Economic and Social Commission for Asia and the Pacific

CGPRT Centre WORKING PAPER No. 69

Coping Strategies against El Nino-induced Climatic Risk: Case of Northeast Thailand

Thamrong Mekhora

United Nations

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"CGPRT Centre Works Towards Reducing Poverty Through Enhancing Sustainable Agriculture in Asia and the Pacific Region"

WORKING PAPER 69

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Foreword

The research project “Stabilization of Upland Agriculture and Rural Development in El Nino Vulnerable Countries (ELNINO)” has come to its final phase after three years.

It is my pleasure to publish “**Coping Strategies against El Nino-induced Climatic Risk: Case of Northeast Thailand**” as one of results of the project. This report is mostly based on in-depth field survey conducted in drought prone Northeast Thailand. In this volume, the details of drought experiences in 2001 and the various mitigation measures at local/farm level were well documented. I hope these information is useful for effective policy formulation to address the problems encountered and stabilize rainfed agricultural production and further development in less favored rural areas.

I thank Mr. Thamrong Mekhora and his research team for their strenuous efforts to conduct field studies. The study much owed continuous support from Ministry of Agriculture and Cooperatives of Thailand. Dr. Rogelio N. Concepcion, Regional Advisor, and Mr. Shigeki Yokoyama, Project Leader, guided the study team leading to its fruitful results. My thank is extended to Mr. Matthew L. Burrows for his careful English editing. Last but not least, I would like to express sincere appreciation to Japanese Government for funding the project.

March 2003

Nobuyoshi Maeno
Director
CGPRT Centre

Acknowledgements

This country report is the second part of the results of the research project, "Coping Strategies against El Nino-induced Climatic Risk: Case of Northeast Thailand." The study focuses on drought effects on upland agriculture and policy and mitigation measures at the farm level in Thailand.

Financial assistance for this research project was provided by the UN ESCAP CGPRT Centre. I am grateful to Dr. Nobuyoshi Maeno and Dr. Haruo Inagaki, current and former Director of the CGPRT Centre, for their initiative to organize and maintain the project.

I would like to thank Mr. Shigeki Yokoyama, Project Leader, and Dr Rogelio Concepcion, Regional Advisor, for their guidance, advice and comments in finalizing the report. Special thanks are due to Matthew L. Burrows for his English editing. I would like to thank Mr. Muhamad Arif and Mr. Harry Zulfikar, staff of CGPRT Centre, for their assistance in graphical editing and Ms. Agustina Mardyanti, for her typing drafts of the publications.

Sincere appreciation is extended to the Office of Agricultural Economics (OAE), Ministry of Agriculture and Cooperatives for assigning me and OAE staff to join the project. I also express my thanks to everyone who helped make this report possible.

The views in this technical paper are those of the author and do not necessarily represent the policy of the organization for which the author works.

Bangkok, Thailand
March 2003

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Executive Summary

The objectives of this study are to collect and analyze data and information concerning drought impacts on production, income, labour allocation and food security at the household level; to evaluate farmers' strategies in coping with drought problems, constraints faced by farmers and support requirements; and to evaluate government measures in handling drought problems, which includes concepts, approaches and its implications in the field. Two provinces are purposely selected, namely Lop Buri in the Central Plains and Nakhorn Ratchasima in the Northeast Plateau. One hundred and twenty samples in each province were randomly selected and face-to-face interviews were conducted in early 2002 after the end of the crop season. The data was based on crop year 2001/02.

The study found that the average number of males and females in the household were four. The male to female ratio was close to one to one. There was no change in these numbers between 2001 and 1996. Farm size in Lop Buri (nearly 12 hectares) is twice as large as Nakhorn Ratchasima. The major crops grown in 2001 were upland rainfed rice in Nakhorn Ratchsima and maize in Lop Buri. There were many kinds of crop diversified in both provinces, including mungbean, groundnut, cassava, sugarcane, sesame, chili, fruit trees and trees. Animals were rasied on some farms, including milk cows, cattle, poultry, local chicken, duck and buffalo. Cropping patterns in 2001/02 were upland rice, maize, cassava, sugarcane, maize-sorghum and maize-sunflower.

The government had warned the villagers about the abnormal weather hitting Thailand in 2001 through various types of media, including radio, television and government agencies. Upon hearing the warning, some farmers made adjustments to their production plan, preparing water for drinking, seeking additional income to compensate the loss of their produce and stocking rice for domestic consumption. The effects of the drought in 2001 put some villagers in debt and a few households moved out of their villages to find new jobs. All villagers had large jars for storing rainwater for household consumption and most of them traditionally had rice storage buildings.

The government's effective measures to mitigate drought effects were seed provisions, the establishment of a village fund, food distribution and water resource development. The village fund satisfied the villagers when they were able to utilize and manage the fund by themselves. For water resource development, the Government of Thailand had fortunately paid attention to developing water resources for decades. This included ground water development, weir construction, reservoirs and rainmaking. The expected support from organizations, when drought was approaching, was from agricultural officers and the central government while the village leader, monks and temples, schools and teachers, tambol council, public health officers, community officer, and district and provincial governor were not expected to help. Measures and support requested by the villagers were water resource development, seed provision, village fund establishment and price intervention. Farm practices concerning environmental issues were manure utilization and crop rotation.

The production function analysis of six different cropping patterns indicated that under drought conditions, land and labour were the most effective inputs. Rice and maize were affected by rain the most.

The study recommends that water for drinking and household consumption is not of interest. This is because most villagers have the facilities already in place and enough water for drinking and household consumption. Also, the Thai Government has paid attention to water resource development continuously and determined it as a first priority for the country development policy. For water for agriculture, since both study areas are located in upland areas, it is difficult to construct reservoirs. Rain is the only water supply source, therefore, rainmaking is the best way to increase the amount of water when drought is approaching. In terms of food security, since Thailand is a food surplus country and most farms in the study areas are self-sufficient in rice, food security measures are not necessary to be implemented. However, one of the most practical policies would be to expand the rice mortgage project (with an interest rate of 3 per cent a year) and expand its repayment period to cover upland areas where the villagers have stored paddy in their barns and require some money with a low interest loan. For cropping systems, most farmers have experience in switching crops from the normal crops to crops with a lower water requirement. Kenaf can replace rice, chili and sugarcane to replace maize and sunflower and sorghum to replace second season maize. Trees and fruit trees are less important to both study areas. If trees bring moisture to the environment, the suggestion would be to encourage farmers to grow them. Moreover, some land should be allocated to grass land for cattle and cows. The drought warning system is very effective to warn people and help them prepare and adjust their activities before the loss comes. Now, the media, in terms of television and radio, is widespread throughout the country. The government should utilize this facility as much as possible. Furthermore, the establishment of a permanent office and staff in 2002, will help mitigate drought effects and provide optional measures to overcome droughts. Crops resistant to abnormal weather and some varieties of traditional crops should be researched and introduced to replace the ones that require a lot of water. However, these projects have been implemented in the past but failed because there was not a market for the new crop. Therefore, both technical and economic (market) feasibility should be considered.

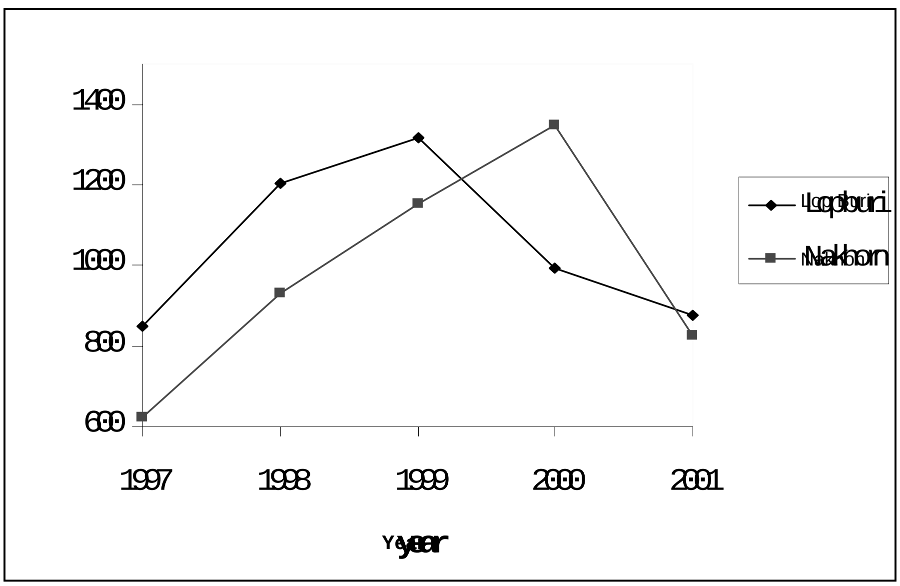
1. Introduction

1.1 Upland agriculture and El Nino effects in Thailand

Upland agriculture in Thailand relies mainly on rainfall and its distribution. Although the influence of the southwest wind brings heavy rains or extremely wet weather throughout the country for six months during May to October every year, Thailand temporarily faces abnormal droughts. The impacts of the so-called El Nino droughts in 1992 and 1997 especially, were significant. Indonesia, Malaysia and the Philippines were also affected. The droughts were linked to decreases in the average amount of rainfall in each region and over the main river basins, including the Chao Praya and the Mune-Shi river basin in the Northeast. These evidently caused a decline in the yields of the major crops, including rice, maize, sorghum and sugarcane, especially in 1997.

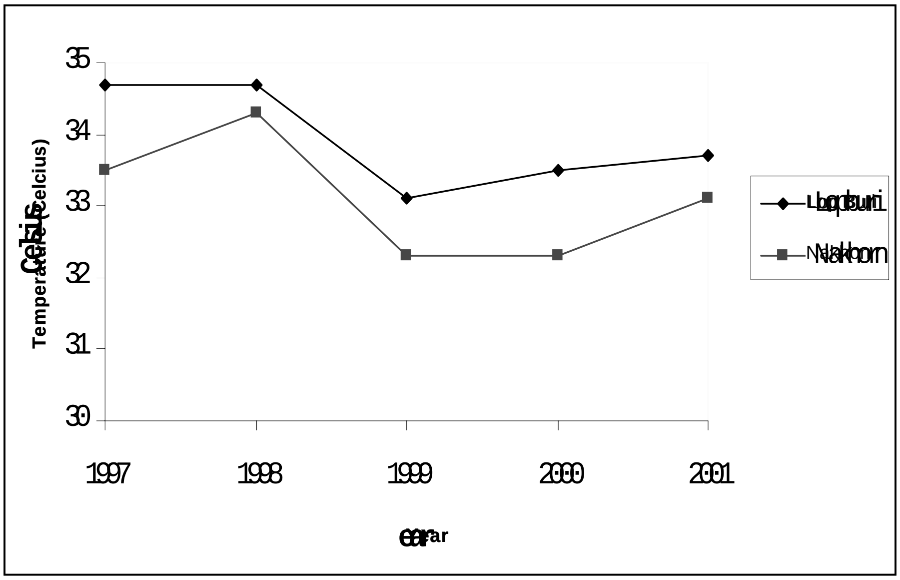
Although it is forecast that El Nino will affect the region in 2002, in 2001 abnormal weather approached Thailand. According to the records of the Meteorological Department, the annual rainfall in Lop Buri and Nakhon Ratchasima (the study areas in this phase) dropped from 1,170.8 and 1,141.8 mm per year of the three-year average of 1998–2000, to 890 and 880 mm in 2001 respectively (Figure 1.1). The temperature also increased significantly (Figure 1.2). Even though the amount of rain was still enough for upland crop production, in practice some loss may have occurred. The loss of major crops may have also affected the socio-economic situations of the people in vulnerable areas. These effects will be collected and explained in the following chapters. Moreover, it is certain that these people have extensive experience of drought and their existing measures to mitigate the loss are proposed. Finally, measures and mechanisms to cope with the El Nino phenomenon are investigated at the farm level.

Figure 1.1 Annual rainfall (mm) in Lop Buri and Nakhon Ratchasima, 1997 - 2001



Source: Meteorological Department.

Figure 1.2 Average maximum temperature (Celsius) in Lop Buri and Nakhon Ratchasima, 1997 - 2001



Source: Meteorological Department.

1.2 Literature review

The first phase of the study revealed that the El Nino phenomenon may affect harvested areas and yield of considered crops in Thailand. In 1997, these impacts, in terms of agricultural production and social and economic conditions, clearly occurred in some parts of the upland regions in the Northeast and Central Plain areas, where most of the CGPRT crops are planted. The impacts on the environment and natural resources were a severe drought and a long period of water shortages. Labour mobilization, a weakened degree of buying and loan repayment abilities were also impacts of El Nino. However, the Thai Government has continuously implemented measures and mechanisms and encouraged local initiatives to deal with abnormal weather effects. Existing effective measures are rainmaking, reforestation, seed subsidies, crop diversification and agricultural restructuring as well as well-planned irrigation management.

The first phase of the study, however, was designed to reveal how far the impacts of abnormal weather affected farmer's households. Moreover, what measures are undertaken by the farmers to overcome their problems and what is the government's role in handling the El Nino problem. Finally, what are the effective mitigating measures used at the farm level. The second phase of the study will focus on these details.

1.3 Scope of the study

The next El Nino is predicted to occur in 2001 or 2002. Thus, the second phase of the study is expected to produce actual and accurate information concerning socio-economic information and measures to cope with the El Nino effects at the farm level. Evidence of abnormal weather was apparent in Thailand in 2001 when the rain was less than the previous years' and the high temperatures were from January to March 2002. However, the rain came early in May 2002. Thus, the period of 2001 is suitable to represent an abnormal year (but not the strongest one) for the study of the second phase of the project.

The objectives of the second phase are to analyze and evaluate drought impacts at farm-household level, farmer's responses and government measures to overcome the problems. These objectives are further broken down into:

(a) To collect and analyze data and information concerning drought impacts on production, income, labour allocation and food security at household level.
(b) To evaluate farmer's strategies in coping with drought problems, constraints faced by farmers and the support requirement.
(c) To evaluate government strategy in handling drought problems, which includes concepts, approaches and its implications in the field.

This research will be conducted in two different communities where the effects of abnormal weather were experienced in 2001. The emphasis of this study is on production, cropping systems, household characteristics, farmer's attitudes toward measures and mechanisms to solve the problems and food security at household and community levels.

1.4 Outline of the report

The report consists of five chapters. Chapter 2 details research methodology. The focus is to introduce the study area, data collection (sampling techniques, questionnaires, field problems and limitations) and concepts of the production function and its model specification. In Chapter 3, the data from the survey is summarized and presented in report form. The details are farm family structure, household size, farm size and land use, villagers' experiences concerning the abnormal weather effects in 2001, measures and support requested by villagers and farm practices concerning environmental issues. Production function analyses of six cropping patterns are taken into consideration in Chapter 4. The details include the estimation, economic interpretations and affects of drought on the major crop yields. Chapter 5 is the summary and recommendations.

2. Data Material and Research Methodology

2.1 The study area

Figure 2.1 indicates that the areas for this study are in two diverse provincial regions. Lop Buri is located in the Central Plains and Nakhon Ratchasima in the Northeast. Each province covers two sample districts (Kok-Samrong and Phatana-Nikom in Lop Buri and Kham-Sakaesaeng and Non-Thai in Nakhon Ratchasima) where upland crops dominate. There is a large variety in the upland cropping patterns in these two provinces. Both are major upland areas in Thailand. Lop buri was once named as the Corn Belt of Thailand while Nakhon Ratchasima was the cassava plantation area. Lop Buri is much more productive due to the high quality of soil, but water is hard due to the limestone rock base. Nakhon Ratchasima, on the other hand, is less productive because of the sandy soil and ground water is salty due to the salty rock base.

Figure 2.1 Study areas

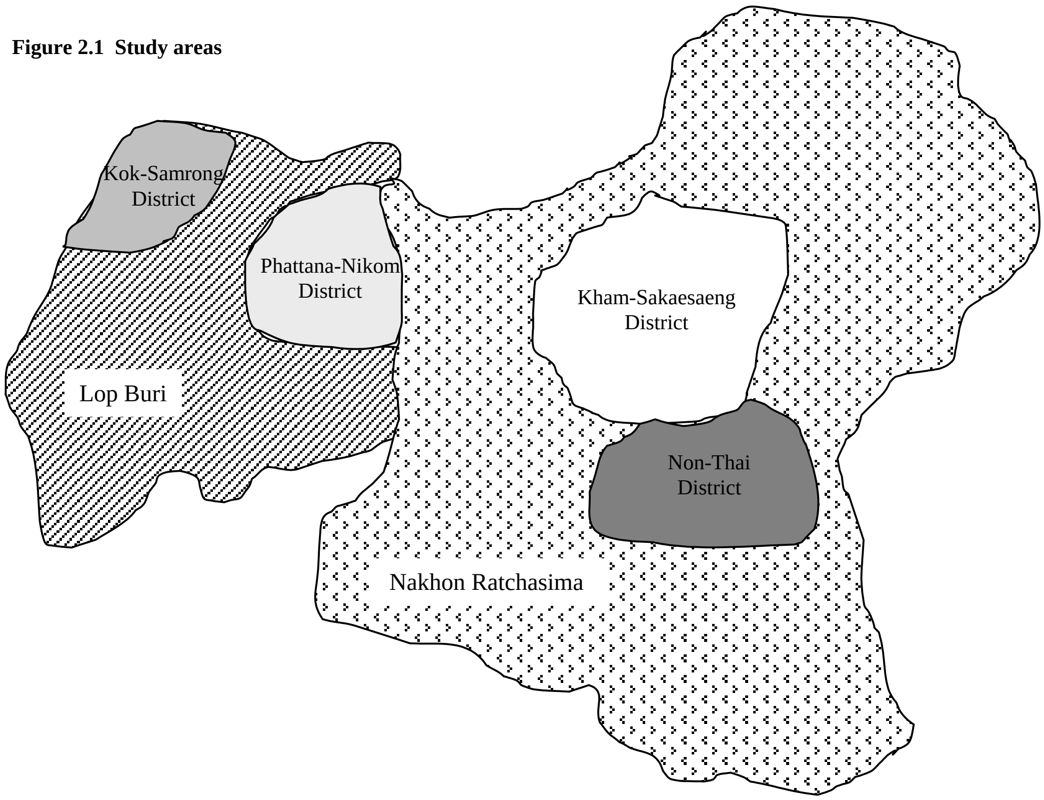
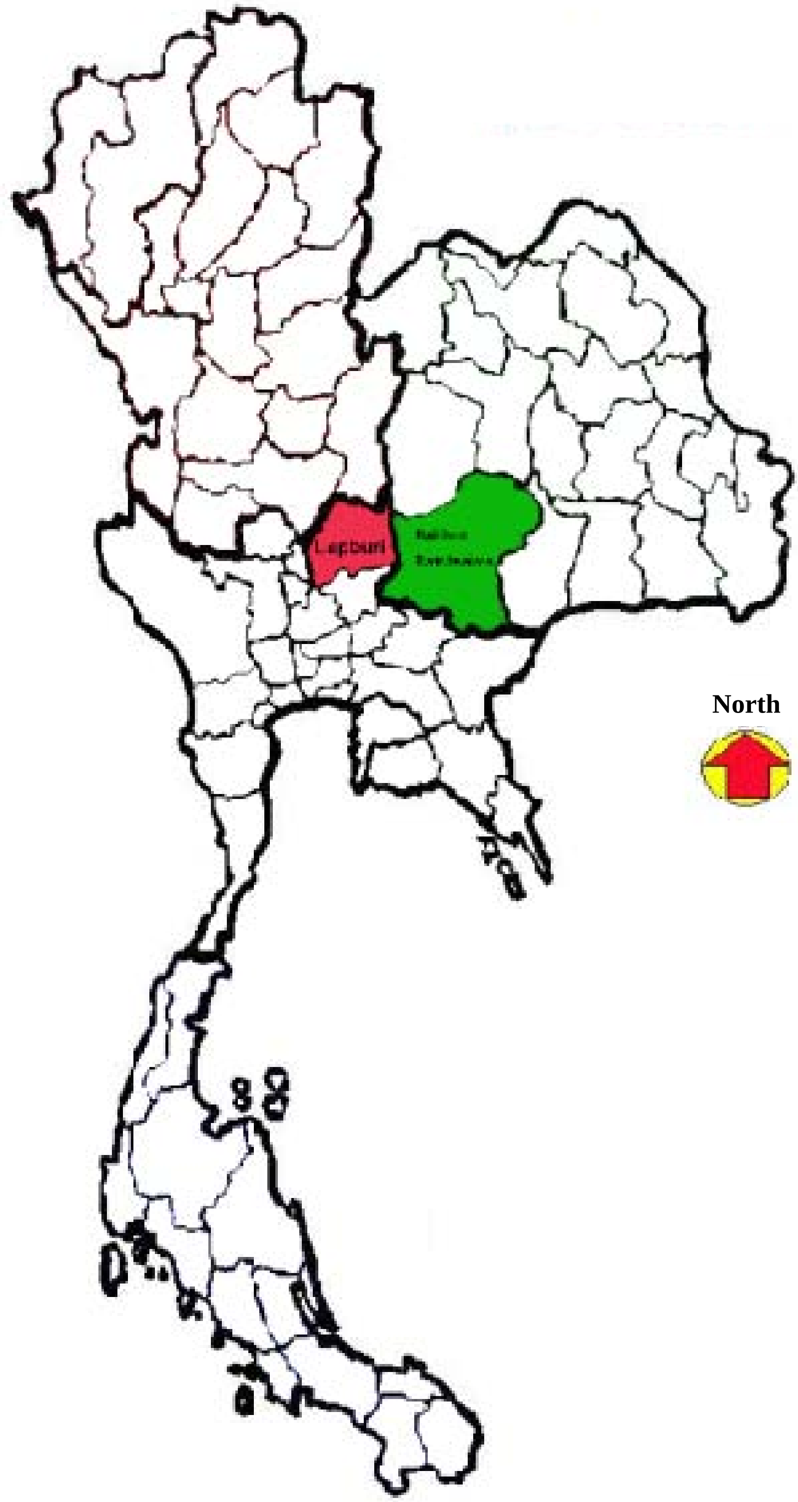


Figure 2.2 Map of Thailand



2.2 Data collection

Choice of data collection methodology is a major aspect of achieving the objectives of the study. The wide spectrum of farm characteristics, measures to cope with the drought problem, cropping patterns of the upland areas and the nature of the envisaged analyses to achieve the objectives precluded the use of only one particular data collection method. Thus, several methods were adopted and used for collecting the data required to satisfy the study objectives.

A lack of available secondary socio-economic data for analysis results in a need to collect primary data in a study of this nature. The major proportion of data used in this study was collected as primary data about household members and their movement, measures to deal with drought problems and different aspects of the small farmer cropping system. Both formal and informal surveys were employed. In addition, supplementary secondary data was used where available. This included rainfall data, village socio-economic information and government policy and measures to address drought conditions.

2.2.1 Sampling techniques

It would have been desirable, as a first stage in sampling, to use theoretical formulation to obtain the size of the sample on the basis of major indices to be studied and relate these to the costs of obtaining information. Lacking prior knowledge of these indices, however, made this impossible. Thus, more practical methods under the small farmer environment in the study area were preferred. Consequently multi-stage cluster sampling techniques were adopted.

The basic administrative areas in Thailand’s provinces were considered to be a cluster. Each province included districts. The first stage of sampling was to select two upland dominated districts in the two provinces. The second stage of the sampling technique was to randomly select five villages from each of the districts. Each village contains approximately 100 farm-families. The final stage of sampling involved the selection of 12 farm-families from the selected villages. The 240 households were selected mainly on a subjective basis. The criteria of the selection are as follows:

- Rainfed agricultural practice.
- Five-year-experience in upland crop production.
- Accessibility of the farmers.
- Ability of the farmers to respond to the questionnaires.
- Willingness of villagers to cooperate and answer the questions.

Data of 240 farm households was used in the major analyses reported in this study.

2.2.2 Questionnaires for primary data collection

In the case where formal surveys were used, several pre-coded questionnaires were developed. Pre-coded questionnaires were preferred because they saved on both time and space and the use of computer analysis had been envisaged. Also, prior knowledge of the farm characteristics and the existing farming system was used in the construction of the questionnaires. Open-ended questions were included to extract information otherwise not specifically accounted for in the pre-coding. Field acreage, yields, costs, incomes, family members and cropping patterns are examples of this type of question.

Information on risk attitude of the farmers was obtained through both formal and informal surveys. These included discussions between the author and the respondents, measurements of yield loss and the observation of constraints experienced by the farmers in their natural environment.

2.2.3 Field problems and limitations

When conducting a study on small farmer agriculture with the objective of collecting farm characteristics, management data on cropping systems and drought and attitudes towards government policy and measures, several problems are encountered. Some of the problems are briefly discussed with an illustration of how they were solved. This was an attempt to improve on the general accuracy of the data used. The problems were experienced both in the field and during data analysis and interpretation.

(a) Enumerators: Despite being trained prior to being sent into the study areas, enumerators faced unexpected obstacles during the survey. Some observations were not available during the daytime and the interview had to be made in the evening. In such cases, tiredness may affect the quality of the interview.

(b) Farmers: Farmers' problems varied from skepticism to unavailability. They did not keep any records about their past or planned activities. Information regarding past events could only be acquired through memory recall. Reliability of this information is questionable since accurate memory recall is greatly reduced where the investigated events are of continuous variability. To circumvent this problem, direct observation and measurements of events by the enumerators were preferred where feasible.
Skepticism arose mainly from past experiences with other data collectors that had made unfulfilled promises. Therefore, while sympathizing with such farmers, efforts were made to establish beneficial support though no promises were made.

(c) Physical: Some small farmers used traditional quantity measures of inputs and outputs based on local measurements. Although the local units were accepted during the survey, official weight scale measures were undertaken. All volume measures were converted to a common metric ton weight measure during data compilation.

2.3 Production function analysis

2.3.1 Model specification and assumption

Specifying multiple regression equations for productivity estimates uses production function analysis. The regression equations are based on the Single Equation Approach Model (SEAM) where the production functions for the different cropping patterns were considered as single independent relationships between the dependent variable and the explanatory variables (factor inputs). The production functions as individual functions were, therefore, assumed not to be influenced by other relationships relevant to the economic milieu enveloping the production process.

Model specification in statistical analysis involves specification of the production function for the different cropping patterns. The technical relationships between the outputs of the various cropping patterns are weighted in monetary units (using local prices) and the various factor inputs in the production process are determined. Monetary unit weighting is preferred in accounting for the preponderance of different physical units in chemical use found between and within the cropping patterns. The production surface for different cropping patterns is portrayed by their different lead regression equations.

2.4 Model specification

The production function is a mathematical way of describing the relationship between the production and the given inputs, namely, the factors affecting the production process. The results of the production function analyses are reported in Chapter 4. The production function is based on the SEAM of the Multiple Regression Analysis (MRA). The MRA is an extension of the Ordinary Least Squares Simple Regression Model (OLSSRM). The OLSSRM is extended to include more than one explanatory variable. Thus, the MRA indicates the technical relationships between the outputs and the various factor inputs in the production process of the different cropping patterns. The changes in the dependent variable can be explained by reference to changes in several other independent variables. The model can, therefore, be used for the estimation of statistical parameters, hypothesis testing and prediction. The underlying model assumptions and consequences of their violations are well described in standard econometric textbooks.

3. Effective Measures and Policies to Mitigate El Nino Effects

3.1 Introduction

This chapter presents the information concerning villagers in terms of farm family structure, household size, farm size and land use. After that, details of villagers' experiences about abnormal weather are examined. Moreover, the analysis is on the investigation of drought effects in 2001. Starting from the perception of the villagers of the government warning, the measures to mitigate the effects are evaluated, including water preparation for drinking and home use, production planning, rice storage and others. Past effective measures are monitored, and the required help from the government to mitigate drought effects are noted. Farm practices concerning environmentally friendly issues are observed.

3.2 Farm-family structure

In consideration of family structure, the establishment of sex composition and distribution is crucial. Sex composition and distribution is so important since labour availability and distribution among farm activities is divided by sexes. Agricultural operation on a household basis in Thai rural areas is traditionally divided by sexes. Generally, males perform strenuous tasks, such as soil preparation and transportation, while females carry out those tasks requiring more dexterity, like seeding, weeding and kitchening.

Table 3.1 shows that comparison of the average number of males and females per household indicates similar variations between the two considered provinces. The average number of males per household ranged from 2.02 in Nakhon Ratchasima to 2.32 in Lop Buri. For females, the number per household ranged from 2.08 in Nakhon Ratchasima to 2.10 in Lop Buri. When compared to data from 1996, the number of males in Lop Buri remained the same, while the number of females increased. On the other hand, the number of males in Nakhon Ratchasima in 2001 decreased from 1996, while the number of females increased.

Table 3.1 Demographic characteristics and labour capacity for farm activities

Details	Lop Buri				Nakhon Ratchasima			
	2001		1996		2001		1996	
	Mean	CV %	Mean	CV %	Mean	CV %	Mean	CV %
Number per household	4.42	29.76	4.32	28.40	4.10	34.53	4.03	53.17
Number of males	2.32	41.38	2.32	42.24	2.02	51.98	2.07	52.17
Number of females	2.10	46.19	2.00	46.00	2.08	48.56	1.97	49.24
Labour force per household	2.97	34.56	2.93	34.36	2.73	39.41	2.82	46.55
Male labour force	1.58	48.73	1.55	47.48	1.42	50.70	1.47	63.95
Female labour force	1.38	45.65	1.38	43.48	1.32	44.70	1.35	62.22
Consumer/worker ratio	1.49	31.80	1.47	34.92	1.50	32.24	1.43	37.97

Note: 1. CV = Coefficient of variation (standard deviation as a percentage of the mean value).

2. Labour force = Total number of household members participating in farm activities, age 15-60 years.

Source: Author's calculation from survey data.

3.3 Household size

In this study, household size indicates the number of persons living wholly or partly together, sharing the same facilities in the house and eating from one pot. This literally implies those persons who constitute a household and are supported from the same fields.

Table 3.1 also indicates household size and their coefficients of variations by province and year. In 2001, the average household size sampled ranged from 4.1 persons in Nakhon Ratchasima to 4.42 persons in Lop Buri. Structural Thai culture dictates, one household has one wife and one husband. Moreover, the impact of birth control campaigns launched decades ago led to one family having only one or two kids.

3.4 Farm size and land use

Legally, the Government of Thailand allow the farmers to own their land titles and the farmers have the private right to utilize their lands profitably. National records of average land holding size is 25 rai per household. This study found that the farm size in Lop Buri, 74.68 rai, was twice as large as in Nakhon Ratchaburi, 37.62 rai. Moreover, farm size in 2001 increased slightly from 1996 in both provinces. Upland rainfed rice dominated the cultivation area in Nakhon Rachasima, while maize dominated the planting area in Lop Buri. The crops in Lop Buri were more diversified than in Nakhon Ratchasima. The cash crops included mungbean, groundnut, cassava, sugarcane, sesame and chili. Trees and fruit trees were also planted by small numbers of villagers. Some fruit trees were difficult to adapt to upland areas. Animals were also raised on some farms. Cattle, milk cows and poultry were found around the study areas. Fish was rarely raised due the difficulty in storing water in fish ponds (Table 3.2).

The change in farm size from 1996 to 2001 was due to land rented from neighbors, while most villagers actually still owned the same size farm (Table 3.3). This indicates that the effects of the drought in 1997 did not cause the loss of farm size or planted area in the study areas. The villagers were still living in their villages and cultivating their land as usual. One important characteristic of Thai people is endurance. After having settled, they tend to live on their land all their lifetime. Movement occurs when they are forced to move out rather than volunteer.

Table 3.2 Farm size and land use

Details	Lop Buri					Nakhon Ratchasima				
		2001		1996			2001		1996	
	N	Mean	Std.	Mean	Std.	N	Mean	Std.	Mean	Std.
Total area	120	74.68	68.21	62.15	41.18	120	37.62	26.06	36.07	24.43
Upland rainfed rice	54	24.26	20.29	22.11	13.43	117	17.18	13.18	19.28	11.37
Maize	102	36.68	33.58	35.37	22.29	54	11.07	12.31	6.96	7.82
Chili	4	10.5	0.69	0	0	80	3.97	2.83	4.90	2.85
Sorghum	44	24.41	17.75	21.05	17.42	0	0	0	0	0
Sunflower	56	29.93	22.85	26.21	25.36	0	0	0	0	0
Mungbean	22	26	19.64	4.08	7.66	2	1	0	0	0
Groundnut	6	4	4.48	9	8.80	0	0	0	0	0
Sesame	12	24.17	12.15	19.17	16.49	0	0	0	0	0
Cotton	11	13.2	8.73	0	0	0	0	0	0	0
Sugarcane	32	64.63	73.54	31.81	35.74	12	17.67	9.40	8.17	9.77
Cassava	8	36.75	19.70	44.25	51.56	42	7.14	7.07	8.52	7.29
Watermelon	10	16.8	4.22	5.00	6.91	0	0	0	0	0.00
Fruit trees (number)	50	44.56	94.82	53.28	103.46	40	84.9	98.91	46.75	79.68
Vegetables	26	7.38	8.99	6.15	9.57	6	1	1.69	0	0
Trees (number)	24	24.42	26.88	21.67	23.57	10	476.6	840.88	486.6	838.65
Cattle (number)	10	4.4	4.07	3.2	2.12	18	6.67	6.54	7.33	4.62
Milk cow (number)	8	17.5	20.17	30.25	15.16	2	5	0	0	0.00
Buffalo (number)	0	0	0	0	0	6	3.00	2.59	7.00	2.59
Poultry (number)	68	27.53	22.05	24.88	23.86	70	28.4	49.09	56.00	105.77
Fish pond (rai)	20	1.40	0.83	0.70	0.66	56	0.93	0.70	0.82	0.75

Source: Author's calculation from survey data.

Table 3.3 Cause of land size change

Province		Causes of change in total area							
		Unchanged	Rented	Bought	Fragmented	Lost	Mortgaged	Leased	Total
Lop Buri									
	Number	79	28	1	8	3	0	1	120
	%	65.8	23.3	0.8	6.7	2.5	0.0	0.8	100.0
Nakhon Ratchasima									
	Number	83	12	1	16	4	1	1	120
	%	69.2	11.7	0.8	13.3	3.3	0.8	0.8	100.0
Total									
	Number	162	42	2	24	7	1	2	240
	%	67.5	17.5	0.8	10.0	2.9	0.4	0.8	100.0

Source: Author's calculation from survey data.

3.5 Villagers' experiences concerning El Nino effects in 2001

This study selects year 2001 as the representative of an abnormal year because the rain was less than normal and the temperature was higher. Moreover, the Government of Thailand had launched a campaign to warn the people, countrywide, about the abnormal weather approaching Thailand. There were many media used, such as radio and television broadcasting, newspaper and government services. The following section focuses on the response of villagers to that warning and their preparation to deal with the drought's effects.

3.5.1 El Nino and abnormal weather warning perception

When asking the villagers about the news of El Nino and abnormal weather (drought), the majority of the respondents in both provinces received that information (Table 3.4).

Table 3.4 Abnormal weather warning news perception

Response	Drought warning news		
	Lop Buri	Nakhon Ratchasima	Total
Yes	63.3	54.8	70.0
No	36.7	23.3	30.0
Total %	100.0	100.0	100.0
Number	120	120	240

Chi-Square = 5.079, df = 1, Significant = 0.024
Source: Author's calculation from survey data.

3.5.2 Production plan after warning

For the respondents who received the warning news, 51 per cent in Lop Buri made adjustments to their production plan while only 35 per cent in Nakhon Ratchasima did (Table 3.5). The villagers in Lop Buri are better able to revise their production plan than those in Nakhon Ratchasima.

Table 3.5 Production planning after having received the warning news

Response	Production planning when drought approaches		
	Lop Buri	Nakhon Ratchasima	Total
Yes	48.6	65.2	57.8
No	51.4	34.8	42.2
Total %	100.0	100.0	100.0
Number	74	92	166

Chi-Square = 4.617, df = 1, Significant = 0.032
Source: Author's calculation from survey data.

3.5.3 Water preparation for drinking and other uses

After receiving the warning, only 29 per cent of the informed villagers in Lop Buri prepared water for drinking and home use, compared to 63 per cent in Nakhon Ratchasima (Table 3.6). A smaller percentage of respondents prepared water in Lop Buri because they had all done it before and it was now common place. Since the villagers in both areas are living in upland areas where water is not sufficient for using the whole year round, all have purchased big jars for storing rain water for drinking for decades. The initial cost of construction was 2,400 baht in Lop Buri and 3,000 baht in Nakhon Ratchasima (Table 3.7). Moreover, in the areas where the ground water table is not so deep and the water quality is good for consumption, government agencies have already constructed shallow tube wells to supply water to the villagers. The heightened alert of villagers in Nakhron Ratchasima may be due to the saline ground water.

Table 3.6 Water preparation for drinking and using

Response	Water preparation		
	Lop Buri	Nakhon Ratchasima	Total
Yes	71.1	37.0	52.4
No	28.9	63.0	47.6
Total %	100.0	100.0	100.0
Number	76	92	168

Chi-Square = 19.398, df = 1, Significant = 0.000
Source: Author's calculation from survey data.

Table 3.7 Initial cost of water storage facilities for home use

Province	Details	Water storage			
		For drinking		For other uses	
		Age (years)	Initial cost	Age (years)	Initial cost
Lop Buri	Mean	15.20	2,383	9.92	3,190
	Std.Deviation	7.84	1,425	8.10	4,968
	Number	120	120	96	96
Nakhon Ratchasima	Mean	10.55	3,000	5.57	4,172
	Std.Deviation	5.90	3,875	5.23	9,656
	Number	120	120	44	88
Total	Mean	12.87	2,682	7.84	3,660
	Std.Deviation	7.28	2,924	7.17	7,552
	Number	240	240	184	184

Source: Author's calculation from survey data.

3.5.4 Additional income

In general, when abnormal weather approached, 50 per cent of the respondents in Lop Buri sought additional income to compensate the loss of their produce, while this figure was 62 per cent in Nakhon Ratchasima (Table 3.8). This implies that the abnormal weather may affect the villagers' income in both provinces, but in Nakhon Ratchasima it was stronger than in Lop Buri.

Table 3.8 Seeking additional income when facing abnormal weather in 2001

Response	Seeking additional income		
	Lop Buri	Nakhon Ratchasima	Total
Yes	50.0	61.7	55.8
No	50.0	38.3	44.0
Total %	100.0	100.0	100.0
Number	120	120	240

Chi-Square = 3.312, df = 1, Significant = 0.069
Source: Author's calculation from survey data.

3.5.5 Rice storage preparation for household consumption

After receiving the information of abnormal weather in 2001, only 26.3 per cent of villagers in Lop Buri stocked rice for family consumption compared to 65 per cent from Nakhon Ratchasima (Table 3.9). The low percentage in Lop Buri was due to the insignificant effects of drought in the past and numerous options to find additional income to compensate the loss from abnormal weather. Moreover, the farm size in Lop Buri was larger than those in Nakhon Ratchasima. Compared to Lop Buri, villagers in Nakhon Ratchasima were a lot more aware of the hazardous effects of the drought. Rice barns are traditionally established within households in upland areas and villagers keep their rice until the new product has already been harvested to make certain that their family members have enough rice for the coming year.

Table 3.9 Rice storage preparation for household consumption

Response	Rice storage		
	Lop Buri	Nakhon Ratchasima	Total
Yes	73.7	34.8	52.4
No	26.3	65.2	47.6
Total %	100.0	100.0	100.0
Number	76	92	168

Chi-Square = 25.251, df = 1, Significant = 0.000
Source: Author's calculation from survey data.

3.5.6 Temporary movement

The effects of drought may force villagers from upland areas to move out of their village to find a new job or additional income. The survey found that the majority of the villagers in Lop Buri still lived in their village while some of the villagers in Nakhon Ratchasima temporarily moved out (Table 3.10).

Table 3.10 Temporary movement of household members

Response	Temporary movement		
	Lop Buri	Nakhon Ratchasima	Total
Some members	15.3	41.7	28.6
All members	1.7	0.0	0.8
No members	83.1	58.3	70.6
Total %	100.0	100.0	100.0
Number	118	120	238

Chi-Square = 21.710, df = 2, Significant = 0.000
Source: Author's calculation from survey data.

3.5.7 New career

The effects of abnormal weather in 1997 and 2001 forced some household members to find new careers out of the villages. From Lop Buri, 20 per cent of respondents stated that members of their households had found permanent careers outside of agriculture. Compared to Lop Buri, 40 per cent of villagers in Nakhon Ratchasima had family members find permanent jobs out of the village (Table 3.11).

Table 3.11 The number of respondents leaving the village to seek alternative careers

Response	New career		
	Lop Buri	Nakhon Ratchasima	Total
Temporary	5.0	1.7	3.4
Permanent	20.0	40.7	30.3
None	75.0	57.6	66.4
Total %	100.0	100.0	100.0
Number	120	118	238

Chi-Square = 13.047, df = 2, Significant = 0.001
Source: Author's calculation from survey data.

3.5.8 Debt increase

One effect of the drought in 2001 was a failure in production, which increased the debt of the households that borrowed money from the bank. The survey found that the debt of the majority of villagers in both provinces increased (Table 3.12). The comparison also indicated that this problem was stronger in Lop Buri than in Nakhon Ratchasima. This may be due to the high value of the debt borrowed from the bank.

Table 3.12 The increase in debt due to the drought in 2001

Response	Debt increase		
	Lop Buri	Nakhon Ratchasima	Total
Increase	56.7	45.0	50.8
No Debt	1.7	13.3	7.5
Unchanged	35.0	38.3	36.7
Decrease	6.7	3.3	5.0
Total %	100.0	100.0	100.0
Number	120	120	240

Chi-Square = 14.011, df = 3, Significant = 0.003
Source: Author's calculation from survey data.

3.5.9 Loan repayment

When the debts increased, loan repayments followed. The survey found that although the majority were able to pay back the loan as normal, 46 per cent of villagers in Lop Buri deferred payment (Table 3.13).

Table 3.13 Loan repayments affected by abnormal weather

Response	Loan repayment		
	Lop Buri	Nakhon Ratchasima	Total
Normal	48.3	74.5	60.9
Deferred	46.7	20.0	33.9
Loanless	5.0	5.5	5.2
Total %	100.0	100.0	100.0
Number	120	110	230

Chi-Square = 18.535, df = 2, Significant = 0.000
Source: Author's calculation from survey data.

3.5.10 Government measures to mitigate the drought effects

In practice, when abnormal weather occurs, government services from the Department of Agricultural Extension will survey the loss and required help of the villagers and then report to the central government with recommendations for mitigating measures. Furthermore, the central government will annually allocate some budget for this purpose, including flooding and other natural disasters. In 2002, the government established a permanent office to cope with natural disasters. Of the proposed measures, the effective ones are as follows:

3.5.10.1 Seed provision

This measure is proposed when drought destroys the crop after having been planted. Almost 60 per cent of respondents in both provinces accepted that the seed provision measure was very useful. Just over 20 per cent of villagers, however, described it as useless because they had experienced delay in its delivery and quality was not satisfactory (Table 3.14).

Table 3.14 Seed provision measure

Response	Seed provision		
	Lop Buri	Nakhon Ratchasima	Total
Very useful	58.3	60.0	59.2
Useful	16.7	20.0	18.3
Useless	25.0	20.0	22.5
Total %	100.0	100.0	100.0
Number	120	120	240

Chi-Square = 1.058, df = , Significant = 0.589
Source: Author's calculation from survey data.

3.5.10.2 Village fund establishment

This transfer policy was implemented in 2001 with the villagers' self operation. The government deposits the one-million-baht fund for villages and city communities through the Bank of Agriculture and Agricultural Cooperatives and the Governmental Saving Bank. The villagers set the members, committee and regulation for using and the return of the loan. They have to maintain and increase the fund permanently.

The village fund has been apart of Thai rural development for a long time. In upland areas during the Fifth and Sixth National Plan (1982–1986 and 1987–1991), the Ministry of Agriculture and Cooperatives provided cash crop seeds to the villages. Farmers borrowed the seeds and then returned the value in cash or in kind. The villagers had to form the village fund or seed bank to support their production in the following season. In rice areas, rice seed and seed barns were subsidized. The villagers could borrow the seeds and the returns could form the rice bank.

The survey found that most villagers in both provinces accepted that the village fund was very useful (80 per cent in Lop Buri and 76.7 per cent in Nakhon Ratchasima) and useful (16.7 per cent in Lop Buri and 20 per cent in Nakhon Ratchasima). Only a few of the respondents did not agree with this measure (Table 3.15). The advantages of the village fund are the low interest rates determined by the villagers and it is the villagers' decision how to make use of their loans.

Table 3.15 Village fund establishment

Response	Village fund establishment		
	Lop Buri	Nakhon Ratchasima	Total
Very useful	80.0	76.7	78.3
Useful	15.0	20.0	17.5
Useless	5.0	3.3	4.2
Total %	100.0	100.0	100.0
Number	120	120	240

Chi-Square = 1.342, df = 2, Significant = 0.511
Source: Author's calculation from survey data.

From observing the villages, some village fund members used the loan to establish a small-scale rice mill in the village, others borrowed it and formed a team seeking construction work in the cities. Other activities included diversifying traditional crops to livestock and poultry and even household consumption.

3.5.10.3 Food supply distribution

Sometimes drought may cause failure in food production and cash crops which earn cash to buy food. The government may supply food to relieve this problem. There is a sense of community and pulling together to help one another in Thai culture. Dry food in plastic bags is usually prepared and distributed to the sufferers. This measure is very useful to 60 per cent of villagers in both provinces (Table 3.16).

Table 3.16 Food supply distribution

Response	Food supply distribution		
	Lop Buri	Nakhon Ratchasima	Total
Very useful	60.0	60.5	60.5
Useful	25.0	17.6	20.9
Useless	15.0	21.8	18.4
Total %	100.0	100.0	100.0
Number	120	119	239

Chi-Square = 3.438, df = 2, Significant = 0.179
Source: Author's calculation from survey data.

3.5.10.4 Water resource development

The Government of Thailand has paid attention to this policy. The Irrigation Department has been allocated the largest amount of the government budget under the Ministry of Agriculture and Cooperatives. Large, medium and small-scale water resource development is under its responsibility. This is to say that all suitable areas for dam and reservoir construction have been surveyed and, where possible, implemented. When asking the villagers, this measure is regarded as the most important to counter the effects of drought. More than 90 per cent of respondents in both provinces would like the government to allocate budget to villages and develop water resources (Table 3.17). Water for household consumption that has been developed, includes ground water and a plumber. For agricultural purposes, weir construction and small reservoirs are examples of water development. Although demand for water development is very high, suitable sites for construction are limited.

Table 3.17 Water resource development

Response	Water resource development		
	Lop Buri	Nakhon Ratchasima	Total
Very useful	90.0	91.7	90.8
Useful	3.3	8.3	5.8
Useless	6.7	0.0	3.3
Total %	100.0	100.0	100.0
Number	120	120	240

Chi-Square = 10.590, df = 2, Significant = 0.005
Source: Author's calculation from survey data.

3.6 Expected support from organizations when drought approaches

When drought is approaching, its concerned effects are the failure in agricultural production and income loss, the difficulty in supplying food and water for drinking and other uses, and the struggle to survive in the villages. Apart from their own self-support, groups of people and organizations are historically expected to help households solve the problem. This issue was addressed when interviewing the household leader on how the groups of people and organizations helped when abnormal weather occurred, a high level of support, moderate or none. The answers were then transformed into the acceptant scores, with their interpretation of 1-1.49 being none, 1.50-1.99 being moderate to none, 2.00-2.49 being moderate to high, and 2.5-3.00 being high. The results are as follows:

3.6.1 Village leader

This person is selected by the villagers. He/she works like a messenger to communicate from the villages to the government agencies and vice-versa. This study found that the attitude of households towards the village head was moderate to none (Table 3.18).

Table 3.18 The expected help for solving drought effects from the village leader

Response	Village leader		
	Lop Buri	Nakhon Ratchasima	Total
Very useful	23.3	26.7	25.0
Useful	40.0	38.3	39.2
Useless	36.7	35.0	35.8
Total %	100.0	100.0	100.0
Number	120	120	240
Expected help score	1.87	1.93	1.90
Std. deviation	0.76	0.78	0.77

Chi-Square =0.356, df = 2, Significant = 0.837
Source: Author's calculation from survey data.

3.6.2 Monk

The temple and monk is the holistic place centered in each village. Some village activities are performed well under the monk's management. However, their support does not cover the problems of drought. Therefore, the attitude score, which was low, meant very little (Table 3.19).

Table 3.19 The expected help for solving drought effects from monks and temples

Response	Monks and temples		
	Lop Buri	Nakhon Ratchasima	Total
Very useful	1.7	8.3	5.0
Useful	0.0	8.3	4.2
Useless	98.3	83.3	90.8
Total %	100.0	100.0	100.0
Number	120	120	240
Expected help score	1.02	1.25	1.13
Std. deviation	0.18	0.60	0.46

Chi-Square =16.820, df = 2, Significant = 0.000
Source: Author's calculation from survey data.

3.6.3 School

Schools and teachers are the centre of education in each village. However, when drought approaches, the households did not expect assistance from this organization. Therefore, the attitude score was also very low (Table 3.20).

Table 3.20 The expected help for solving drought effects from schools and teachers

Response	Schools and teachers		
	Lop Buri	Nakhon Ratchasima	Total
Very useful	1.7	0.0	0.8
Useful	0.0	0.0	0.0
Useless	98.3	100.0	99.2
Total %	100.0	100.0	100.0
Number	120	120	240
Expected help score	1.02	1.00	1.02
Std. deviation	0.18	0.00	0.18

Chi-Square =2.017, df = 1, Significant = 0.156
Source: Author's calculation from survey data.

3.6.4 Tambon council

Tambon is a subdivision of a district and comprises of villages. A Tambon council is elected by villagers' votes and established as a local organization to use a transfer budget from the central government for local development and infrastructure construction. When drought is approaching, some households expected help from this organization. The attitude score was low (Table 3.21).

Table 3.21 The expected help for solving drought effects from the tambon council

Response	Tambon council		
	Lop Buri	Nakhon Ratchasima	Total
Very useful	13.3	3.3	18.3
Useful	28.3	25.0	26.7
Useless	58.3	51.7	55.0
Total %	100.0	100.0	100.0
Number	120	120	240
Expected help score	1.55	1.72	1.63
Std. deviation	0.72	0.82	0.78

Chi-Square = 4.008, df = 2, Significant = 0.135
Source: Author's calculation from survey data.

3.6.5 Regional agricultural extension officer

The Department of Agricultural Extension divides its administration and offices into provinces and districts. Each district office has personnel who are responsible for transferring agricultural technology to farmers, collecting information of disaster and crop failure by pest and disease and recording the annual agricultural statistics of crop and animal production for planning in each tambon, namely 'kaset tambon'. These officers work very closely with the households. They not only report the evidence to the central government to allocate budget and materials to alleviate loss, but also distribute them to the households. As such, they received the second highest attitude score among the groups and organizations from which the households expected support to solve the drought effects (Table 3.22).

Table 3.22 The expected help from regional agricultural extension persons

Response	Regional agricultural extension officers		
	Lop Buri	Nakhon Ratchasima	Total
Very useful	31.3	25.0	28.3
Useful	52.9	40.0	42.5
Useless	23.3	35.0	29.2
Total %	100.0	100.0	100.0
Number	120	120	240
Expected help score	2.08	1.90	2.01
Std. deviation	0.74	0.77	0.76

Chi-Square = 4.094, df = 2, Significant = 0.129
Source: Author's calculation from survey data.

3.6.6 Public health officers

The Ministry of Public Health have also established their local offices in each tambon. Drought may cause problems with villagers' health, however, overall, health care facilities are not required by the people in the study areas when drought approaches. The respondents attitude score for this issue was low (Table 3.23).

Table 3.23 The expected help for solving drought effects from public health officers

Response	Public health officers		
	Lop Buri	Nakhon Ratchasima	Total
Very useful	1.3	10.0	5.9
Useful	14.3	18.3	16.3
Useless	84.0	71.7	77.8
Total %	100.0	100.0	100.0
Number	119	120	239
Expected help score	1.17	1.38	1.28
Std. deviation	0.42	0.66	0.56

Chi-Square = 9.128, df = 2, Significant = 0.010
Source: Author's calculation from survey data.

3.6.7 Community officer

The Ministry of Interior localized the community development office in each district. Rural households and community development are under its responsibility. This mostly entails organizing the village fund and off-farm activities. The attitude of householders towards community officers was low, meaning that they did not provide any help concerning the drought problem (Table 3.24).

Table 3.24 The expected help for solving drought effects from community officers

Response	Community officers		
	Lop Buri	Nakhon Ratchasima	Total
Very useful	6.7	8.3	7.5
Useful	11.7	18.3	15.0
Useless	81.7	73.3	77.5
Total %	100.0	100.0	100.0
Number	120	120	240
Expected help score	1.25	1.35	1.30
Std. deviation	0.57	0.63	0.60

Chi-Square = 2.538, df = 2, Significant = 0.281
Source: Author's calculation from survey data.

3.6.8 District governor

The Ministry of Interior also localised the district governor to look after the people in each district. Community order, calamity, peace and happiness under law and government policy are under its responsibility. The attitude of households towards community officers was low, meaning that they did not provide any help concerning the drought problem (Table 3.25).

Table 3.25 The expected help for solving drought effects from the district governor

Response	District governor		
	Lop Buri	Nakhon Ratchasima	Total
Very useful	13.3	8.3	10.8
Useful	23.3	30.0	26.7
Useless	63.3	61.7	62.5
Total %	100.0	100.0	100.0
Number	120	120	240
Expected help score	1.50	1.47	1.48
Std. deviation	0.72	0.65	0.68

Person Chi-Square = 2.411, df = 2, Significant = 0.299
Source: Author's calculation from survey data.

3.6.9 Provincial governor

The provincial governor is a representative of the central government to administrate all government services in the province and to provide activities to the villages. The attitude of households towards community officers was low, meaning that the villagers did not expect any help concerning the drought problem. (Table 3.26).

Table 3.26 The expected help for solving drought effects from the provincial governor

Response	Provincial governor		
	Lop Buri	Nakhon Ratchasima	Total
Very useful	6.7	1.7	4.2
Useful	13.3	5.0	9.2
Useless	80.0	93.3	86.7
Total %	100.0	100.0	100.0
Number	120	120	240
Expected help score	1.27	1.08	1.17
Std. deviation	0.58	0.29	0.47

Chi-Square = 9.376, df = 2, Significant = 0.009
Source: Author's calculation from survey data.

3.6.10 Central Government

The present government came to power in 2000 and have launched new projects and programs to develop both rural and urban areas. Well-known projects include low interest loans, one million baht village fund, thirty baht for medical care and one village one product. These projects are affective and satisfy the demand of the villagers. Therefore, the villagers expected that when abnormal weather occurs, the central government was able to solve their problems (Table 3.27).

Table 3.27 The expected help for solving drought effects from the central government

Response	Central government		
	Lop Buri	Nakhon Ratchasima	Total
Very useful	65.0	40.0	52.5
Useful	6.7	21.7	14.2
Useless	28.3	38.3	33.3
Total %	100.0	100.0	100.0
Number	120	120	240
Expected help score	2.37	2.02	2.19
Std. deviation	0.90	0.89	0.91

Chi-Square = 18.472, df = 2, Significant = 0.000
Source: Author's calculation from survey data.

3.7 Measures and support requested by villagers when drought occurs

Each household was asked to respond if drought occurred, what kinds of measures and support were requested from the government. Three measures were ranked openly and freely. For the first measure, 37.5 per cent of the total households requested water resource development, 23.3 per cent needed seed subsidies and 16.7 per cent wanted the establishment of a village fund which provides low interest rates to the villagers (Table 3.28).

Table 3.28 Initial measure and support requested by villagers when drought occurs

Provinces	Initial measure and support requested by villagers when drought occurs						
	Seeds	Price intervention	Village fund	Water development	Road	Others	Total
Lop Buri							
Number	32	20	14	44	1	9	120
%	26.7	16.7	11.7	36.7	0.8	7.0	100.0
Nakhon Ratchasima							
Number	24	1	26	46	14	8	119
%	20.2	0.8	21.8	38.7	11.8	7.0	100.0
Total							
Number	56	21	40	90	15	17	239
%	23.4	8.8	16.7	37.7	6.3	7.0	100.0

Other measures include rain making, input price support, knowledge training, food subsidy, additional career and medical care.
Source: Author's calculation from survey data.

For the second measure, the village fund was requested by the majority of the households (35.8 per cent). Seed subsidy, water resource development and price intervention measures followed and accounted for 24 per cent, 17.2 per cent and 14.7 per cent respectively (Table 3.29). Villagers in both provinces responded similarly to price intervention and other measures. The differences occurred in the case of the village fund, water resource development measures (Lop Buri required more) and seed subsidies (Nakhon Ratchasima required more).

Table 3.29 Second measure and support requested by villagers when drought occurs

Provinces	Second measure and support requested by villagers when drought occurs						
	Seeds	Price intervention	Village fund	Water resources	Road	Others	Total
Lop Buri							
Number	20	16	45	24	4	7	116
%	17.2	13.8	38.8	20.7	3.4	6.0	100
Nakhon Ratchasima Number	36	18	38	16	1	7	116
%	31.0	15.5	32.8	13.8	0.9	6.0	100
Total							
Number	56	34	83	40	5	14	232
%	24.1	14.7	35.8	17.2	2.2	6.0	100

Other measures include rain making, input price support, knowledge training, food subsidy, additional career, medical care.
Source: Author's calculation from survey data.

For the third measure, the village fund was still the most popular measure, accounting for 29.5 per cent. Price intervention, water resource development and seed subsidy followed and counted for 19.1 per cent, 18.2 per cent and 11.8 per cent, respectively (Table 3.30).

Table 3.30 Third measure and support requested by villagers when drought occurs

Provinces	Third measure and support requested by villagers when drought occurs						
	Seeds	Price intervention	Village fund	Water resources	Road	Others	Total
Lop Buri							
Number	14	24	35	20	1	16	110
%	12.7	21.8	31.8	18.2	0.9	14.5	100
Nakhon Ratchasima							
Number	12	18	30	20	0	30	110
%	10.9	16.4	27.3	18.2	-	27.3	100
Total							
Number	26	42	65	40	1	46	220
%	11.8	19.1	29.5	18.2	0.5	20.9	100

Other measures include rain making, input price support, knowledge training, food subsidy, additional career, medical care.
Source: Author's calculation from survey data.

It can be concluded that when drought approaches, the effective measures requested by villagers are those of water resource development, a village fund, seed subsidy and price intervention. These measures have been implemented. However, water resource development, such as reservoirs and dams is limited due to the characteristics of upland areas. The village fund is very popular since the government transferred the budget to establish one million baht in each village in 2001. Villagers have to formulate their committee and rule to use this fund to maintain its value indefinitely. Some villagers utilized the money to solve the problem of drought in 2001. Some established a small-scale rice mill, others used it to find additional work in cities. Both seed subsidy and price intervention were occasionally implemented.

3.8 Farm practices concerning environmental issues

Most upland crops grown in Thailand, a tropical country, are prone to attack by many kinds of insects. Chemical utilization is normally adopted as the fast and effective method to control pests and diseases. However, the use of chemicals may lead to environmental damage and insecticide resistance in pests. Alternative methods to control the pests and good practices of using chemicals were investigated in the study areas. Included is insect counting before using chemicals, physical insect control, biological insect control, bio-chemical insecticides and integrated farming systems. The survey found the following:

3.8.1 Insect counting before using chemicals

Chemical utilization is normally to overdose due to the lack of farmers' knowledge and the outbreaks of pests and diseases. Insect counting before using chemicals has been proposed by agricultural extensionists, in order to use chemicals wisely and safely, for a decade. However, the study found that only 4 per cent of households practised this method and the percentage in Nakhon Ratchasima was higher than in Lop Buri (Table 3.31).

Table 3.31 Insect counting before using chemicals

	Investigating and counting insects before using chemicals		
Response	Lop Buri	Nakhon Ratchasima	Total
No	98.4	93.1	95.8
Yes	1.6	6.9	4.2
Total %	100.0	100.0	100.0
Number	120	116	236

Chi-Square = 16.169, df = 1, Significant = 0.000

Source: Author's calculation from survey data.

3.8.2 Physical insect control

This method is cleanliness but requires intensive labour. This study found that only 6.9 per cent of respondents in Nakhon Ratchasima used this method, while none of the households in Lop Buri used it (Table 3.32).

Table 3.32 Using physical insect control

	Physical insect control		
Response	Lop Buri	Nakhon Ratchasima	Total
No	100.0	93.1	96.7
Yes	0.0	6.9	4.2
Total %	100.0	100.0	100.0
Number	120	120	240

Chi-Square = 8.85, df = 1, Significant = 0.003

Source: Author's calculation from survey data.

3.8.3 Bio-insecticide

Some plants and tree leaves are able to be extracted to produce bio-insecticides, such as neem trees. With simple tools and techniques, farmers themselves can produce bio-chemicals and use them for insect control. The survey found that only 7.5 per cent of observations used bio-insecticides while the majority did not. Both provinces had a small proportion of households that used bio-chemicals (Table 3.33).

Table 3.33 Using bio-insecticides

	Bio- insecticides		
Response	Lop Buri	Nakhon Ratchasima	Total
No	90.3	94.8	92.5
Yes	9.7	5.2	7.5
Total %	100.0	100.0	100.0
Number	120	120	240

Chi-Square = 1.75, df = 1, Significant = 0.185

Source: Author's calculation from survey data.

3.8.4 Residual ploughing

Top soil in upland areas is likely to be eroded by wind and heavy rain. The following techniques may be useful to protect the topsoil from erosion. Residual ploughing; after having harvested crops, some farmers ploughed their residuals back into the soil, accounting for 26.3 per cent. The number of households using this method in Lop Buri (36.7 per cent) was higher than in Nakhon Ratchasima (15.5 per cent) (Table 3.34).

Table 3.34 Ploughing residuals after harvesting the major crops

	Residual ploughing		
Response	Lop Buri	Nakhon Ratchasrima	Total
No	63.3	84.5	73.7
Yes	36.7	15.5	26.3
Total %	100.0	100.0	100.0
Number	120	116	236

Chi-Square = 16.17, df = 1, Significant = 0.000
Source: Author’s calculation from survey data.

3.8.5 Manure utilization

The utilization of manure may improve the soil condition and increase humus in the soil. The survey found that the majority of farmers (61.7 per cent) in Lop Buri used manure while some (34.5 per cent) in Nakhon Ratchasima used it (Table 3.35).

Table 3.35 Using manure

	Manure utilization		
Response	Lop Buri	Nakhon Ratchasima	Total
No	38.6	65.5	51.7
Yes	61.7	34.5	48.3
Total %	100.0	100.0	100.0
Number	120	116	236

Chi-Square = 15.27, df = 1, Significant = 0.000
Source: Author’s calculation from survey data.

3.8.6 Crop rotation

This technique is useful not only for soil conservation but also for the reduction of pests and diseases. The survey found that more than 67 per cent of the farmers in Lop Buri had experience in this technique while very few in Nakhon Ratchasima had (Table 3.36).

Table 3.36 Crop rotation

	Crop rotation		
Response	Lop Buri	Nakhon Ratchasima	Total
No	32.5	99.1	65.3
Yes	67.5	0.9	34.7
Total %	100.0	100.0	100.0
Number	120	116	236

Chi-Square = 113.64, df = 1, Significant = 0.000
Source: Author’s calculation from survey data.

3.8.7 Mixed farm system

Growing crops with others and raising livestock within one area may reduce the risk of abnormal weather and uncertain price fluctuations. The survey found that only 9 per cent of farmers in both provinces practiced this technique (Table 3.37).

Table 3.37 Mixed farm system practice

Response	Mixed farm system		
	Lop Buri	Nakhon Ratchasima	Total
No	92.2	89.2	90.7
Yes	10. 8	7.8	9.3
Total %	100.0	100.0	100.0
Number	120	116	236

Chi-Square = 0.475, df = 1, Significant =0.491
Source: Author's calculation from survey data.

3.9 Conclusion

The farm family in both provinces was rather small. The average number of members was four and the family labourers were two. These numbers were not different from 1996. The farm size in Lop Buri, 74 rai, was twice as large as the farm size in Nakhon Ratchasima, 37 rai, but increased from 1996. There were large varieties of crops and trees grown in the study areas. Upland rainfed rice, cassava, sugarcane and maize, however, dominated. Moreover, there were cattle, milk cows and buffalo raised throughout the study areas.

The villagers in both provinces had long experience in rice and water shortages. All households had had big jars to store rain water for drinking the whole year round for decades. The government has also implemented shallow well construction for household consumption where the groundwater is suitable. There were also some weirs, small reservoirs and water plumbers in the study areas. Rice storage for household consumption was common in both provinces. The paddy would be traditionally kept in a rice storage building until the new harvesting season was coming.

Abnormal weather effects have always been in the governments interest. Radio, television broadcasting and its regional agencies are the media utilized for this purpose. In 2001, a warning campaign was conducted and villagers in both provinces received the warning. The results were adjusting production plans, water preparation, rice storage, and additional income seeking. The effects of drought were those of loss in crop yields and earnings, and increases in debt and difficulty in repaying the loan. Seed provision, a village fund, water resource development and food supply distribution were effective counter measures that satisfied the needs of the villagers. The expected persons and organizations to help mitigate adverse effects were the central government, regional extension officers and the village leader. The most preferred measures were seed provision, water resource development, village fund establishment and price intervention.

The investigation of the farm practices concerning environmental issues found that the use of manure and crop rotation were practiced by most farms. Only a few used the method of counting the number of insects before using chemicals, bio-chemicals, physical insect control and residual ploughing.

4. Production Function Analysis

4.1 Model specification and assumption

Specifying a multiple regression equation for productivity estimates uses production function analysis. The regression equations are based on the Single Equation Approach Model (SEAM) where the production functions for the different cropping patterns were considered as single independent relationships between the dependent variable and the explanatory variables (factor inputs). The production functions as individual functions were, therefore, assumed not to be influenced by other relationships relevant to the economic milieu enveloping the production process.

Model specification in statistical analysis involves the specification of production functions for the different cropping patterns. The technical relationships between the outputs of the various cropping patterns are weighted in monetary units and the various factor inputs in production are determined. Monetary unit weighting is preferred in accounting for the preponderance of different physical units found between and within the cropping patterns. The production surface for different cropping patterns is portrayed by their different lead regression equations. The degree and direction of influence of the factor inputs on the outputs with consequent implications are also noted. This is important in directing policies at government and farmer levels. Other than the conventional assumptions underlying the Multiple Regression Model, land, labour, seeds, fertilizers and variable costs of chemicals were assumed to be important explanatory variables and are included in the implicit function. The postulated relationship between the dependent and explanatory variables for the different cropping patterns is implicitly expressed as follows:

y = f(x1, x2, x3, x4, x5, D, u), where:
y = value of the outputs of the cropping patterns in baht.
x1 = farm size of the cropping patterns in rai.
x2 = labour inputs for the cropping patterns in ME-days.
x3 = seed inputs for the cropping patterns in kg.
x4 = chemical fertilizers for the cropping patterns in kg.
x5 = variable costs of chemicals for the cropping patterns in baht.
D = dummy variable, 1 = Lop Buri, 0 = Nakhon Ratchasima.
u = stochastic random error term covering both unquantifiable and omitted explanatory variables from the function.

From the relationship of the implicit function, it is implied that the variables in the value of the outputs of the copping patterns are explained by variations in explanatory variables. However, since for any production process, there are unquantifiable and omitted explanatory variables, the relationship is not exact, hence the inclusion of a stochastic error term in the model.

The production function can further be explicitly expressed as follows:

$$\log(y) = \log b_0 + b_1\log(x_1) + b_2\log(x_2) + b_3\log(x_3) + b_4\log(x_4) + b_5\log(x_5) + D$$

where: b_0 = constant or intercept, indicating output of the cropping pattern when there is no organized production.

$b_1, \ldots b_5$ = regression coefficients for the equations.

log = natural log linear or linearised Cobb-Douglas.

4.2 Correlation among variables

The interpretation of the partial correlation coefficients is closely connected to the multiple regression model (MRM). For the MRM, correlation might exist between any two variables included in the function. The degree of correlation is examined through the partial correlation coefficients. These measure the correlation between any two variables, when all other variables are held constant, that is, when the influence of other variables has been removed. Where the degree of correlation is between only two variables, it is a simple correlation. The simple correlation between any two variables x_1 and x_2 (Rx_1x_2) can be defined by a correlation coefficient as:

$$R_{X1X2} = \frac{\Sigma x_1 x_2}{\sqrt{\Sigma x_1^2}\sqrt{\Sigma x_2^2}}$$

The correlation coefficient only assumes values from –1 to +1. Where $Rx_1x_2 > 0$, the variables increase or decrease together. If $Rx_1x_2 = +1$, then there is perfect positive correlation between the variables. If $Rx_1x_2 < 0$, the variables x_1 and x_2 move in the opposite direction and when $Rx_1x_2 = 0$, the two variables are uncorrelated.

Table 4.1 Partial correlation coefficient matrices among variables used in the multiple regression model of the cropping patterns

Cropping Pattern	Output	Size	Labour	Seed	Fertilizer	Chemicals
1. Rainfed rice						
Value of output	1.00					
Farm size	0.78	1.00				
Labour	0.87	0.89	1.00			
Seed	0.76	0.98	0.87	1.00		
Fertilizers	0.85	0.74	0.76	0.76	1.00	
Chemical cost	0.17	0.20	0.17	0.20	0.17	1.00
2. Cassava						
Value of output	1.00					
Farm size	0.87	1.00				
Labour	0.80	0.98	1.00			
Seed	0.75	0.78	0.75	1.00		
Fertilizers	0.46	0.36	0.30	0.33	1.00	
Chemical cost	0.60	0.44	0.31	0.41	0.43	1.00
3. Sugarcane						
Value of output	1.00					
Farm size	0.91	1.00				
Labour	0.90	0.92	1.00			
Seed	0.86	0.87	0.82	1.00		
Fertilizers	0.77	0.73	0.70	0.79	1.00	
Chemical cost	0.80	0.91	0.82	0.78	0.57	1.00
4. Maize						
Value of output	1.00					
Farm size	0.79	1.00				
Labour	0.84	0.99	1.00			
Seed	0.75	0.98	0.96	1.00		
Fertilizers	0.82	0.73	0.95	0.90	1.00	
Chemical cost	0.35	0.32	0.37	0.29	0.42	1.00
5. Maize-sunflower						
Value of output	1.00					
Farm size	0.80	1.00				
Labour	0.82	0.85	1.00			
Seed	0.70	0.65	0.72	1.00		
Fertilizers	0.84	0.83	0.75	0.70	1.00	
Chemical cost	0.73	0.73	0.60	0.58	0.83	1.00
6. Maize-sorghum						
Value of output	1.00					
Farm size	0.89	1.00				
Labour	0.86	0.94	1.00			
Seed	0.79	0.91	0.90	1.00		
Fertilizers	0.70	0.71	0.86	0.73	1.00	
Chemical cost	0.87	0.86	0.85	0.83	0.73	1.00

Source: Author's calculation from survey data.

4.2.1 Partial correlation

Table 4.1 indicates the partial correlation coefficients derived between the variables included in the production function analysis for the different cropping patterns. It is evident that correlation between the value of the outputs and selected input variables are positive in all cases, although varying from one cropping pattern to another. Most variables are highly correlated to the value of outputs, except the chemical cost in the case of rainfed rice, cassava and maize. Further examination of the correlation matrices among unexplained variables reveals a high correlation between farm size and some variable inputs. In all cases, farm size had high correlation with labour and seed. This included its high correlation with chemical costs in the cases of sugarcane and maize-sorghum cropping patterns. However, correlation between chemical costs and other selected inputs was relatively low. A high correlation between any two explanatory variables usually causes concern because of the possibility of multi-collinearity. In this study, however, there are some major problems of multi-collinearity of farm size since collinearity statistics of explanatory variables prevail a high tolerance value and low VIF.

4.3 Empirical results

Prior to reporting the results of the multiple regression model, it was essential to identify the most suitable mathematical equation of the production function that could best fit the data. Appropriate equations were selected on the basis of the following criteria:

(1) Ease of mathematical manipulation and economic interpretation of the production parameters.
(2) "Goodness of fit" using the magnitude of the CMD, R^2.
(3) The significance of the overall production function as judged by the F-values.
(4) The appropriateness of the signs of the regression coefficients within the range of the observations and the production logic.
(5) The significance of the t-values of the regression coefficients.

Cobb-Douglas was initially selected since it meets the first criterion. Furthermore, it is easy to manipulate mathematically and economic interpretation of the production parameters is simple. Appendix 1 presents a summary of the multiple regression model's results. Considering rainfed rice, the coefficients of multiple determination (R^2) for the fitted equation was 0.83. This then implied that the explanatory variables explained 83 per cent of the variability in the output value. The remaining proportion of the variability in the output can, therefore, be attributed to the variability in the stochastic error term (u). The latter accounts for omitted explanatory variables and such erratic variables as climatic effects, pest and disease incidence and specific soil quality conditions that are normally not easy to quantify.

For the cassava, sugarcane, maize, maize-sunflower and maize-sorghum cropping patterns, the CMD (R^2) was 0.81, 0.86, 0.85, 0.76 and 0.82 respectively. Consequently, the explanatory variables explained approximately 81 per cent, 86 per cent, 85 per cent, 76 per cent and 82 per cent of the variability in the output of cassava, sugarcane, maize, maize-sunflower and maize-sorghum respectively.

4.4 Economic interpretation

4.4.1 Production elasticities

Production elasticities can be considered as elasticities of response with respect to different explanatory variables. They indicate a percentage change in output resulting from a relative percentage change in input. The coefficient indicating individual input elasticity can be calculated as the product of the marginal physical product of a given input and the reciprocal of the average product of that input. The production elasticity can also be obtained as direct regression coefficients of the log-linear function.

Production elasticity, indicating a percentage change in the outputs of the different cropping patterns relative to a percentage change in the individual inputs are presented in Table 4.2 Where there are several explanatory variables, the sum of their elasticities of response, indicating the effect of a similar change on all the inputs together, gives the economies of scale of production. The scale of production, also known as the 'scale coefficient', indicates the returns to scale which are considered under three categories, according to the magnitude of the coefficients. If the sum of the production elasticities is greater than 1 ($\sum E_p > 1$), there are increasing returns; if it is less than 1 ($\sum E_p < 1$), there are decreasing returns; and if the sum is equal to 1 ($\sum E_p = 1$), there are constant returns to scale. When there are either constant or increasing returns to scale and the prices of both inputs and outputs remain constant, there is no economic optimum level of production.

Table 4.2 Production elasticities for the different cropping patterns

	Production elasticities					
Cropping pattern	Land	Seed	Fertilizer	Chemical	Labour	Returns to scale
Upland rainfed rice	-0.347	0.153	0.260	-0.002	1.071	1.135
Cassava	1.106	0.100	0.028	0.027	-0.572	0.689
Sugarcane	0.743	-0.034	0.294	0.066	-0.119	0.950
Maize	-0.468	-0.497	0.236	-0.006	2.146	1.411
Maize-sunflower	0.043	0.097	0.386	0.139	0.342	1.007
Maize-sorghum	1.111	-0.318	0.082	0.776	-0.517	1.134

Source: Author's calculation from survey data.

Further discussion of the production elasticities in this section and as indicated in Table 4.1 are based on the Cobb-Douglas function. For the maize-sunflower cropping pattern, for example, the production elasticities of the individual explanatory variables are less than one and positive. Thus, if each of the inputs is increased by 1 per cent, the output of this cropping pattern will increase by less than 1 per cent. Hence marginal production becomes smaller as the level of any individual input increases while others are held at a geometric mean resulting in diminishing returns. Where diminishing returns occur and the elasticities of production for each of the inputs remain positive, production will, on average, be maintained in the economic range at the stage II level. However, when elasticity of production is greater than 1, as is in the case of land in cassava and maize-sorghum cropping patterns and labour in the cases of rice and maize, increasing marginal productivity is greater than the average productivity. If the other resources are kept constant, only greater use of land and labour would increase the output and the level of this output in stage I (and irrational stage) of production.

Negative elasticities of production occurred in various inputs in most cropping patterns. Included are farm size in the case of upland rainfed rice and maize, labour in the case of cassava, sugarcane and maize-sorghum, seed in the case of sugarcane, maize and maize-sorghum, and chemicals in the case of rice and maize. The negative elasticities imply that the use of more of these inputs would reduce the output of the various cropping patterns. This is a result of the negative marginal productivity of these inputs being at the level of stage III production.

The summation of the production elasticities of the various explanatory variables gives a measure of the returns to scale. There are increasing returns to scale for rice, maize and maize-sorghum cases. Consequently, increases in profits for these cropping patterns can be achieved if outputs are expanded through varying all the inputs together and keeping both factor and input prices constant. For cassava and sugarcane, the returns to scale have a coefficient of less than 1. Therefore, decreasing returns to scale prevail. This indicates a situation of economic optimum, however, certain important factors of production might be omitted, such as soil and labour quality. For the maize-sunflower cropping pattern, the sum of production elasticities accruing to individual explanatory variables is equal to one. Therefore, this cropping pattern exhibits constant returns to scale. A point of economic optimum is attained since the marginal product and average product are equal here and the latter is at a maximum, marking the start of the rational stage of production.

4.4.2 Marginal value productivities (MVP)

Judging from the level of technology, availability and price of both inputs and outputs, marginal value productivities can be used as a measure of the resource use efficiency in a given production process. Maximum efficiency of resource use is attained when the MVP are equal to the cost of the input. In such a situation, an economic optimum occurs. The MVP are the value terms of the marginal physical products and are derived as the products of the marginal physical outputs and the output price.

The marginal value productivities are attained as direct regression coefficients of the linear equations for the different cropping patterns. Table 4.3 indicates the marginal value productivities with respect to the variable inputs in the production function analyses for the different cropping patterns.

Table 4.3 Marginal value productivities of inputs for the different cropping patterns

Cropping pattern	Production elasticities				
	Land	Seed	Fertilizer	Chemical	Labour
Upland rainfed rice	-495.79	18.99	15.74	-0.51	126.62
Cassava	1,721.78	0.43	-7.27	6.31	-56.45
Sugarcane	1,798.39	1.86	40.52	-0.04	55.18
Maize	-256.24	-334.08	14.57	0.14	406.61
Maize-sunflower	331.56	6.63	13.81	5.78	144.52
Maize-sorghum	2,731.28	226.24	0.76	26.83	-240.32

Source: Author's calculation from survey data.

The marginal productivities of land for the cassava, sugarcane, maize-sunflower and maize-sorghum cropping patterns were highest in comparison to those of either labour or variable inputs. This means that land plays a major role in explaining the variation in outputs of these cropping patterns. Moreover, land under cultivation could be expanded. However, the capacity to expand acreage was limited, the MVP of land may be useful as a proxy to indicate an estimate of the potential rental values attached to each cropping pattern.

In the case of labour, the MVP for maize and rice were highest in comparison to those of either land or variable inputs. This reflects the efficient use of labour and its generally high productivity. Moreover, the MVP of labour were slighly lower than those of land in the case of sugarcane and maize-sunflower cropping patterns. Therefore, labour was second in major importance in these cropping patterns.

The MVP of variable inputs of seed, fertilizer and chemical were very low in comparison to those of land and labour, except in the case of seed in the maize-sorghum cropping pattern. This again indicates an inefficient use of planting material due to the effects of abnormal weather.

4.4.3 Effects of drought on major crop yields in 2001

Abnormal weather affected Thailand in 2001, although it was not as strong as the one in 1997. Less rain fell in the study areas and the regional records revealed that the rainfall was less than the three-year average of 1998-2000. It is certain that the rainfall factor will physically influence the efficiency and ability to produce upland crops under the ceteris paribus assumption. The method applied for this measure is elasticities, which are frequently used for convenience to express the demand and supply response to price. Elasticity (ε_p) shows the percentage change in one variable associated with the percentage change in another variable and hence, is independent of the units of measurement. The calculation of the rainfall affect on yield is simply expressed as the percentage change of yield over the percentage change of rainfall. The average yield and rainfall are in Table 4.4 and results of the calculation are in Table 4.5.

Table 4.4 Average yield (kg/rai) and rainfall during the growing period (millimeters)

Crop	Crop year							
	1998-2000				2001			
	Yield		Rainfall		Yield		Rainfall	
	average	stdev.	average	stdev.	average	stdev.	average	stdev.
Rainfed rice	398.64	152.11	683.03	127.25	169.05	75.49	405.76	98.89
Cassava	2,745.25	606.89	1,069.56	98.95	1,951.91	470.51	635.78	47.17
Sugarcane	9,903.46	2,389.18	1,134.58	86.83	8,034.54	1,975.46	655.97	10.17
Maize	610.49	190.03	581.84	48.71	332.61	126.11	342.82	40.16
Sorghum	289.53	63.99	427.38	94.22	165.76	46.34	192.16	44.56
Sunflower	117.54	23.70	328.98	101.22	48.23	22.70	120.15	46.20

Source: Author’s calculation from survey data.

Table 4.5 The ranking effect of drought on major crop yields in 2001

Major crops	ε_p	Std.
Rice	1.66	0.63
Maize	1.19	0.43
Sunflower	0.94	0.30
Sorghum	0.74	0.22
Cassava	0.67	0.17
Sugarcane	0.41	0.12

Source: Author’s calculation from survey data.

From Table 4.5, among the considered crops, the less rain in 2001 affected rice the most, followed by maize. Compared to the other crops, the reduced rainfall affected sugarcane the least, followed by cassava.

5. Summary and Recommendations

5.1 Summary of findings

The objectives of this study are to investigate the effects of El Nino at the farm level and to evaluate the measures to mitigate those effects in upland areas in Thailand. Two representative provinces, one in the Central Plains, namely Lop Buri, and one in the Northeast Plateau, namely Nakhon Ratchasima, are focused upon. One hundred and twenty samples in each province were randomly selected from the study areas. The survey was conducted in early 2002 and the data was based on crop year 2001/02.

The survey found that the average farm family in both provinces was rather small. The average number of members was four including two family labourers. These numbers were not different from 1996. The farm size in Lop Buri, 74 ria, was twice as large as the farm size in Nakhon Ratchasima, 37 rai and both slightly increased from 1996. There were various crops and trees grown in the study areas. Upland rainfed rice, cassava, sugarcane and maize, however, dominated. Moreover, there were cattle, milk cows and buffalo raised throughout the study areas.

Upland area villagers in both provinces had long experience in rice and water shortages. All households had had big jars to store rain water for drinking the whole year round for decades. Moreover, where the groundwater is suitable, the government had implemented shallow well construction for household consumption. There were also some weirs, small reservoirs and water plumbers in the study areas. For rice storage, some households in Lop Buri had buildings for this purpose, while most villagers in Nakhon Ratchasima had. The paddy would be traditionally kept in rice storage buildings until the new harvesting season came. This is to make certain that the household members have enough rice for consumption the whole year round.

The Thai government always pays attention to abnormal weather. Radio, television broadcasting and its regional agencies were the media utilized for this purpose. A campaign was conducted in 2001 and villagers in both provinces received this warning. The results were adjusting production plans, water preparation, rice storage, and additional income seeking. The effects of drought were a loss in crop yields and earnings, and an increase in debt and difficulty in repaying the loan. Seed provision, a village fund, water resource development and food supply distribution were effective measures that satisfied the needs of villagers. When drought was approaching, persons and organizations to help mitigate its effects were the central government, regional extension officers and the village leader. The most preferred measures were those of seed provision, water resource development, village fund establishment and price intervention.

The next study was to investigate farm practice concerning environmental issues. The study found that most farms had experience in the use of manure and crop rotation. Only a few farmers counted the number of insects before using chemicals, used bio-chemicals, physical insect control and residual ploughing.

The application of a production function analysis revealed that sugar and sugarcane cropping patterns had decreasing returns to scale. An increase of all inputs together may lead to a decrease in output. Upland rainfed rice, maize and maize-sorghum cropping patterns revealed increasing returns to scale, therefore, the increase of all inputs together may lead to an increase in output. The maize-sunflower cropping pattern was the only pattern that revealed constant returns to scale and economic efficiency. The decrease in rainfall from the normal years of 1997-2000 to 2001 led to a decrease in crop yields. Rice and maize yields were affected the most, while sugarcane and cassava the least.

5.2 Recommendations

(1) Water for drinking and household consumption: The evidence indicates that most villagers have the facilities already and enough water for drinking and household consumption. Moreover, the Thai government has paid attention to water resource development continuously and determined it as a first priority for country development policy. Therefore, this issue is not of interest.

(2) Water for agriculture: Since both study areas are located in upland areas, it is difficult to construct reservoirs. Rain is the only water supply source, therefore, rainmaking is the best way to increase the amount of water when drought is approaching.

(3) Food security: Since Thailand is a food surplus country and most farms in the study areas are self-sufficient in rice, food security measures are not necessary to be implemented. However, one of the most practical policies is to expand the rice mortgage project (with an interest rate of 3 per cent a year) and expand its repayment period to cover upland areas where the villagers have stored their paddy in their barns and require some money with a low interest loan.

(4) Cropping systems: Most farms have experience in switching crops from normal ones to crops with a lower water requirement. Kenaf is to replace rice, chili and sugarcane to maize, sunflower and sorghum to second season maize. Trees and fruit trees are less important to both study areas. If trees bring moisture to the environment, the suggestion should encourage farmers to grow them. Moreover, some land should be allocated to grass land for cattle and cows.

(5) Drought warning system: The warning system is very effective to warn people and help them prepare and adjust their activities before the losses come. Now, the media, in terms of television and radio is widespread throughout the country. The government should utilize this facility as much as possible. Moreover, the ready establishment of a permanent office and staff in 2002 will help mitigate drought effects and provide optional measures to overcome drought.

(6) Some crops, resistant to abnormal weather and some varieties of traditional crops should be researched and introduced to replace the ones that require alot of water. However, these projects have been implemented in the past but failed because there was not a market for the new crop. Therefore, both technical and economic (market) feasibility should be undertaken.

6. References

Greene, W. H., 2000. Econometric Analysis, New Jersey: Prentice-Hall, Inc.

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Appendix 1. Multiple Regression Results for Different Cropping Patterns

1. Log-linear model of upland rainfed rice

Descriptive Statistics

Variables	Mean	Std. Deviation	N
LNY	9.3024	0.9242	74
LNXA	2.7543	0.7507	74
LNXS	5.5353	0.7659	74
LNXF	5.6574	0.9928	74
LNXC	1.8495	2.8344	74
LNXL	4.7108	0.6087	74

Correlations: Pearson Correlation

Variables	LNY	LNXA	LNXS	LNXF	LNXC	LNXL
LNY	1.000					
LNXA	0.777	1.000				
LNXS	0.772	0.974	1.000			
LNXF	0.701	0.686	0.692	1.000		
LNXC	0.171	0.198	0.198	0.233	1.000	
LNXL	0.872	0.889	0.869	0.631	0.171	1.000

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
				R Square Change	F Change	df1	df2	Sig. F Change
0.897	0.804	0.789	0.4241	0.804	55.745	5	68	0.000

a Predictors: (Constant), LNXL, LNXC, LNXF, LNXS, LNXA

ANOVA

Details	Sum of Squares	df	Mean Square	F	Sig.
Regression	50.120	5	10.024	55.745	0.000
Residual	12.228	68	0.180		
Total	62.348	73			

a Predictors: (Constant), LNXL, LNXC, LNXF, LNXS, LNXA
b Dependent Variable: LNY

Coefficients	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Constant)	1.956	0.943		2.073	0.042					
LNXA	-0.347	0.315	-0.282	-1.101	0.275	0.777	-0.132	-0.059	0.044	22.651
LNXS	0.153	0.288	0.126	0.530	0.598	0.772	0.064	0.028	0.051	19.725
LNXF	0.260	0.070	0.280	3.704	0.000	0.701	0.410	0.199	0.507	1.974
LNXC	-0.002	0.018	-0.007	-0.127	0.899	0.171	-0.015	-0.007	0.942	1.061
LNXL	1.071	0.151	0.837	7.113	0.000	0.872	0.653	0.382	0.208	4.809

a Dependent Variable: LNY

2. Log-linear model of cassava

Descriptive Statistics

Variables	Mean	Std. Deviation	N
LNY	10.2710	0.5967	42
LNXA	2.6178	0.6329	42
LNXS	8.4893	0.7870	42
LNXF	5.1317	1.8388	42
LNXC	2.2104	3.4145	42
LNXL	4.8740	0.5432	42

Correlations: Pearson Correlation

Variables	LNY	LNXA	LNXS	LNXF	LNXC	LNXL
LNY	1.000					
LNXA	0.868	1.000				
LNXS	0.747	0.780	1.000			
LNXF	0.464	0.362	0.334	1.000		
LNXC	0.600	0.436	0.405	0.426	1.000	
LNXL	0.798	0.975	0.754	0.302	0.306	1.000

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	Change Statistics F Change	Change Statistics df1	Change Statistics df2	Change Statistics Sig. F Change
0.915	0.837	0.814	0.2574	0.837	36.870	5	36	0.000

a Predictors: (Constant), LNXL, LNXF, LNXC, LNXS, LNXA

ANOVA

Details	Sum of Squares	df	Mean Square	F	Sig.
Regression	12.212	5	2.442	36.870	0.000
Residual	2.385	36	0.066		
Total	14.597	41			

a Predictors: (Constant), LNXL, LNXF, LNXC, LNXS, LNXA

b Dependent Variable: LNY

Coefficients	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Constant)	9.107	1.207		7.542	0.000					
LNXA	1.106	0.390	1.173	2.834	0.007	0.868	0.427	0.191	0.026	37.769
LNXS	0.100	0.082	0.132	1.220	0.230	0.747	0.199	0.082	0.385	2.597
LNXF	0.028	0.025	0.086	1.120	0.270	0.464	0.183	0.075	0.774	1.292
LNXC	0.027	0.017	0.157	1.627	0.113	0.600	0.262	0.110	0.486	2.058
LNXL	-0.572	0.422	-0.521	-1.354	0.184	0.798	-0.220	-0.091	0.031	32.579

a Dependent Variable: LNY

3. Log-linear model of sugarcane

Descriptive Statistics

Variables	Mean	Std. Deviation	N
LNY	11.9512	0.5400	47
LNXA	3.5086	0.4154	47
LNXS	9.3405	0.3184	47
LNXF	7.4037	0.7010	47
LNXC	8.3856	0.9868	47
LNXL	5.2815	0.3052	47

Correlations: Pearson Correlation

Variables	LNY	LNXA	LNXS	LNXF	LNXC	LNXL
LNY	1.000					
LNXA	0.873	1.000				
LNXS	0.797	0.874	1.000			
LNXF	0.858	0.783	0.760	1.000		
LNXC	0.722	0.648	0.638	0.722	1.000	
LNXL	0.698	0.848	0.727	0.629	0.459	1.000

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	F Change	df1	df2	Sig. F Change
0.922	0.850	0.832	0.2213	0.850	46.596	5	41	0.000

a Predictors: (Constant), LNXL, LNXC, LNXF, LNXS, LNXA

ANOVA

Details	Sum of Squares	df	Mean Square	F	Sig.
Regression	11.406	5	2.281	46.596	0.000
Residual	2.007	41	0.049		
Total	13.414	46			

a Predictors: (Constant), LNXL, LNXC, LNXF, LNXS, LNXA

b Dependent Variable: LNY

Coefficients	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Partial	Part	Collinearity Statistics Tolerance	VIF
(Constant)	7.566	1.660		4.558	0.000					
LNXA	0.743	0.228	0.571	3.257	0.002	0.873	0.453	0.197	0.119	8.433
LNXS	-0.034	0.218	-0.020	-0.156	0.877	0.797	-0.024	-0.009	0.220	4.545
LNXF	0.294	0.085	0.381	3.436	0.001	0.858	0.473	0.208	0.297	3.369
LNXC	0.066	0.050	0.121	1.327	0.192	0.722	0.203	0.080	0.440	2.274
LNXL	-0.119	0.207	-0.067	-0.577	0.567	0.698	-0.090	-0.035	0.266	3.754

a Dependent Variable: LNY

4. Log-linear model of maize

Descriptive Statistics

Variables	Mean	Std. Deviation	N
LNY	9.9292	0.8966	48
LNXA	2.4438	0.7281	48
LNXS	3.6169	0.7337	48
LNXF	6.1722	1.0485	48
LNXC	0.9098	2.3500	48
LNXL	4.5585	0.5879	48

Correlations: Pearson Correlation

Variables	LNY	LNXA	LNXS	LNXF	LNXC	LNXL
LNY	1.000					
LNXA	0.790	1.000				
LNXS	0.751	0.967	1.000			
LNXF	0.822	0.794	0.815	1.000		
LNXC	0.347	0.323	0.330	0.368	1.000	
LNXL	0.835	0.957	0.934	0.830	0.367	1.000

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	F Change	df1	df2	Sig. F Change
0.928	0.861	0.848	0.3497	0.861	66.774	5	42	0.000

a Predictors: (Constant), LNXL, LNXC, LNXF, LNXS, LNXA

ANOVA

Details	Sum of Squares	df	Mean Square	F	Sig.
Regression	40.827	5	8.165	66.774	0.000
Residual	6.603	42	0.122		
Total	47.431	47			

a Predictors: (Constant), LNXL, LNXC, LNXF, LNXS, LNXA
b Dependent Variable: LNY

Coefficients	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Constant)	1.639	0.783		2.093	0.041					
LNXA	-0.468	0.312	-0.377	-1.501	0.139	0.790	-0.200	-0.076	0.041	24.486
LNXS	-0.497	0.255	-0.407	-1.948	0.057	0.763	-0.256	-0.099	0.059	16.910
LNXF	0.236	0.082	0.276	2.891	0.006	0.807	0.366	0.147	0.283	3.537
LNXC	-0.006	0.021	-0.016	-0.282	0.779	0.347	-0.038	-0.014	0.843	1.187
LNXL	2.146	0.293	1.407	-7.332	0.000	0.890	0.706	0.372	0.070	14.282

a Dependent Variable: LNY

5. Log-linear model of maize-sunflower

Descriptive Statistics

Variables	Mean	Std. Deviation	N
LNY	11.3152	0.6175	42
LNXA	3.7631	0.4312	42
LNXS	5.0753	0.5049	42
LNXF	7.9165	0.6066	42
LNXC	7.6593	0.4968	42
LNXL	5.7563	0.3586	42

Correlations: Pearson Correlation

Variables	LNY	LNXA	LNXS	LNXF	LNXC	LNXL
LNY	1.000					
LNXA	0.800	1.000				
LNXS	0.703	0.654	1.000			
LNXF	0.842	0.825	0.697	1.000		
LNXC	0.726	0.729	0.581	0.827	1.000	
LNXL	0.815	0.846	0.718	0.751	0.600	1.000

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	Change Statistics F Change	Change Statistics df1	Change Statistics df2	Change Statistics Sig. F Change
0.890	0.793	0.764	0.3001	0.793	27.505	5	36	0.000

a Predictors: (Constant), LNXL, LNXC, LNXS, LNXA, LNXF

ANOVA

Details	Sum of Squares	df	Mean Square	F	Sig.
Regression	12.389	5	2.478	27.505	0.000
Residual	3.243	36	0.090		
Total	15.632	41			

a Predictors: (Constant), LNXL, LNXC, LNXS, LNXA, LNXF

b Dependent Variable: LNY

Coefficients	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Constant)	2.763	1.107		2.497	0.017					
LNXA	0.043	0.249	0.030	0.172	0.865	0.800	0.029	0.013	0.190	5.258
LNXS	0.097	0.143	0.080	0.682	0.500	0.703	0.113	0.052	0.424	2.360
LNXF	0.386	0.175	0.389	2.212	0.033	0.842	0.346	0.168	0.186	5.371
LNXC	0.139	0.173	0.112	0.804	0.427	0.726	0.133	0.061	0.297	3.369
LNXL	0.342	0.146	0.373	2.345	0.025	0.815	0.364	0.178	0.228	4.388

a Dependent Variable: LNY

6. Log-linear model of maize-sorghum

Descriptive Statistics

Variables	Mean	Std. Deviation	N
LNY	10.8583	0.7195	30
LNXA	3.2135	0.5958	30
LNXS	4.4612	0.4896	30
LNXF	7.4306	0.4499	30
LNXC	7.2018	0.4026	30
LNXL	5.1860	0.5762	30

Correlations: Pearson Correlation

Variables	LNY	LNXA	LNXS	LNXF	LNXC	LNXL
LNY	1.000					
LNXA	0.890	1.000				
LNXS	0.794	0.907	1.000			
LNXF	0.704	0.711	0.727	1.000		
LNXC	0.871	0.855	0.830	0.733	1.000	
LNXL	0.862	0.984	0.900	0.677	0.846	1.000

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	F Change	df1	df2	Sig. F Change
0.923	0.852	0.822	0.3039	0.852	27.704	5	24	0.000

a Predictors: (Constant), LNXL, LNXF, LNXC, LNXS, LNXA

ANOVA

Details	Sum of Squares	df	Mean Square	F	Sig.
Regression	12.796	5	2.559	27.704	0.000
Residual	2.217	24	0.092		
Total	15.013	29			

a Predictors: (Constant), LNXL, LNXF, LNXC, LNXS, LNXA

b Dependent Variable: LNY

	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
Coefficients	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
(Constant)	4.543	2.022		2.247	0.034					
LNXA	1.111	0.492	1.086	2.258	0.033	0.890	0.419	0.177	0.027	37.548
LNXS	-0.318	0.292	-0.216	-1.089	0.287	0.794	-0.217	-0.085	0.156	6.406
LNXF	0.082	0.200	0.051	0.409	0.686	0.704	0.083	0.032	0.393	2.544
LNXC	0.776	0.294	0.434	2.644	0.014	0.871	0.475	0.207	0.228	4.388
LNXL	-0.517	0.573	-0.414	-0.901	0.376	0.862	-0.181	-0.071	0.029	34.268

a Dependent Variable: LNY

7. Linear model of upland rainfed rice model

Descriptive Statistics

Variables	Mean	Std. Deviation	N
Y	16520.31	17506.58	74
XA	20.09	14.09	74
XS	329.76	242.05	74
XF	468.51	551.79	74
XC	201.22	547.98	74
XL	132.69	84.40	74

Correlations: Pearson Correlation

Variables	Y	XA	XS	XF	XC	XL
Y	1.000					
XA	0.774	1.000				
XS	0.790	0.967	1.000			
XF	0.848	0.744	0.761	1.000		
XC	0.438	0.399	0.391	0.506	1.000	
XL	0.845	0.912	0.899	0.749	0.425	1.000

Model Summary

				Change Statistics				
R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
0.910	0.828	0.815	7523.45	0.828	65.454	5	68	0.000

a Predictors: (Constant), XL, XC, XF, XS, XA

ANOVA

Details	Sum of Squares	df	Mean Square	F	Sig.
Regression	18524120126.41	5	3704824025.28	65.454	0.000
Residual	3848954505.44	68	56602272.14		
Total	22373074631.85	73			

a Predictors: (Constant), XL, XC, XF, XS, XA

b Dependent Variable: Y

Coefficients	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Partial	Part	Collinearity Statistics Tolerance	VIF
(Constant)	-3855.084	1704.389		-2.262	0.027					
XA	-495.788	277.999	-0.399	-1.783	0.079	0.774	-0.211	-0.090	0.050	19.802
XS	18.988	14.873	0.263	1.277	0.206	0.790	0.153	0.064	0.060	16.715
XF	15.739	2.688	0.496	5.856	0.000	0.848	0.848	0.295	0.353	2.836
XC	-0.501	1.875	-0.016	-0.267	0.790	0.438	0.438	-0.013	0.734	1.362
XL	126.622	26.461	0.610	4.785	0.000	0.845	0.845	0.241	0.155	6.432

a Dependent Variable: Y

8. Linear model of cassava

Descriptive Statistics

Variables	Mean	Std. Deviation	N
Y	34603.10	23327.62	42
XA	16.68	11.25	42
XS	6340.71	4370.65	42
XF	354.76	328.86	42
XC	690.48	1446.15	42
XL	149.52	74.16	42

Correlations: Pearson Correlation

Variables	Y	XA	XS	XF	XC	XL
Y	1.000					
XA	0.914	1.000				
XS	0.774	0.803	1.000			
XF	0.794	0.739	0.736	1.000		
XC	0.826	0.674	0.624	0.869	1.000	
XL	0.785	0.940	0.792	0.643	0.478	1.000

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	F Change	df1	df2	Sig. F Change
0.960	0.921	0.910	6982.81	0.921	84.315	5	36	0.000

a Predictors: (Constant), XL, XC, XS, XF, XA

ANOVA

Details	Sum of Squares	df	Mean Square	F	Sig.
Regression	20555952107.27	5	4111190421.45	84.315	0.000
Residual	1755349233.23	36	48759700.92		
Total	22311301340.50	41			

a Predictors: (Constant), XL, XC, XS, XF, XA
b Dependent Variable: Y

Coefficients	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
(Constant)	9824.097	2835.655		3.464	0.001					
XA	1721.778	446.663	0.830	3.855	0.000	0.914	0.541	0.180	0.047	21.214
XS	0.430	0.471	0.081	0.913	0.367	0.774	0.151	0.043	0.281	3.556
XF	-7.269	8.383	-0.102	-0.867	0.392	0.794	-0.143	-0.041	0.156	6.390
XC	6.308	2.118	0.391	2.979	0.005	0.826	0.445	0.139	0.127	7.887
XL	-56.446	63.211	-0.179	-0.893	0.378	0.785	-0.147	-0.042	0.054	18.476

a Dependent Variable: Y

9. Linear model of sugarcane

Descriptive Statistics

Variables	Mean	Std. Deviation	N
Y	176663.02	84745.24	47
XA	36.43	15.75	47
XS	11994.68	4106.43	47
XF	2014.89	1140.36	47
XC	6200.43	3936.63	47
XL	206.41	70.26	47

Correlations: Pearson Correlation

Variables	Y	XA	XS	XF	XC	XL
Y	1.000					
XA	0.876	1.000				
XS	0.786	0.833	1.000			
XF	0.898	0.791	0.711	1.000		
XC	0.606	0.556	0.546	0.654	1.000	
XL	0.676	0.813	0.659	0.551	0.352	1.000

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
				R Square Change	F Change	df1	df2	Sig. F Change
0.940	0.883	0.869	30721.53	0.883	61.806	5	41	0.000

a Predictors: (Constant), XL, XC, XF, XS, XA

ANOVA

Details	Sum of Squares	df	Mean Square	F	Sig.
Regression	291664473672.28	5	58332894734.46	61.806	0.000
Residual	38696316910.70	41	943812607.58		
Total	330360790582.98	46			

a Predictors: (Constant), XL, XC, XF, XS, XA
b Dependent Variable: Y

Coefficients	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Constant)	-3899.829	16597.699		-0.235	0.815					
XA	1798.394	798.316	0.334	2.253	0.030	0.876	0.332	0.120	0.130	7.708
XS	1.856	2.036	0.090	0.912	0.367	0.786	0.141	0.049	0.294	3.406
XF	40.517	7.313	0.515	5.541	0.000	0.898	0.654	0.296	0.295	3.389
XC	-0.037	1.548	-0.002	-0.024	0.981	0.606	-0.004	-0.001	0.552	1.810
XL	5.176	115.146	0.046	0.479	0.634	0.676	0.075	0.026	0.313	3.190

a Dependent Variable: Y

10. Linear model of maize

Descriptive Statistics

Variables	Mean	Std. Deviation	N
Y	30591.07	29874.44	48
XA	17.90	11.87	48
XS	48.53	38.49	48
XF	840.00	993.49	48
XC	145.33	432.41	48
XL	113.83	74.31	48

Correlations: Pearson Correlation

Variables	Y	XA	XS	XF	XC	XL
Y	1.000					
XA	0.841	1.000				
XS	0.790	0.973	1.000			
XF	0.879	0.931	0.911	1.000		
XC	0.315	0.214	0.208	0.353	1.000	
XL	0.877	0.957	0.932	0.969	0.359	1.000

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	Change Statistics F Change	Change Statistics df1	Change Statistics df2	Change Statistics Sig. F Change
0.895	0.801	0.760	14775.64	0.801	19.319	5	42	0.000

a Predictors: (Constant), XL, XC, XS, XF, XA

ANOVA

Details	Sum of Squares	df	Mean Square	F	Sig.
Regression	51088551448.53	5	1017710289.71	34.830	0.000
Residual	1539671429.33	42	29219642.89		
Total	52428222877.87	47			

a Predictors: (Constant), XL, XC, XS, XF, XA
b Dependent Variable: Y

Coefficients	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Correlations Partial	Correlations Part	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Constant)	-7923.340	1838.840		-4.309	0.000					
XA	-256.243	319.410	-0.101	-0.802	0.426	0.841	-0.109	-0.019	0.035	28.681
XS	-334.082	80.476	-0.430	-4.151	0.000	0.838	-0.492	-0.098	0.051	19.472
XF	14.571	1.944	0.485	7.494	0.000	0.942	0.714	0.176	0.132	7.572
XC	0.144	1.883	0.002	0.076	0.939	0.315	0.010	0.002	0.744	1.345
XL	406.612	47.986	1.011	8.474	0.000	0.948	0.755	0.119	0.039	25.806

a Dependent Variable: Y

11. Linear model of maize-sunflower

Descriptive Statistics

Variables	Mean	Std. Deviation	N
Y	96938.86	53087.53	42
XA	46.83	17.94	42
XS	178.21	74.10	42
XF	3260.71	1919.30	42
XC	2404.76	1292.51	42
XL	333.71	97.24	42

Correlations: Pearson Correlation

Variables	Y	XA	XS	XF	XC	XL
Y	1.000					
XA	0.817	1.000				
XS	0.676	0.616	1.000			
XF	0.896	0.747	0.674	1.000		
XC	0.788	0.701	0.615	0.806	1.000	
XL	0.818	0.857	0.661	0.732	0.605	1.000

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	Change Statistics F Change	Change Statistics df1	Change Statistics df2	Change Statistics Sig. F Change
0.934	0.873	0.855	20210.54	0.873	49.377	5	36	0.000

a Predictors: (Constant), XL, XC, XS, XF, XA

ANOVA

Details	Sum of Squares	df	Mean Square	F	Sig.
Regression	100844957992.72	5	20168991598.54	49.377	0.000
Residual	14704772782.42	36	408465910.62		
Total	115549730775.14	41			

a Predictors: (Constant), XL, XC, XS, XF, XA

b Dependent Variable: Y

Coefficients	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.	Correlations Zero-order	Partial	Part	Collinearity Statistics Tolerance	VIF
(Constant)	-26941.129	12313.680		-2.188	0.035					
XA	331.559	382.946	0.112	0.866	0.392	0.817	0.143	0.051	0.211	4.737
XS	6.630	62.012	0.009	0.107	0.915	0.676	0.018	0.006	0.472	2.199
XF	13.813	3.314	0.499	4.168	0.000	0.896	0.571	0.248	0.246	4.061
XC	5.783	4.400	0.141	1.314	0.197	0.788	0.214	0.078	0.308	3.246
XL	144.518	69.330	0.265	2.085	0.044	0.818	0.328	0.124	0.219	4.562

a Dependent Variable: Y

12. Linear model of maize-sorghum

Descriptive Statistics

Variables	Mean	Std. Deviation	N
Y	66737.0	49706.08	30
XA	29.50	17.80	30
XS	97.90	52.38	30
XF	1871.67	946.56	30
XC	1452.67	598.18	30
XL	209.09	117.80	30

Correlations: Pearson Correlation

Variables	Y	XA	XS	XF	XC	XL
Y	1.000					
XA	0.943	1.000				
XS	0.926	0.935	1.000			
XF	0.780	0.761	0.769	1.000		
XC	0.898	0.880	0.894	0.729	1.000	
XL	0.899	0.971	0.924	0.698	0.894	1.000

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics R Square Change	F Change	df1	df2	Sig. F Change
0.965	0.932	0.918	14256.36	0.932	65.707	5	24	0.000

a Predictors: (Constant), XL, XF, XC, XS, XA

ANOVA

Details	Sum of Squares	df	Mean Square	F	Sig.
Regression	66772271545.10	5	13354454309.02	65.707	0.000
Residual	4877853434.90	24	203243893.12		
Total	71650124980.00	29			

a Predictors: (Constant), XL, XF, XC, XS, XA
b Dependent Variable: Y

Coefficients	Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
(Constant)	-26130.859	7712.167		-3.388	0.002					
XA	2731.281	745.574	0.978	3.663	0.001	0.943	0.599	0.195	0.040	25.128
XS	226.238	161.535	0.238	1.401	0.174	0.926	0.275	0.075	0.098	10.214
XF	0.762	4.839	0.015	0.157	0.876	0.780	0.032	0.008	0.334	2.993
XC	26.826	11.060	0.323	2.426	0.023	0.898	0.444	0.129	0.160	6.245
XL	-240.317	109.031	-0.570	-2.204	0.037	0.899	-0.410	-0.117	0.042	23.538

a Dependent Variable: Y

Appendix 2. Figures during Interviews

Figure A.1 Traditional household barn standing beside house, pictured by the author

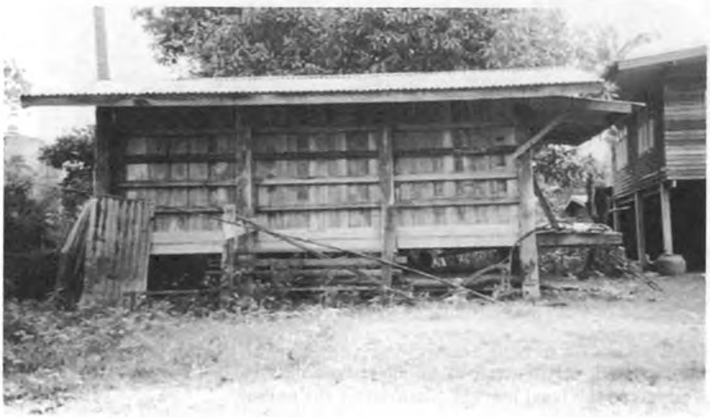

Figure A.2 Groundwater manual pump for household consumption (above) and big jars for storing rainwater for household drinking the whole year round, pictured by the author

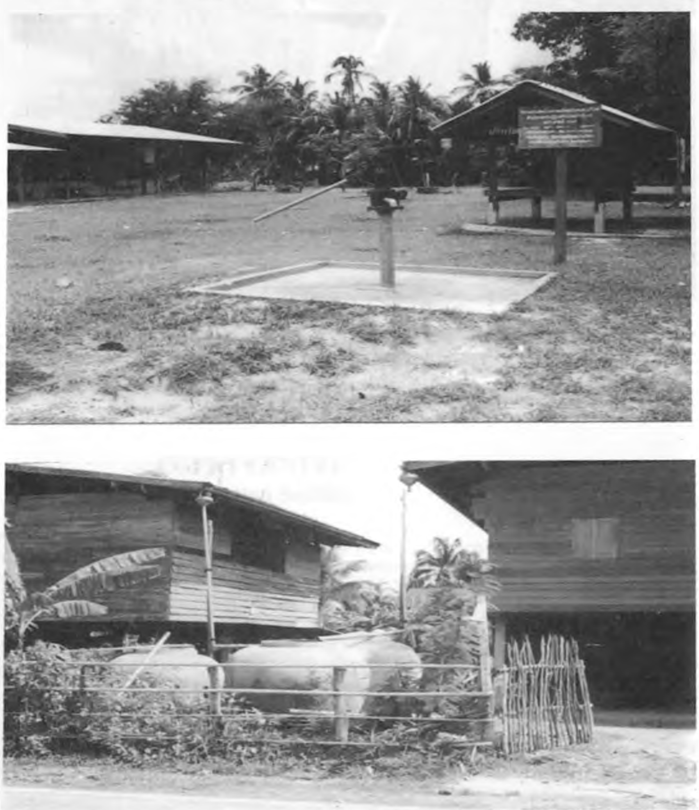

Figure A.3 Village 30-tonne rice barn, supported by the government and constructed during the Fifth Master Plan (1982 – 1986). It is used for storing paddy for many purposes, pictured by the author

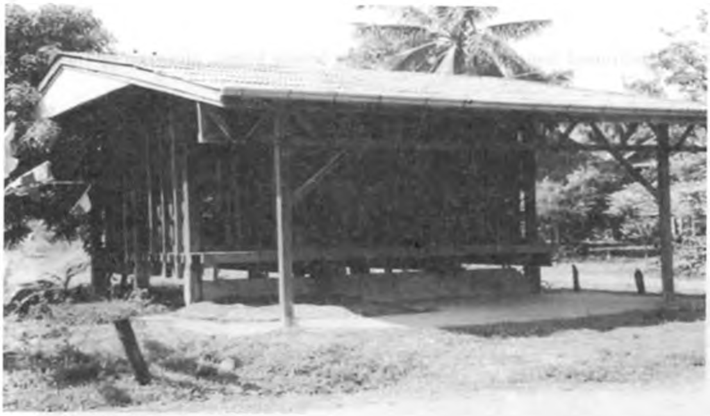

Figure A.4 Small scale rice mill, constructed by villagers who borrowed the money from the village fund and supply products to the local market, pictured by the author

Figure A.5 Local variety cattle, favorite among the villagers, pictured by the author

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