses to grow his own subsistence glutinous rice crop then his choice of strategy depends on the amount of land he has available (this includes whatever land he owns plus that which he rents). Where his land is insufficient or only marginally sufficient to produce his subsistence crop either because the total area is too small or because it receives insufficient water supply in one or both seasons, then his cropping strategies are subsistence dominated (Table 4.3). We can distinguish two such strategies. If the land area is insufficient then he will grow glutinous rice as far as possible in the wet season and will use the remaining land or the dry season to cultivate crops he can readily sell or exchange to meet subsistence rice requirement. It is also likely that he will work as a labourer on neighbours' farms where he will receive a cash payment or payment in rice. This, we have termed the Exchange Subsistence strategy. With slightly more land, which means that at least in some years he can meet his whole subsistence requirement, he may grow glutinous rice in both seasons and use any extra land to grow crops such as soybean, peanut or chilli pepper which are low in cash input requirement but may

efficiently utilise his family labour. In this way he can get a small cash income in some years and we have termed this the Subsistence Plus strategy.

Once a farmer has more than enough land to grow his subsistence rice and can be assured of this each year, he can then chose a cash strategy which will provide him with an income every year over and above subsistence At this stage, for simplicity, we have assumed there are only two such strategies. In the first we consider a farmer with relatively low access to cash or credit inputs and land that is irrigated for only one or two crops a year. Such a farmer is likely to follow an Income Generating but Risk Minimizing strategy. In addition to his glutinous rice he may grow non-glutinous rice, tobacco or soybean-for-seed in the wet season on land which is close to his dwelling (non-glutinous rice) or land which is at a higher elevation (tobacco, soybean-for-seed). The rice is then most likely to be followed by a low input crop such as soybean or peanuts. However where cash and credit inputs are readily available, particularly to hire extra labour, and where the land is irrigated for at least two seasons, the farmer may take greater risks and aim for profit maximization. Typically such a strategy will result in the growing of garlic or vegetables or non-glutinous rice or vegetables such as shallots and tomatoes.

This Profit Maximization, High Risk strategy is the one practised in most of the triple cropping areas of the Valley (Figure 3.2). It is also the strategy most researched on the MCP experimental plots and in the farmers trials (see Chapter 5). It is also evident that the tactical options are greater in this strategy than in the risk minimizing or subsistence dominated strategies.

CHAPTER FIVE

THE EVALUATION OF CROPPING SYSTEMS

Cropping systems on the University experimental plots

Introduction

In the early years the work of the MCP was component crop orientated, concentrating on essential basic research such as trials on varieties, planting-date, fertilizer rate, etc. for each crop. Systems work, once begun, concentrated on designing and testing a number of high technology three crop systems. Although perhaps not explicitly stated at the time, the systems being tested were essentially in line with the commercial strategies outlined in Chapter Four (see Table 4.3). The objectives were to find triple cropping systems that, under near optimum conditions, gave high net returns to farmers willing and able to invest in and take the risks associated with adopting new technology and ideas.

The systems were tested on the MCP Experimental Station which consists of approximately 6 ha. of well irrigated land on the University Campus. The soil is predominantly San Sai series closely associated with Lampang series. It differs from the latter in being sandy, with lower cation exchange capacity, lower available phosphorus and a higher pH.

Six cropping systems were designed and tested on the experimental plots in the period 1974-1976 to study their agronomic and economic potentialities under various management practices. A randomized complete block design with three replications was adopted. The plot size was 800 m^2 and treatments consisted of three levels of nitrogen fertilizer.

All the systems were based on RD non-glutinous rice varieties.

Table 5.1 indicates the yields of the most profitable treatments together with the gross returns, costs of production and net incomes with and without considering labour costs for each crop and system. Land and water costs are not included in the costs of production.

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Table 5.1: Actual cropping system budgets for 1975/76 at the Multiple Cropping Project experimental plots-Chiang Mai University

System No.	Crops	Yield Kg/Rai	Gross return	Cost of production		Net income	
				With labour	Without labour	With labour	Without labour
1. Wet	Rice	980.3	1764.54	1238.94	835.92	525.60	928.62
Cool	Wheat	806.0	4030.00	1786.74	1336.26	2243.26	2693.74
Hot	Field corn	895.6	1791.20	1141.68	650.38	649.52	940.82
	Total	-	7585.74	4167.36	3022.56	3418.38	4563.18
2.	Rice	846.1	1522.98	1088.82	708.72	434.16	814.26
	Garlic	1788.8	5366.40	5686.80	3526.80	-320.40	1839.60
	Sweet corn	1735.3	1532.60	1044.84	805.56	1487.76	1727.04
	Total	-	9421.98	7820.46	5041.08	1601.52	4380.90
3.	Rice	883.18	1589.72	958.20	568.50	631.52	1021.22
	Soybean	381.64	1908.20	1847.64	1378.56	60.56	529.64
	Cabbage*	882.00	2205.00	1157.00	737.80	1048.00	1467.20
	Total	-	5702.92	3962.84	2684.86	1740.08	3018.06

* The cabbage crop failed in 1976, therefore, the figures for 1975 were used.

Table 5.1 ... (cont'd)

System No.	Crops	Yield Kg/Rai	Gross return	Cost of production		Net income	
				With labour	Without labour	With labour	Without labour
4.	Rice	771.9	1389.42	863.04	582.84	526.38	806.58
	Peanut (shelled)	282.8	2262.40	1620.67	993.79	641.73	1268.61
	Tomato	1884.0	5652.00	1501.56	1082.61	4150.44	4569.39
	Total	-	9303.82	3985.27	2659.24	5318.55	6644.58
5.	Rice	802.57	1444.63	1129.17	794.82	315.46	649.81
	Tomato	3851.2	5761.80	1480.20	1013.85	4281.60	4747.95
	Mungbean	187.0	1944.80	1621.29	1019.34	323.51	925.46
	Total	-	9151.23	4230.68	2828.01	4920.57	6323.22
6.	Rice	724.13	1303.43	1136.70	755.70	166.73	547.73
	Tomato	1978.13	2967.20	1715.62	1189.12	1251.58	1778.08
	Rice	1136.0	2044.80	1292.46	684.66	752.34	13601.14
	Total	-	6315.43	4144.78	2629.48	2170.65	3685.95

System 1: Rice-Wheat-Field Corn

As the 1975/76 yields show, wheat can be highly profitable, providing disease is absent and stem borers are controlled (Furadan was used to control stem borers in 1975/76). The system requires relatively little labour and has a low cash input requirement with a high potential net income. It is however unfamiliar to farmers in northern Thailand, and requires sophisticated land preparation and critical timing of irrigation. (Rice-RD 1; Wheat-INIA 66; Corn-Early Thai Composite).

System 2: Rice-Garlic-Sweet Corn

The relative profitability of this system depends on which costs are included. If all labour costs are included it is the least profitable, but if these costs are excluded it has the fourth best net income. Performance of the system is largely governed by the garlic crop which requires large amounts of labour and cash inputs (straw for mulching and the costs of bulbs); in fact, garlic had the highest labour and cash input requirement of the twelve crops tested in the systems plots. It also had the highest total production costs of any crop. Sweet corn was also relatively profitable and required the least amount of labour and the fourth least amount of cash input. However, the marketing of sweet corn is not assured.

The improved performance of the system in 1975/76 was due primarily to a reduction in "tip burn" and other diseases in garlic. The early planting of garlic to avoid disease incidence is critical (Rice-RD 7; Garlic-local variety; Sweet corn-hybrid H68).

System 3: Rice-Soybean-Cabbage

The cabbage crop in this system failed in 1975/76 because the variety planted did not form heads. Thus the figures in Table 5.1 represent the 1974/75 cabbage yields. The system produced a very low net income. It has the lowest overall production cost, even when the labour cost is included, but the soybean crop had relatively low net returns, high production costs, and high cash input requirements (Rice-RD 7; Soybean-SJ 2; Cabbage-Copenhagen 86).

System 4: Rice-Peanut-Tomato

This system resulted in the highest net income of the systems tested. It had relatively low total production costs and about average cash input and labour requirements. The primary reason for the good performance was the highly profitable hot season tomato crop. It ranked first in net income of all crops and had medium relative production costs, labour and cash input requirements. The yield of the hot season tomato variety is somewhat lower than for cool season tomatoes, but may be sold at prices

that are 3-4 times as high as those prevailing in the cool season. The peanut crop received an average ranking on all criteria except labour requirement where it ranked second highest (Rice-RD 1; Tomato-L22).

System 5: Rice-Tomato-Mungbean

The system performed well in both years and in 1975/76 achieved the second highest net income with relatively low production costs, average labour requirements and the lowest cash input usage. The cool-season tomato crop had the second highest net income, primarily because of the high yield and reasonable market price. If the crop had been harvested a few weeks later, the price received would have been substantially lower. The mungbean crop ranked relatively low in terms of net income but required the second least amount of cash input (Rice-RD 7; Tomato-Sida; Mungbean-CES 55).

System 6: Rice-Tomato-Rice

This system was relatively low in terms of net income and had relatively high production costs;in fact the highest costs when labour was excluded. Success of the system depends upon timely rice transplanting. The tomato crop can only be successfully inserted if the hot-season rice is planted in early April and harvested in early July with the wet-season rice transplanted a few days later.

Comparisons

Tables 5.2 and 5.3 show the ranking of crops and systems by selected criteria. It is of interest to note that the RD rice crop had relatively stable yields and net incomes both within 1975/76 and between 1974/75 and 1975/76. In terms of comparison with other crops, the RD non-glutinous rice ranked average to low in relative net returns, but had one of the lowest production costs. The cash input requirements for producing wet-season non-glutinous rice were lower than for any other crop tested, while its labour requirement was average to low. By comparison the alternative crops have:

(1) somewhat more variable yield over space and through time;

(2) higher production costs;

(3) higher cash input requirements; but

(4) the potential for substantially higher net incomes.

In general the cropping systems which give relatively high net returns are usually the ones where total costs, labour costs and cash costs, are also relatively high; and vice versa. This clearly has an

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Table 5.2: Crops Ranked by Selected Criteria, MCP Experimental Plots 1975/76

Net income		Cost of production		Labour used	Cash cost
Including labour	Excluding labour	Including labour	Excluding labour	(high to low)	(low to high)
(high to low)		(low to high)			
Tomato (hot season)	Tomato (hot season)	Garlic	Rice (hot season)	Garlic	Rice (wet season)
Tomato (cool season)	Tomato (cool season)	Sweet corn	Rice (wet season)	Peanuts	Mungbean
Wheat	Wheat	Rice (wet season)	Cabbage	Rice (hot season)	Rice (hot season)
Sweet corn	Garlic	Field corn	Sweet corn	Mungbeans	Sweet corn
Cabbage*	Sweet corn	Cabbage*	Field corn	Cabbage*	Wheat
Rice (hot season)	Cabbage*	Rice (hot season)	Peanuts	Tomato (cool season)	Field corn
Field corn	Rice (hot season)	Tomato (hot season)	Mungbean	Soybean	Cabbage*
Peanuts	Peanuts	Tomato (cool season)	Tomato (hot season)	Wheat	Tomato (hot season)
Rice (wet season)	Field corn	Peanuts	Tomato (cool season)	Tomato (hot season)	Peanuts
Mungbeans	Mungbeans	Mungbeans	Wheat	Rice (wet season)	Tomato (cool season)
Soybeans	Rice (wet season)	Wheat	Soybean	Field corn	Soybean
Garlic	Soybeans	Soybeans	Garlic	Sweet corn	Garlic

* The cabbage crop failed in 1976. Therefore, the figures for 1975 were used.

* The cabbage crop failed in 1976. Therefore, the figures for 1975 were used.

Table 5.3: Systems Ranked by Selected Criteria, MCP Experimental Plots 1975/76

Net income		Cost of production		Labour used	Cash cost
Including labour (high to low)	Exluding labour (high to low)	Including labour (low to high)	Excluding labour (low to high)		
Rice-Peanut-Tomato	Rice-Peanut-Tomato	Rice-Soybean-Cabbage*	Rice-Tomato-Rice	Rice-Garlic-Sweet corn	Rice-Tomato-Mungbean
Rice-Tomato-Mungbean	Rice-Tomato-Mungbean	Rice-Peanut-Tomato	Rice-Peanut-Tomato	Rice-Tomato-Rice	Rice-Wheat-Field corn
Rice-Wheat-Field corn	Rice-Wheat-Field corn	Rice-Tomato-Rice	Rice-Soybean-Cabbage*	Rice-Tomato-Mungbean	Rice-Soybean-Cabbage*
Rice-Tomato-Rice	Rice-Garlic-Sweet corn	Rice-Wheat-Field corn	Rice-Tomato-Mungbean	Rice-Peanut-Tomato	Rice-Peanut-Tomato
Rice-Soybean-Cabbage*	Rice-Tomato-Rice	Rice-Tomato-Mungbean	Rice-Wheat-Field corn	Rice-Wheat-Field corn	Rice-Tomato-Rice
Rice-Garlic-Sweet corn	Rice-Soybean-Cabbage*	Rice-Garlic-Sweet corn	Rice-Garlic-Sweet corn	Rice-Soybean-Cabbage*	Rice-Garlic-Sweet corn

* The cabbage crop failed in 1976. Therefore, the figures for 1975 were used.

important implication in terms of the farmers' need for agricultural credit. Even though funds may be available often only those farmers who are relatively well-off will benefit from this availability while those who are relatively poor, will lack the necessary collateral to borrow. The traditional attitude against being-in-debt, and the value placed on self-reliance may also add constraints to the adoption of such high cost systems.

2. Experience from the village programme

Objectives

The village programme of the MCP was begun in 1975 with the object of verifying, under actual farm conditions, the biological feasibility and economic viability of the cropping systems developed at the experimental plots on the University Campus. The latter are essentially field laboratories well supported by manpower, with plentiful water, and lacking most of the constraints typical of farms in the Valley. The village programme was thus seen as a way of testing the relevance of the MCP research and also a means of exposing the research workers to farmer problems on a day to day basis.

The Test Villages

The following criteria were used in selecting the test villages:

(1) water availability all year round;

(2) soils typical of the valley;

(3) accessible by road all year, reasonably close to the University and to each other, and

(4) with socio-economic characteristics, typical of the irrigated areas.

Two sites were chosen: Ban Han Kaew at *Mu* 1 *Tambon* Han Kaew in Amphur Hang Dong and the adjoining villages Ban Mae Kung and Ban Klang Nuo at Tambon San Klang in Amphur San Patong. Both lie about 18 km. to the south of Chiang Mai.

Both receive irrigation water from the Mae Taeng Irrigation Project laterals 22 and 23 feeding Han Kaew and laterals 23 and 24 feeding Mae Kung and Klang Nuo. About 54% of the households rely solely on the Mae Taeng, 13% solely on natural streams and shallow wells and 1% on rain, the remainder relying on various combinations of these. Han Kaew is on Hang Dong series soil and Mae Kung and Klang Nuo on Lampang series.

A base line survey of the villages was conducted by the Social Science Research Center at Chiang Mai University. The villages were first

established 80-150 years ago when there was a surplus of land and the cropping was almost entirely dependant on direct rainfall. By 1975 the villages comprised 2,397 people in 503 households, with an average paddy land holding of only 4-5 rai, below average for the Valley and for Thailand.

The survey found that 70% of the population accept family planning and newly married men express a desire for 2 or 3 children. 70% of the population over 6 years of age had finished primary 4 education.

The majority of the population (65%) are engaged in farming, with cottage industry, general and agricultural employment as secondary occupations. Only half of the farm households, however, own paddy land. Half the remainder are engaged as agricultural labourers and half as tenant farmers. The villages suffer from a shortage of leasehold land. In addition to paddy land, 32% of the households have orchards, mostly devoted to coconuts and longan. Most households have home gardens, growing vegetables and raising chickens, and about half of the households also raise 2 or 3 pigs.

Double cropping is normal practice in the villages. In the wet season local glutinous rice varieties (Kam phay, Kaew and RD 2) are grown. In the dry season non-glutinous rice, RD 1, is grown (with RD 7 being introduced). This is partly for sale, but because of the land shortage there is increasing planting of rice in the dry season for household consumption. Field crops in the dry season include soybeans, peanuts, garlic, lettuce, green pepper and tobacco.

Seeds and fertilizer are generally purchased from local merchants on credit, with payment in kind after harvest. Only a few farmers use cash for labour and other inputs.

Methods

The MCP has assigned one extension staff member to work in each village. They make visits at least 3 days a week and there are back-up visits from members of the research staff. Labourers are hired to assist the farmers in managing the cropping systems and for record keeping. Some of the inputs are provided by the Project on credit and the farmers are also assisted in finding market outlets for new crops. There is also compensation for loss.

Farmers selected for the tests must have the right to year-round cultivation on the same land (they may be owners or tenants), access to good year-round water supply and a willingness to take part. The test plots on each farm are about one half rai in size.

Cropping Systems Tested

Table 5.4 shows the systems tested each year with their net income returns.

Table 5.4: Cropping systems tested by the MCP in the villages with net income returns (averages of the two Villages).

	Net income (Baht
1975/76	
RD1 Rice-Peanut-Tomato	4809.14
RD1 Rice-Tobacco-Chinese Cabbage	3509.02
RD1 Rice-Soybean-Caggage	2254.65
RD1 Rice-Tomato-RD1 Rice	1586.00
1976/77	
RD7 Rice-Peanut-Tomato	5811.95
RD7 Rice-Tobacco-Peanut	4834.55
RD7 Rice-Garlic-Corn	3939.37
1977/78	
RD7 Rice-Peanut-Tomato	4787.15
RD7 Rice-Tobacco-Peanut	4130.71
RD7 Rice-Soybean-Sweet corn+	3945.06
RD7 Rice-Garlic-Mungbean	3759.50
1978/79	
Kao Dor Rice-Peanut+-Tomato+	
San Patong Rice-Peanut-Tomato+	
RD7 Rice-Peanut-Tomato+	
RD7 Rice-Soybean-Sweet corn	
RD7 Rice-Garlic-Mungbean+	
RD7 Rice-Tomato-Stringbean+	
Kao Dor Rice-Tomato-Stringbean+	
Kao Dor Rice-Pepper	7865.24

+ Crop failure

Table 5.5: Estimated Costs and Returns to Various Systems Operated by the Farmers in the Village Programme 1975/76

Tables 5.5 and 5.6 show the cost and returns to various systems operated by the farmers in 1975/76. Tables 5.7 and 5.8 show the ranking of crops and systems by net income, cost of production, labour utilization and cash cost. The first two criteria were calculated including and excluding labour costs.

The most profitable individual crop was hot season tomatoes[1/] due to the high prices received by the farmers. By contrast rice in the hot seas was the lowest ranking crop, because of its low yield and moderate costs o

1/ = New system

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by the Farmers in the Village Programme 1975/76

System No.	Crops	Gross return	Cost of production		Net income	
			With labour	Without labour	With labour	Without labour
		(- - - - - - - - - - - - - - - -	-Baht/rai-	- - - - - - - -	- - - - - - - -	- - - - - - - -)
1	Rice	1,462.62	1,092.01	621.25	370.61	840.87
	Peanut	933.61	844.43	451.92	89.18	481.69
	Tomato	5,199.72	1,379.53	1,116.93	3,820.19	4,082.79
	Total	7,595.95	3,315.97	2,190.60	4,279.98	5,405.35
2	Rice	1,462.52	1,092.01	621.75	370.61	840.87
	Tobacco	2,591.49	1,620.4[illegible]	827.32	971.05	1,764.17
	Chinese Cabbage	-	-	-	-	-
	Total	4,054.01	2,712.45	1,367.47	1,341.66	2,605.04
3	Rice	1,462.62	1,092.01	621.75	370.71	840.87
	Soybean	1,129.08	609.92	318.98	519.16	810.10
	Cabbage	265.19	262.21	130.97	2.98	134.22
	Total	2,856.89	1,964.14	1,071.80	892.85	1,785.19
4	Rice	1,462.62	1,092.01	621.85	370.71	840.87
	Tomato	1,594.46	532.96	300.32	1,061.50	1,702.37
	Rice	386.46	746.30	430.06	-359.83	-43.59
	Total	3,443.55	2,371.27	94[illegible].00	1,072.38	2,499.65

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Table 5.5 ... (Cont'd)

System No.	Crops	Gross return	Cost of production		Net income	
			With labour	Without labour	With labour	Without labour
		(- - - - - - - - -	- - - - - - -Baht/rai-	- - - - - - - - -	- - - - - - - - -	- - - - - - - -)
Traditional 1	Rice	1,073.71	717.97	304.14	355.74	769.57
	Tobacco	3,198.12	1,976.18	1,113.27	1,223.94	2,084.85
	Total	4,271.83	2,692.15	1,417.41	1,579.68	2,254.42
Traditional 2	Rice	1,073.71	717.97	304.14	355.74	769.57
	Soybean	1,173.32	531.89	253.98	641.43	919.34
	Total	2,247.03	2,149.86	1,458.12	996.17	1,688.91
Traditional 3	Rice	1,073.71	717.97	304.14	355.74	769.57
	Chilli	2,446.27	1,305.37	532.64	1,140.90	2,193.63
	Total	3,519.98	2,023.36	556.78	1,496.64	2,963.20

Table 5.6: Estimated Costs and Returns to Various Systems Operated by the Farmers in the Village Programme 1976/77

the Farmers in the Village Programme 1976/77

System No.	Crop	Gross return Baht/rai	Cost of production Baht/rai	Net return Baht/rai	Net return without labour Baht/rai	Sample size
1	Rice	1,873.80	837.54	1,036.26	1,403.17	25
	Soybean	1,137.60	769.23	368.37	727.94	7
	Sweet corn	3,165.65	669.19	2,466.5	2,794.04	1
	Total	6,177.05	2,275.93	3,871.13	4,925.15	
2	Rice	1,873.80	837.54	1,036.26	1,403.17	25
	Peanut	1,137.60	769.23	896.73	1,897.32	6
	Tomato	3,210.22	1,350.96	1,859.26	2,426.64	3
	Total	6,221.62	2,957.73	3,792.25	5,727.13	
3	Rice	1,873.80	837.54	1,036.26	1,403.17	25
	Tobacco	2,587.07	1,733.34	853.73	1,775.2	6
	Peanut	610.50	977.66	336.36	201.08	6
	Total	5,071.37	3,547.94	1,523.63	3,379.45	
4	Rice	1,873.80	837.54	1,036.26	1,403.17	25
	Garlic	3,908.26	3,524.15	384.11	1,214.01	6
	Mungbean	145.02	474.70	-329.68	-105.68	4
	Total	5,927.08	4,836.39	1,090.69	2,511.3	

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Table 5.7: Crops Ranked by Selected Criteria in the Village Programme 1975/76

Net income		Cost of production		Labour used (high to low	Cash cost (low to high)
Counting labour cost	Not counting labour cost	Counting labour cost	Not counting labour cost		
(high to low)		(low to high)			
Tomato (hot season)	Tomato (hot season)	Ch. cabbage	Ch. cabbage	Chili pepper*	Rice (hot season)
Tobacco*	Chili pepper	Soybean	Soybean	Tobacco*	Rice*
Chili pepper*	Tobacco	Tomato (cool season)	Soybean	Tobacco	Ch. cabbage
Tomato (cool season)	Tobacco	Soybean	Rice (hot season)	Tomato	Tomato
Tobacco	Tomato (cool season)	Rice*	Rice*	Tomato (hot season)	Soybean*
Soybean	Soybean	Rice (hot season)	Soybean	Rice (hot season)	Soybean
Soybean	Rice (wet season)	Peanut	Tomato (cool season)	Peanut	Rice (wet season)
Rice	Soybean	Rice (wet season)	Peanut	Rice*	Peanut
Rice*	Peanut	Chili pepper*	Tobacco	Rice (hot season)	Tobacco*
Peanut	Rice	Tomato (hot season)	Tomato (hot season)	Soybean	Tobacco
Ch. cabbage	Ch. cabbage	Tobacco	Tobacco*	Soybean	Chili pepper*
Rice (hot season)	Rice (hot season)	Tobacco*	Chili pepper	Ch. cabbage	Tomato (hot season)

* Traditional

Table 5.8: Systems Ranked by Selected Criteria in the Village Programme 1975/76

Counting labour cost (high to low)	Not counting labour cost (high to low)	Counting labour cost (low to high)	Not counting labour cost (low to high)	Labour used (high to low)	Cash cost (low to high)
Rice-Peanut-Tomato	Rice-Peanut-Tomato	Rice-Soybean-Cabbage	Rice-Soybean-Cabbage	Rice-Peanut-Tomato	Rice-Soybean-Cabbage
Rice-Tobacco*	Rice-Chili*	Rice-Chili*	Rice-Chili*	Rice-Chili*	Rice-Soybean*
Rice-Chili*	Rice-Tobacco*	Rice-Soybean*	Rice-Soybean*	Rice-Tobacco-Ch. cabbage	Rice-Chili*
Rice-Tobacco-Ch. cabbage	Rice-Tobacco-Ch. cabbage	Rice-Tomato-Rice	Rice-Tomato-Rice	Rice-Tobacco*	Rice-Tomato-Rice
Rice-Tomato-Rice	Rice-Tomato-Rice	Rice-Tobacco	Rice-Tobacco*	Rice-Soybean-Cabbage	Rice-Tobacco*
Rice-Soybean*	Rice-Soybean-Cabbage	Rice-Tobacco-Ch. cabbage	Rice-Tobacco-Ch. cabbage	Rice-Soybean*	Rice-Tobacco-Ch. cabbage
Rice-Soybean-Cabbage	Rice-Soybean*	Rice-Peanut-Tomato	Rice-Peanut-Tomato	Rice-Tomato-Rice	Rice-Peanut-Tomato

Traditional

production. Chinese cabbage[1/] and soybeans[1/] required the least input. Cool season tomatoes had a lower production cost than hot season tomatoes (whether or not labour cost was included). Tobacco required the most input per rai when labour was counted, but chili was the third most profitable crop. It was the most costly crop to grow, requiring the greatest amount of labour, and it remained in the field longer than any other crop.

In terms of systems, the most profitable system was Rice-Peanut-Tomato[1/] followed by Rice-Tobacco[2/] and Rice-Chili[2/] when labour was included in the calculation. Rice-Soybean-Cabbage was least profitable because of the high cost of production. The system which required most cash was Rice-Peanut-Tomato but this had the best cash return. In general the systems which gave a good cash return normally required extra work and capital investment. It also became clear that some of the more promising systems were too risky because of insect and disease problems in the off-season for such crops as: cabbage, chinese cabbage and tomato.

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Comparison with the MCP Experimental Plot Results

It is to be expected that crop production on an experimental station will take more resources than in a farmer's field. Comparing Tables 5.1 and 5.5 it is apparent that only the production costs of tomato in the hc season in the MCP plot was less than that in the farmer's plot. However, the net returns appear to be in the opposite direction. Net returns were higher in the experimental plots than in farmers' fields,except for hot season tomato and soybean.

In terms of component crops Tables 5.2 and 5.3 and 5.7 and 5.8 indicate that both cool and hot season tomatoes performed well both in the MCP and the village plots in terms of net income. Hot season rice produc a higher net income than the wet season rice in the MCP plots but the reverse was the case in the village due to the poorer water supply. Pean production was similar in both places, but required rather high costs (including labour) at the MCP plots. At the village plots it gave a good net return, but less than chili peppers and tobacco. Soybeans gave a low net return at the MCP plots, but it gave moderately good return on the farmers' plots. Production costs were very much lower for soybeans grown on the village plots, especially when labour was considered.

In summary, the Rice-Peanut-Tomato system was the most profitable system in both places. Rice-Soybean-Cabbage produced very low returns, because of the poor cabbage crop in both places and Rice-Tomato-Rice was moderately successful.

1/ = New system

2/ = Traditional system

The team concluded that the most promising systems for further extension trials are:

1. Rice-Soybean-Sweet corn

Rice and soybean double cropping is well known in the area and a third crop of sweet corn has the advantage of utilising the residual fertility from the soybean crop. Sweet corn also requires little labour and fetches a good, although not assured, market price.

2. Rice-Peanuts-Tomato

Again the double crop is well known and tomatoes can be grown on the peanut beds, thus reducing the labour requirement. The new heat-tolerant tomato varieties (L-22) yield well in the hot season and fetch a high price.

3. Rice-Tobacco-Peanuts

Rice and tobacco are already extensively grown, the latter being assured of a guaranteed price from the tobacco kilns. The peanuts are grown on the tobacco beds and utilise residual fertilizer. They are also heat tolerant and require little labour.

Experience from the Programme

The test plots also demonstrated the superior yields and incomes of the new non-glutinous varieties of rice. Average yields were increased from 60-95 *thang* per rai and income from 1,100 Baht to 1,800 Baht per rai. However, the non-glutinous rice was not acceptable for home consumption and the increased yields were thus irrelevant in the context of providing self-sufficiency in rice production. Because of the small landholdings in the test villages after planting sufficient glutinous rice in the wet season to meet home consumption requirements, there was little or no land remaining on which a cash rice crop could be grown.

The early planting of rice also created a severe problem of bird damage, since the rice maturing ahead of the main crop attracted the full attention of the local bird population. There appears to be no ready solution other than synchronous maturity of the village rice crop which results in a more dispersed bird attack. The team did, however, find that rice stem borer could be controlled in the field by applying BHC only once or as needed, as opposed to the standard recommendation of three applications.

The test plots also demonstrated the value of rhizobium inoculation in improving soybean yields. Originally farmers were encouraged to plant soybeans in beds following the rice crop. Yields were higher but the greater return was more than eliminated by the higher cost of land preparation. Subsequently the team adopted the traditional farmers practice of

planting soybean directly into the rice stubble, after burning off the r stalks. The latter practice appears to control weeds and pathogens and ash is likely to increase potassium levels in the soil.

As far as peanut is concerned, the test plots demonstrated the ben fits of liming. Initially the recommendation was to plant peanuts in tw rows per metre bed, but the farmers' practice of 3 rows per metre bed proved to be more productive.

Garlic production in the test plots demonstrated the value of fert lizer and herbicide applications. However the farmers maintained that fertilized garlic results in seed shrinkage and hence a lower percentage germination. Experience also showed that RD1 rice straw is an inferior mulch to local rice since it decomposes more quickly and is of shorter stature.

The test plots also demonstrated the residual effects of fertilize applied to tomatoes on the subsequent rice crop. The farmers, though, maintain that heavy and frequent use of chemical fertilizer results in soil compaction.

Problems and Constraints

The most serious physical problem encountered in the test villages was the unreliability of irrigation water, paticularly in the dry season. By contrast, in the wet season many of the farmers suffered from excess water due to inadequate lateral canals and poor drainage systems. Draina mainly consists of the passing of water from one plot to another.

The matching of crops to land elevation also caused problems in the test villages. Farmers were recommended to grow rice on the well irrigated low-lying land, soybeans at the intermediate level and peanuts or oth field crops on the high elevations. However these recommendation were frequently ignored, largely because of the fragmentation of land holdings. In consequence rice is often grown on elevations above peanuts, or other field crop plots, resulting in irrigation water leaking from the former i to the latter.

Pest problems, particularly birds, rats and insects, were often serious in the test villages. There were also losses due to crops being stolen when planted on land distant from the residential areas of the village.

Attempts to intensify multiple cropping were constrained by a shortage of farm machinery, particularly the unavailability of tractors for hire, which were needed to shorten the turn-around time between crops in the sequence. A futher constraint was the lack of seed at critical times and its poor germination qualities.

Marketing of crops in the introduced systems suffered from low prices ;ived for the second and third crops in the sequence. Lack of ready or / access to processing and canning factories also caused problems with ishable crops such as tomatoes, cabbage and other vegetables.

Farmer attitudes and practices were also observable constraints to ensifying multiple cropping. For example the tradition of transplanting ng carried out by the women and children, and ploughing and land prepara- n by the men, resulted in longer turn-around times in the cropping uence. In the hot season the preparation for and participation in tivals reduced the attention given to cropping at that time.

Finally it was observed that much of the extra income generated by e profitable multiple cropping tended to be spent on clothing, recreat- on and the purchase of "luxury" goods rather than being reinvested in farm. In a number of cases successful farmers left farming and set up traders or commercial drivers.

The problems encountered in the testing villages is an indication of necessity for such a testing phase in multiple cropping research. It o demonstrates that a very large number of farmers are constrained in ious ways from operating under the conditions for which 'optimum systems' designed.

A portrait of the Valley systems and the constraints to increasing intensity

It becomes obvious that if the work of any multiple cropping research p is to serve the needs of the majority of the farmers for whom it is ring, rather than a single group following a particular strategy, then arch must consider the constraints faced by all groups of farmers.

The MCP testing villages are, if anything, relatively well endowed regards multiple cropping infrastructure compared to a large number of lages in the Valley. This section attempts to portray the more common straints to increasing system profitability that are likely to be erie. ed in the more common systems that are actually operating through- the Valley.

gle Cropping Systems

As we have seen in Chapter 3, the majority of these systems are mono- pped rice systems, using traditional glutinous rice varieties, trans- nted in July or August when water (rainfall supplemented by irrigation) usually adequate. The rice remains in the ground for about 120 days, usually ruling out the possibility of a second crop from rainfall e. They usually occur in unirrigated, rainfed areas in the poorer itional irrigation systems, in RID areas distant from the main canals in flood-prone areas, although here the single rice crop is grown after

the threat of flooding is over. Although other monocrop systems do exist, usually of high value crops such as tobacco, they tend to be on higher land that cannot be used for rice or on land surplus to that needed to gr the household's rice subsistence requirement.

Single cropping systems are usually characterized by the existence of obvious major constraints to increasing cropping intensity; lack of adequate dry season water probably being the most common. Inadequate labour may be a constraint to some of the larger land owners, but this ca often be overcome by renting the land in the dry season to landless farme Other, generally less common and more subtle, constraints may include lac of capital, credit, markets or knowledge and unwillingness to risk a dry season crop.

Double Cropping Systems

These are generally found in the better traditional irrigation schemes where some dry season water is available, across large areas of the RID schemes and in areas of good all-year-round water supply which, however, are prone to water-logging at the end of the wet season. They ar also found in some tube-well areas or on the higher elevation land in some triple-cropping areas (see Chapter 3).

A considerable number of these systems tend to be owner-operated in the rainy season for glutinous rice and then tenant operated, usually for high-input, high-return crops, in the cool season. At the high input end upland crops such as garlic or tobacco follow short-season glutinous rice or R.D. varieties, while at the low input end traditional glutinous rice varieties are followed by a low-input crop such as soybean, peanuts or non glutinous rice in the warm-season.

The benefits of going to triple cropping in some of these systems ar less obvious than in the change from single to double cropping. Indeed, in some double cropping systems no water or time constraint appears to preclude a change to triple cropping but the potentiality for increasing cropping intensity is not exploited. It may simply be that the attendant risks are too great for the farmer, or that double cropping is in fact superior to triple cropping in these instances.

The constraints to triple cropping are thus generally difficult to define. Labour and credit constraints are probably important along with the fact that the tenant who rents the land only in the dry-season is constrained by being unable to manage the wet-season rice crop in such a way as to permit triple-cropping. Another major constraint within the farm is the height of the field. Low lying fields tend to be prone to water-logging after the rice harvest or the harvest is delayed due to flooding earlier in the season, thus precluding the early planting of the second crop and leaving insufficient time for a third crop to be grown. On the other hand high elevation fields tend to be more difficult to irri gate when water is scarce in the dry-season. Thus sometimes it is only in

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be medium elevation fields where triple cropping can be undertaken with ay confidence.

Because of the higher sensitivity of the high input double cropping nd all triple cropping systems to turn-around time and planting-date of he second crop, time delays are very important constraints. These arise rom the tendency of some fields to be water-logged at the end of the rice rop, from lack of irrigation water at, and immediately after, second crop lanting times (due to closure of canals for maintenance) and from in- ufficient labour at the right time. A high subsistence demand in the ainy season may also preclude the use of short duration (lower yielding) lutinous rice or non-glutinous RD rice varieties.

riple Cropping Systems

The main characteristic of the triple cropping areas is their good ter supply. They are usually found in a number of small areas in the D systems, usually near to the main canals, in areas where traditional stems complement the RID schemes, in tube-well and dug-well areas and in e smaller side Valleys where traditional irrigation schemes, taking ter from the mountain streams, are more reliable throughout the year, r example areas in Chomthong (see Chapter 3). Triple cropping systems e usually either owner operated or single tenant operated for all 3 ops and are characterised by the use of short duration glutinous rice rieties or RD varieties harvested in October/November. Another dis- nguishing characteristic seems to be a high input, high return second op such as garlic or tobacco followed by a low-input, upland, catch-crop RD rice in the third season. Another type of system common in the dug- l area is glutinous rice followed by vegetable crops (often cabbage). this system cropping indices as high as 500 are sometimes achieved.

Constraints to increasing the profitability of triple cropping tems are much more difficult to pinpoint but probably include labour, ital and time constraints and the fact that some systems are precluded, ause of the elevation of the field and its susceptibility to either er-logged or dry conditions at different times of the year. Attempts to rease the profitability of triple-crop systems are also likely to in- ase the risk involved and certain systems may be undesirable for this son.

Means of increasing productivity may include allowing earlier plant- dates for the planting-date-sensitive second crops, thus ensuring ner yields and prices. Another means may be the fuller utilization of system properties emanating from interactions between the crops in the tems (see Chapter 6).

Constraints at the Valley Level

In pursuing their goals farmers are constrained by a variety of physical, economic, social and political limitations. They may also be constrained by the demand of conflicting goals or values which they also hold. If the most significant of these can be overcome, at least in part, then presumably agricultural production and the well-being of farmers and their families in the Valley will markedly improve. However, although a considerably effort is being made to identify and quantity the effects of the existing constraints, their relative importance is still difficult to assess.

Lack of water is likely to prove the most significant constraint to increased crop production. The observations and experience of the MCP team suggest that in most, if not all, parts of the Valley farmers are able to make good, if not necessarily optimal, use of water throughout the year providing the supply is reliable and secure. However, there is also evidence that more dry season water is available than is currently being used; thus a marked increase in cropping intensity in the Valley can possibly be brought about by improving water use efficiency.

Although the existing marketing system in the Valley is working relatively efficiently it is characterised by wide fluctuations in price which reflect a changing supply-demand balance and farmers may thus be constrained from adopting new cropping systems on the grounds of risk. In general, although a number of work traditions and values held by the farmer hinder increased cropping intensity, experience suggests that these are not severe constraints.

Farmers in the Valley are generally innovative and enterprising, particularly with respect to introducing new crops and the techniques associated in the growing of individual crops.

But, even if the information is available, new crops and systems will not be adopted if the inputs (seed, fertilizers, labour or machinery) are unavailable at the right time, are not of the desired quality or are too expensive. Inputs must be priced so that the expected return from their use is several multiples (perhaps at least three) of their cost. Seeds of good quality are often unavailable when required.

Many of the inputs required have to be purchased and unless farmers have the necessary working capital, credit is required. In Thailand mechanisms for the provision of agricultural credit are still being developed.

The lack of formal land titles by farmers hinders the expansion of institutional credit. The form of land tenure may also be a general constraint to the intensification of cropping systems. Landlords may set restrictions on what crops are to be grown and tenants may have little incentive to institute medium or long term improvements to the land.

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Rice bears an output tax through the operation of the rice premium. Part of the tax is collected by the government on export of the crop. The other, larger, part is collected by the consumer in the form of lower prices. Rice prices to the producer are thus low compared both with other crops and international rice prices. This is one, although perhaps not the most important, reason why the new shorter duration, fertilizer responsive rice varieties that may remove some of the time constraints associated with increasing cropping intensity, are being only slowly adopted in the rainy season. The return to use of fertilizer is not sufficiently attractive. Labour and machinery become critical constraints where intensive multiple cropping requires rapid crop turn around times. Shortages of labour arise where off farm employment in industry, craft manufacture or tourism related activity is an attractive alternative. Family labour may also be unavailable at critical periods because it is committed to neighbouring farms as part of a traditional labour exchange scheme (see Chapter 6). Tractors are still not readily available for hire and costs are rapidly increasing with the current oil price rise.

CHAPTER SIX

SYSTEM PROPERTIES

1. Introduction

A system can be most usefully defined as a set of components that interact with one another in such a way that, in many important respect they behave as a whole entity. Each component has its characteristic behaviour but the pattern of interaction between the components, the to logy of the system, is such that the behaviour of the whole system is m than a mere summation of the behaviour of its components. For example, the yield response of a field of rice to fertilizer application or to drought is not the simple summation of the yield response of individual plants treated and measured in isolation. Rice plants compete with one another for nutrients and water and this affects the final yield of a r field in a complex manner.

When conceptualizing a system it is useful to consider the elemen listed in Table 6.1 An agricultural system typically, although often n exclusively, has the purpose of producing plant and animal crops for f or fibre. Such systems, since they contain living components are often also ecological systems and may be termed agro-ecosystems.

The identification of a system and its boundary is the first and ten most significant task of systems analysis. The wrong choice may re in eventual findings which are too limited or inapplicable in terms of original purpose of the study. Systems, however, usually occur in a hi archy, the boundaries of one containing all or part of the boundaries o the next down in the hierarchy and it is essential to consider also the systems in the hierarchy up and down from the focal system of the study and of course, the neighbouring overlapping systems. There is, then, le chance of ignoring important properties and interactions.

Some systems are strong, with well defined boundaries and signific system properties, others are weaker and more poorly defined. In this study which is aimed at examining the relevance and future direction of MCP research programme, we have taken as our primary focus the continuo paddy land system of the Chiang Mai Valley. But we have also gone up t hierarchy looking, for example, at national planning and policy and exa ing the influences on and interaction with the Chiang Mai Valley. We h also gone down the hierarchy examining the RID systems, the village, th farm and the field or field plot, as well as looking at the relatively we er systems of the Amphur and Changwat. Our secondary focus has been th field plot, since it encompassess the multiple cropping system, that is the pattern of cropping involving a discrete sequence or rotation of cr grown on a single piece of land in a year. The crops are the principal components of the system at this level. They have relationships with e other through time and also interact with each other through the physic biological, economic and social processes of the larger farm and villag systems.

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Table 6.1: The major elements of a system, with examples drawn from a typical multiple cropping system in the Chiang Mai Valley. Any concept of an agricultural system must include these elements as a minimum (after Spedding, 1975).

	EXPLANATION	HYPOTHETICAL MULTIPLE-CROPPING SYSTEM IN THE CHIANG MAI VALLEY
PURPOSE	Why is the system being operated?	Subsistence rice production and the generation of cash income be selling cash-crops.
BOUNDARY	Determines what is inside the system and what is external to it.	Field boundary of the field where this cropping system is being followed.
CONTEXT OR ENVIRONMENT	The external environment in which the system is operating.	Weather, price movements, economic infrastructure, household size, etc.
COMPONENTS	The main elements that are related to form the system.	The crops grown in a one year period, e.g. possibly rice, tobacco, cucumber.
INTERACTIONS	The relationships between the components.	The effect of the carry-over of tobacco pests to the cucumber crop, etc.
RESOURCES	Elements lying within the system that are used up in it's functioning.	Soil nitrogen, soil-moisture, etc.
INPUTS	Materials used by the system but originating from outside.	Fertilizer, manure, pesticide, irrigation-water, labour, etc.
PRODUCTS OR PERFORMANCE	Main desired outputs.	Paddy, tobacco-leaf and cucumbers.
BY-PRODUCTS	Useful but incidental outputs.	Rice-straw, used for: roofing material, animal-fodder, mulching, etc.

2. The Properties of agro-ecosystems

System properties can be of a physical (e.g. soil-structure), biological (e.g. disease-levels), managerial (e.g. crop turn-around time) or economic (e.g. cash-flow) nature. The most important properties of agro-ecosystems, however, are their productivity, stability and durability. These are complex properties, capable of various definitions. Productivity, for example, may be in terms of biomass, reproductive potential, agricultural yield or in terms of social or economic return, but these are all measures of some increment in the system which can be removed and utilized. Stability by contrast is a measure of how a system resists or recovers from a disturbing factor from outside the system. A highly stable system may show virtually no response to disturbance, a less stable system may show a response marked, for example, by a drop in yield but recover quickly. A very unstable system will show very dramatic fluctuations under the influence of a factor such as the weather. Durability is a measure of the long term productivity. A continuing or recurrent disturbance may stress the system; it may remain stable for a while but eventually change under the influence and decline in some property, such as yield. Sometimes the decline may be very sudden following a large disturbance and perturbation to the system. The perturbation itself may be sufficient in itself or may only be effective if the system has suffered from a period of stress. Holling (1973) has used the term "resilience" to describe the ability of systems to retain their structural integrity under disturbance. There is evidence both from experiment and observation that ecological systems may flip from one state to another under severe perturbation.

Agricultural systems are derived from natural ecosystems through human modification and management. The resulting systems are simpler and can be thought of as equivalent to the early stages of the natural ecological succession. Agro-ecosystems are thus highly productive but also inherently undurable. Without continued management they would change rapidly and proceed towards a natural climax vegetation that was stable but of little agricultural value. This potentially unstable position in the succession is maintained by complex control mechanisms that include cultivation, sowing, pest-control and other management activities.

Natural ecosystems with large inflows and outflows and with small reserves, such as estuaries of rivers, usually suffer large fluctuations (Elston *et al.*, 1976). Intensively managed agricultural ecosystems are similar in the size of these inflows and outflows and reserves. They are thus similarly unstable and despite careful management and tight control can exhibit yield fluctuations as a result, for example, of climate and other disturbances from outside (Snaydon *et al.*, 1976). The trend of increasing integration of agriculture with the economic system means that agricultural systems are also susceptible to economic disturbances. The effect may be simple, for example a fluctuation in income, or it may be more complex: falling market prices or increasing costs, for example, may cause the farmer to respond by using a lower level of production-enhancing inputs, thus causing yield fluctuations.

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In the longer term the complex interaction between management activities and the biological and physical processes of the agro-ecosystem may affect the durability of the system. Stresses may be set up, for example, by the progressive movement of the water table in irrigation, or by frequent spraying or by the periodic flooding and drying of paddy land soil. These may bring about the salinisation of irrigated land, or the build up of eventually unmanageable pest populations or, as appears to be occurring in the MCP plots, a gradual decrease in soil pH levels causing manganese toxicity problems.

Cropping also takes up considerable quantities of nutrients and trace elements from the soil which are removed from the system with the harvest. The long term durability of the system thus depends on those essential materials being replaced and made available to future crops. Traditional 'closed' systems rely on the natural recharge of those materials by the environment (often during a period of bush or forest fallow) and by 'on-farm' recycling. However as the nutrient demands of the higher productivity levels overtake the natural recharge rate and as the crops are consumed in areas distant from the site of production, thus limiting 'on-farm' recycling, then inputs of these materials from other areas of the economy becomes necessary. An important consequence is that the long term durability of the agro-ecosystem becomes economically as well as ecologically based.

Although there is an important distinction between stability and durability there can be strong relationships between them. For example, large fluctuations in yield from year to year (low yield stability) can reduce the longer term economic durability of the farm system by creating unworkable cash flow problems which lead to economic collapse of the farming system. Low yield stability may also affect the ecological durability of the system. For example, in a grazing situation of inflexible stocking-rate, large fluctuations in herbage production below the mean can lead to over-grazing and soil-erosion problems. Large fluctuations above the mean can lead to under-grazing, causing detrimental changes in sward composition.

Management practices or technological innovations to increase yield stability may also affect the durability of the system. In some cases the effects will be beneficial to both stability and durability. For example it has been shown that by practicing intercropping, annual yield perturbations from insect pests can be reduced (Banta and Harwood, 1975). In addition intercropping can be useful in reducing soil erosion problems by providing more efficient ground cover for a longer time (Beets, 1978). Conversely the practice of applying insecticide will, in the short term, reduce yield fluctuations attributable to pests; but the practice may cause pest resurgence, secondary pest and pesticide resistance problems thus reducing the longer term ecological durability of the system (E.M.U., 1980).

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3. The Chiang Mai Valley agro-ecosystem

Context.

The paddy land which is our primary focus accounts for only 10% of the total land area of the whole Valley, although agriculturally it is the most productive. The Valley also contains uplands and highlands, the latter occupying approximately 80% of the total area. The Valley is also one of many in the Northern Region which together form the main catchment area of the Chao Phya River which drains into the Gulf of Thailand. The Northern Region, in turn, is one of the four main administrative units of Thailand.

Many interactions occur between the paddy land and the larger systems in which it lies. For example deforestation and agricultural activities in the upland and highland regions of the Valley and in the smaller valleys which form the upper catchment areas of the Ping River, affect water supply in the Chiang Mai Valley system. Major decisions on water-use in the Valley must in turn be made in the larger context of national utilization of the country's water resources and have to take into account the needs for irrigation, navigation and flood control in the Central Plain as well as national hydro-electricity generation (see Chapter 4, Section 2).

The higher elevation regions outside the system may also have important agricultural interactions. For instance, the Valley population are consumers of upland and highland agricultural produce and these areas in turn supply agricultural inputs in the form of bamboo and other timber, seed potatoes, strawberry seedlings and indirectly in the form of pasture for water buffalo which are often grazed outside the system boundary when not needed for land cultivation.

The Valley.

The Valley is a strongly defined system, characterised by very clear structural integrity, geographical isolation, and a high position in the hierarchy of systems described above. But it is also very diverse in agro-ecological terms.

While there are no measures for productivity of the Valley system, as such, various measures are available for the Changwats of Chiang Mai and Lamphun. Conventional measures are gross provincial product and gross agricultural production by crops. In virtually all cases these have increased over the past few years reflecting the influence of the spreading irrigation schemes, better infrastructure, transportation, markets, better varieties of crops and knowledge from extension and other sources, and a better use of the comparative advantages of these different sub-systems which these improvements have facilited. Contributions to overall productivity have also been made by the various extraction and manufacturing industries, by craft manufacture, and by tourism.

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Measures of stability have been portrayed in Chapter 3. As was seen, oduction and prices of soybean and mungbean have remained fairly stable it there have been wide fluctuations in production and prices of garlic d tomato. In general we might expect that many of the factors increasing oductivity such as more reliable irrigation, better transportation and re accessible marketing will also promote stability. But better communi-itions between the Valley and the outside world exposes farmers to greater mpetition and to world price fluctuations which may reduce the stability prices and production.

In some cases the agro-ecological diversity of the Valley as a whole y counter the instability shown by particular subsystems. For example, ove-average rainfall, while causing problems in flood-prone areas, may prove water supply in poor irrigation areas and vice versa.

Durability is more difficult to assess. The only major perturbation at the Valley has experienced in recent years was the massive fertilizer ice increase of 1973. This happened to coincide with extra heavy rain-ll and the slump in production of paddy rice and garlic probably were sociated with this. In general, however, the Valley seems to be adequate-absorbing and accommodating the fertilizer, oil price and related in-eases. One can see a variety of system adaptations: a slowing down of e substitution of buffalos by tractors, installation of electric pumps r tube wells rather than petrol pumps, etc. In the future we might ex-ct more reliance on legumes for nitrogen as a substitute for high-priced rtilizers.

An example of how durability can be maintained by Valley system operties is illustrated by the case of garlic seed production. A large mber of garlic growing areas in the Valley are deficient in boron. In e first few years of the use of new seed-stock there are no problems as e seed contains sufficient levels of trace elements to sustain mature ant growth. However, after one or two years of using the same seed-stock ace element levels are reduced and deficiency symptoms appear in the op. The Valley system has adapted to this by certain naturally high soil-ron areas becoming seed-stock producing regions from which farmers obtain w seed-stock every few years.

lley Subsystems.

During our analysis it has become clear that a number of distinctive bsystems occur in the Valley. Their boundaries typically encompass veral villages and in some cases several amphurs. They are primarily fined in terms of the availability and reliability of water supply, with ctors such as access to markets and processors, opportunities for off-rm employment and distance from Chiang Mai also playing a part.

Figure 6.1 and Table 6.2 describe the main systems.

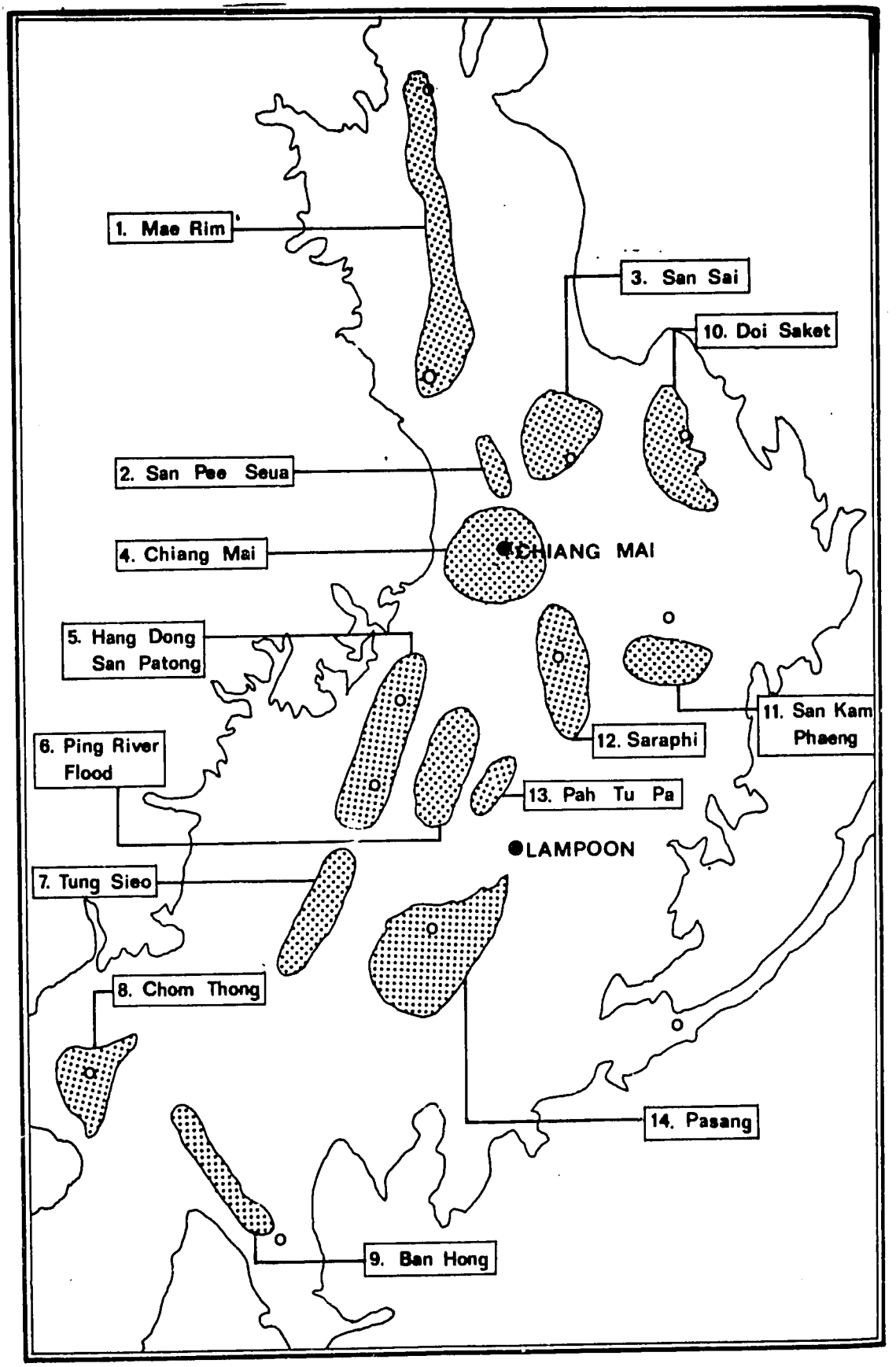

Figure 6.1 Subsystems within the Chiang Mai Valley

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Table 6.2: Characteristics of the Valley subsystems.

Subsystem	Features
1. Mae Rim	Narrow stretch on the upper Mae Taeng Project, dominated by rice-tobacco double cropping patterns.
2. San Pee Seua	Lower end of Mae Fack Project and along the Ping River with rich recent alluvial soils; rice followed by continuous vegetables.
3. San Sai	Water supply from Mae Fack Project; rice-soybean and rice-tobacco; soybean-seed production on high elevation land in wet season.
4. Chiang Mai	Urban, high tenancy rate.
5. Hang Dong - San Patong	Lower end of Mae Taeng Project;rice-soybean, rice-rice, rice-tobacco and to a certain extent rice-vegetables; water insufficient in hot season.
6. Ping River Flood	Flood prone area in wet season;non-photosensitive glutinous and non-glutinous rice grown in wet season only.
7. Tung Sieo	Lower end of lateral canal 23 of Mae Taeng and along San Patong-Tung Sieo subsystems. Traditional irrigation water supplements RID system in hot season. Rice-soybean, rice-rice double cropping and rice-soybean-rice triple cropping.
8. Chom Tong	Traditional irrigation system only. Rice-garlic-rice, rice-garlic-mungbean and rice-garlic-vegetables. Garlic is planted relatively later than in other areas.
9. Ban Hong	Three crops, rice and vegetables rice-garlic-vegetables. Dug wells.
10. Doi Saket	Upper section of Mae Kuang Project where water in the hot season is more reliable than other parts within the project. Rice-peanut, rice-garlic double cropping.

Table 6.2 ... (Cont'd)

Subsystem	Features
11. San Khamphaeng	Tube-well areas, rice-peanut double cropping. Weaving, bamboo work, handicrafts.
12. Saraphi	Traditional irrigation systems of Mae Ping and Mae Kuang. Rice-peanut, rice-vegetables, rice-rice.
13. Pah Tu Pa	Within Mae Ping Kao Project; rice-peanut, rice-garlic and soybean-garlic-vegetables on high elevation plots. Lamyai orchards. Intercropping in orchards.
14. Pa Sang	Tube-well area with triple cropping of rice-garlic-mungbean, rice-garlic-rice and rice-garlic-shallots.

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Village.

Village system properties reflect the choices and performance of cropping systems that would not occur if groups of people did not live in coherent and tight-knit village communities. Villages originally arose because a group of people found that such communal living was mutually beneficial, for example in reducing the individuals' risk of starvation or in supplying the optimal number of people to construct, maintain and use a local irrigation system. Communal organization of such activities as the construction and repairs to an irrigation system and the timing and rotation of water supply enhance the productivity of the system over that attainable by individual farmers acting alone.

The village in the Chiang Mai Valley is also an important level of organisation for agricultural information. The village headman is instrumental in determining the progressiveness of a village and what new agricultural information flows into the village. Calavan (1978) maintains that once one farmer in the village has new information then it is rapidly disseminated throughout the village by informal conversation and observation. Information flow between villages may not be so rapid or complete, however.

Probably the most important village-level benefit arises from the sharing of labour. Farmers must rely primarily on within-village labour to overcome labour peaks in their cropping patterns (Potter, 1976). Although individual farm systems will be designed to utilise household labour as efficiently as possible (this does not necessarily mean maximising returns to labour) there may be periods when extra help is required either in the form of hired labour or as labour-exchange. Thus when farmers plan their

own cropping systems they must consider their labour requirement taking into account the labour supply situation of the 'village-system'.

Within any village there are usually a small number of exchange labour groups (see Potter, 1976) where individuals will work together on each other's farms and receive an equivalent amount of work on their own farm in return. This practice increases labour efficiency by allowing economies of scale to labour input. Labour exchange is invariably practiced for transplanting and harvesting the wet season rice crop. It helps to remove some of the drudgery associated with these processes and, being a group activity, it also acts as a forum for the exchange of agricultural information within the village. However, if a farmer is committed to an exchange labour group then he may be constrained from following various systems on his own farm. For example the planting of early second crops such as garlic or tobacco occurs at a time when labour may be committed to an exchange labour harvesting group. Thus a traditional stabilizing practice for sole cropping may act as a constraint to multiple cropping. There is also the danger that if labour exchange is dropped by some farmers in order to increase cropping intensity then the farmers who are constrained from increasing intensity for other reasons may no longer be able to rely on this stabilizing practice for their all-important subsistence rice crop.

A similar dichotomy exists with respect to land tenure. Lack of ownership may inhibit more intensive cropping but the village pattern of land tenure probably maintains stable cropping rotations within the village. Calavan (1978) has shown that the close knit social organisation of the village allows tenant farmers to rent from a large number of landlords. This enables farmers to follow a desired constant cropping pattern from year to year. This might be difficult to follow on a single field plot, because of slippages in scheduling or poor water supply in a season. However a stable rotation can be practised by renting different land each year or even from season to season. In general the village land-rental characteristics ensure a flexibility in the choice of cropping pattern for farmers who are not necessarily constrained by what they grew in the previous season.

The stability properties of the village are, however, being challenged by changes arising from outside. With improvements in communication and increasing Government intervention in rural areas, villages are being transformed from traditional socio-ecological units to become more akin to political administrative units. Village boundaries are now defined by the Government along political administrative lines without regard to the original ecological factors that shaped them. With improvements in communication in the Valley, villages are exposed to interactions with an increasing number of other systems, the most important probably being the national marketing system and the large scale Government irrigation systems. Some of the consequences are generally beneficial, but in other cases the stresses may be too much and may result in a deterioration in the system. The rate of change in conditions is often very rapid and the village system may be unable to adapt quickly enough; this is probably exacerbated by the spatial boundaries and the administrative structures of villages now being laid down and fixed by the Government. As an example, some regional development

projects have failed to consider the village as a system in its own right and in this connection it is probably significant that much fewer water-use conflicts exist in the traditional irrigation schemes than in the large-scale Government-sponsored projects.

Well-intentioned intervention may thus fail to yield the expected results if the system properties acting at the village level are not fully considered. As we have seen, in the Chiang Mai Valley approximately one half of the farmers own all the land they farm, one quarter own part and rent the rest and the remaining quarter rent all of their land. Traditionally the renting of land has been very much on a village basis with tenants renting land from relatives, friends or other members of the village, the rent paid being a 50:50 division of the rice crop between landlord and tenant. The picture is now being complicated, however, by the question of who pays for fertilizer and other modern inputs and what should the rent be for dry season cropping in irrigated areas where this is now becoming possible. The 1974 Rice Rent Law addressed this problem by stating that the rent for the rainy season rice crop should be divided by thirds: one third going to the land owner, one third to the tenant and the remaining third to the party that paid for fertilizer and ploughing. Further, it stated that rentors would have the right to rent land for a period of six years and that any further crops grown after each year's rainy season rice crop would not be subject to any rent at all. Under this law, Dennis (1977) has shown that a landlord would maximise his income by ceasing to rent out his land and instead using his former tenants as seasonal day labourers. Clearly if this were to occur it would have a serious retrogressive effect on wealth distribution in rural areas and a disruptive effect on presently stable cropping rotations. Fortunately the law seems to have been enforced only in a few areas in the Valley, where the hypothesised changes do appear to have taken place (Dennis, pers. comm.).

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Farm.

Much less is known about the system properties of the farm in the Chiang Mai Valley. We can assumed that most farmers will practice a number of different cropping systems that complement each other in terms of labour and cash demand, household food need and by-products. This optimal pattern will probably be arrived at by the kind of process of decision making described in Chapter 4. What, however, we do not know is the effect of the fragmentation of land holdings on the system properties of the farm. It may well be that the farmer is constrained in his choices by the number, size, elevation and relative remoteness of his land parcels. Productivity is likely to be increased by the consolidation of land into a single parcel. On the other hand land fragmentation may confer some benefits in terms of stability and durability. Land of different types and different elevations may force a more varied cropping pattern which spreads risk. It may not be the pattern that a farmer would most prefer or even one that generates the most income in the short term but it may confer long term benefits.

Credit requirements of the farmers are currently calculated on a mponent crop basis (see Chapter 3 Section 4), the banks determining the edit needs of a system by summing individual component requirements. wever, cash requirements for peanut vary considerably depending on ether they are grown as a second or third crop (Thani, 1979); the require-nt for garlic will vary depending on whether straw for mulching is avail-le from other enterprises in the farm system; soybean requirements depend whether they are in a direct-sown or a bed-planted system and the credit mand for fertilizer for any crop will depend on residual fertility from e previous crop in the system.

These factors may to some extent explain the difference between the anks' estimated credit needs and the actual crop requirements when grown s part of a system (see Table 3.1). The net cash flow is the important actor when considering the credit demand for systems. For instance, to hat extent can the proceeds from the first crop supply the required capi-l for inputs to the second crop at the right time or is the cash commit-d to pay back the initial loan? This is especially important in the case a farmer following a subsistence dominated strategy who may be con-rained from improving his subsistence rice crop if these improvements quire credit, as no cash is generated by the crop to pay back the loan. us poorly devised credit schemes may in fact commit the farmer to a ubsistence-trap'.

As shown in Figure 6.2, interactions at the level of the farm system y enable the farmer to ease his credit requirements by choosing a number different systems with complimentary credit demands so that the credit aks of individual systems tend to be spread throughout the year.

Multiple cropping systems

e System Properties.

In the remainder of this Chapter we will consider the system as de-ned by the pattern of multiple cropping on a single field plot. Here e system properties are those which arise from the relationships between e component crops as distinct from component properties which arise from teractions within component crops and affect the performance of that com-nent only.

Figure 6.3 shows how the practice of sequential multiple cropping creases the management complexity over sole-cropping. Not only must oices be made on which crops to grow and how to grow them, but decisions ust be based on system properties as these determine the relative trade-ffs in the allocation of limited resources between the different component ops.

Thus, although the biological interactions in multiple cropping may t first sight appear similar to those of sole-cropping, the intensification the time dimension, which multiple cropping represents, means that some

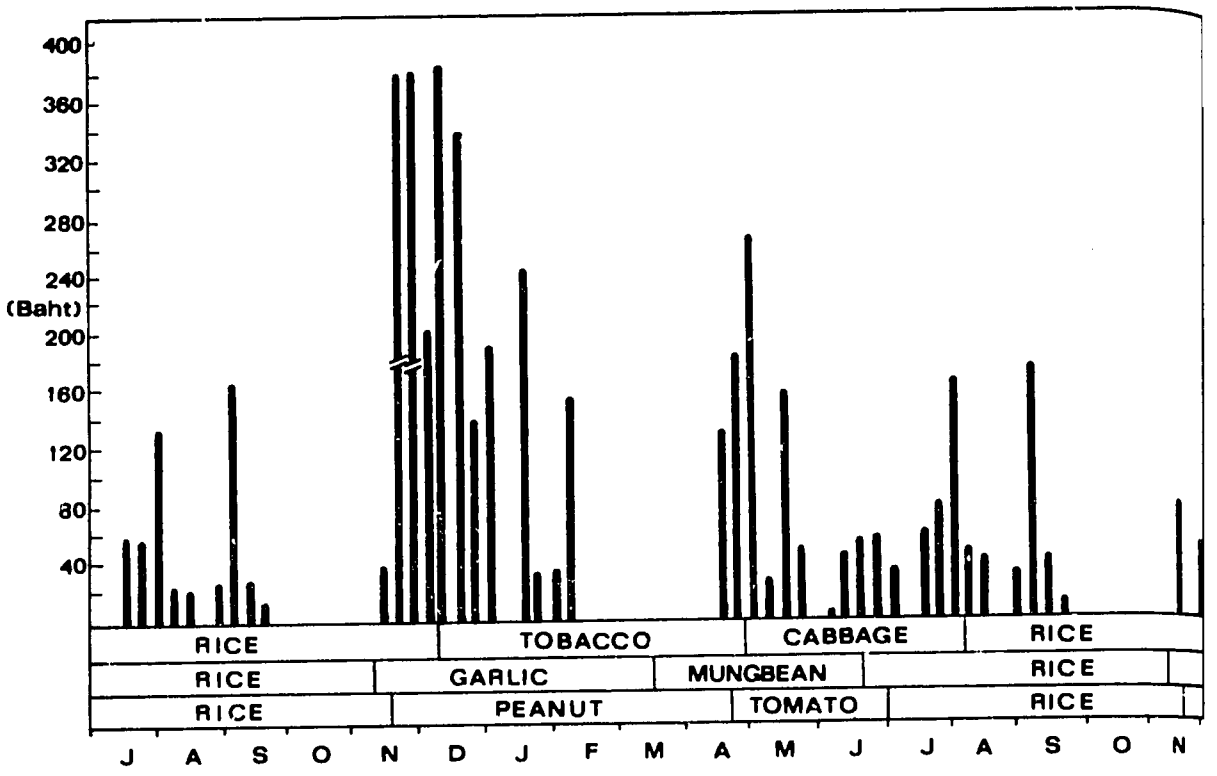

Figure 6.2 A combined cash expenditure profile from three cropping systems

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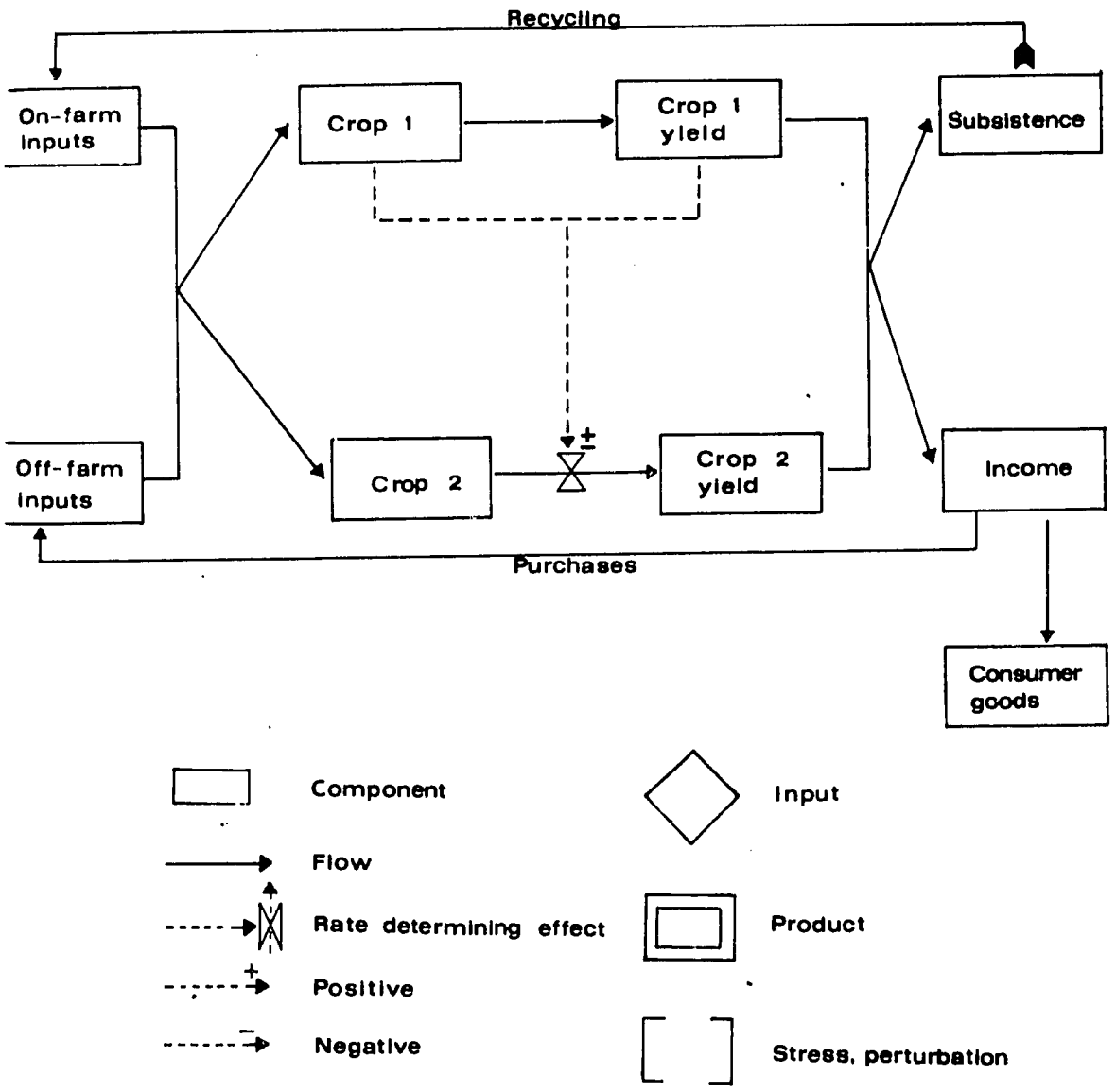

Figure 6.3 Major elements of multiple cropping systems

interactions become more critical. For example, late herbicide applicatio on one crop will be more likely to have phytotoxic effects on the followin crop, due to the reduced time available for biodegradation to occur (Litsinger *et al.*, 1976). Furthermore new forms of interaction may appear For example, pest build-up between component crops may occur because there is no longer a fallow or flood 'kill' (I.A.R.I., 1972). The distinction between system and component properties and their effects on productivity, stability and durability of the system are illustrated in Table 6.3.

Table 6.3: Distinction between system and component properties and their effects on productivity, stability and durability.

	COMPONENT-PROPERTY	SYSTEM-PROPERTY
Productivity (Mean yield levels obtained.)	Property of, or action on, one crop which increases mean yield levels in that crop. E.g. Response of crop to the fertilizer applied to that crop.	Property of, or action, (any crop which increases mean yield levels in any other crop in the system. E.g. Response of a crop to the residual fertilizer applied to a previous crop.
Stability (Variation of yields about the mean yield level.)	Property of, or action on, any crop which reduces the variations of yield about the mean level in that crop. E.g. Response of the pest natural enemy complex to increases in pest levels in that crop.	Property of, or action on, any crop which reduces the variation of yield about the mean level in any other crop. E.g. Effect of pesticide application in previous crops on the pest natural enemies of any following crops.
Durability (Long term potential productivity of the system.)	Non causal. Rate determining only	Property of, or action on, any crop which affects the productive potential for following crops. E.g. Continued sequence of flooded-rice followed by an upland-crop and it's effect on soil pH.

A good example arises in the growing of soybean after rice which has been the subject of experiment and farmer trials. As described in Chapter 5, Sections 1 and 2, the MCP found on their experimental plots that soybean

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yields were maximised by planting on specially prepared beds. The MCP, thus, initially recommended farmers in the test villages to follow rice by complete cultivation and the raising of beds before soybean planting. However it became clear that when the simple system property of interaction between crops in the time dimension (turn-around time) is considered it may be more efficient in terms of the entire system performance to direct-sow soybeans into the rice-stubble, as indeed is the practice of the large majority of farmers in the area.

System properties also result in attempts to maximise the productivity of each component in a cropping system not producing an overall maximisation of productivity of the system as a whole. This is especially true if profitability is the main criterion used. For instance component research at the MCP suggests that, an early planted R.D. rice variety followed by early planted garlic would increase cash profit levels in each component over a traditional-rice, late-planted-garlic system common in the Chom Thong area. The Chom Thong farmers, however, are constrained from planting early maturing R.D. rice varieties due to their families' high subsistence requirement for traditional rice. They must therefore plant garlic late obtaining both lower yields and lower prices. These farmers characteristically store their garlic before sale instead of selling fresh at harvest time. Storing allows advantage to be taken of the higher prices later in the year but weight-loss considerably reduces the amount available for sale (Wipoobongse *et al.*, 1979). Research at the MCP has subsequently shown that late planted garlic, although yielding less, loses considerably less weight in storage thus compensating for the lower yields obtained. The Chom Thong farmers have thus optimised their system to meet their own objectives although, when considered individually, neither component is optimal when based on profitability criteria.

Many of the important system properties in multiple cropping are a function of the effect of soil management practices on one crop upon the soil physical and biochemical properties, and water and nutrient availability of the succeeding crops. MCP research (Wivutvongvana *et al.*, 1975) has shown for example that phosphate fertilizer applied to field corn in a corn-soybean cropping sequence had less residual effect on the subsequent soybean crop when compared with the effect of phosphate applied to rice on a subsequent soybean crop. This is probably due to the higher utilization of phosphate fertilizer by field corn compared to the rice crop. Moreover, the release of soluble phosphate from paddy rice during soil submergence may contribute to the higher residual effect of phosphate fertilizer on the subsequent cropping of soybeans. Experiments also generally indicate that a cropping practice where a soybean crop is included in the sequence generally requires less nitrogen fertilizer than a system which contains no soybean.

Wivutvongvana (1979) has also shown that large amounts of Fe^{+3} and Mn^{+4} were reduced to Fe^{+2} and Mn^{+2} and released into soil solution during soil submergence (47 days). After drainage, Fe^{+2} was reoxidized quickly, within 1-2 weeks, but Mn^{+2} was oxidized very slowly and remained in the soil at a very high level (toxic to soybeans) for 1-2 months after the flooded soil was drained. Thus how soon the crop following paddy rice can

be successfully planted will become important, especially for a crop such as soybean which is relatively sensitive to manganese toxicity. Under field conditions, oxidation of Mn^{+2} to the relatively insoluble Mn^{+4} form is mainly biological (Wivutvongvana, 1979) and thus the advantage of direct seeding of soybeans into the rice stubble could be at least in part due to the higher biological activities in the rice stubble as compared to its surroundings.

The effects of a particular stress may vary dramatically with the particular cropping sequence and the timing of the stress. For instance, water-stress in a high nitrogen input crop in one season could be expected to have a destabilizing effect on yield in that crop. But in a system where this is followed by a nitrogen responsive crop such as garlic, one might expect some compensation due to the utilization of the high residual nitrogen levels unused by the first crop (Figure 6.5). However, in a system where the first crop is followed by a legume, one might expect a depressant effect on legume nodulation caused by the high residual nitrogen levels (see Figure 6.4).

Finally, certain cropping sequences or repeated management practices may affect the long-term durability of the system. As we have seen in Chapter 3 certain multiple cropping systems lead to a gradual reduction in soil pH over a number of cropping seasons and the potential productivity of the land is reduced by the associated increase in manganese toxicity problems. Other examples may include the build-up of pest, disease or weed population, detrimental trends in soil structure and soil nutrient or trace-element depletion. These trends occur because of interactions between component crops and, although the rate can be affected by component crop properties, their overall dynamics are determined by system properties.

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Multiple Cropping Research.

The importance of system properties in multiple cropping means that a fundamentally different research approach from that employed in sole-cropping is required. A review of the literature would indicate, however, that no new research methodology, tailored to the specific needs of multiple cropping, has so far been developed. The reason may be partly historical. The practice of multiple cropping is older than scientific agricultural research and thus has never been considered as a new technique meriting its own research methodology. Today most scientists working on multiple cropping are primarily interested in specific aspects of component crop research and tend to pay little attention to entire-system performance. Furthermore at the outset, multiple cropping research requires a heavy emphasis on component crop experimentation focussed on such questions as planting-dates, fertilizer-rates, variety-trials and so on and traditional sole-cropping research methodology can conveniently be used for this stage.

Undoubtedly a major proportion of the gains in productivity accrue from component properties and to date most multiple cropping research throughout the world has concentrated on exploiting this potential. However, the

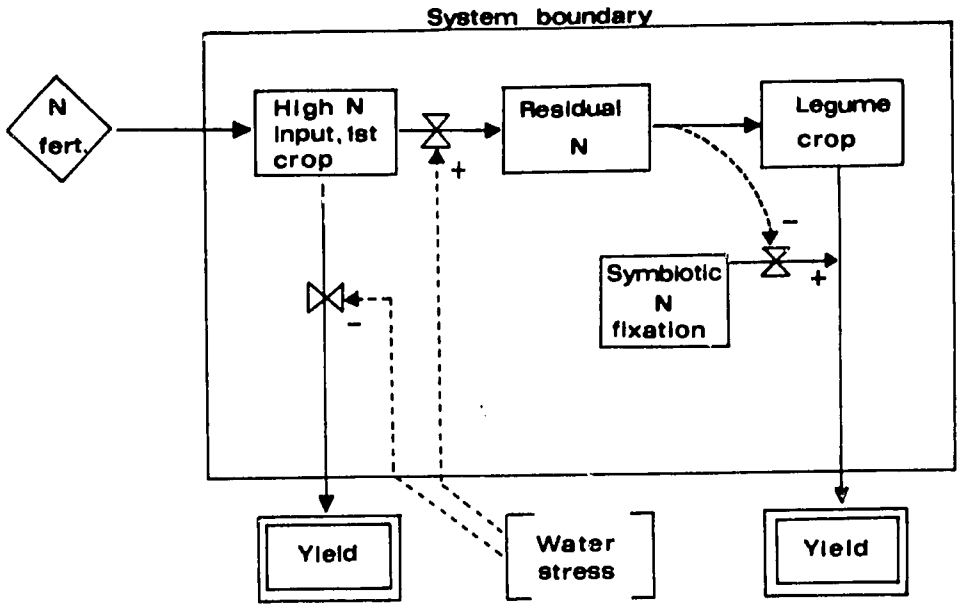

Figure 6.4 A model of destabilizing effects of a perturbation on a multiple cropping system

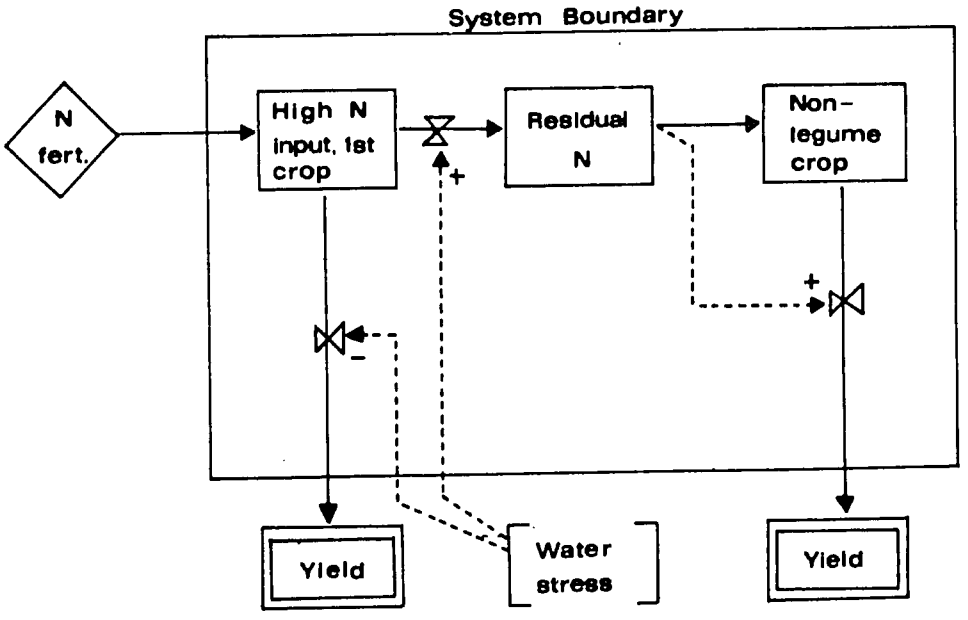

Figure 6.5 A model of compensatory effects of a perturbation on a multiple cropping system

effects of component crop technology are now fairly well known and a larg percentage of the potential gains in productivity from this approach have now been realized. The next stage, of analysing these components as part of functional cropping systems requires a different methodology, capable of handling the critical interactions between crops. However, the tenden is still to concentrate on maximising returns in component crops which ar then assembled into cropping systems merely as a series of unrelated unit and the only system properties considered are in the time dimension.

System properties have been poorly researched and thus, to date, gains in productivity from these effects have been minimal. Indeed it is usually only in situations where large detrimental effects occur that system properties are investigated. For example Pathak (1968) reports the increasing incidence of brown planthopper (Nilaparvata lugens (Stall)) due to increased multiple cropping of rice in Asia. Indeed one of the first system properties to come to light at the MCP experimental plots was of a detrimental nature, namely the gradual lowering of soil pH in some multiple cropping sequences. However, system properties of a beneficial nature also exist and merit more attention. For example, Jereza and De Datta (1976) have shown how three different cropping systems can drastically affect weed-populations and composition, illustrating how it may be possible to reduce weed and other pest problems by manipulation of the system properties of multiple cropping. In fact the large increase in biological and ecological diversity inherent in multiple cropping offers considerable potential for enhancing system performance by such cultural means, and the increase in complexity of the relationships in multiple cropping over sole cropping means that a greater contribution towards increasing productivity is likely to come from the system properties.

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Component-crop-orientated research may also be misleading, yielding recommendations that, although optimal for individual crops, are not optim in terms of the performance of the whole system (Oelsligle *et al.*, 1976). The case of the rice soybean sequence, already referred to, illustrates this well. Furthermore, basing recommendations on component crops may reduce or completely negate beneficial system properties. For instance, high levels of insecticide application in one crop, although maximising returns in that component may negate any carry-out of natural enemies thus increasing pest problems in the following crop, possibly with a net detrimental affect to the economic performance of the system as a whole (Raros 1973).

The Conventional Approach to Multiple Cropping Research.

Scientists at the International Rice Research Institute (I.R.R.I.) several years ago recognised the need to develop a research methodology exclusively for multiple cropping (Harwood, 1975). Their approach is to identify a wide range of zones defined in terms of precise agro-climatic, soil and topology parameters and then develop systems specifically tailor to these areas. They rightly emphasize the importance of on-farm testing with direct farmer involvement and the systems are then further modified the light of this research phase. These systems are then extended as

'packages' with specific instructions on planting dates and methods, fertilizer rates, pest, disease and weed control measures and so on (Cropping System Working Group, 1975; 1976 and 1977).

The drawback to this approach is that it still tends to be component crop oriented with the research aimed primarily at maximising returns within component crops (Banta, 1972), thus leaving a potential 'blind-spot' of the system properties. Furthermore, it tends to lead to systems of multiple cropping which are inflexible in terms of adaption to different environmental and economic conditions and to individual farmers preferences and, because of the large differences in soil types, topography, irrigation water supply and other agro-economic conditions in the Chiang Mai Valley (Seetisarn, 1975 and 1976; Scholten, 1974), this agro-climatic zone approach is of limited utility. A large number of zones would have to be individually serviced by a limited research base. Research has also shown (Tongsiri *et al.*, 1975; Thodey *et al.*, 1974) that there are very great differences in the socio-economic circumstances and the desires and aspirations of the individual farmers both within and between different localities in the Chiang Mai Valley. These factors have been shown to have an important effect on cropping patterns (Ireson, 1976; Suthasupa, 1977) and thus developing cropping systems on a limited set of criteria will not be sufficient. Experience further suggests that the farmers of the Chiang Mai Valley are good innovators and, given the component crops and infrastructure, are quite capable of devising cropping systems tailored to their own individual needs. Thus this cropping system 'package-approach' may well be competing with the farmers themselves and the example of direct-sown soybean production would suggest that the farmers may be more efficient at this task.

Agricultural development is a dynamic process of change and adjustment to changing conditions and knowledge, consequently a fixed 'package' cannot be expected to remain optimal or even viable in the longer-term. A more relevant research approach would be one which gives a better understanding of the processes involved, in particularly the system properties of different sequences and patterns of management. Systems can then be modified or new systems devised by the logical application of this knowledge in the face of changing conditions, rather than having to start from scratch each time in the search for a new optimal package whose own viable life will also be of limited duration.

Optimal and Marginal Situations.

Component crop oriented research tends to emphasis fairly high levels of technological inputs, because gains in component crop productivity are made most easily by this means. In areas of optimal conditions in terms of reliable water, access to markets, supplies, credit, extension-help, etc. 'package-type' cropping systems developed by this means may give large gains in productivity. However, in more marginal areas, which probably account for a large proportion of farms in the Chiang Mai Valley the recommendation of high levels of inputs is unrealistic and may even be damaging as the success of these 'packages' depends on them being adopted in their entirety.

Manipulation of the system properties may well be a more rewarding approach and may offer scientists a way of helping those marginal farmers who are most in need of aid but for whom conventional, high-input, component-crop-based research fails to cater. Furthermore, it may be, in these low-input situations that system properties are most easily researched as the effects are not disguised or reduced by high input levels (see Raros, 1973). It is often the case that study of stressed systems, which these marginal situations often represent, gives a better understanding of how they operate at or near the optimum.

The 'strategy approach'.

In summary we can identify a number of servere limitations of the current multiple cropping research approach of developing system packages based mainly on component research. These include the inflexibility of th approach in terms of adaption to different environmental, economic and social conditions; its inability to cater for marginal situations and the difficulty in dealing with system properties. Furthermore agricultural development is a dynamic process of adjustment to changes in economic conditions, to advances in technology and to new knowledge; thus a fixed 'package' cannot be expected to remain optimal or even viable indefinitely We have argued that a more appropriate approach would be to aim at gaining a better understanding of the system relationships involved in multiple cropping.

However, because of the large number of component crops potentially suitable for inclusion in multiple cropping systems in the Chiang Mai Valle and the large variety of agronomic practices that could be performed on each, the number of combinations for which system properties would have to be researched is almost infinite. Furthermore, because of price fluctuations, the inclusion of a certain crop in the cropping system one year does not mean that it will be the best for inclusion the following year. Thus there is some difficulty in knowing which crop combination to test when looking at interaction effects, especially as some of these effects may take more than one year to become observable. For example an experiment conducted at the M.C.P. over one cropping year (Wivutvongvana *et al.*, 1975) showed no residual effect of nitrogen applied in the preceeding crop. However, it is believed that this may have been due to the already quite high levels of nitrogen in the soil due to previous intensive cropping and thus no effect would be observable over such a short experimental period.

It seems appropriate, therefore, instead of thinking in terms of cropping systems, to carefully define various 'cropping strategies' designed to meet national, regional and farmer's objectives. For instance one might test a high-input 'strategy' designed for a risk-taking farmer with good infrastructure and access to capital or credit. This 'strategy' could be tested over a number of years and will remain the same but the 'tactics' (crops grown, fertilizer rates, plant protection levels, etc.) may change depending on environmental or economic conditions. Certain system properties will be more important in some cropping strategies than in others. For

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nstance one would expect residual nitrogen interaction to be more importnt in a high input strategy, where high fertilizer rates are used, than n a low input strategy; and soil moisture interaction between component rops to be more important in a moisture conservation strategy than in a trategy designed for areas of completely reliable irrigation. After etermining which system properties are likely to be important and how hey function in the different strategies it then becomes possible to etermine how they are affected by 'tactics' and thus how they may be beneicially manipulated in terms of the performance of the system as a whole.

This procedure also enables the different strategies to be more fully assessed in terms of how successful they are in meeting a wide range of conomic, social and agro-ecological objectives. Previously assessment as tended to be purely economic and has favoured the higher input systems ven though they may not be the most appropriate for all situations (see .C.P., 1978, 160-169; Bunoan, 1975, 387-389; Suryatna, 1976, 47-48).

CHAPTER SEVEN

KEY QUESTIONS

1. Introduction

Ideally, key questions are highly focussed on a critical process in the system or on a crucial area of decision making and are intended to provide a significant understanding of how the system works and clues as to how its performance may be improved. In practice, in studies such as are described here, the review and assessment of existing knowledge often reveals quite broad areas of ignorance and a proportion of the key questions are inevitably more generally focussed.

Questions may initially be framed in purely agricultural, ecological or socio-economic terms, but the most powerful questions are those which, through a process of discussion and experiment, combine elements of each. There is, as yet, no general guide to key questions in the study of agro-ecosystems, nor is there any easy prescription for their formulation. In this study the key questions arose naturally during the intensive seminar sessions which formed the basis for the previous studies in this report. Essentially they are the products of the collective insights and experienc of the study group.

In this Chapter the key questions have been classified under a number of headings, partly for reasons of convenience. The scheme of classification is based on the hierarchy of systems which contains the Valley system. This has a number of advantages. First, it establishes a holistic framework so that all possible groups of questions can be accommodated. Second, it enables interactions between the different groups of key questions to be considered through the links in the hierarchical framework. Third, different levels in the hierarchy tend to contain groups of questions that correspond to the special areas of responsibility or expertise of one of the various research institutions or decision making bodies and this helps in identifying who is best suited to answering the questions (See Chapter 8). Finally it is still sufficiently flexible to accomodate new key questions as they emerge from new findings and changes in the system.

The questions are thus grouped under 6 headings : context questions, which are concerned with links between the focal system of study, the Valley, and the larger regional and natural systems which envelop it; valley system questions which operate at the level of the whole valley; valley sub-systems; village system; farm system to finally cropping system questions, which are concerned with processes and decisions operating within one year at the field level.

The study has also shown that in addition to answering key systems questions there is a need for further accumulation of component knowledge on such topics as testing new varieties, fertilizer trials in component

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crops, etc. even though it may not be possible at first to relate this knowledge directly to key processes and decisions. These component questions are dealt with in Section 8 of this Chapter.

Although the key questions have been classified in this way, it must be reiterated that this classification scheme did not form the basis for posing the key questions which emerged naturally during the intensive seminar sessions.

2. Context questions

All systems higher in the hierarchy than the focal system under study and other systems at the same level with which the Chiang Mai Valley interacts are described as "the context." This section includes key questions concerned with the interactions between the valley system and its external environment, including both the immediate environment such as the uplands, highlands and other Northern Region Valleys and the more highly aggregated systems such as the national economy, the world market, etc.

Some of the questions in this section, especially those dealing with larger systems such as National policy or world markets, are scenario-type questions which probably cannot as yet be answered with any degree of certainty. They are included, however, in the hope that a number of possible scenarios to these questions will be considered when research is conducted in an attempt to answer some of the more specific key questions on which they impinge.

A.1 In what ways can the interaction of the highland and upland areas of the Chiang Mai Valley with the lowlands be exploited to the common good of the whole area?

Because of their very different agro-ecological make-up the lowlands, highlands and uplands are suited to rather different types of agriculture. This coupled with their close proximity means that their integrated development could bring about greater regional productivity and stability than that attainable by individual development of each area in isolation. For example to what extent could the highlands be used as a seed production area for the lowlands for such possible crops as potatoes, strawberries or flowers, etc. thus simultaneously overcoming some of the marketing problems of the highlands and some of the seed availability problems of the lowlands?

Other important questions may concern such areas as the way in which cropping patterns in the highlands affect water supply in the lowlands; how population pressure in the lowlands may cause expansion of agricultural land into the uplands; etc.

A.2 To what extent will the research and practical experience of groups working in the valley be relevant to other similar agro-ecosystems?

There are a number of other valleys in the Northern Region of Thailand which may have similar problems to those of the Chiang Mai Valley. Indeed some characteristics of the valley may be common to many agro-ecosystems throughout the world. How should the relevance of local findings to other areas be tested and how can relevant information be best disseminated?

A.3 What will be the likely changes in domestic and international markets for crops in the Valley?

This question is closely related to projected population and standard-of-living trends in the region and likely improvements in transport networks to other areas. Changes in demand for agricultural produce will be both quantitative, depending on population and qualitative, depending on income levels. Multiple cropping must remain flexible enough to meet both of these changes in demand.

With the exception of a few isolated areas, road networks both within and to other areas outside the Valley are fairly adequate. Thus, the potential for storable produce is unlikely to change drastically in this respect in the near future. However, the recent upgrading of Chiang Mai Airport to international status may increase the potential for high value perishable crops that could be incorporated into multiple cropping systems.

A.4 How may foreseeable major policy decisions of the National Government affect multiple cropping in the valley?

Major policy decisions with respect to various issues such as energy-policy, national-security, trade agreements and international aid programmes may have considerable impact on the valley. What are the likely scenarios and how can flexibility in cropping systems be best maintained to accommodate possible shifts in National Policy?

3. Valley system questions

This section includes questions which address key processes and decisions occurring at the level of the valley as a whole. These processes determine the productivity, stability and durability for the whole valley system in such a way that these parameters may be qualitatively and quantitatively different from a mere summation of the component areas. For instance heavy rainfall is likely to cause flooding problems in flood-prone areas but may well improve water supply in higher-elevation, rain-fed areas and lack of rainfall may have the reverse effect. Thus, although these two sub-systems are unstable when considered individually, the variability is reduced at the level of the valley.

B.1 How is the quantity and quality of underground water being affected by increasing water-use in the expanding multiple cropping in the Valley and what effect will

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this have on the further potential role of underground water for multiple cropping in the Chiang Mai Valley?

Farmers' own supply of underground water, from tube wells or shallow dug wells, is the most reliable source for irrigation water during the dry season. The use of underground water is increasing rapidly in the Valley, probably causing a rapid lowering of the water-table in some areas. There are already reports from certain tube-well areas (e.g. San Khamphaeng) of difficulties in obtaining domestic water. In other areas pumps are having to be lowered to greater depths as the use of tube wells produces coning of the water-table. Even in shallow water-table areas such as Ban Hong, where pumping from shallow dug-wells is common and no problems were expected, many farmers are having to install deeper tube-wells as the water-table recedes. In addition diversion of water from rivers affects down-stream flow with potential effects on the water-table.

Increasing water use from any source for multiple cropping may also interact with either a net beneficial or detrimental effect on the overall valley water-table. The increased leaching into the water-table of nutrients and toxic materials associated with increased cropping intensity may also affect the quality of subsurface water with future effects on cropping and the rural population who obtain domestic water supplies from this source. Thus future planning for water utilization should be based on an understanding of the interactions between different water sources and the effects of these on all potential uses.

Even now farmers in the Mae Kuang project are responding to water-shortages by sinking tube-wells while the response of the RID is to put in a dam with water storage facilities which, when it comes on line may make the tube wells redundant, or the water may not be used because the farmers already have tube-wells. Thus there is a critical need for an assessment of the water resource of the Valley as a whole before more projects are implemented.

B.2 What are the likely consequences of planned major impoundments in the Valley?

Two water-storage reservoirs are nearing completion to service the Mae Taeng and Mae Kuang systems. These will be the first storage structures in the Valley and could be expected to have a large impact on the 2 systems in terms of flood control in the rainy season and water availability in the dry season. What new potentialities for multiple cropping will these structures allow and what new problems are likely to occur. For instance how is the available water to be fairly apportioned and what are the likely conflicts between agriculture and hydro-electricity generation?

B.3 Is land consolidation desirable in the Chiang Mai Valley?

It is generally believed that consolidation of fragmented holdings will improve irrigation efficiency. However, the advantage has to be weighed against the loss of diversity within the farm. In the existing

system, with parcels of land on different elevations, farmers derive a certain degree of stability from employing different cropping patterns. In addition, the critical question of water distribution has to be answered. In the face of a water shortage, which is often very serious in the Valley, many farmers who depend on diversion systems, will be left with their land removed from irrigation systems while a few may get better access to water.

Furthermore the present pattern tends to spread risk as any one farmer is likely to have land at all 3 elevations and while heavy rainfall may cause problems at the low elevations it may improve water availability at the higher elevations.

B.4 Can vegetables, produced in multiple cropping systems, meet the year round requirements of a processing factory in a manner acceptable to both farmers and processors?

Vegetables are an ideal crop for the cool season and there is a high potential demand for them in Chiang Mai and in Bangkok and other markets. Processing factories have been established in Chiang Mai but have been unsuccessful because of the inability of the processors to obtain sufficient economic quantities for processing at the right time, in practice on a specified day. Can production, harvesting and transportation be improved to solve the problem, perhaps by better planning, processor contracts and harvesting by the processors themselves? In addition does the preponderance of the subsistence rice crop in the wet season mean that vegetables to sustain processing requirements would not be available at this time?

B.5 Are different management strategies needed for the different soil types in the Valley?

From the classification of soils in the Valley, the differences among the major soils are not great. However we are often told by farmers that their soils are good for some crops and not for others. Cropping systems also differ greatly in their requirement for land preparation and soil treatments. We need to know how the different soil types lend themselves to different management tactics and how they are affected in the long run, for example how are different soils affected by non-tillage systems, or double rice cultivation?

B.6 How can the problem of the availability and the quality of seed, which is a constraint to multiple cropping in the Chiang Mai Valley, be overcome in the near future?

The seed industry in Thailand is not very well organized, except perhaps for vegetable seeds. For seeds which are not storable, e.g. soybea and peanut, the problem is very serious. Even for crops for which seed ca be kept from the previous year's crop, farmers believe that it is essentia to renew their seed stock every 3-4 years, from sources either in other parts of the Valley or from outside the Valley. A reliable seed supply is

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likely to contribute greatly to agricultural development and multiple cropping in the Valley.

B.7 What are the likely effects of increasing urbanization on agricultural employment patterns, the price of land and the size of holdings in the Valley?

The high rate of industrialization made possible by a developing agriculture in the Valley means that a demand for both part and full-time labour is created in the urban centres which must be supplied mainly from the rural sector. Furthermore, profits generated within the urban centres may be invested in agricultural-land, forcing up prices and causing a larger proportion of absentee-landlords with resultant changes in tenancy patterns throughout the Valley. What are the various likely scenarios and what will the effect be on multiple cropping?

B.8 How do changes in relative prices affect the choice of rice varieties grown and how does this in turn affect the relative prices?

Non-glutinous rice usually commands a higher price than glutinous rice. High prices are paid for good eating quality in varieties such as Kao Dawk Mali (non-glutinous), and Neow Sanpathong (glutinous). Under present subsistence farming and the prevailing small price difference between glutinous and non-glutinous rice, farmers in the Valley grow glutinous rice and generally would not change to non-glutinous varieties. However, the price difference between Kao Dawk Mali and improved RD varieties may affect varietal choice; for instance, farmers in San Khamphaeng district tend to grow Kao Dawk Mali instead of RD varieties.

4. Valley sub system questions

Chapter 6 identified a number of Valley sub systems with unique properties and problems. The questions in this section focus on these problems and on processes occurring at a level of organization intermediate between the Valley and the village, such as the irrigation systems and administratively or ecologically similar areas.

C.1 How can systems for areas of poor or no dry-season irrigation be manipulated to extend the crop growing season?

Substantial rainfed or partially-irrigated areas in the Valley are presently rice monocropped because rainfall or irrigation supply is too uncertain to adopt conventional double cropping systems. It may however be possible, by manipulating cropping systems in the light of a good understanding of rainfall probabilities (both primary and secondary probabilities), soil moisture characteristics and crop requirements, to develop double cropping systems for these currently mono-cropped areas.

Soil moisture conservation can be improved either by increasing soil moisture storage or by decreasing the rate of evapotranspiration. For a given amount of precipitation the amount of moisture stored in the soil is dependent on the infiltration rate of the soil and its moisture holding capacity. Infiltration rate may be enhanced by cultivation techniques that promote good aggregation and stable surface soil structure. Studies are required of the effect of different techniques on the structure of the soil types of the Valley together with a better understanding of their moisture-holding characteristics. Research is also required on the conflict between the impermeable soil surface requirement for paddy rice with the soil structure needs of the following dry season crops on the same land. Studies on mulching techniques to decrease evapotranspiration are also required.

C.2 What is the best time to close irrigation systems for maintenance so as to improve cropping system options?

Water supply virtually ceases during the period the canals are maintained. Ideally, this should coincide with the periods of low irrigation water requirement in the cropping season. It is easier to realise this on an individual farm than for a larger region, say the command area of a lateral where the cropping patterns may be heterogeneous. The time required for maintenance also varies with the size of the system. It is current practice to close the canals in December and June. This fits with a rice followed by soybean or peanut rotation but inhibits a triple crop rotation involving cool and hot season crops. However the choice may be due to the better availability of labour for maintenance at these times. It may be possible to devise a more optimal pattern of maintenance, probably involving differing closure times for individual laterals or cropping regions depending on when, in some areas, water may be available from the traditional systems thus allowing cropping at these times.

C.3 What are the special characteristics of flood-prone-areas and how can they be best managed.

Some areas in the Valley close to the rivers are prone to flooding during the rainy season. Farmers in these areas have devised various strategies with varying degrees of success in overcoming the problem. Some plant their higher-elevation fields at double density so that if lowe elevation fields are lost to flooding they can replant from the higher fields, others in RID system areas plant their rice crop in the hot season when flooding doesn't occur and the RID guarantees adequate water for this Can these systems be manipulated, possibly with the inclusion of a deep-water-tolerant rice variety, to increase productivity and stability?

5. Village system questions

Villages originally arose because a group of people found that such communal living was mutually beneficial (See Chapter 6). It can therefore be expected that a large number of processes which affect the productivity

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and stability of individual farms occur at the level of the village. Thus this section includes questions addressing such aspects as exchange labour groups, tenure patterns and other village level processes.

D.1 Is labour availability important in constraining the options to increased profitability of cropping systems and how can such constraints be overcome?

Labour availability is crucial for some high profit crops. Tobacco production, for instance, is highly profitable relative to other competing crops, having a secured market outlet, but it requires an intensive labour input. Therefore, farmers are not likely to expand production beyond the level that family labour can cope with. Hiring of external workers means high cash expenditure, and cash is usually scarce. The exchange labour system is not suitable for crops with continual high-labour-input.

For the crops with seasonally high requirement of labour to finish certain production activities in a short time,like rice transplanting or harvesting,the labour problem can be overcome by the labour exchange system. However, in intensive cropping areas, the reciprocal work group is not so prevalent as it was formerly, because the labour exchange system cannot cope with the increased labour peaks caused by the planting of early crops coinciding with harvesting the previous rice crop. Multiple cropping requires short turn-around times and sometimes requires definite planting dates, the labour exchange system does not meet this requirement. In the absence of an energy shortage problem, machinery use may be the best solution but may be attainable by only a few of the rich farmers who then leave the traditional labour exchange system,thus bringing about its collapse to the detriment of the farmers who do not have the financial capability to mechanize.

D.2 To what extent do present land ownership and tenure patterns constrain operators from adopting multiple cropping and other strategies for increasing cropping system profitability?

It is commonly assumed that existing patterns of land ownership and rental are constraints to increased profitability although they may foster a degree of stability in terms of the variance about the expected annual return. How true is this?

It is also commonly assumed that lack of ownership and insecurity of tenure inhibit farmers from intensifying their cropping patterns. However, willingness to embark on hot season cropping, for example, might be increased on rented land, particularly where inputs from the preceeding owner-cultivated-crop may carry over and where no rental is paid in the event of crop failure. How true is the general assumption and how important a constraint is it?

6. Farm family system questions

The farm family is the basic unit of production and consumption in the Valley, supplying labour for agriculture and eating the subsistence rice crop. Thus many important processes revolve around this level of organization and many key decisions are related to it. Questions in this section deal with such aspects as: family subsistence requirement and the constraints that this puts on intensifying multiple cropping, the complementarity between the different enterprises on the farm, ways of dealing with fragmented holdings, etc.

E.1 How should different cropping systems within a farm be combined to produce an optimal farm system?

Many farmers in the Valley will grow a diversity of crops in the dry season. These they will allocate to their field plots on the basis of field elevations, distance from the dwelling, etc. As more intensive double and triple cropping systems are introduced the problem of optimising the distribution of different systems within the farm becomes more complicated. We need to understand the current basis of farm optimisation as practised and how it may be improved.

In many areas of the Valley, particularly in the Mae Kuang and Mae Ping Kao Projects, there is considerable high elevation land which is not best suited for paddy rice and can be planted to tobacco (for high quality), soybean and peanuts (for seed) and tomatoes (for high prices). However, because of the fragmentation of holdings and the subsistence-rice-crop requirement, attempts are often made to grow paddy rice on the higher elevation and tobacco on good paddy land with attendant water problems and poor yields. On the other hand, at the beginning of the cool season fields in low lying areas around some villages are too wet for an early cool season crop. Different cropping patterns and improved crop and water management and drainage systems might help to optimise the utilization of different elevations within farms and villages.

In addition fields at a distance from the farmers dwelling may often be of good quality; but farmers may not be able to invest sufficient labour or may be unwilling to invest costly inputs because the crop cannot be regularly monitored or there is a danger of the harvest being stolen or lost through unexpected catastrophe. Ideally systems of low input and high security are required.

E.2 To what extent do farmers rotate cropping systems in one field from year to year and what are the advantages and disadvantages?

Decisions each year on what to grow vary according to individual preference, risk-taking, neighbour influence, new ideas, market prices and tenure patterns. Any one field plot may thus support different cropping systems from one year to the next. What are the advantages and disadvantages of this?

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E.3 How can the tactical options of farmers pursuing subsistence dominant strategies be improved?

Farmers close to subsistence are unable to improve system productivity by growing high-profit, cool-season crops because they are constrained to growing long-maturity, traditional rice varieties to meet family subsistence requirements. They are thus forced into double cropping at most, with low-input, low-return crops in the warm-season such as soybeans or peanuts.

By improving productivity in their rice crop they may free some land from this constraint, permitting more profitable double or triple cropping. However, farmers in this group are very risk averse in their subsistence rice crop and may be unwilling to take the chances associated with adopting new technology in this crop. These farmers are thus caught in a kind of "subsistence-trap" whereby increases in system productivity can come only with improvements in the wet-season rice crop but, due to subsistence requirements, they are prevented from making these improvements.

7. Cropping system questions

Questions in this section focus at the level of the field, the basic spatial production unit of cropping systems. The questions address the processes that occur when crops are assembled into systems but which do not usually come to light when the component crops are studied in isolation. They include questions related to the productivity, stability and durability of the entire system which may be both quantitatively and qualitatively different from a summation of the component stabilities of the individual crops. The processes involved are related to effects occuring between the different crops in the system in terms of time, soil, pest and weed populations, cash flow, labour requirements, etc.

F.1 How can cropping intensity be best defined and measured?

Cropping intensity is currently defined as the average number of crops per field-plot per year. This is a very crude and rather unsatisfactory index. It does not, for example, take into account the number of days the land is under a crop nor consider the constraints. For example, in order to compare different land receiving water for less than the whole year the intensity might be better measured in terms of the number of days of water availability rather than the total days in the year. Also how can we most usefully distinguish, for example, two crops each of 150 days and 3 crops of 100 days each?

Furthermore, under the current concept of cropping intensity the project has assumed that one of its goals is to increase cropping intensity, i.e. triple cropping is more desirable than double cropping. However, triple cropping is much less extensive in the Valley than double cropping. With existing farmers' goals and constraints and the availability of water, crops and cultivation techniques in some areas and situations in the Valley,

improving double cropping may be a better strategy than changing to triple cropping. This aspect of land use will also have to be considered in defining cropping intensity.

F.2 How are the productivity, stability and durability of multiple cropping systems to be best understood and how are these properties affected by different cropping strategies?

Superficially productivity is easily measured in terms of biomass, yield or net return. However, it is clear that the mix of a subsistence crop, a cash income and a variety of less tangible objectives followed by the majority of the farmers in the Valley requires a more complex definition and measurement of productivity. Stability and durability pose an even more difficult problem. Declining pH and increasing pest, disease and weed problems are only some of the indications that need to be considered. This is closely allied to the preceding question. We need to know how resilient are different cropping systems to such stresses as drought, soil-acidity and weed infestation. In particular is the resilience altered by the kind of management strategy? Do high input strategies reduce the resilience?

F.3 What are the effects of a fallow period in the cropping system?

One of the advantages of double over triple cropping may be the presence of a fallow period. Fallows typically produce a heavy grass cover which may increase the weed problems in subsequent crops. The grass may also utilize available nutrients; on the other hand there may be a reduction in losses due to leaching which at certain times of the year may be high under alternative crops. Fallows may also have beneficial effects on disease problems and have wider benefits in socio-economic terms. They may. for example, provide grazing which permits the continued efficient use of draught animals.

F.4 What system properties are important in determining nutrient-use-efficiency and how can these be beneficially manipulated?

With the increasing cost of fertilizers the efficient use of applied nutrients is becoming more critical. There is good knowledge of optimal timing and amounts of fertilizer when applied to individual component crops, but there is very little information on the nutrient cycles of the entire system.

F.5 What is the residual effect of grain legumes particularly in terms of nitrogen donation to subsequent crops including rice?

In temperate agriculture grain legumes leave very little nitrogen for subsequent crops if the tops are removed. However it is believed that the position may be different under certain tropical conditions. We need

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to know the benefits to be derived from including grain legumes in the range of cropping systems we are studying. The anaerobic conditions in the paddy rice crop may mean that any residual nutrients are "locked up" and being unavailable to the rice are lost from the system. Is this true in the case of residual nutrients from legume crops?

F.6 How is yield stability of component crops within a system as well as performance of the whole system affected by fluctuations in the soil under rice-based multiple cropping and how are these fluctuations affected by management practices?

Soils under rice-based multiple cropping are unique because of the alternately oxidized and reduced periods in each year. Changes in flooded soils have been thoroughly investigated at IRRI (see IRRI Annual Report, 1964), but there is little information on the changes that occur when the soil is drained. The other obvious effect of the rice crop is the drastic change in soil structure caused by puddling during land preparation for the rice crop. Recent experiments at the MCP have shown that the soil under rice-based multiple cropping is highly dynamic. Yearly cycles of fluctuation have been observed for soil acidity and available phosphorus. Results have also suggested biological cycles of fluctuation in rhizobial populations and possibly biological oxidation of manganese. On the other hand no tillage experiments have suggested that there may also be positive residual effects of the rice crop. Cereal and legume crops sown into rice stubble, with no tillage, gave yields as high as or even higher than those sown in conventional beds prepared with rotary hoes. There is a critical need to understand the processes behind these changes, how nutritional status, growth and yield of crops are affected and how can they be manipulated and also what are the possible long term implications (see Question F.13).

F.7 How does a perturbation or management action in one crop affect overall system performance?

Various actions or perturbations in one crop may well be carried over to following crops by a number of possible routes. Research at the MCP has suggested a number of possible routes:

1. Chemical: residual effects of persistent herbicides and pesticides.
2. Soil fertility status: residual effects of fertilizer application, liming, crop-residue management, etc.
3. Time dimension: slips in the schedule in one crop may have important repercussions in following crops.
4. Weed, disease and pest populations: effects such as removal of natural enemies, pesticide resistence, shifts in weed floras, etc.

5. Soil structure: changes in soil structure due to cultivation techniques in one crop.

We need to gain an understanding of the possible modes of behavior of these various routes so as to be able to assess their effects in terms of entire system performance rather than solely in the crop in which they occur.

F.8 Which system properties affect pest populations and how can these be manipulated to give enhanced pest control?

We have observed, from the MCP experiment station, that weed infestation in the rice fields which have been subjected to several years of continued cropping is more severe than that found in the farmers' fields under less intensive cropping.

It is also noted that different cropping patterns, with their inherent cultivation measures, showed different pest species and degrees of infestation. The potential temporal diversity inherent in multiple cropping may give a new means of controlling pests by alternating favourable habitats with unfavourable ones or tolerant crop species with susceptible ones. By gaining an understanding of the dynamics involved it may be possible to manipulate system properties to reduce pest infestation or to shift weed populations to a flora that is susceptible to chemical control.

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F.9 What are the characteristic requirements of multiple cropping for credit and how should credit systems be designed to meet these requirements?

As seen in Chapter 6, credit requirements are currently determined on a component crop basis. However, when these crops are grown in a system their requirements may change considerably. How should credit arrangements be tailored to meet these special needs? In particular how can credit systems be best arranged for the subsistence rice crop in which improvement is critical if cropping is to be intensified but which normally generates no cash to pay back the loan in the normal pay-back period.

F.10 What are the desired characteristics of rice varieties as components of a multiple cropping system?

Currently the glutinous rice varieties which are predominantly grown are all photosensitive,with average yields of about 500 kg/rai. They are all late maturing with the exception of Kao Dor which has relatively low yield and poor quality. Early maturity coupled with high yield and good quality, is a critical characteristic for multiple cropping, but are there others? For example will rice variety characteristics affect soil structur nutrients, pests, disease or weeds in subsequent crops?

Glutinous varieties such as RD 2 and RD 6 have high yields but their quality and acceptability is not as high as Sanpatong which is photosensitive and produces lower yields. If the eating quality of the RD varieties

could be improved and their maturity also brought forward, they would provide a good basic crop for intensifying multiple cropping based on glutinous rice. An alternative would be to improve the yields and quality of Kao Dor.

F.11 How large is the biological nitrogen fixation under rice and how can it be best exploited to improve cropping system performance?

Without nitrogen fertilizer traditional glutinous rice in the Chiang Mai Valley can yield up to 5 tons/ha of paddy. This is equivalent to 80-100 kg of nitrogen harvested each year, including that in the straw. About 20 kg are estimated to have come from rain and irrigation water (Brown, 1979). We are postulating that biological nitrogen fixation must have significantly contributed to the remaining 60-80 kg N/ha. We need to identify how much of the total N harvested each year in non-fertilized rice crops comes from biological nitrogen fixation and what are the factors that might be limiting its further exploitation.

F.12 How can the wet season rice crop and the following cool season crop be best managed for optimal system performance?

Early planting of photononsensitive rice varieties allows timely planting of second, cool-season crops such as chilli-peppers, garlic, tobacco and vegetables, thus ensuring maximum benefit from the low temperatures. However, early planted rice may be subjected to a water-stress period in June when there is often insufficient water in the irrigation systems and traditional short maturity varieties currently available have lower yields. On the other hand, late-planting of the cool season crops reduces yield as the critical period of crop development no longer coincides with the low temperatures.

Thus because, under present technology, optimal crop management for both seasons cannot be achieved a critical assessment of the trade-offs concerned is necessary. Better water management for, and timely planting of, early rice varieties with good drought tolerant characteristics or high value second crops which require cool temperatures only for establishment and early growth may be the ways of optimising entire system performance.

F.13 What are the likely effects of increasing cropping intensity and high inputs on the stability and durability of rice-based multiple cropping systems?

Cropping intensity has been increasing rapidly in the Valley in the past 15 years. The amount of inputs of fertilizers and pest control chemicals used has also increased greatly. Problems emerging in farmers' fields may be related to these trends. Farmers' in a very intensive triple cropping area in Ban Hong have stopped growing mungbean altogether because of a drastic yield reduction. In another triple crop area south of Sanpatong there are complaints of soils becoming "hard" and "salty". At the MCP

experiment station a trend in declining yield of rice is highly evident in fields which have been intensively cropped, with high levels of inputs, over the last 10 years. Performance of other crops has also lately been very poor. Most multiple cropping research programmes are based on the assumption that the agro-ecosystem concerned is durable, i.e. productivity can be increased simply by growing more crops per year and raising the input levels. We are putting forward a hypothesis that this assumption may be wrong, due possibly, in part, to the within-year dynamics of the system (see Question F.6) leading to a gradual change in the system relationships over a number of years.

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8 Component questions

As described in Chapter 6, component research is an essential prerequisite to systems research in multiple cropping. A good understanding of component crops and their characteristics when grown as sole crops is essential before they can be assembled into systems. Although this document concentrates on developing a framework for efficient systems research, the group support the view that component research must also be continued in order to test new crops and varieties and to improve agronomic practices on existing crops.

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The approach adopted here allows the more pertinent component questions to be asked and enables some priorities to be put on component research in terms of its potential impact on the whole system. All component questions may not initially be 'key system' questions but, as this component research is initiated and results are obtained, the consequences of these results begin to pin-point potential interactions at the system level thus posing new 'key system' questions and thus gradually becoming a part of the systems research.

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This section deals with component questions which the procedure of work has shown have immediate implications in terms of the performance of the system under study.

G.1 What is the potential for intercropping in the Valley?

Intercropping, with the exception of some limited relay cropping of chilli-pepper into garlic, is rare in the Valley. Yet in other parts of Asia intercroppings have been used to increase productivity, stability, and resource-use-efficiency. What is the potential here?

G.2 To what extent is nitrogen, i.e. the symbiotic fixation of N, a limiting factor to the yield of legumes grown in rice-based multiple cropping systems and what is the potential role of rhizobial inoculation?

The importance of leguminous crops in rice-based multiple cropping in the Chiang Mai Valley is unquestionable. However, information on the efficiency of symbiotic N_2 fixation of legume-*Rhizobium* symbioses is very

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limited, whereas yields of legumes are generally low. The question is whether the symbiotic N_2 fixation is fully exploited, and if not, what are the limiting factors? Recent experiments at the MCP have shown that the indigenous rhizobial population is greatly reduced by the end of the rice season. The presence of sufficient number of appropriate rhizobia at the time of legume germination is crucial to a successful symbiotic development. In cases where rhizobial survival under rice and/or growth after the field is drained are adversely affected, then rhizobial inoculation may be the answer.

G.3 How can on-farm water use efficiency be improved?

Current methods of irrigation for upland crops in the Valley include flood (for no-tillage soybean), furrow (for peanut and mungbean) and splashing (for garlic, shallot and vegetables). The efficiency of water use in these methods needs to be evaluated against economically viable alternatives. On-farm, water-conserving measures, e.g. removal of weeds in irrigation ditches, mulching, low-input sprinkler systems need to be examined.

Furthermore, recent evidence from the MCP plots suggests that the use of some forms of these irrigation techniques in some systems may cause salinisation problems which must be avoided for cropping system durability considerations.

G.4 If late planting of rice is inevitable how can yield reduction be avoided?

Planting date studies (Rerkasem, 1978) have shown that when planted later than August 15 all of the rice varieties currently grown in the Valley showed marked yield reduction. While an early rice crop followed by an early cool season crop are essential for a high profit cropping system, late planting of rice is sometimes inevitible,either because of delayed wet season rain or a loss of first planting,due to flood making a second planting necessary. In addition, in the system of labour exchange, which is employed extensively in rice transplanting and harvesting, many fields are bound to get planted outside the optimal time. In 1972 63% of farmers in the Valley planted their rice in the whole month of August and 10% planted after August. Shortened vegetative growth may be responsible for yield reduction in late planted photosensitive varieties. However, for the new non-photosensitive RD varieties phenological development did not appear to be affected by planting time. Declining night temperature towards the end of the wet season is one possible cause of yield reduction. Thus breeding work on cold tolerant rice varieties may be one way of tackling this problem. Another way may be by adjusting the combination of seedling age and transplanting density. Young seedlings establish faster than old seedlings after transplanting. With high yielding varieties, 20 day old seedlings are used for transplanting at 1-2 plants/hill. In the event of drought or when water supply is not readily available, late planting is inevitable. Then seedling age and transplanting density interaction would be a relevant issue with respect to rice yield stability.

G.5 How can the cool season in the Chiang Mai Valley be used to the maximum advantage?

The cool temperatures in the period from mid-November to early-March are unique to areas of the Northern Region in Thailand. The Chiang Mai Valley thus has a comparative advantage over many other areas in the country in the growth of various temperate crops. How can this advantage be used to its maximum potential?

G.6 Can the profitability of late planted garlic be improved?

Because of late maturity of the rice crop, garlic tends to be planted late but the yield of garlic is highly dependent on the date of planting; November planting gives the best yield. One testable hypothesis is that with late plantings yield is reduced because of the increasing temperature, which starts in January. Another question would be: how is garlic affected by the rapid increase in evapotranspiration, which accompanies the rise in temperature and alters the water balance? Can the problem be overcome by varietal improvement?

This question is also relevant for all cool-season crops and the system implications for all crops have already been dealt with in Question F.12. The garlic crop is chosen as a priority for component research of this nature, however, for a number of reasons. First it is already extensively grown in the Chiang Mai Valley and offers potentially good returns to the farmers. Secondly there are large variations in yield between farms in the Valley which could well be attributable to the considerable variation in planting dates that have also been observed. In addition, work at the MCP has shown that late planted garlic, although yielding less, loses less weight on drying for storage which enables higher prices to be obtained later in the season than those prevailing when the garlic is sold fresh from the field. Research in this direction may therefore also be a means of increasing returns to late planted garlic.

G.7 What are suitable alternative mulches to rice straw for high input crops?

When cool season crops are planted early, as in the Mae Ping Kao area, the mulch must be rice straw either left over from the previous year or straw from early maturing glutinous rice cultivars. Demand is usually over supply and this makes the price of rice straw very costly; the cost of rice straw for one rai of early garlic is about 600 Baht. RD varieties produce poor quality mulch straw. Are there satisfactory alternatives, for example tree leaves, that can be used?

G.8 What is the cause of tip burn in garlic and how can it be controlled?

In early 1975, the off season rain in early January resulted in heavy loss of garlic bulb yield. The crop was severely damaged by "tip-burn" incidence, a symptom characterized by the leaf wilting from the tip down-

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wards, then browning and the plant eventually dying. The diseased leaf was isolated for signs of pathological organisms, but the results were negative. The cause of tip burn is still not fully understood but it is hypothesized that the cause is more likely physiological than pathological. Perhaps the studies would involve a controlled environment where light, humidity and moisture could be properly manipulated to test for these effe

CHAPTER EIGHT

CONCLUSION

An assessment

At the outset of this analysis we set ourselves the task of reviewing the current state of our knowledge of multiple cropping as practised in the Chiang Mai Valley and, on this basis, formulating the priorities for future research of the Multiple Cropping Project at Chiang Mai University. What we have achieved is a better understanding of multiple cropping and its significance in the context of the development of the Valley and a set of some thirty key system questions and a further 8 component questions which merit high research priority. Most importantly, this understanding and the set of questions reflect the shared consensus of the authors of the report, arrived at through the intensive seminars and writing sessions. The report thus reflects a systemic understanding by a multidisciplinary team. In retrospect it may seem that many of the key questions were obvious and could have been discerned without the elaborate analysis. However, many of the questions were not perceived at the outset particularly in their final precise form. Moreover, the process of shared analysis and the arrival at a set of questions which are agreed upon as critical provides a basis for genuine interdisciplinary research which was not present before.

As outlined in the first chapter the procedure of analysis does not stop here. The set of key questions is large, providing sufficient fuel for many years of research. They require further discussion and evaluation to discuss priorities for immediate attention. They also vary greatly in the skills, experience, facilities and financial resources that they individually require in order to be successfully answered. Only a portion can and should be tackled by the MCP and in this final chapter we discuss the basis on which the choices are to be made.

2. Priorities

Strategies of Research

In the early years of the MCP a linear model of research and implementation was followed. Triple cropping systems were designed on the basis of agronomic theory, tested and evaluated under good experimental conditions and then tried under supervision in farmers' fields, with the successful systems then to be urged on farmers through normal extension channels. For the reasons that have been described in this report, particularly in Chapter 5, this model has not been very fruitful. Few of the systems have been successful enough to warrant extension effort. In many situations the MCP research workers have found themselves learning more from farmers' practice than they have to offer. This, of course, does not mean that there are no major improvements in agricultural production in the Valley to be made or

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that there are not serious problems to be solved. But it does mean that research objectives have to be chosen with care and in the light of a thorough analysis of the systems to be changed. The key questions reflect this emphasis but to further ensure the continued utility and relevance of our work we feel it is important to replace this simple linear model of research, characterised by the distance it imposes between basic research and farmers' practice, by a more complex close-knit model in which the feedback between theory and practice dominates the research programmes (Figure 8.1).

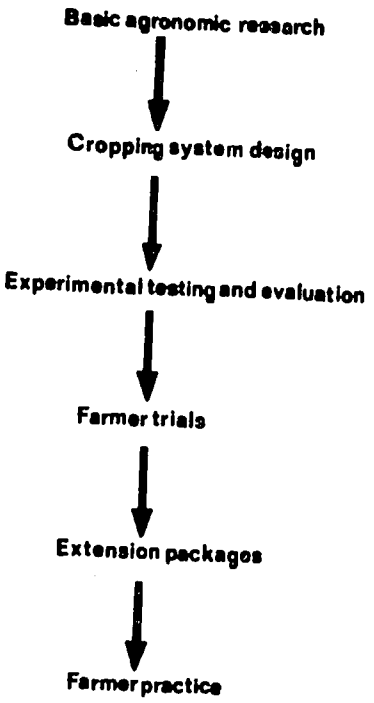
Constraints

Everything that we have seen and heard points strongly to the water supply as the major constraining factor to more intensive cropping. Given adequate and, in particular, secure water, farmers rapidly develop a variety of reasonably efficient cropping systems. The questions concerning the improvements in the RID system (C2) and the provision of alternative sources (B1) are thus strong contenders for high priority. For many parts of the Valley, however, adequate, secure water may be a long time coming, if ever, and for these farmers the problem is how to make better use of what water they may have. Questions C.1 and C.3 then become important.

The constraints of credit and labour availabilities, land tenure, access to inputs and markets and the prices prevailing (Questions B.3, B.4, B.6, B.7, B.8, D.1, D.2 and F.9) are still largely unassessed. They could turn out individually or in combination to be more critical than water supply and hence they justify a fairly high priority of research. They do, however, pose more complex problems of analysis. For example, labour or timing constraints which appear critical in one part of the Valley appear to have been readily overcome in another, for reasons that are not immediately obvious. Very careful and detailed comparative studies are required.

Finally there are the agronomic constraints. Much of the triple cropping, both experimentally and in farmer practice, depends on relatively ill-assorted and poorly fitted component crops. Finding new components or agronomic practices or breeding new specially suited varieties is important (Questions G.1 - 8); but their success will depend on a much better understanding of the agro-climatological seasons and the time dependent constraints (Questions C.1, C.2, G.4 and F.13). However, our analysis suggests that of even greater priority are Questions B.8, E.3, F.4, F.5, F.6, F.10, F.11, F.12, F.13 and G.2 which relate to the productivity, timing and residual effects of the wet season rice crop (both glutinous and non-glutinous). Better timing and less adverse residual effects on subsequent crops opens up many more possibilities for cropping combinations and frees the farmer from the tight constraints of time and labour. Increasing the yields of the glutinous rice crop will free more land for better timed non-glutinous rice or alternative rainy season crops, but it is not yet clear that this is a better strategy than attempting to build more intensive and productive cropping systems on the existing glutinous rice crop with better management techniques.

a) The Linear Model.



b) The Close-knit Model.

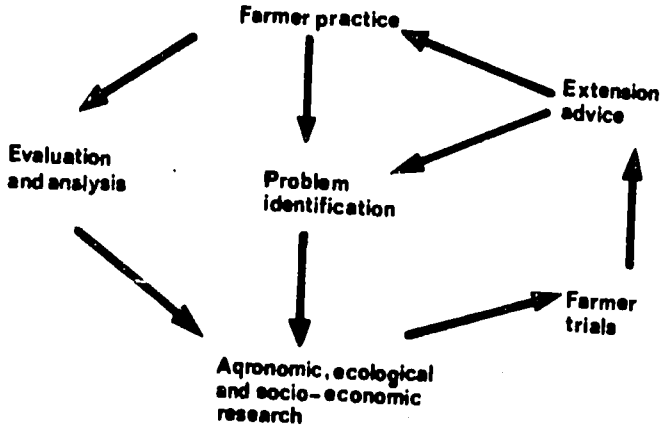


Figure 8.1 A comparison of two models for multiple cropping research

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Double Versus Triple Cropping

Much of the research of the MCP has been based on the implicit assumption that triple cropping is superior to double cropping. But there is no hard evidence to support this. Removing or lessening the constraints discussed above may trigger an extensive move towards triple cropping but many farmers may prefer, on all or part of their land, to invest their resources in improving the existing double cropping pattern. Double cropping leaves time for off-farm economic activities which may be considerably more profitable than the production of a third crop. A very major effort in removing a number of interconnecting constraints may be required before the riskiness of triple cropping is reduced enough to make it worthwhile. An assessment of the relative advantages and disadvantages of double and triple cropping (Question F.1) has therefore a very high priority at this stage.

Stability and Durability

The previous question is also intimately linked with the issues of stability and durability. The value of the fallow period in double cropping (Question F.3) may for example be greater than has been assumed.

The problem of increasing soil acidity, clearly apparent on the MCP experimental plots and becoming evident in farmers' fields in a number of locations in the Valley, is a matter of top priority (Questions F.6 and F.13). If it continues along the present course the durability of the whole Valley agro-ecosystem may be seriously threatened and the thrust toward highly intensive triple cropping systems could be seen, in retrospect, as a short-lived and disastrous course of action. The soil problem may also be accompanied by problems of pest, disease and weed outbreaks, similarly caused by high input and intensive management techniques (Question F.8). It is already thus clear that systems questions (for example E.1 and F.1 - F.13), far from being academic exercises, are at the heart of the central issue of raising productivity without damaging the durability of the Valley's agriculture.

The Context and the Future

The questions of context (A.1 - 4) and future development (B.2 and B.7) inevitably are lower in the scale of priorities. But they need to be looked at from time to time. Many developments, such as the construction of new reserviors and irrigation schemes, changes in government policy and the rapidly changing pattern of demography in the Valley, may well overtake and invalidate the research findings of the MCP or at best provide opportunities for innovative discovery which may be overlooked.

ng research

3. Comparative advantage of the MCP

The priority issues and questions discussed above are not necessarily all appropriate or suitable for the MCP to tackle, even though they may be

considered of crucial importance. Some questions may be best answered by other research institutions alone or in collaboration with the MCP and a major purpose of this report is thus to convince other institutions of the significance of the issues that have been raised.

In determining which questions should be answered by which institutions and in what precise manner depends on the assessment of each institution's function and purpose and on its research skills and capacity.

Institutional Assessment

By laws, as well as by tradition, the university in Thailand is supposed to perform a triumvirate function of education, research and extension. This is equally applied to the field of agriculture and these are thus the functions laid down for the Faculty of Agriculture at Chiang Mai University. Being an academic institution it has, with Kasetsart, Khon Kaen and Prince of Songkhla Universities and the Agricultural Institute of Technology at Mae Jo, sole responsibility for higher education in agriculture. However, the position is different for research and extension. These two functions can be performed either by the university or by other government agencies or both and the choice depends on the policy and direction of the government.

In our view it is essential that the university should be committed to research and extension. They are essential for upgrading the quality of university teachers as well as providing the necessary experience and practical materials for improving educational programmes. Unfortunately, in Thailand, research conducted by the university is not considered part of the country's agricultural research system. The university is confined to conducting research solely for instructional purposes. Any cooperation between the university and government agencies in research on agricultural problems is thus not a result of a well formulated plan of joint action approved by the government. Rather, it results from the voluntary personal conviction and efforts of the researchers involved.

In our view the university should not be limited to carrying out research only for educational purposes. We believe that universities in Thailand are capable, at present, of conducting research on problems relevant to the development of the country. This is partly because of the high quality of the scientists employed by the universities but also because, as institutions, they are uniquely qualified to bring together the variety of disciplines which are required in development-orientated research. They provide an ideal setting in which systematic, multidisciplinary research can be conducted. Finally, the universities are less subject to political pressures from the government than other research institutions. This is not to say that universities should engage in agricultural research which has political overtones. But it does mean that a high quality and standard of research can be assured. In particular medium and long term experimentation and extended research programmes can be undertaken without fear of disruption from frequent changes in government policies and objectives. As we believe the MCP has already demonstrated, given adequate support,

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scientists can produce high quality research of significance and service to the development of the country.

The role of the university in research, however, needs to be looked upon as complementary and supportive to the national research system, rather than competitive. Within such a framework, the research conducted by university scientists on an interdisciplinary and systemic basis, as is occurring in the MCP, illustrates at least two comparative advantages for the university over other research institutions. First, the systems orientated approach, drawing on the whole resources of the university, provides an ideal mechanism for identifying pertinent and relevant problems that require research. As we have argued it does not then follow that the university has to conduct research on all the problems that have been identified. But the university setting is an appropriate forum for establishing priorities, particularly of medium and long term research and for a continued monitoring and evaluation of the results.

Secondly, the university, being an academic institution, has a special role to play in developing research methodology which can be used by other research institutions. Again the advantage stems from the necessarily long term nature or this kind of work. Government research institutions may have sufficient qualified staff but may be under such pressure to produce short term results that they have insufficient time to devote to such inquiries.

Research Capacity

If we finally now return to the key questions and the priorities outlined previously it becomes clear in which direction the thrust of the MCP work is required.

Taking, for example, the water supply questions, many of these lie firmly in the province of the specialist government agencies. Improvement in the RID system (Question C.2) is an issue for the RID to solve while the assessment and discovery of alternative water supplies (Questions B.1 and B.2) are for the Geological Survey and the RID who have the necessary skills and technical facilities. However insofar as these questions are intimately concerned with the maintaining of water supply, quantity and timing, to meet the specific requirements of multiple cropping systems, the MCP has a role to play, collaborating with the relevant government agencies, thus providing precise knowledge of the patterns and tolerance of water requirements.

Similarly questions relating to improving rice and other crop varieties (Questions F.10 and many of the component questions) lie largely within the province of the Rice Department and the Government Testing Stations of the Ministry of Agriculture and the Agronomy Department in the Faculty. Much of the necessary work on pest, disease and weed control, particularly the identification of species and the elaboration of life histories and epidemiology is more appropriate for the Plant Protection Department of the

Ministry of Agriculture and Entomology and Plant Pathology Departments in the Faculty. However, wherever these questions lead towards the fundamental issue of fitting component technology into viable cropping systems, the MCP needs to assume the lead role.

But it is primarily in the key questions which directly address system issues that the MCP has the outstanding comparative advantage. The Project has ideal research facilities including experimental plots, laboratories and access to computing and library facilities plus in the team the range of skills and disciplines required for the work. Some of the system questions are of medium term significance, others such as the soil problems and the issue of double versus triple cropping require urgent attention, but all raise challenges in basic science, in experimental methodology and in interdisciplinary interaction, which the MCP is in a unique position to meet.

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REFERENCES

BANTA, G.R. (1972):
Mechanisation, Labor and Time in Multiple Cropping. Agricultural Mechanisation in Asia. 4, (1), 27-30.

BANTA, G.R. AND HARWOOD, R.R. (1975):
The Multiple Cropping Programme at IRRI. The Philippine Economic Journal, XIV, (1, 2), 300-307.

BEETS, W.C. (1978):
Multiple Cropping Systems Reviewed. SPAN, 21, (3), 114-116.

BOONDUANG, A (1974):
Village Rice Study II Effects of potassium fertilisation on rice. In:
University of Chiang Mai, Faculty of Agriculture - Multiple Cropping Project : Annual Report 1973 - 1974.

BROWN, A.D. (1979):
Ground water transport of nitrogen in rice fields in Northern Thailand. Paper presented at the Workshop on Nitrogen Cycling in South East Asian Wet Monsoonal Ecosystems. Chiang Mai University, 5-10th November 1979.

DUNOAN, J.C. Jr. (1975):
Recent developments in cropping systems applied research in the Philippines. In Proc. Cropping Systems Workshop, IRRI, Los Banos, Philippines.

DALAVAN, M.M. (1978):
Decisions Against Nature: An Anthropological Study of Agriculture in Northern Thailand. Center for South East Asian Studies. Special Report No. 15. Northern Illinois University.

CROPPING SYSTEMS WORKING GROUP (1975):
Third Report of the Cropping Systems Working Group. IRRI, Los Banos, Philippines.

CROPPING SYSTEMS WORKING GROUP (1976):
Fourth Report of the Cropping Systems Working Group. IRRI, Los Banos, Philippines.

CROPPING SYSTEMS WORKING GROUP (1977):
Fifth Report of the Cropping Systems Working Group. IRRI, Los Banos, Philippines.

DANNIS, J. (1977):
The effect of cropping intensification on the status of the land-poor farmer. MCP Working Paper.

DEPARTMENT OF AGRICULTURE (1976):
Survey on post-harvesting practices in Thailand. Agricultural Engineering Division.

ELSTON, J. AND SNAYDON, R.W. (1976): Flows and cycles of natural resources. In: Duckham, A.N., Jones, J.G.W. and Roberts, E.H. (eds.) Food Production and Consumption. The Efficiency of Human Food Chains and Nutrient Cycles. North Holland Publishing Company, Amsterdam.

E.M.U. (1980):
Pesticide resistance and world food production. A report to the Systems Analysis Research Unit (SARU) Department of Environment, U.K. Environmental Management Unit, Imperial College Field Station, Silwood Park.

FAO (1975):
Annual Fertilizer Review, F.A.O. Rome.

GASSON, R. (1973):
Goals and values of farmers. Journal of Agricultural Economics, 24, (3), 1-542.

HARGREAVES, G.H. (1975):
Water requirements manual for irrigated crops and rainfed agriculture. EMBRAPA and Utah State University, Publication No. 75-D158, pp. 40.

HARWOOD, R.R. (1975):
Methodologies in Cropping Systems. In Lecture Syllabus, IRRI Cropping Systems. Specialist Course. IRRI, Los Banos, Philippines.

MOBBS, P.R. (1974):
Peanuts
In:
University of Chiang Mai, Faculty of Agriculture Multiple Cropping Project, Annual Report in 1973-74, 97-111.

HOLLING, C.S. (1973):
Resilience and stability of ecological systems. Annual Review of Ecology and Systematics, 4, 1-23.

I.A.R.I. (1972):
Recent research on multiple cropping, I.A.R.I. Res. Bull. (New Series No. 8). New Delhi, India.

IRESON, W.R. (1976):
Socio economic components of agricultural decision making: the adoption of new technology in multiple cropping in Northern Thailand. Unpublished Ph.D. thesis, Cornell University.

JEREZA, H.C. AND DE DATTA, S.K. (1976):
The use of cropping systems and land and water management to shift weed species. Philippine Journal of Crop Science 1, (4), 173-178.

ASIA COLLECTION UNIVERSITY OF HAWAII LIBRARY

ULSRIGIVAL, S. (1975):
Varietal and nitrogen trial of sesame (*sesame indisum*).
In:
University of Chiang Mai, Faculty of Agriculture,
Multiple Cropping Project: Agricultural Technical Report for
1974-75. Agricultural Technical Report No. 1, 73-75.

JNG, P. (1974):
A Review of Irrigation Systems in Northern Thailand.
In:
Agricultural Development Council National Seminar Report No. 5
Irrigated Agriculture in Northern Thailand, 52-71.

ERSSUPAWITHNAPA, B. (1979):
A study of effects of source of nitrogen fertilizer on changes in soil acidity under an upland (sweet corn) and waterlogged (rice) condition. Unpublished report of a research exercise for B.Sc. degree requirement, Agronomy Department, Faculty of Agriculture, Chiang Mai University.

TSINGER, J.A. AND MOODY, K. (1976):
Integrated pest management in multiple cropping systems. In Multiple Cropping, ASA Special Publication Number 27.

P (1974):
University of Chiang Mai, Faculty of Agriculture, Multiple Cropping Project. Annual Report for 1973-74.

P (1975):
University of Chiang Mai, Faculty of Agriculture, Multiple Cropping Project. Annual Report 1974-75.

P (1976):
University of Chiang Mai, Faculty of Agriculture, Multiple Cropping Project. Annual Report for 1975-76.

NISTRY OF AGRICULTURE AND COOPERATIVES, THAILAND (1976):
Detailed Reconnaissance Soil Map of Chiang Mai Province.
Department of Land Development, Soil Survey Division, Province Series No. 27, 26 sheets.

AMPANG, N. (1974):
Soybean: The effects of planting date, planting density and nutrient level on the yield and agronomic character of cultivar SJ2.
In:
University of Chiang Mai, Faculty of Agriculture - Multiple Cropping Project, Annual Report 1973-74, 169-178.

AMPANG, N. AND HOBBS, P.R. (1974):
Status of Crop Research Related to Irrigated Agriculture. In Irrigated Agriculture in Northern Thailand. ADC National Seminar Report No. 5.

NIPPANUTIYAN, P. (1979):
Land tenure and agricultural land use in the Chiang Mai Valley 1977-78. B.Sc. Research Exercise Report. Faculty of Agriculture, Chiang Mai University.

OELSLIGLE, D.D., MC COLLUM, R.E. AND KANG, B.T. (1976):
Soil fertility management in tropical multiple cropping. In Multiple Cropping. ASA Special Publication Number 27.

PARDTHAISONG, T. (1978):
The recent fertility decline in the Chiang Mai area of Thailand. Papers of the East West Population Institute No. 47, (February).

PATHAK, M.D. (1968):
Ecology of rice pests. Ann. Rev. Entomol. 13, 257-294.

PENCHAN, S. (1979):
Changes in soil pH under the different cropping systems in the Chiang Mai Valley. Unpublished report of a research exercise for B.Sc. degree requirement, Agronomy Department, Faculty of Agriculture, Chiang Mai University.

POTTER, J.M. (1976):
Thai Peasant Social Structure. University of Chicago Press. Chicago.

PRASIT-RATHSIN, S., ARTHORNTHURASOOK, T. AND SUKREE-YAPONGSE, P. (1978):
A micro socio-economic analysis of Thai fertility behaviour: a rural family perspective. The Findings. Mahidol University. Bangkok.

RAROS, R.S. (1973):
Prospects and Problems of Integrated Pest Control in Multiple Cropping. Paper presented at IRRI Saturday Seminar, August 4th, 1973. IRRI, Los Banos, Philippines.

RASMIDATTA, V. (1972):
Rice Calendar of Thailand. Thai J. Agric. Sci. 5, 63-76.

RID. (1962):
Royal Irrigation Department Survey, RID, Chiang Mai, Thailand.

SANMANEECHAI, M. (1974):
Village rice study 1 Effects of nitrogen and phosphosus fertilisation on growth, yield and nutrient content of rice.
In:
University of Chiang Mai, Faculty of Agriculture Multiple Cropping Project: Annual Report for 1973-1974, 135-147.

SCHOLTEN, J.J. (1974):
Physiographic, Climatic and Pedological Basis for Irrigated Agriculture in Northern Thailand. In Irrigated Agriculture in Northern Thailand. AIC National Seminar Report No. 5.

ASIA COLLECTION UNIVERSITY OF HAWAII LIBRARY

SEETISARN, M. (1975):
Maximizing the utilization of rice areas in the Chiang Mai Valley. Proc. Cropping Systems Workshop, 18-20 March 1975. IRRI, Los Banos, Philippines.

SEETISARN, M. (1977):
Farm and aggregate-level description of multiple cropping.
In:
International Rice Research Institute. Proceedings, Symposium on cropping systems research and development for the Asian rice farmer, 21-24 September, 1976. IRRI Los Banos, Philippines.

SEKTHEERA, R. AND THODEY, A.R. (1975):
Irrigation Systems in the Chiang Mai Valley; organisation and management.
In:
Thodey, A.R. (ed.) Multiple Cropping in Northern Thailand: Selected Papers.
Chiang Mai University, Faculty of Agriculture, Agricultural Economics Report 6, 81-95.

SENTHONG, C. (1973):
The effects of weed control and planting methods on the yield and growth of lowland rice. M.Sc. Thesis, Department of Agronomy, University of the Philippines.

SENTHONG, C. (1974):
Rice I Nitrogen rate experiment.
II Potassium rate experiment.
In:
University of Chiang Mai, Faculty of Agriculture
Multiple Cropping Project: Annual Report 1973-74, 112-122, 123-126.

SNAYDON, R.W. AND ELSTON, J. (1976):
Flows Cycles and Yields in Agricultural Ecosystems. In Duckham, N.A., Jones, J.G.W. and Roberts, E.H. (eds.), Food Production and Consumption. Nutrient Cycles. North Holland Publishing Company, Amsterdam.

SOCIAL SCIENCE RESEARCH CENTRE (1979):
Population Structure of Villages practising Multiple Cropping. Faculty of Social Sciences. Chiang Mai University (In Thai).

SOMKASAME, S. (1979):
Duration of weed competition on mungbean. Unpublished B.Sc. special project. Department of Agronomy, Chiang Mai University.

SOUTHWOOD, T.R.E. (1978):
Ecological Methods: with particular reference to the study of Insect Populations.
London; Chapman and Hall, 2nd Edn.

SPEDDING, C.R.W. (1975):
The Biology of Agricultural Systems. Academic Press, London. p.24-25.

SURYATNA, E.S. (1976):
Cropping Systems Research in Indramayu and Lampung Indonesia.
In:
Fourth Report of the Cropping Systems Working Group. IRRI, Los Banos Philippines.

SUTHASUPA, P. (1977):
Socio-economic factors affecting multiple cropping in Northern Thailand. Unpublished Ph.D. thesis, University of Nottingham.

THANI, P. (1978):
Labour requirements of various crops in the multiple cropping test plots in the villages of Mae Kung and Han Kaew during the 1977-78 cropping year. In the Multiple Cropping Project Extension Newsletter No. 5 September - October, 1978 (In Thai).

THODEY, A.R. (1975):
Farmer adoption of multiple cropping in the Chiang Mai Valley: the need for an effective infrastructure.
In:
Multiple cropping in Northern Thailand: selected papers. Agricultura Economics Report No. 6, Faculty of Agriculture, Chiang Mai University.

THODEY, A.R. AND LA RAMEE, P. (1974):
Ban Pa Mark, Northern Thailand: Results of a daily record keeping study, 1973-74. University of Chiang Mai, Faculty of Agriculture Agric. Econ. Report 4.

THODEY, A.R. AND SEETISARN, M. (1974):
Irrigated agriculture in Northern Thailand: a perspective. In A.D.C. National Seminar Report No. 5: Irrigated agriculture in Northern Thailand. Proceedings of a seminar, March 17-19, 1974.

TITAYAVAN, M. (1976):
Tip burn control in garlic.
In:
Chiang Mai University, Faculty of Agriculture, Multiple Cropping Project, Annual Report for 1975-76, 12-13.

TITAYAVAN, M., RERKASEM, K. AND LAMYONG, P. (in press):
Evaluation of multiple cropping systems in the Chiang Mai Valley.
In:
Chiang Mai University, Faculty of Agriculture, Multiple Cropping Project, Annual Report for 1977-78.

TONGCHAI, S. AND CHIWAT, R. (1978):
Migration of labour into the city of Chiang Mai. Department of Social Sciences, Working Paper. Chiang Mai University.

ASIA COLLECTION UNIVERSITY OF HAWAII LIBRARY

TONGSIRI, B., LERFFAMRAB, P. AND THODEY, A.R. (1975):
Agro-economic characteristics of the Chiang Mai Valley, 1972-73. Agricultural Economics Report No. 5. Faculty of Agriculture, Chiang Mai University.

TROLL, C. (1965):
Seasonal climates of the earth.
In:
Rodenwaldt, E. and Jusatz, H. (eds.) World Maps of Climatology, Berlin, Springer-Verlog, pp. 28.

VIRMANI, S.M., SIVAKUMAR, M.V.K. AND REDDY, S.J. (1978):
Rainfall probability estimates for selected locations of semi-arid India. Research Report 1, ICRISAT.

WALKER, B.H., NORTON, G.A., CONWAY, G.R., COMINS, H.N. AND BIRLEY, M.(1978):
A procedure for multidisciplinary ecosystem research: with reference to the South African Savanna Ecosystem Project. Journal of Applied Ecology, 15, 481-502.

WIBOONPONGSE, A. AND KELLOGG, E.D. (1979):
Study of farm to wholesale marketing in the Chiang Mai Valley. Chiang Mai University, Faculty of Agriculture, Ag. Econ. Report, No. 7.

WIBOONPONGSE, A. AND THODEY, A.R. (1974):
The Chiang Mai central crop market: structure, conduct and performance. Agricultural Economics Report No. 2, Faculty of Agriculture, Chiang Mai University.

WIVUTVONGVANA, M. AND P. (1974a):
Cabbage and corn: yield effect of nitrogen, phosphate and potassium fertilizer.
In:
University of Chiang Mai, Faculty of Agriculture, Multiple Cropping Project, Annual Report 1973-74.

WIVUTVONGVANA, P. AND M. (1974b):
Garlic (*Allium sativum*): The effect of nitrogen fertilization on yield and keeping quality.
In:
University of Chiang Mai, Faculty of Agriculture, Multiple Cropping Project, Annual Report for 1973-74.

WIVUTVONGVANA, M. AND P., AND DAWSON, M.D. (1975):
Effects of plant population and nitrogen fertilization on yield of garlic (Allium sativum).
In:
University of Chiang Mai, Faculty of Agriculture, Multiple Cropping Project: Agricultural Technical Report for 1974-75.

WIVUTVONGVANA, P. (1979):
Oxidation of Fe and Mn following drainage of a reduced soil and Mn toxicity in soybeans. Ph.D. Thesis, Cornell University, Ithaca, N.Y.

WIVUTVONGVANA, P., JULSRIKAIVAL, S. AND DAWSON, M.D. (1975):
The Effect of Nitrogen and Phosphate Fertilizers Initially Applied to a Field Corn - Soybean - Sweet Corn Cropping sequence. Multiple Cropping Project: Agricultural Technical Report for 1974-75.

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GLOSSARY

RICULTURAL SYSTEM:
A system with an agricultural output managed by man for this purpose.

OLOGICAL CONTROL:
The use of one biological agent to control another undesirable one, usually by predation, parasitism or competition.

-PRODUCT:
Incidental but useful output(s).

MICAL CONTROL:
The control of noxious agents such as insects, diseases and weeds by the application of chemical biocides.

SED SYSTEM:
A system that does not exchange matter with the surroundings; it may, however, exchange energy with it's surroundings.

MON IRRIGATOR:
Outside the official RID structure but working closely with RID officials, he operates under the direction of the Water Users Association and supervises the distribution of water into the farmers' fields. He is usually a farmer and is elected by members of the Water Users Association in his area of responsibility. Since 1970 common irrigators have been paid by their Water Users Associations.

PONENT:
The main elements that are related to form the system.

PONENT CROP:
Any single crop in a multiple cropping system.

PONENT PROPERTY:
A property of or an action on <u>one</u> crop which affects the performance of only <u>that</u> crop.

STRAINT:
Any factor which actually constrains the farmer from doing something. It is essentially a stress or perturbation that the farmer knows or expects will occur causing him to change his practices. A constraint may become a stress if it is minor and the farmer decides to ignore it and continues with his original policy, or a perturbation if the farmer takes the gamble that it will not occur but it does.

EXT OR ENVIRONMENT:
The external environment in which the system is operating.

CROPPING INDEX:
The number of crops grown per annum on a given piece of land x 100.

CROPPING INTENSITY:
The number of crops grown on the same piece of land in one year.

CROPPING PATTERN:
The yearly sequence and the agronomic practices on crops or crops and fallow in one year.

CROPPING SEQUENCE:
Merely the sequence of crops in a cropping pattern over a 12 month period.

CROPPING SYSTEM:
The crops and agronomic practices in a cropping pattern together with the interaction effects between them.

CROPPING YEAR:
12 month period starting at the time of land preparation of one crop. The starting point can be chosen according to one's purpose. For our purpose it is usually taken as the time of land preparation for the rainy season rice crop.

CULTURAL CONTROL:
The control of any noxious agent by crop management manipulation in terms of crops grown, their sequence, cultivations, fallowing, crop-residue management, etc.

DEPENDENCY RATIO:
The proportion of the population in the eleven to sixty years age-group to the rest of the population.

DIVERSION SYSTEM
Any form of irrigation system using water diverted from a natural river or stream that has no storage facility, water availability thus being dependant on water flow in the natural water-course.

DOUBLE CROPPING:
The growth of two crops on the same piece of land in one year.

DUG WELL:
A means of tapping groundwater for either agricultural or domestic purposes. It is usually dug by hand and may be as deep as 8 metres and is usually at least 1 metre in diameter. It is restricted to areas with a high water-table.

DURABILITY:
The long term potential productivity of a cropping system, i.e. its ability to continue unchanged with the same relationships, and thus with the same potential productivity, c.f. 'stability'.

ECOSYSTEM:
A system which includes both living and non living substances interacting to produce an exchange of materials between the living and non living units.

EFFICIENCY:
A ratio of output (or performance or success) to the input(s) (or costs) involved, over a specified time and in a specified context.

FALLOWING:
Resting land from deliberate cropping; not necessarily without cultivation or grazing but without sowing.

FARM DITCHES:
Terminal water-ways in the irrigation system which are situated within the farmland.

FARM SIZE:
The area of agricultural land cultivated by the farm family. This does not include the area of the homestead. c.f. 'holding-size'.

FARM SYSTEM:
The cropping systems practiced on a farm and their interaction with farm resources, other farm enterprises, and available technology which determine their makeup.

GATE TENDER:
Employed by the RID and, under the supervision of the watermaster, they operate the water regulating structures in the system.

GROUNDWATER SYSTEM:
Any form of irrigation system which uses groundwater e.g. tube-well, dug-well. Water supply is thus dependant on the conditions of the water-table.

HEAD GATE:
A gate on the intake side of the water delivery line which controls water level.

HEAD REGULATOR:
A device at the head of the irrigation system for the purpose of admitting water and regulating flow.

HEAD WORKS:
The various structures at the head of an irrigation system where water is diverted from the water source into the system, most important are the diversion weir, sand-sluice and head-regulator.

HIGH INPUT CROP:
A crop requiring relatively large amounts of fertilizer, pesticide, labour, management or other inputs and usually of a high value, high return nature.

HOLDING SIZE:
The area of agricultural land and homestead occupied by a farm family. c.f. 'farm size'.

INFORMATION FLOW:
Where one component influences another without the physical transfer of material.

INPUT:
Materials used by the system but originating from outside it.

INTEGRATED CONTROL:
The integrated use of biological, cultural and chemical methods of controlling noxious agents.

INTERACTION:
The relationships between the components.

INTERCROPPING:
The growth of two or more crops simultaneously on the same piece of land where the crops are planted in rows.

IRRIGABLE AREA:
The maximum area that can be planted and receive sufficient water for crop needs based on the types of crops grown and their water requirements.

KEY QUESTION:
Questions that are focussed on a key process of the system or a crucial area of decision making. Answering key questions should ideally either increase the understanding of the system and/or enable it's performance to be improved.

LATERAL:
A waterway feeding off the main canal.

LOW INPUT CROP:
A crop requiring relatively little fertilizer, pesticide, labour, management or other inputs and usually of a relatively low value, low return nature.

MIXED CROPPING:
The growth of two or more crops simultaneously on the same piece of land with no distinct row arrangement.

MODEL:
A simplified representation of a system. It may be expressed in form, word, diagrammatic or mathematical terms.

MONOCROPPING:
The growth of one crop in a pure stand in one 12 month period.

MUAN
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MUANG LEADER:

Or *Kae Muang* is approximately equivalent to the Project Engineer of the RID systems but he is elected by the members of the system and usually holds office for life although members do have the right to vote him out of office. The Muang leader, with the help of assistants, who he usually appoints himself, is responsible for water allocation, planning and supervising maintenance, settling disputes, keeping records and representing the system before other systems and Government agencies. Payment may include some cash, payment in produce and/or exemption from water-fees and supplying materials for system maintenance.

MULTIPLE CROPPING:

The growth of two or more crops on the same piece of land in one year.

OBJECTIVE OR GOAL:

A desirable condition or product as perceived by the farmer, towards which he is striving and which is compatible with his values. c.f. 'value'.

PACKAGE SYSTEM:

A cropping system as extended to the farmers with specific instructions on: planting dates and methods; fertilizer rates; pest disease and weed control measures; etc.

PADDY LAND:

Land on which wet season rice is usually grown in bunded fields, where the soil is submerged for most of the rice growing season.

PARCEL:

All fields belonging to one farm household that are contiguous with each other. One parcel may contain one or many fields and any farm may be made up of a number of seperate parcels.

PERCEPTION:

The situation or any aspect of it as seen by any individual. It may or may not be correct but is used as the basis for decision-making.

PERTURBATION:

Large, single, adverse shock to the system that is unexpected. c.f. 'stress'.

PRODUCTIVITY:

The mean annual level of yield (useful yield) of any crop or cropping system.

PRODUCTS OR PERFORMANCE:

Main desired output(s).

PROJECT ENGINEER:
The official responsible for the planning and operation of an RID system and for liasing with other RID systems in the area and with the RID Offices in Bangkok. Appointed by RID in Bangkok.

RELAY CROPPING:
The growth of two or more crops simultaneously during part of the life cycle of each on the same piece of land. A second crop is planted after the first crop has reached it's reproductive stage, but before it is ready for harvest.

RESILIENCE:
The ability of a system to absorb stress and perturbation without a large drop in productivity.

RESOURCES:
Elements lying within the system that are used up in it's functioning.

SLUICE GATE:
A structure to ensure a constant water level despite fluctuations in water demand further down the system.

SPILLWAY:
A structure in a diversion weir which serves to dispose of surplus flow safely.

STABILITY:
The degree of variation in yields from year to year either above or below the mean yield value. C.f. 'durability'.

STRATEGY:
The overall course of action that is chosen to meet a goal or an objective. C.f. 'tactic'.

STRESS:
Smaller adverse effect to the system which is applied continuously or at fairly regular intervals over a longer time period and may be expected. C.f. 'perturbation'.

SUB LATERAL:
A branch of the lateral.

SUBSISTENCE REQUIREMENT:
The total food requirement of all farm household members. Here it usually refers to the amount of wet season glutinous rice produced for household consumption as opposed to production of crops for sale.

SUBSYSTEM:
Any part of a system that contributes to the same output as the system itself. Any group of components may be considered as a subsystem if it aids in the analysis.

:YSTEM:
the A number of interacting components linked together for some common purpose or function.

:YSTEM BOUNDARY:
A means of deciding what is inside and what is outside the system. It is decided on according to purpose and can be at a number of different levels depending on the purpose of the study.

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:YSTEM PROPERTY:
A property of or an action on any crop or component which affects the performance of any other crop or component in the system.

:ACTICS:
The more day to day management of affairs already set in motion by the choice of strategy. C.f. 'strategy'.

ng.

:RIPLE CROPPING:
The growth of 3 crops on the same piece of land in one year.

n

:UBE WELL:
A means of tapping deep groundwater usually for agricultural purposes. These require expensive drilling equipment to install and are of 2 major types: shallow wells 7.5 to 45 m. deep by 5-10 cm in diameter costing 3,000 - 7,500 baht and deep wells up to 120 m deep by 20 cm. or in diameter, costing up to 200,000 Baht and thus usually requiring government assistance to a group of farmers.

:URN AROUND PERIOD:
The length of time between harvesting and completing essential post harvest operations one crop and beginning land preparation for the next crop in a multiple cropping system.

:LAND CROP:
Any crop that is grow under unflooded conditions. Used here to make a distinction between rice which is grown under flooded condition, and other crops, which are not.

'ALUE:
A fairly permanent conception of what is desirable. Values are often closely related to cultural tradition. C.f. 'objective'.

'ATERMASTER:
The RID official responsible for a portion of the main canal and its associated structures and laterals. He supervises the operation, maintenance and the water allocation, between laterals in his command area (up to 150,000 rai). Responsible to the Project Engineer.

WATER USERS ASSOCIATION:

Established under the Civil Commercial Code on Irrigation to create closer cooperation and information flow between water users and RID officials. Members of the Association are the water users in that area (up to 100,000 rai) and pay an annual fee to the Association based on their irrigated area.

WATER USERS ASSOCIATION LEADER:

They are elected by members of the Association and serve for a 2 year term. Their duties include the supervision of common irrigators, water allocation, investigating and settling disputes, etc. and most importantly they represent the water users before the RID and other Government agencies. They are unpaid but their position has certain perks and carries considerable status.

ZONEMAN:

Comes under the authority of his respective water master and is responsible for water allocation between laterals and sub laterals in his command area (up to 10,000 rai). He also supervises system maintenance in his area.

AMP

BAHT

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CHAN

DOR:

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KAO:

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AMYAI

THAI LANGUAGE GLOSSARY

AMPHUR:
Districts or subdivisions of the *Changwats* each headed by a civil servant appointed by the Ministry of the Interior.

BAHT:
The Thai unit of currency. One U.S. Dollar is worth approximately 20 Baht at the time of going to press.

CHANGWAT:
Closest translation is a Province. Thailand is divided into 74 Changwats which are administrative units each headed by a governor who is appointed by the Ministry of the Interior.

CHANODE:
Full title deed to land ownership. Under this title, land can be sold or disposed of in any way desired and can also be used as collateral for a loan and on the death of the owner can be interited by his heirs.

DOR:
A Northern Thai word which literally means 'precocious' and is often used in the names of rice varieties to denote their short maturity nature.

KAE MUANG:
The *Muang* leader of a traditional irrigation system who is responsible for organising water distribution and maintenance within that system. He is elected by members of the system and is a member of that system himself.

KAMNAN:
The 'commune-leader' or head of the *Tambon*. The residents of all the villages in the *Tambon* elect one of the village headmen to be *Kamnan*. In the North of Thailand he is usually the most influential person in the area. In addition to his headman duties his responsibilities include submitting periodic reports to the District Office, calling meetings of the commune councils, etc. For these duties he receives certain official privileges and receives a small monthly renumeration.

KAO:
The Thai word for rice which is also used synonomously to mean food.

KUI SALAK:
A ceremony where villagers 'make-merit' by taking gifts to the Temple where they are presented to the monks in a type of raffle system. When any Temple holds this ceremony most of the villagers from the surrounding villages will be involved.

LAMYAI:
Longan, *Nepholium longanum*. An evergreen tree bearing an edible fruit harvested in July/August.

LOI KRATHONG:

The annual festival of setting adrift small floats adorned with candles and incense in the rivers and waterways. Normally lasting for 2 days with associated ceremonies and celebrations.

MU:

Shortened form of *muban* or village. It is often used in this form suffixed with a number to differentiate between different administrative units within what was originally one village but which has been split up into a number of smaller ones for administrative purposes.

MUANG:

The Thai word for city or town which differentiates it from the *Changwat* or *Amphur* which may go by the same name.

MUANG:

Literally the main waterway in the traditional irrigation systems or the equivalent of the main canal in the RID system. It is also used to describe the entire system.

MUBAN:

The smallest administrative unit in Thailand at the village level. Each *Muban* is headed by a village head man who is elected by members of that village.

NAI AMPHUR:

The District Officer, appointed by the Ministry of Interior and responsible to both the *Changwat* Governor and the Department of Local Administration in the Ministry of the Interior. He forms the administrative link between the people via the *Kamnan* under his jurisdiction and the Central Government. The District Officer generally has a staff of 20 - 50 people and may be responsible for up to 150,000 citizens.

NAKORN:

City. *Nakorn* Chiang Mai is often used to differentiate the actual city of Chiang Mai from *Changwat* Chiang Mai or *Amphur Muang* Chiang Mai.

NGAN RUDOO NAW:

The annual winter fair in Chiang Mai. It lasts for 7 days and includes side-shows, commercial stalls, agricultural competitions and local handicraft and cultural exhibitions. Visited by people from the whole Chiang Mai area.

NIAW:

Literally meaning 'sticky' but also used in the names of rice varieties to denote that the variety is a glutinous or 'sticky' variety.

NOR

PAI

PHA

PHU

PII M

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PRATH

RAI:

NOR SOR 3:

A license recognising that land has been brought into agricultural use and giving permission to continue cultivation. After a specified time under occupancy the license can be changed to a '*Sor Kor 1*'. A *Nor Sor 3* can be inherited by legal heirs but cannot be sold or used as collateral for a loan.

PAI BUAT:

The ordination of new monks. The candidate himself will normally enter monkhood for a period of 3 months and will thus be unavailable for farm-work. The family and close friends will also be involved in ceremonies and celebrations for up to a week.

PHA PAA:

The donation of gifts to the Temples. This ceremony got its name ('jungle clothes') from the traditional practice of hanging new monks' robes in the jungle for them to be collected by the monks at a later time.

PHU YAI BAN:

The village headman. He is elected by the villagers and will normally serve until he retires or dies but the villagers do have the power to vote him out of office if they feel he is not performing his duties. His responsibilities include representing the village before Government agencies and District Officers, record-keeping, arbitrating in disputes and reporting illegal activities, etc. For these duties he receives a small monthly renumeration.

PII MAI:

'The New Year'. Two days public holiday with a number of fairs, parties and general celebrations at this time.

POI LUANG:

A festival held once a year by the Temple where people take gifts to the monks. The date is determined by the individual Temple and villagers may be involved for 2 or 3 days: going to the market, preparing food and gifts and then going to the Temple.

PRATHOM:

The grading of the Thai Primary education system. Children enter *Prathom 1*, or first grade, usually at the age of 6 and may continue up to *Prathom 6* or sixth primary grade finishing usually at the age of 13 when they may enter secondary education. Thus someone with *Prathom 4* educational level has completed grade 4 or four years of primary education.

RAI:

The Thai unit of land measurement, 1 *rai* equals 0.16 Hectares.

SONGKHRAN:

Probably the most important festival in the Northern Region especially in rural areas. It is the Thai New Year festival and farm-work will be minimal during this period.

SOR KOR 1 (sitti Khrawp Khrawing):

A reserve license issued to farmers after they have held a '*Nor Sor 3*' for a specified period of time. It is a legal recognition by the Government that the occupier has cultivated the land for a number of years and has permission to continue to do so. It can be passed on to legal heirs at death but cannot be sold or used as collateral for a loan.

TAMBON:

Groups of villages which form the smallest administrative units above the village. Each is headed by a member of the community who is elected by the head-men of the villages in that Tambon, and who is also a village headman himself.

THANG:

Standard Thai measurement for paddy rice which equals 10 kg. This should not be confused with *Tang* which is a volumetric measure for rice and varies slightly between different areas from approximately 12 - 15 kgs.

WAT:

The Temple and centre of religious life of the village. Most villages or at least groups of villages will have their own Temple which is maintained by donations from the community.

WI SA KA BOOCHA:

An important religious festival to celebrate the Buddha's birthday and death.