To the Graduate Council:

I am submitting herewith a dissertation written by Chumnarn Sirirugsa entitled "Potential Swine Production on Small Farms in Northeast Thailand." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

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We have read this dissertation
and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

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POTENTIAL SWINE PRODUCTION ON SMALL FARMS IN NORTHEAST THAILAND

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Chumnarn Sirirugsa

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ABSTRACT

The objectives of this study were: (1) to assess the capability of small family farms to increase swine production through increasing the efficiency of using available resources; (2) to determine the effect of variations in selected management and efficiency factors in swine production on income potentials; and (3) to interpret the findings so they relate to agricultural policy for the Northeast Thailand livestock industry. The analysis was conducted under various resource and price situations for five representative farms in five agro-economic zones.

Linear programming techniques were used to examine the organization of farm resources that would maximize farm income under limited resource situations, varying capital arrangements, different land resource mixes, and varying feed and swine prices. The objective function to be maximized was the net farm return over variable costs.

Results of this study are: (1) Capital and land were the most limiting factors for increasing farm income in Northeast Thailand. (2) Capital was the most limiting factor for the swine enterprise. Without credit being made available to farmers, four out of five representative farms did not produce any swine. (3) By providing 30,000 baht of credit to individual farmers, the net returns to most of the representative farms would increase by more than 100 percent, primarily as a result of substantial increases in swine production. (4) Increasing both capital and land resources resulted in increases to net returns. Increasing both land and capital resources yielded higher net returns than increasing capital alone. (5) An increase of 30,000 baht of credit and 50 percent more land

land per farm resulted in the May-August labor requirements becoming the limiting production factor. (6) Feed cost accounted for more than 10 percent of the total swine production costs in 1974-75. Swine production was very sensitive to variation in feed prices. As feed prices increased to 2.50 baht per kilogram, swine production farms dropped from the optimum solution for most of the representative farm situations. (7) When the price of swine was varied from 13.06 to 20.06 baht per kilogram, the enterprise organization remained stable. In other words, swine production responded very little to increases in the price of swine. (8) The findings suggest that there is considerable potential to improve farm incomes in Northeast Thailand by increasing Swine production. An adequate and sound production credit policy is needed for farmers to increase their farm incomes and/or swine production.

TABLE OF CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION	1
	The Setting	1
	The Problem	3
	Review of Literature	6
	Objectives	10
II.	AREAS FOR STUDY	11
	Zone 01	11
	Zone 02	11
	Zone 03	13
	Zone 04	13
	Zone 05	13
III.	SWINE PRODUCTION IN NORTHEAST THAILAND	14
	Swine Production of Thailand	14
	Swine Breeds and Fertility	15
	The Importance of Swine Production in Northeast Thailand	16
	Swine Production Systems	18
	Feed	19
	Feed Rations	19
	Swine Markets	20
IV.	RESEARCH METHODOLOGY AND MODEL	22
	Methodology	22
	The Linear Programming Model	23
	Duality of Linear Programming	24
	Structure of Linear Programming Model	26
V.	DATA SOURCE AND PARAMETER ESTIMATION	30
	Data Resources	30
	Estimation of Production Coefficients	30
	Estimation of Prices	33
	Estimation of Resources	38
	Capital	40
VI.	OPTIMUM ORGANIZATION FOR THE REPRESENTATIVE FARM WITH EXISTING AND CHANGING RESOURCES AND PRICES	43
	Assumptions	43
	Presentation Scheme	44
	Optimum Organization for the Representative Farm with Existing Resources and Prices	44
	The MVP'S of Resources Used for the Optimum Base Plan	47
	Stability Limits for the Base Plan Resources	51

CHAPTER PAGE

VI. (Continued)
Effects of Increasing Capital on the Optimum Organization 55
Stability Limits of the Activities Included in the Optimum Solution with Respect to Prices and Variable Costs for Plan Alternative A 64
Effects of Increasing Land and Capital on the Optimum Organization 68
Effects of Varying Feed Prices on the Optimum Plan 77
Effects of Varying Swine Prices on the Optimum Plan 85

VII. SUMMARY 92
Problem and Data Summary 92
Summary of Results 93
Policy Implications 95
Some Limitations of the Study 96

BIBLIOGRAPHY 97

APPENDICES 101

Appendix A 102
Appendix B 111
Appendix C 114

VITA 120

LIST OF TABLES

TABLE		PAGE
1-1.	Regional Average Farm Family Income by Source and Total Family Income Generated in Nonagricultural Sectors by Agriculture, 1970	4
3-1.	Swine Production of Thailand in 1966-1975	15
3-2.	Number Farrowing and Weaning Pigs Per Litter of Different Breeds	16
3-3.	Number of Cattle, Buffalo, Swine, Chickens, and Ducks in Thailand in 1970 by Regions	17
3-4.	Swine Finishing Rations Which are Recommended by Livestock Department (From Weaning to 100 Kilograms of Hog)	21
5-1.	Average Yield Per RAI of Paddy and Upland Crops in Northeast Thailand in 1974-75 Crop Year	31
5-2.	Comparison of Performance of Pigs on NEARC Ration At NEARC and at the Farm Level	34
5-3.	Average Farm Prices of Paddy and Upland Crops in Northeast Thailand in 1974-75 (Unit: baht per kilogram)	35
5-4.	Average Variable Cost of Producing Paddy and Upland Crops in Northeast Thailand in 1974-75 (Unit: baht per kilogram)	35
5-5.	Monthly Average Farm Prices of Hogs in Northeast Thailand in 1973-75 (Unit: baht per kilogram)	37
5-6.	Number of Workdays in a Year	39
5-7.	Number of Man-hours Family Labor Available per Farm per Year	39
5-8.	Total Land Holding and Percentage of Paddy Land and Upland in Northeast Thailand in 1975	41
5-9.	The Average Paddy Land and Upland Area per Farm in the Five Agro-economic Zones in Northeast Thailand, 1975	41
6-1.	Optimum Base Plan Without Credit for Zone 01, Zone 02, Zone 03, Zone 04, and Zone 05	45

TABLE		PAGE
6-2.	Marginal Value Products (MVPs) of Resources Used for the Base Plan	48
6-3.	Stability Limits for the Base Plan Resource (Without Credit) in Zone 01-05	52
6-4.	Optimum Organization of Plan Alternative A and B for Zone 01	57
6-5.	Optimum Organization of Plan Alternative A and B for Zone 02	58
6-6.	Optimum Organization of Plan Alternative A and B for Zone 03	59
6-7.	Optimum Organization of Plan Alternative A and B for Zone 04	60
6-8.	Optimum Organization of Plan Alternative A and B for Zone 05	61
6-9.	Activities Included in the Optimal Solution and Their Stability Limits with Respect to Prices or Variable Costs for Plan Alternative A	65
6-10.	Optimum Organization of Plan Alternative I and II for Zone 01	70
6-11.	Optimum Organization of Plan Alternative I and II for Zone 02	71
6-12.	Optimum Organization of Plan Alternative A and B for Zone 03	72
6-13.	Optimum Organization of Plan Alternative I and II for Zone 04	73
6-14.	Optimum Organization of Plan Alternative A and B for Zone 05	74
6-15.	Optimum Farm Organization for Zone 01 with 2,402.54 Baht of Credit and Varying Feed Price from ฿ 1.00-3.00 per Kilogram	78
6-16.	Optimum Farm Organization for Zone 02 with 3,476.00 Baht of Credit and Varying Feed Price from ฿ 1.00-3.00 per Kilogram	80

TABLE PAGE

6-17. Optimum Farm Organization for Zone 03 with 3,705.00 Credit and Varying Feed Price from ฿ 1.00-3.00 per Kilogram . . . 81

6-18. Optimum Farm Organization for Zone 04 with 2,826 Baht of Credit and Varying Feed Price from ฿ 1.00-3.00 per Kilogram 83

6-19. Optimum Farm Organization for Zone 05 with 6,167.00 Baht of Credit and Varying Feed Price from ฿ 1.00-3.00 per Kilogram 84

6-20. Optimum Organization with Varying Swine Prices from ฿ 13.06-20.06 per Kilogram Zone 01 86

6-21. Optimum Organization with Varying Swine Prices from ฿ 13.06-20.06 per Kilogram Zone 02 87

6-22. Optimum Organization with Varying Swine Prices from ฿ 13.06-20.06 per Kilogram Zone 03 88

6-23. Optimum Organization with Varying Swine Prices from ฿ 13.06-20.06 per Kilogram Zone 04 89

6-24. Optimum Organization with Varying Swine Prices from ฿ 13.06-20.06 per Kilogram Zone 05 90

A-1. Crop Budgeting for Zone 01 103

A-2. Crop Budgeting for Zone 02 104

A-3. Crop Budgeting for Zone 03 105

A-4. Crop Budgeting for Zone 04 106

A-5. Crop Budgeting for Zone 05 107

A-6. Farrow to Finish Budget. Estimated Returns and Expenses per Sow and 2 Litters of Pigs (1 sow unit) 108

A-7. Feeder Pig Budget. Estimated Returns and Expenses per Sow and 2 Litters of Pigs 109

A-8. Finishing Budget. Estimated Returns and Expenses for Finishing Purchased Feeder Pig 110

B-1. Resources (Rows) 112

B-2. Activities (Columns) 113

TABLE PAGE

C-1. Input-Output Coefficient Matrix of Linear Programming for Zone 01 115

C-2. Input-Output Coefficient Matrix of Linear Programming for Zone 02 116

C-3. Input-Output Coefficient Matrix of Linear Programming for Zone 03 117

C-4. Input-Output Coefficient Matrix of Linear Programming for Zone 04 118

C-5. Input-Output Coefficient Matrix of Linear Programming for Zone 05 119

CHAPTER I

INTRODUCTION

A. THE SETTING

Northeast Thailand is geologically known as the Korat Plateau (Figure 1). It is bounded on the south and west by high hills and ridges sloping gradually towards the east to the Meknog River which forms the eastern and northern boundaries. The region is the part of the Mekong watershed.

The plateau consists of sedimentary layers of sandstone, yielding a thin lateritic topsoil over impermeal flat rock strata. The monsoon rains cause flooding and swampy areas to develop where the land is low, mainly along the Mekong River, while the higher land quickly becomes dry and dusty due to the rapid water runoff.

The people of the Northeast are agriculturalists, growing rice, kenaf, and herding water buffalo and cattle. The slope of land is toward Laos, and their lifestyle has historically been symbolic of the North-eastern culture. The people living there share ancestry, language, religion, poverty, and the Mekong River with the Laotians. They are known as Laos-Thais.

The Northeast Region consists of 16 provinces. It has a population of 11.7 million according to the 1970 Population Census. There was a total of 1.9 million households in the Region of which 1.5 million household heads were farmers. In 1970, there were approximately 6.1 residents per houdehold in the Region, of which 1.9 were economically

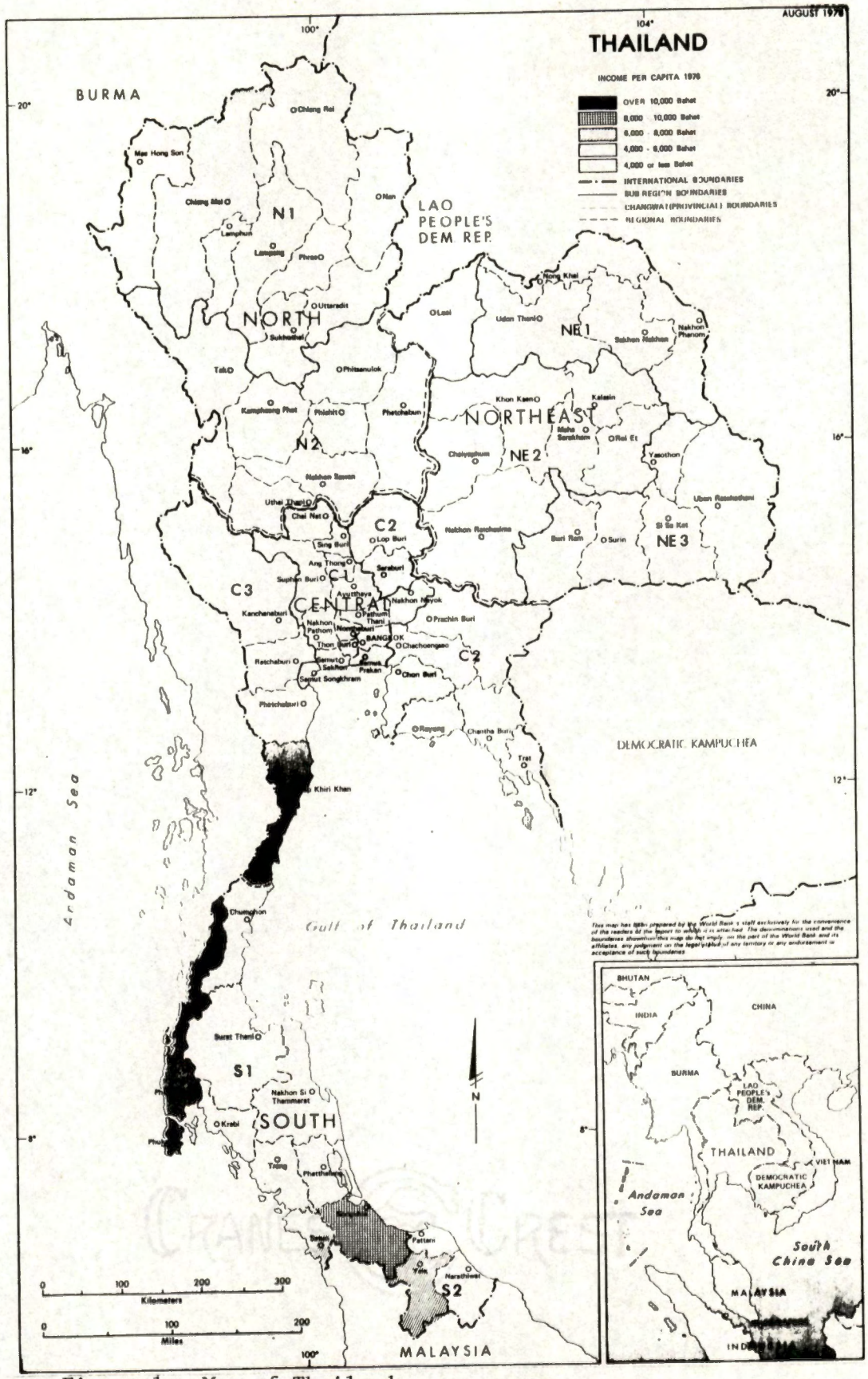


Figure 1. Map of Thailand.

active. However, significant differences are apparent between sectors. There are 3.75 economically active members per agricultural household and only 1.30 per nonagricultural household. The average size of farm holding in the Northeast was about 30 rai per farm in 1970.[1] The farm unit generated 2,122 baht of annual gross income. The annual net cash income was 972 baht, or 259 baht per economically active member of the household.[2] The average cash income from the nonagricultural sector was 1,081 baht per agricultural household, or 288 baht per economically active member (10, 1974).

B. THE PROBLEM

Because one-third of Thailand's population live in the Northeast Region and earn a lower per capita income than what is earned elsewhere in the Kingdom, the Region is the source of many problems to the country's economy (Table 1-1). First, the poverty of the Region represents a drag on the overall growth of the economy and contributes to disparities in income. Second, the low level of living experienced by the traditional farmer is a source of political discontent which may lead to problems of political instability. Third, the combination of a low level of living, a high level of unemployment, and a high rate of population growth in the Region has resulted in outmigration, usually to Bangkok, the capital city,

---

[1]The measure of area, rai, is equivalent to 0.16 hectare or 0.395 acre (or 2.50 rai = 1 acre).

[2]Twenty baht are equal to U.S.A. $1.00.

Table 1.1. Regional Average Farm Family Income by Source and Total Family Income Generated in Nonagricultural Sectors by Agriculture, 1970

Region	Income from Farm Sources Less Operating Expenses[a]	Income from Off-farm Work	Farm Family Disposable Income	Total Family Income Generated in Non-agricultural Sectors by Agriculture 1973
	Baht			
North	2,187	1,602	3,789	-
Northeast	927	1,080	2,007	-
Central Plain	1,343	4,585	5,928	-
South	1,784	2,170	3,954	-
Thailand	1,486	2,044	3,530	44,325 Million Baht

[a]Includes value of rice grown and consumed by the family.

Source: Division of Agricultural Economics, Ministry of Agriculture and Cooperatives, Royal Thai Government Farm Income and Expenditures in Thailand--1970, Bangkok, Thailand.

and to other major cities in the Kingdom. Most migrants are unskilled laborers. This has contributed to high unemployment rates in the cities, particularly in Bangkok. This condition leads to increasing crime rates which represents another source of discontent contributing to political instability.

The poverty in the Northeast is associated with low crop yields. The principal causes of low yields have been identified as: low soil fertility, uneven rainfall distribution in the rainy season, and extreme aridity in the dry season. Other factors identified as causes of low productivity are: inadequate credit to farmers, inadequate infrastructural support, price policies which reduce incentives, and the lack of technical knowledge by farmers in utilizing modern inputs.

Misallocation of resources and inefficient use of limited resources are also important sources of low agricultural productivity in the Northeast. Because of low soil fertility, crop production increases require large applications of fertilizer, but the use of fertilizer in this region is limited by a number of factors such as, high price of fertilizer, lack of credit, and often the lack of water during the period of fertilizer application.

It is possible for livestock to be an important industry in Northeast Thailand if the government carefully develops a sound production plan and uses the proper implementation policy. There are several reasons which suggest that the development of livestock enterprises would provide improvement in farm incomes and opportunity for employment. First, the income elasticity of demand for meat is elastic. In the country, per capita income is expected to rise because of economic activities generated

from national economic development policies. Because of this, combined with increases in population, the future demand for meat is expected to be very strong. Second, Thailand is one of the major agricultural exporters of the world. Most of the agricultural products exported are raw materials. The country exports primarily rice, corn, sorghum, soybeans, peanuts, and cassava. Most of these products or their by-products can be converted to feed for meat production. Third, increased livestock production leads to the improvement of the national nutrition level which in turn generates a more efficient labor force.

In 1970, the average gross income generated by livestock was about 820 baht per farm family, or about 39 percent of the total gross income (9, 1973). This indicates that presently livestock production is not as important as crop production to the economy. Three immediate questions arise: can livestock production be increased using the present resources and technology available in the Northeast? What are the limiting factors to improving livestock production? Under what conditions can livestock be economically produced?

C. REVIEW OF LITERATURE

The first economic study of livestock in Northeast Thailand, "Aggregate Bovine Supply in Northeast Thailand," was completed in 1973 by Brice, Jr. (24, 1973). The purpose of the study was to estimate the aggregate supply of cattle and buffalo in the Northeast Region under present farm conditions. The study was formulated as an attempt to determine why bovine production in the Northeast lagged behind the growth of other agricultural industries despite substantial government emphasis on

bovine production. Also, the study attempted to determine how various policy alternatives might affect future output. The study used linear programming techniques to map an aggregate supply curve of bovine in the Northeast Region. The parameters of the model were prices, technological resources, and institutional conditions prevailing in the Northeast during the 1969-70 crop year. Enterprises included in the model were the major Northeast upland crops; rice production; raising of buffalo, native and crossbreed cattle; and various activities which interrelate crop and bovine enterprises.

The study found that feed supply was the primary constraint on bovine production, but at 1969-70 bovine prices, reallocation of land from crop production to natural forage was not a profitable alternative for farmers.

At 1969-70 prices, bovine produced in the Northeast Region were projected to increase at about 0.25-2.00 percent per year. Long run bovine uptake was indicated to be relatively unresponsive to the price of bovine. Twenty-five percent higher bovine prices would be required in order to obtain supplies greater than would be offered at 1969-70 prices. Projected bovine supply was more elastic at lower paddy prices, and less elastic at higher paddy prices.

According to a study by Smith et al. (26, 1974), "Economic Potential of the Cattle and Buffalo in Northeast Thailand," at present levels of technology of other major enterprises, at present prices of alternative commodities which utilize land resources, and under present cattle and buffalo production technology, a large price increase for animals to be used for draft and slaughter is required to make it profitable to increase

cattle and buffalo production significantly. Even under very low prices and yields for paddy, price increases do not result in proportionately large increases in output of these meat animals in the aggregate. The dynamic element in the industry is the production of Brahma cross cattle which, under modified institutional conditions would rapidly replace native cattle and improve efficiency. They also suggested that at low prices, cattle and buffalo were not profitable alternatives to the traditional staple food commodity, rice, much less the higher valued upland crops. Cattle and buffalo become profitable only when they utilized feeds for which there were no alternative economic uses. Therefore, according to this study, it is unlikely that the cattle and buffalo industry can become the leading edge of a successful regional agricultural development program. In the long run, the prospect for increases in the price of animals is encouraging. The Thai economy had a good record of per capita income growth in the 1960's despite a population growth rate of almost 3.0 percent. If a per capita income growth rate of 3.5 per year could be maintained over the 1980's, we might expect an increase in the per capital demand for meat of more than 40 percent at constant prices. This, plus the increase in demand resulting from rapid increases in population growth, means that if the supply of all meat is relatively inelastic, price may be expected to increase substantially.

The study also claimed that:

> Countering these favorable demand prospects is the possibility that paddy yields will increase rapidly in the next decade. The high yielding technologies which have important impacts on population-food balances throughout the world are only beginning to have their effects in Thailand. If our conjectures are correct, the adoption of this technology in rice production is likely to

be rapid and will have an adverse effect on the cattle and buffalo industry for three reasons.

The first reason that high yielding technologies in rice will adversely affect the cattle and buffalo industry is that the supply of cattle and buffalo is quite sensitive to price and yields of paddy. High yield of paddy make it necessary to have higher price for the animals and/or higher animal productivity if they are to be profitable alternatives to paddy. The second reason that high yield rice technology will make it difficult to expand bovine production is that rice by-products are the main sources of feed for hogs and chickens. Thus, if rice output increases, feed supplied, and hence, chicken and hog supplied will increase in about the same proportion. Both convert concentrate feed into meat much more efficiently than cattle and buffalo, and the efficient production technologies employed in broiler chicken production and feedlot pork production in the United States are apparently transferrable to the tropics with only minor adaptations. They are already being used on a limited scale. Since pork and chicken are readily substituted for beef in diet, and pork is preferred by Chinese, this would undoubtedly have an adverse affect on demand for beef and buffalo meat. The third reason is that if it becomes highly profitable to use fertilizers, the main reason for maintaining fallow land to be used for pasture will disappear. (26, 1974).

In the United States, Trede and James (28, 1969) analyzed a typical farm situation in Iowa and found that swine generated more income than cattle feeding and that corn was the most profitable crop of those considered in the analysis. They concluded that numerous swine producing systems could be profitable, but that management was the most important factor in determining the profitability of a given system.

Colyer and Irwin (6, 1967) showed that mixed crop-livestock farms with emphasis on livestock provide higher levels of income. They stated that, "This was particularly true for farms with limited funds, where land is not readily available for expansion, and where labor is relatively abundant."

D. OBJECTIVES

The general objective of this study is to develop an analytical framework which can be used to estimate the potential effect of swine development programs on small farms in Northeast Thailand so that farm incomes can be improved. Specifically, the major objectives are:

1. To assess the capability of the small family farm to increase swine production through increased efficiency in resource use.

2. To determine the effect of variation in selected management and efficiency factors in swine production on income potentials for a representative farm situation.

3. To interpret findings as they relate to agricultural policy for the Northeast livestock industry.

The study is restricted to the examination of potential adjustments on a representative farm in Northeast Thailand. This will be accomplished by reallocating existing resources and by adding additional resources to the farm. The analysis is concentrated on crop and swine enterprises and does not consider cattle and buffalo. It emphasizes individual farm adjustments in each agro-economic zone and does not focus on interregional or international aspects.

CHAPTER II

AREAS FOR STUDY

The Northeast Region consists of 16 provinces (Figure 2). The area is divided into five agro-economic zones. The term agro-economic zone refers to a production zone for agriculture, each zone being internally homogeneous with respect to physiographic, agricultural, and economic characteristics (27, 1972).

The growing and harvesting season for the same crop are different from Zone to Zone depending on the starting and ending months of rainfall. For Zones 01, 02, and 05, the growing season ranges from June to mid-September, while Zones 03 and 04 are suitable for growing crops from July to mid-October.

A. ZONE 01

Zone 01 consists of four provinces: Udorn, Nongkai, Sakolnakhorn and Nakornpanom. In 1975, total paddy land in this zone was about 7,950,000 rai and the upland crop land area was about 1,405,000 rai. Zone 01 is located at the northern part of the Northeast Region.

The major crops of this zone are rice, kenaf, cassava, and corn. Most people in this area prefer eating glutinous rice to nonglutinous rice.

B. ZONE 02

Zone 02 consists of two provinces, Ubolrachtani and Yasotorn. In 1975, paddy land was about 5,468,000 rai and the upland crop area was about

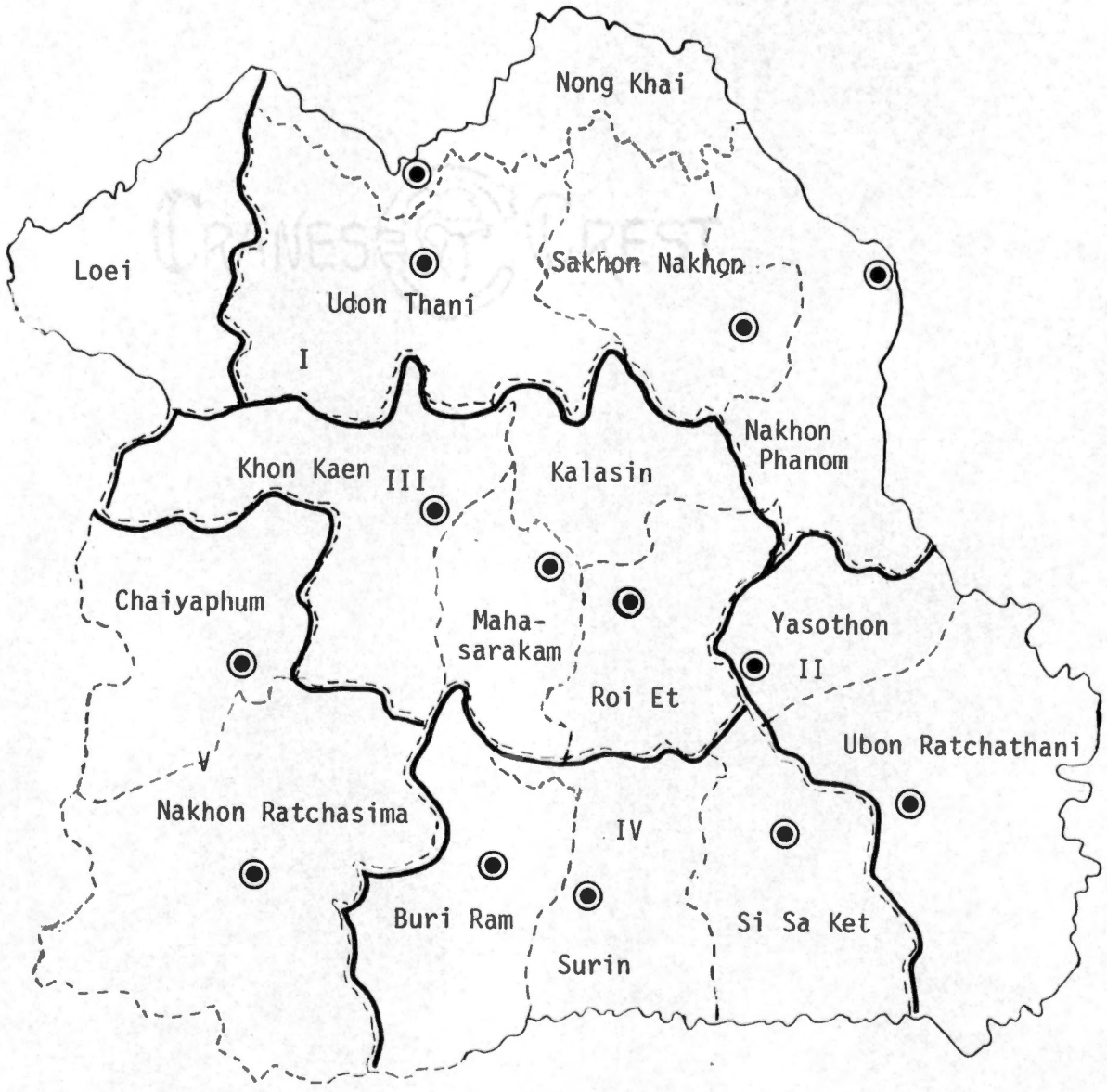


Figure 2. Map of Five Agro-Economic Zones.

558,000 rai. The major crops of this zone are rice, kenaf, cassava, corn, and peanut. People in this zone consume both glutinous and nonglutinous rice.

C. ZONE 03

There are four provinces in Zone 03, Khonkaen, Kalasin, Mahasarkam, and Roiet. Paddy and upland crop areas were about 8,451,000 and 2,126,000 rai, respectively, in 1975. Zone 03 is located in the central part of the Northeast Region. The major crops are rice, peanut, cassava, and kenaf. Most of the people in this zone consume glutinous rice.

D. ZONE 04

Zone 04 is located southeast of the Northeast Region. It consists of three provinces, Surin, Burirum, and Srisaket. People in this Zone speak Thai-Cambodian and eat nonglutinous rice. The major crops of Zone 04 are rice, corn, and cassava. In 1975, the paddy area was about 7,829,000 rai and the upland crop area was about 998,500 rai.

E. ZONE 05

There are two provinces in Zone 05, namely Nakornrachsima (Korat) and Chaiyapum. Zone 05 is located to the southwest of the Northeast Region which borders the Central Plain Region of Thailand. In this zone there was about 4,790,000 rai of paddy land and 3,042,000 rai of upland crop area in 1975. Rice, kenaf, peanut, cassava, and corn are the major crops of Zone 05. Zone 05 consists of more upland area proportionally than the other zones in the Northeast.

CHAPTER III

SWINE PRODUCTION IN NORTHEAST THAILAND

The general objectives of this chapter are: (1) to provide a degree of familiarity to the readers who are not familiar with the Northeast Thailand swine industry, (2) to provide bases and linkages for constructing the model, and (3) to provide basic knowledge for policy makers.

A. SWINE PRODUCTION OF THAILAND

The statistics show that during the last decade swine production fluctuates from year to year (Table 3-1). The fluctuations in the number of swine produced each year are due to:

(1) *The relationship between the price of swine and the price of feed.* When the ratio between the price of swine and the price of feed is low, it indicates that farmers may have net losses from producing swine. Production will normally decrease the following year. When this ratio is high, more swine will be produced.

(2) *The capital situation of swine producers.* When the price of feed is high and the price of swine is low, farmers with limited capital often have to sell hogs and sows quickly to avoid bankruptcy.

(3) *Price expectations.* Like other agricultural products, price expectations play an important role in decision making of farmers.

Table 3-1. Swine Production of Thailand in 1966-1975

Year	Production (heads)
1966	3,960,473
1967	4,221,517
1968	4,503,005
1969	4,806,746
1970	5,132,244
1971	3,883,870
1972	3,892,133
1973	4,460,372
1974	3,515,559
1975	3,211,141

Source: Agricultural Statistics of Thailand in 1966-1975.

B. SWINE BREEDS AND FERTILITY

There are many breeds of swine produced in Thailand. Most are native swine; others include Large White, American Landrace, Hampshire, and Duroc Jersey. In 1967, a study at Kasetsart University showed that the rate of fertility of native breeds was low when compared to foreign breeds (Table 3-2). The native breed yields only 1.5 to 2.0 litters per year while the foreign breeds normally produce 2.0 to 2.5 litters per sow per year. The study also indicated that the number of farrowing and weaning pigs per litter of the foreign breed sow was higher than those of the native sow (11, 1975).

Table 3-2. Number Farrowing and Weaning Pigs Per Litter of Different Breeds

Breed	Litter Size	No. of weaning	Average
Native	8.6	6.8	6.8
Large White	10.3	8.7	-
American Landrace	9.0	8.3	7.5
Hampshire	9.5	7.8	-
Duroc	6.9	5.3	-

Source: The report of the Sixth National Conference on Agricultural Science at Kasetsart University, Bangkok, Thailand, February 1967.

C. THE IMPORTANCE OF SWINE PRODUCTION IN NORTHEAST THAILAND

Swine ranks second in terms of the value of crops and livestock sold per farm in the Northeast, accounting annually for 18 to 20 percent of total agricultural sales. About one-third of Thailand's market hogs are produced in the Northeast, thus making this enterprise an important one for Northeast Thailand.

In general, the Northeast Region is the most important source of livestock supply in the country (Table 3-3). In 1970, about 40.5 percent of the cattle, 55.7 percent of the buffalo, 27.4 percent of the swine, 35.8 percent of the chickens and 34.0 percent of the ducks were raised in the Northeast Region (21, 1971).

Table 3-3. Number of Cattle, Buffalo, Swine, Chickens, and Ducks in Thailand in 1970 by Regions

Item	Thailand (heads)	North (heads)	Central (heads)	South (heads)	Northeast (heads)	Northeast Percent of Thailand
Cattle	4,666,969	527,571	1,552,795	694,495	1,892,108	40.5
Buffalo	5,734,500	655,921	1,652,206	230,539	3,195,834	55.7
Swine	5,132,244	563,792	2,352,197	810,792	1,405,463	27.4
Chicken	58,791,426	8,492,727	22,801,441	6,496,615	21,063,643	35.8
Duck	7,109,165	631,117	3,093,266	946,896	2,419,886	34.0

Source: Division of Agricultural Economics, Ministry of Agriculture and Cooperatives "Agricultural Statistic Bulletin #18, March 1976."

D. SWINE PRODUCTION SYSTEMS

There are two production systems in Thailand: commercial and traditional.

Traditional Production

Traditional production is a method of raising swine by feeding rice bran, a limited amount of broken rice, and little or no protein supplement. Most of the pigs raised by the traditional method are native or native-foreign hybrids. This type production requires a longer time from weaning to finishing than commercial type production. Farmers usually keep their pigs under the houses on an earth floor. According to a 1975 study of the Division of Agricultural Economics (DAE), Ministry of Agriculture and Cooperatives, it was found that about 50 percent of the total swine production was attributed to traditional methods. The average number of swine per farm range from one to five head per year (11, 1975).

Commercial Production

The commercial farm is a farm that raises 10 or more hogs per year. The feed consists of a concentrate, or rice bran with broken rice, and protein supplement. This type of production requires western breeds, better management, and more operating capital than production under the traditional methods. The commercial farmer raises hogs in a pen with a concrete or wood floor.

E. FEED

Feed is the most important input for swine production as it accounts for more than 70 percent of the total cost. Changes in the price of feed cause a change in swine production. The main sources of feed in Thailand are rice bran and broken rice. Rice bran has been used for feeding since the Thai people learned how to raise pigs. Thais trust the price of rice bran as an indicator of the price of swine (when rice bran is cheap the swine is dear and the reverse is also true). This is because rice bran is the source of feed which is used intensively by both traditional and commercial type of farmers. With a limited use of rice bran for other industries and a very small amount exported each year, the rise (drop) in price of rice bran is mainly caused by an increase (decrease) in the demand for feed in the swine industry. The demand for pork is rather stable; therefore, an increase in supply causes a rapid decrease in the price of hogs.

F. FEED RATIONS

It is very difficult to identify the exact ration used by small farmers. Traditional rations may be changed every day depending on the sources of feed that farmers can acquire in the villages or at local markets. Basically, the traditional ration consist of rice bran, broken rice, and vegetables. Some farmers boil broken rice or plain rice with vegetables and then mix the ingredient with rice bran.

Farmers usually feed their pigs two times a day, early in the morning and in the evening.

The commercial rations consist of different combinations of rice, broken rice, soybean meal, peanut meal, fish meal, corn, cassava, and others food items. Some farmers use commercial concentrates mixed with rice bran and broken rice. One of the rations recommended by the Department of Livestock, Ministry of Agriculture and Cooperatives is detailed in Table 3-4.

G. SWINE MARKETS

The Northeastern farmers usually sell swine to local dealers who live in the same village. These local dealers resell the swine to district and/or provincial dealers or to the slaughter house buyers. About half of the hogs produced in the Northeast are exported to other regions, mainly to Bangkok.

It is required by law that the wholesale live weight price for hogs be on a per kilogram basis. In the villages, however, some dealers still buy hogs on a price per head basis. Prices of hogs vary depending on weight, breed, and age. Dealers and the slaughter house buyers prefer hogs between 100-125 kilograms. The average price for hogs that weigh more than 100 kilograms is generally one baht higher than those under 100 kilograms. The price of the western breed hog is also higher than the price for native breeds.

Table 3-4. Swine Finishing Rations Which are Recommended by Livestock Department (From Weaning to 100 Kilograms of Hog)

Ingredient / Ration	Rice bran Percent	Corn Percent	Cassava Percent
Rice bran	36.19	19.87	19.84
Broken rice	30.59	-	1.66
Corn	16.45	60.93	-
Cassava	-	-	51.62
Fish meal	6.59	6.63	7.27
Soybean meal	3.29	4.64	8.27
Peanut meal	4.90	5.93	9.50
Shell	1.32	1.00	.67
Bone	.17	.50	.67
Salt	.50	.50	.50
Total	100.00	100.00	100.00
Feed conversion	3.47	3.69	4.00

Source: Division of Agricultural Economics, "Farm Management Hand Book 1975."

CHAPTER IV

RESEARCH METHODOLOGY AND MODEL

A. METHODOLOGY

The specific objective of this study is to estimate the potential effect of the swine program on income from small farms. The analytical technique chosen to accomplish this objective must satisfy the following general criteria. First, it should be capable of generating solutions for all relevent cropping and livestock enterprises, resource set for each, and technology level of combinations. Second, it should be capable of estimating which of the farmer's resources is most limiting. These estimates need to be made within a consistent logical framework that allows inclusion of all relevant production activities. Such information will make it possible to suggest programs to increase the availability of constraining resources. Third, it should be flexible enough to capture all essential aspects of small farm production in Northeast Thailand.

Linear programming is the analytical technique which comes closest to fulfilling these requirements. Linear programming models are capable of considering many diverse types of production and nonproduction activities and can be designed to allocate large numbers of different resources between equally large numbers of production activities in order to achieve a specified objective, and be run at comparatively low cost. Linear programming models can usually be as flexible and realistic as the problem demands provided that the model builder thoroughly understands the production process.

Linear programming is particularly appropriate for the analysis of swine potential in Northeast Thailand because of the ease with which the model can be adapted to analyze the effect of new technologies and changes in the farmer's set of resources. New technologies at the farm level are usually embodied in new production activities. Thus, for the farmer, the choice of which technology to employ reduces to a choice between alternate activities in which new activities compete with older activities for the farmer's resources. The farmer's goal is to select that set of activities which will maximize his net income subject to the constraints imposed by his limited set of resources, his personal desires, and by existing institutions.

The linear programming model could aid the planner in his decision by pointing out which factors are in short supply now, and what would be in short supply if one or a combination of these programs were successful in increasing resource supplies. The linear programming model can also be very helpful in identifying and quantifying program targets.

B. THE LINEAR PROGRAMMING MODEL

The mathematical formulation of the linear programming model may be expressed by the following equations:

maximize

$$Z = \sum_{\varepsilon}^{\eta} C_i X_i \qquad (1)$$

subject to

$$\sum_{i=1}^{\eta}{}_{\varepsilon} a_{ji} X_i \leq b_j \qquad (2)$$

and

$$X_i \geqq 0 \qquad (3)$$

where

Z =objective function to be maximized

X_i =activity i (i = 1, 2,...,n)

C_i =the net contribution to Z of activity i

b_j =the quantity available of resources j (j = 1, 2,....,m)

a_{ji}=the amount of resource j needed for one unit of activity i

Equation (1) is the objective function. Equation (2) is a shorthand for a group of constraint equations and transfer rows which make up the heart of the linear program and specify that no more resources can be used by the activities X_i than are present in the resource base (b_j). Equation (3) specifies that all activities (X_i) can only take on nonnegative values.

C. DUALITY OF LINEAR PROGRAMMING

With every linear programming problem there is a related linear programming problem called the dual problem of the original linear programming problem (7, 1974). In a free economic system, prices play an important role in allocating resources within the economy. For the economy as a whole both input and output prices are free to vary, and determinate levels are established as a balance of economic forces

Vandermeulen (29, 1971) showed the important role of duality in resource allocating of the multiproduct firm. He stated that:

> In the model of the multiproduct firm under purely competitive conditions, the prices of outputs are assumed to be constant. What is needed, then, is a set of internal prices for services of

> the fixed inputs that will guide management to the most profitable set of products. The word "services" cannot be emphasized too strongly. A firm must decide what it is worth to the firm to have the use of a machine for a specified period of time, not what the machine itself is worth to the firm. Thus, the prices sought are akin to rental prices or leasing prices rather than to purchase prices. The two types of prices are, of course, related by process of capitalization, but it is the price of the services that is required at present.

He also suggested that

> To obtain prices for inputs the management must find a basic feasible set of output. It can calculate the imputed unit cost for products not being produced and determine whether any are worth producing. For prices to play a major role in the allocative process, they must be the sole guide in determining how much of each input to devote to each of outputs. There must also be some criterion for evaluating different sets of input prices and determining whether the present set of prices can be replaced by a better set. The dual linear programming problem for the multiproduct firm fits these general requirements.

Heady and Candler (16, 1969) showed the twin dangers of over and underevaluating the resources which are faced by farmers. A farmer cannot obtain the optimum allocation of his resources without knowing the cost of using the resource.

Baumol (2, 1965) indicated that the analysis of the primal production problem proceeds largely in terms of the relevant physical and technological considerations. The dual which is always hiding behind this primal problem informs us that if we want to determine the optimal magnitudes of our outputs and the optimal allocation of our bottleneck inputs, we should value the inputs in terms of their marginal (profit) yields and produce only the items for which the opportunity costs, so evaluated, are zero.

The dual value or shadow price of the input, the marginal value of inputs, and the opportunity cost of using the input can be obtained from

$Z_j - C_j$ value of the final simplex of the primal problem. The value of the duals of the resources plays an important role in the policy problem

For the analysis of potential swine production on small farms in Northeast Thailand, the MPSX program package was used to obtain the requirement of the objectives.[1]

D. STRUCTURE OF LINEAR PROGRAMMING MODEL

This section provides the structural components of the model in terms of zones, activities included, prices, and resource levels. The model consists of five agro-economic zones in Northeast Thailand. The general types of activities included, are classified as follows: (also see Appendix Tables A-1 to A-5)

(1) crop production activities

(2) crop selling activities

(3) feed buying activity

(4) feeder pig activity

(5) swine production activities

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[1] MPSX is the abbreviation of Mathematical Programming System Extended. It is the major linear programming routine available for IBM machines. The detail of the MPSX program package can be obtained from the following references.

a. IBM Manuals

1. Introduction to Mathematical Programming System-Extended (MPSX), Mixed Interger Programming (MIP) and Generalized Upper Bounding (GUB)-GH20-0849-3.

2. Mathematical Programming System-Extended (MPSX) and Generalized Uper Bounding (GUB), Program Description-SH20-0968-1

b. User's Guide

1. A User's Guide to the IBM MPSX Linear Programming Package-Part 1, Small Models AE 4316, Dept. of AG. Econ., University of Illinois, June, 1973.

(6) swine selling activities

(7) capital borrowing activity

Crop Production Activities

Crop enterprises included in each zone are slightly different, especially upland crops, some of which can be grown well in some specific zones. All five zones grow rice.

Zone 01

Crops included in the model are glutinous rice new variety, glutinous rice native variety, nonglutinous rice new variety, corn, cassava, and kenaf (Appendix Table A-1).

Zone 02

Crops included in the model are glutinous rice new variety, glutinous rice native variety, nonglutinous rice new variety, nonglutinous rice native variety, corn, peanuts, cassava, and kenaf (Appendix Table A-2).

Zone 03

Crops included in the model are glutinous rice native variety, nonglutinous rice new variety, nonglutinous rice native variety, peanuts, cassava, and kenaf (Appendix Table A-3).

Zone 04

Crops included in the model are nonglutinous rice new variety, nonglutinous rice native variety, glutinous rice new variety, glutinous rice native variety, corn, and cassava (Appendix Table A-4).

Zone 05

Crops included in the model are nonglutinous rice new variety, nonglutinous rice native variety, glutinous rice new variety, glutinous rice native variety, corn, peanuts, cassava, and kenaf (Appendix Table A-5).

Crop Selling Activities

All crop productions are assumed to be sold at the average market prices in each zone.

Swine Production Activities

It was assumed that the production coefficients of swine enterprises to be the same for all zones because swine production depends largely on the quality of feed, breeds, and management. All of these factors are very similar for all the Northeast region. There are three production activities included in the model; namely, feeder pig production activity, farrow to finish activity, and finishing activity. The detail of these activities are discussed as follows:

Feeder Pig Production Activity

This activity includes one brood sow producing 2 litters of 7 pigs per litter. There are 14 pigs at weaning age; .33 pig is kept for sow replacement, and 13.67 pigs are sold (Appendix Table A-7).

Farrow to Finish

This activity includes one brood sow producing 2 litters of 7 pigs per litter. Fourteen pigs will be weaned per sow per year of which .33 will be kept for sow replacement, and 13.67 sold.

Finishing Activity

The finishing includes one purchased pig and finishing up to 110.00 kilograms of slaughter hogs.

Feed Buying Activity

The model allows for a feed buying activity in a separate column. Because feed is the most important input in producing swine, varying feed prices will result in a change in the overall supply of swine.

Feeder Pig Buying Activity

This activity provides the transfer row for the finishing activity.

Swine Selling Activity

All hogs and feeder pigs are assumed to be sold at market prices in 1975.

Capital Borrowing Activity

Capital is one of the most limiting factors of small farms in developing countries. For farmers in Northeast Thailand, capital is an important limiting factor. The main source for borrowing money is the Bank for Agriculture and Agricultural Cooperatives. This bank provides short-term, medium-term, and long-term credits to individual farmers directly, through farmer associations, and through the farmer cooperative associations. The maximum amount for short-term credit is about 60 percent of market value of the agricultural products that a farmer will produce in a given season. Repayment is due within a year at a 12 percent rate of interest per year.

CHAPTER V

DATA SOURCE AND PARAMETER ESTIMATION

A. DATA RESOURCES

Several sources of data are used. The major data source for estimating the resource base and crop input-output coefficients was drawn from the General Farm Survey which was conducted by Division of Agricultural Economics (DAE) in 1975. Data on swine input-output coefficients were obtained from the farm records of the members of the farm management project under the supervision of DAE. Secondary sources of data included the annual report on research of the Northeast Agricultural Center, Research Reports of the Department of Livestock, and personal interviews with technical agricultural extension specialists and economists. Information was also drawn from research publications pertaining to the dissertation subject available in the USA and Thailand.

B. ESTIMATION OF PRODUCTION COEFFICIENTS

Crop Production

The average production of crops per rai of land was obtained directly from the DAE General Farm Survey in 1975. Crop budgets, in Appendix Tables A-1 through A-5, showing total variable costs, labor requirements, and net returns to labor, capital, and management, were also developed from the DAE General Farm Survey Data. Costs were estimated at current input prices. The average yield per rai of paddy and upland crop are shown in Table 5.1.

Table 5-1. Average Yield Per RAI of Paddy and Upland Crops in Northeast Thailand in 1974-75 Crop Year

Crop	Zone 01	Zone 02	Zone 03	Zone 04	Zone 05
	(KILOGRAM)				
Nonglutinous paddy (na)	281.81	179.56	210.15	173.04	170.23
Nonglutinous paddy (n)	265.55	189.43	200.99	180.71	195.49
Glutinous paddy (na)	215.89	165.89	167.44	154.97	187.35
Glutinous paddy (n)	265.55	189.43	-	181.71	195.49
Corn	505.84	582.51	-	461.94	395.43
Peanuts	-	301.18	159.39	-	439.84
Cassava	1,087.67	1,322.20	2,111.21	1,371.05	1,946.80
Kenaf	182.27	163.60	146.20	-	144.14

Note: na = native variety, n = new variety

Source: DAE General Farm Survey 1974-1975.

Swine Production

From Chapter III, the readers may already know that it is virtually impossible to estimate the coefficients of traditional swine production. With extraordinary hard work, a researcher might obtain some limited data on the amount of traditional feed use in producing swine, but the accuracy of such information would be doubtful. Many of the farmers raise swine and chickens together. Substantial amounts of the swine's feed is consumed by the chickens and therefore cannot be estimated accurately. Estimation of swine production coefficients for this study is therefore only for commercial farms in the Northeast Region.

The Estimation of Feed Conversion

The feed conversion ratio is the ratio of the kilograms of feed consumed per 1 kilogram of weight gain in swine. The feed ratio used for swine production in this study is the Rice Bran Ration (Table 3-4, page 21) which was recommended by the Department of Livestock, Ministry of Agriculture and Cooperatives, Government of Thailand. A mixture of feed ingredients consists of 36.2 percent of rice bran, 30.6 percent broken rice, 16.4 percent corn, 6.6 percent fish meal, 3.3 percent soybean meal, 4.9 percent peanut meal, 0.2 percent bone, 1.3 percent shell, and 0.5 percent salt. The feed conversion ratio for this ration was 3.47. This ratio was estimated from data developed at the research stations where feeding experiments were conducted using the more desirable breeds of swine and using higher technology and better management than found under average farm conditions. Therefore, this feed conversion is much better, that is, more efficient than the one that would be obtained under average farm conditions.

The existence of a technological gap between yield results obtained under carefully controlled conditions at a research station and those realized by actual producers under normal farm conditions is widely accepted. It is suspected that this gap may be accentuated in the case of limited resource farmers in developing countries. To provide this information, the Northeast Agricultural Research Center (NEARC) conducted an experiment to test the research results of swine rations obtained under the carefully controlled conditions of NEARC in two villages in Khon Khaen Province in Northeast Thailand (4, 1974). The test results showed that the average feed conversion ratio achieved at NEARC was 3.11; the average conversion ratio for a similar test at the farm level was 5.64. The summary result of the comparison of the performance of pigs fed the NEARC Ration at NEARC and of pigs fed the test ration at the farm level is shown in Table 5-2.

In this study, the feed conversion ratio of Rice Bran Ration used for swine production by commercial farms in Northeast Thailand is assumed to equal to 4.50.[1]

C. ESTIMATION OF PRICES

Price data required for the study include the prices for the major crops, swine, breeding costs, and the interest rate on money.

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[1]The assumed value of feed conversion ratio was based on records of average farms in Kentucky, USA. The feed conversion ratio for the average farms in Kentucky was about 3.5 to 3.6 (4, 1974). It appeared that a farmer in Northeast Thailand used at least 1 kilogram of feed more than a farmer in Kentucky to produce 1 kilogram of pork.

Table 5-2. Comparison of Performance of Pigs on NEARC Ration at NEARC and at the Farm Level[a]

	At NEARC	At the Farm Level
Beginning weight (kg.)	18.10	7.90
End weight (kg.)	90.00	98.30
Gain in weight (kg.)	71.90	89.30
Daily gain (gm.)	642.00	366.00
Feed Conversion ratio	3.11	5.64
Feed cost per kg. of gain (baht)	4.01	6.55
Average number days on feed	112.00	244.00

[a]Data refer to one pig (average for the trial).

Prices of Crops and Crop Production Costs

Prices for paddy, kenaf, corn, peanuts, and cassava were drawn from the DAE General Farm Survey as shown by zones in Table 5-3. These prices were the prices received by farmers in each zone in crop year, 1974-75.

Variable costs required in the model consisted of costs for fertilizer, seeds, insecticides, and labor. The average variable cost per rai is shown in Table 5-4.

Prices of Swine and Production Costs

Prices for marketed swine used in the model were the average farm prices of the swine which weighed 100 kilograms or more per head in the 1973-1975 period. Dealers and slaughter-house buyers usually prefer

Table 5-3. Average Farm Prices of Paddy and Upland Crops in Northeast Thailand in 1974-75 (Unit: baht per kilogram)

Crop	Zone 01	Zone 02	Zone 03	Zone 04	Zone 05
Nonglutinous paddy	1.31	1.47	1.27	1.26	1.33
Glutinous paddy	1.27	1.38	1.26	1.15	1.26
Corn	1.59	1.42	-	1.30	1.36
Peanuts	-	3.00	3.00	-	3.00
Cassava	.37	.39	.34	.40	.36
Kenaf	2.22	2.98	2.67	-	2.53

Source: DAE General Farm Survey 1974-75.

Table 5-4. Average Variable Cost of Producing Paddy and Upland Crops in Northeast Thailand in 1974-75 (Unit: baht per kilogram)

Crop	Zone 01	Zone 02	Zone 03	Zone 04	Zone 05
Nonglutinous paddy (na)	252.67	111.24	100.28	86.36	73.30
Nonglutinous paddy (n)	192.83	144.52	254.21	107.51	107.56
Glutinous paddy (na)	147.68	105.75	103.63	100.53	69.44
Glutinous paddy (n)	195.45	146.91	-	112.05	106.32
Corn	457.73	475.05	-	446.91	294.85
Peanuts	-	302.29	121.09	-	259.65
Cassava	275.55	318.74	271.04	260.65	164.42
Kenaf	128.47	114.32	84.58	-	53.16

na = native variety.

n = new variety.

Source: DAE General Farm Survey 1974-75.

those hogs which weigh no more than 100 kilograms because the transportation and slaughter license cost is based on a per head basis. Prices of sows and boars are the same as that for finishing hogs which weigh more than 100 kilograms. The total value of sows or boars is estimated after discounting them by 25 percent of their liveweight. Table 5.5 shows the monthly average farm price of market hogs weighing more than and less and 100 kilograms per head in 1973-75.

Estimation of Feed Costs

Feed cost accounted for more than 70 percent of the total cost of producing swine during the past 3 years (1973-75). The average feed price used in this study was estimated as follows:

Total amount of feed use = 4.5^{2} X 97^{3} = 437 kgs.

Total feed cost = 874 baht[4]

Feed price per kilogram = 874/437 = 2.00 baht.

Because of the impact of the specified feed conversion ratio, the amount of feed used, and the price of feed ingredients, it was considered desirable to use parametric analysis for determining the effect of varying feed prices on the optimum farm organization.

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[2]Four and one half kilograms of feed to 1 kilogram of gain is the feed conversion ratio for the commercial farms in Northeast Thailand.

[3]Ninety-seven kilogram are the total net weight gain of swine from weaning to finishing (from 13 to 110 kilograms).

[4]See Appendix Table A-8.

Table 5-5. Monthly Average Farm Prices of Hogs in Northeast Thailand in 1973-75 (unit: baht per kilogram)

Year	Month												
	J	F	M	A	M	J	JL	AU	S	O	NO	D	Average
					Hogs weighing 100 kilograms or more								
1973	8.20	8.2	8.5	8.8	8.6	9.6	8.6	10.3	9.1	11.1	10.5	10.5	9.30
1974	12.40	12.9	14.0	15.1	14.6	14.5	17.4	15.6	16.8	17.2	16.6	16.8	15.50
1975	16.80	16.1	15.6	15.0	14.5	14.6	14.2	13.9	13.9	13.7	14.2	13.8	14.30
					Hogs weighing 99 kilograms and less								
1973	7.10	7.0	8.0	8.0	7.5	8.5	7.7	9.0	8.1	10.1	9.7	10.1	8.40
1974	10.05	11.6	11.4	13.3	13.6	12.3	15.6	15.0	15.0	15.6	15.0	15.4	13.65
1975	15.20	15.3	14.3	14.4	13.1	13.3	13.0	12.5	12.3	12.3	12.5	12.6	13.30

Source: Marketing Section DAE.

D. ESTIMATION OF RESOURCES

Labor

The primary source of labor on small farms in Northeast Thailand is the family. From 1970 statistics, the average economically active labor available was 3.75 man equivalents per farm per year (27, 1975). The total annual work hours were estimated by counting all family members who worked on the farm. Farm family members whose ages were between 15 and 64 years were classified as full time laborers. The working hours were assumed to be 8 hours per day. The number of working days in a year was estimated by assuming that all farmers did not work on the Buddhist religious days and other national holidays. There are about four Buddhist religious days per month, namely, new moon (NM), first quarter (FQ), full moon (FM), and last quarter (LQ). The number of work-days in a year are shown in Table 5-6.

To obtain the number of working hours per man per year, one must multiply the number of working days by 8. Assuming that the number of economically active labor available in 1975 is the same as that which was available in 1970, then the total family labor available per farm in a year is equal to 306 X 8 X 3.75, or 9,180 man hours.[5]

The available family labor in each four-month period is shown in Table 5-7.

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[5]Although the rate of population growth is high in most developing countries, the rate of outmigration from the agricultural sector, at the same time, is also high. It seems reasonable to assume that family labor in the Northeast Thailand is constant, at least in the short-run.

Table 5-6. Number of Workdays in a Year

Month	Number of working days
January	26
February	24
March	27
April	25
May	24
June	26
July	25
August	27
September	26
October	25
November	25
December	26
TOTAL	306

Table 5-7. Number of Man-hours Family Labor Available per Farm per Year

Period	Number of man hours
JFMAp	3,060
MJJAu	3,060
SOND	3,060
TOTAL	9,180

Land

The average agricultural land holding in the Northeast Thailand is about 30 rai.[6] Most of this land is paddy land which accounts for more than 60 percent of the total land holdings. The proportion of paddy and upland area to total land varies from zone to zone. Table 5-8, shows the percentage of the land in the five agro-economic zones in the Northeast in 1975.

If one assumes that the average farm size is equal to 30 rai in each zone, then the average paddy land and upland area is as shown in Table 5-9.

E. CAPITAL

Capital is often recognized as one of the most constraining resources of small farmers in the developing countries. In Northeast Thailand where the average income is low compared to other regions of the country, capital is the most constraining resource. Capital requirements in this study are defined as (1) cash on hand, (2) short-term credit, and (3) medium-term and long-term credit.

The demand for operating capital by enterprises was assumed to be equal to the variable costs per unit of production and the prices paid per unit of inputs (feed, feeder pigs, etc.). The opportunity cost of operating capital was assumed to be 7 percent per year which was equal to the rate of interest on savings accounts.

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[6]Total agricultural land is the paddy land and the upland area. This land does not include the lot around the house.

Table 5-8. Total Land Holding and Percentage of Paddy Land and Upland in Northeast Thailand in 1975

Zone	Paddy Land (1,000 rai)	Percent	Upland (1,000 rai)	Percent
01	7,950.0	85.0	1,405.6	15.0
02	5,486.0	90.8	558.1	9.2
03	8,541.0	80.1	2,125.8	19.9
04	7,829.0	88.7	998.5	11.3
05	4,970.0	62.0	3,041.7	38.0

Source: DAE General Farm Survey

Table 5-9. The Average Paddy Land and Upland Area per Farm in the Five Agro-economic Zones in Northeast Thailand, 1975

Zone Number	Paddy Land (rai)	Upland (rai)
01	25.5	4.5
02	27.1	3.0
03	24.0	6.0
04	26.6	3.4
05	18.6	11.4

The major sources of borrowed money are dealers, neighbors, relatives, commercial banks, and the Bank for Agriculture and Agricultural Cooperatives. The Bank for Agriculture and Agricultural Cooperatives provide credit to farmers in every region of the country and is the most important source of farm credit. The Bank provides short-, medium-, and long-term credit to farmers, farmer associations, and farmer-cooperatives. The maximum amount of short-term credit is about 60 percent of the market value of crops and livestock and it has to be paid back in one year. The interest rate for the short-, medium-, and long-term credit is 12.0 percent per year. The maximum amount of credit farmers can borrow from the Bank for Agriculture and Agricultural Cooperatives was assumed to be 30,000.00 baht.[7]

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[7]The maximum amount of credit includes short-term, medium-term, and long-term.

CHAPTER VI

OPTIMUM ORGANIZATION FOR THE REPRESENTATIVE FARM WITH EXISTING AND CHANGING RESOURCES AND PRICES

The former chapters have presented data base and methodology to be used in analyzing whether the existing farm organization could be reorganized to increase swine production and the level of farm income. The optimum organization for the representative farm using existing resources and prices are estimated by using linear programming techniques assuming that resources and prices are the same as the 1975 levels. The results are then recognized as the base plan.[1] The alternative plans are determined by varying the land and capital resources and by varying feed and swine prices.

A. ASSUMPTIONS

For this analysis, the technology measured by the technical input-output coefficients as found in 1974-1975 will remain constant. Prices of inputs and outputs are the average prices for 1974-1975. Farm resources used for the analysis are those taken from the DAE General Farm Survey. It is also assumed that the Bank for Agriculture and Agricultural Cooperatives will continue to provide credits for the farmers in Northeast Thailand.

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[1] The base plan is defined as the plan that uses the existing farm resources that were available in 1974-75 season and assuming no credit was available to farmers.

B. PRESENTATION SCHEME

The first optimum plan is the base plan obtained by using linear programming techniques. The linear programming solutions were obtained by using the IBM 360 computer at the University of Tennessee with the MPSX computing routine. The alternative plans using varying resources and prices were estimated after obtaining the base plan.

The output resulting from linear programming provides information on the optimum combination of the activities included, the value of the objective function, the amount of resources used, their respective marginal value products, and the activities included in the solution. The objective function is to maximize farm income over variable costs. Therefore, the results do not take fixed costs into account.

C. OPTIMUM ORGANIZATION FOR THE REPRESENTATIVE FARM WITH EXISTING RESOURCES AND PRICES

The complete input-output coefficients and resource requirements of the linear programming tableau of Agro-economic Zones 01 through 05 are shown in Appendix Tables C-1 through C-5. The first optimum solutions obtained are shown in Table 6-1. In these solutions, it was assumed that no credit was available to farmers. The model allows farmers to use only the working capital they have on hand.

Zone 01

In optimum solution for Zone 01, the representative farm produced 21.8 rai of glutinous paddy and 4.5 rai of kenaf. The total man hours labor used was 2,770. Of this amount, 180 man hours were from January-

Table 6-1. Optimum Base Plan Without Credit for Zone 01, Zone 02, Zone 03, Zone 04, and Zone 05

Item	Unit	Zone 01	Zone 02	Zone 03	Zone 04	Zone 05
Net Return over Variable Costs	baht	4,004.24	5,793.13	6,173.79	4,709.64	10,277.59
Resources Used						
Paddy land	rai	21.81	27.00	24.00	26.60	13.64
Upland area	rai	4.51	3.00	6.00	3.40	11.64
Operating capital	baht	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00
Total labor	hour	2,769.64	2,388.91	3,801.70	3,982.89	6,235.77
Labor 1	hour	179.54	18.54	590.87	1,109.55	753.38
Labor 2	hour	1,570.37	1,402.84	1,890.47	1,898.05	3,060.00
Labor 3	hour	1,018.38	967.52	1,356.23	975.29	2,049.55
Crop Production						
Nonglutinous paddy	rai	-	27.00	24.00	26.60	-
Glutinous paddy	rai	21.80	-	-	-	13.64
Corn	rai	-	-	-	-	-
Peanuts	rai	-	2.41	1.52	-	7.46
Cassava	rai	-	-	4.48	3.40	3.94
Kenaf	rai	4.51	.59	-	-	-
Swine Production						
Market hogs	kg.	-	-	-	64.73	-
Feeder pigs	head	-	-	-	-	-
Feed Used	kg.	-	-	-	304.50	-

April, 1,570 from May-August, and 1,080 from September-December. There was 3.7 rai of paddy land left idle. The net return over variable cost for the representative farm in Zone 01 was 4,004.00 baht.

Zone 02

The optimum solution for the representative farm in Zone 02 consists of 27.0 rai of nonglutinous paddy, 2.4 rai of peanuts and .6 rai of kenaf. At the optimum solution, all paddy land and upland area were fully utilized. The total amount of labor used was 2,389 man hours. The man hours of labor used in January-April was 19; in May-August, 1,403 hours; and in September-December, 968 hours. The net return over the variable costs of the representative farm in Zone 02 was 5,793 baht.

Zone 03

The optimum organization situation of the representative farm in Zone 03 consisted of 24.0 rai of nonglutinous paddy, 1.5 rai of peanuts, and 4.5 rai of cassava. All paddy land and upland area were fully utilized while only 3,802 man hours of labor was used with January-April contributing 591 man hours, May-August 1,890 man hours, and September-December 1,356 man hours. The net return over variable costs were 6,174 baht.

Zone 04

The optimum organization of the representative farm operating under a non-credit situation in Zone 04 was where 26.6 rai of glutinous paddy and 3.4 rai of cassava were produced. The total swine production was 65.0 kilograms of market hogs. All land and capital resources were fully

used. The total labor used was 3,981 man hours. The man hours of labor used in January-April was 1,110; in May-August, 1,898 hours; and in September-December 975 man hours. At the optimum solution, the net return over the variable costs was 4,710 baht.

Zone 05

The optimum farm organization of the representative farm operating under a noncredit situation in Zone 04 was 13.6 rai of glutinous paddy, 7.5 rai of peanut, and 3.9 rai of cassava were produced. No swine enterprise was in the optimum solution. All of the upland area was fully utilized and only 13.6 rai of the total 18.4 rai of paddy land was used. All capital resources were used. The total labor requirement was 6,236 man hours which were broken down into January-April labor of 753 man hours; May-August labor of 3,060 man hours; and September-December labor of 2,050 man hours. The total net return over the variable costs was 10,228 baht which is more than the net return in the other zones.

D. THE MVP'S OF RESOURCES USED FOR THE OPTIMUM BASE PLAN

The marginal value products of the resources for the optimum base plan for the five zones are shown in Table 6-2. The marginal value products (MVP) of the resources in this care are defined as the number of baht that would be added to the net return over the variable costs by utilizing an additional unit of the resources. The economic interpretation of the MVPs of the resources for the maximization process are the inputed values to the inputs (or resources). These inputed values represent the worth of the inputs when used within this firm, not their

Table 6-2. Marginal Value Products (MVPs) of Resources Used for the Base Plan

Item	Unit	Zone 01	Zone 02	Zone 03	Zone 04	Zone 05
Paddy land	baht	0	17.76	109.01	99.62	0
Upland area	baht	166.12	234.51	301.93	191.05	247.58
Operating capital	baht	0.86	1.21	0.46	0.37	1.42
Total labor	baht	0	0	0	0	0
Labor 1	baht	0	0	0	0	0
Labor 2	baht	0	0	0	0	0.67
Labor 3	baht	0	0	0	0	0

value when sold directly in the input markets outside the firm. The value of the MVP tells us two things, first, the limitation of the resource and second, the amount of money which could be added to the objective function by adding one more unit of that resource. When the MVP is equal to zero, it suggests that that resource is redundant to the firm.

The concept of MVP in linear programming and in production function analysis is similar but the derivation is different. In order to understand this concept clearly the following statement from Cowan (8, 1964, page 46) is quoted.

> The value of the MVP of a resource which is computed from a production function is independent of the use of the other resources involved, and it can be computed at any level of use. However, in linear programming the MVP's are computed only for resources that are restricting, and the value of the MVP is a result of complementary effect among the resources. For example, if there is a combination of resources such as

land, labor, and capital, and labor is the restricting resource, the values of land and capital are assumed to be free. These free resources facilitate the computing of the MVP for labor and partly explain the higher MVP since only the one resource was restricting. But if land and labor were restricting, there is an interaction among the restricting resources insofar as the computation of their MVP's are concerned.

Zone 01

In Zone 01, the amount of upland area and operating capital are the limiting input resources for the average farm. The paddy land family labor inputs are redundant as reflected by a zero value of their MVP's. The value of the MVP for the upland area is 166 baht, indicating that the net return could be increased by 166 baht if 1 rai of upland area could be acquired.[2] In the same fashion, the value of the MVP for operating capital is determined as .86 baht which suggests the net return could be increased by .86 baht if 1 baht of capital could be obtained. The value of the MVPs can be also used to determine the cost of using the resources. As long as the cost of acquiring one more unit of the resource is less than its MVP, increasing the amount of the resources will increase the value of objective function. For example in this case, if the cost of renting in 1 rai of the upland area is less than 166 baht, farmers can improve their income by acquiring more upland area. The same analysis can be applied to operating capital. As long as the cost of borrowing money (e.g., interest) for 1 baht is less .86 baht, the net return could be increased by borrowing money for farm production.

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[2]It should be noted that the MVP is constant only over a certain range. We do not know what this "range" is and, therefore, must interpret the implications of MVP's cautiously (5, 1971, page 86).

Zone 02

Paddy land, upland area, and operating capital are the limiting resources for the average farm in Zone 02. The operating capital is the most limiting resource under the noncredit condition. One more baht of operating capital could increase the net return by 1.21 baht; in other words, it is profitable to borrow money for farm production even though the interest rate is as high as 100 percent per year. The MVP's of the upland area and the paddy land are 235 and 18 baht per rai, respectively.

Zone 03

Paddy land and upland area are more limiting as resources in Zone 03 than in the other Zones. The MVP's for upland and paddy land are 302 and 109 baht, respectively. The MVP for the operating capital is .46 baht. Labor is not a limiting resource in Zone 03.

Zone 04

Paddy land, upland area, and operating capital are limiting factors for farmers in Zone 04. The MVP's for paddy land, upland, and operating capital are 100 baht, 191 baht, and .37 baht, respectively.

Zone 05

Upland area, operating capital, and the May-August labor situation are the limiting resources for farmers in Zone 05. The operating capital resources is the most limiting. By increasing operating capital 1.0 additional baht, the net return would increase by 1.41 baht. The MVP for the upland area is 248 baht and the MVP for the May-August family labor is .7 baht per hour.

E. STABILITY LIMITS FOR THE BASE PLAN RESOURCES

We have already discussed the importance of the MVP's of resources in the optimum base plan. As mentioned before, MVPs are constant over a certain range. Without stability limit analysis, the interpretation of the level of resources used, as well as the conclusions that arose from the MVP's analysis, would not be complete (1, 1975). The stability or range analysis provides information about the effects of resource variation upon the optimum plans (23, 1973, page 14).

> If the optimum plan appears to be relatively sensitive to small change of certain values, care must be taken in selecting a plan which is stable over a wide range of values or more frequent adjustments should be made in farm operation. (22, 1972, page 40).

Stability limits of the base plan (no credit) with respect to resources used are given in Table 6-3. These limits provide an estimate of the range over which the MVP's are relevant and the optimum farm organization remains the same even though the level of the enterprises may change.

Zone 01

The initial level of the upland area (UPL) is 4.5 rai. The lower limit of the upland area is .3 rai and the upper limit is 29.6 rai. The marginal value product of the upland area is constant at 166 baht between this range. Beyond this level, less than 13 rai, the paddy land (PDL) would be utilized to the upper limit level (25.5 rai), since operating capital can be used for growing rice in the paddy area. Beyond the upper level, more than 29.6 rai, native glutinous rice production activity

Table 6-3. Stability Limits for the Base Plan Resource (Without Credit) in Zone 01-05

Zone No.	Resource	Unit	Initial[a] level	Lower level	Changing[b] variable	Upper level	Changing[b] variable
01	UPL	rai	4.51	.28	PDL(UL)[c]	29.58	A301(LL)
	OCAP	baht	3,800.00	579.40	A301(LL)[d]	4,343.76	PDL(UL
02	PDL	rai	27.00	26.00	A1402(LL)	31.07	A1202(LL)
	UPL	rai	3.00	2.63	A802(LL)	6.97	A1202(LL)
	OCAP	baht	3,800.00	3,346.44	A1202(LL)	3,910.34	A802(LL)
03	PDL	rai	24.00	21.74	A903(LL)	30.65	A1003(LL)
	UPL	rai	6.00	5.16	A903(LL)	11.51	A1003(LL)
	OCAP	baht	3,800.00	3,133.26	A1003(LL)	4,026.96	A903(LL)
04	PDL	rai	26.60	0	A704(LL)	33.74	A1304(LL)
	UPL	rai	3.40	0	A1004(LL)	5.76	A1304(LL)
	OCAP	baht	3,800.00	3,183.38	A1304(LL)	90,334.23	LAB 2(LL)
05	UPL	rai	11.40	9.95	A1305(LL)	15.73	A605(LL)
	OCAP	baht	3,800.00	3,482.57	PDL(UL)	4,048.08	A1305(LL)
	LAB 2	hour	3,060.00	2,697.92	A1305(LL)	3,301.08	PDL(UL)

[a]Initial level of resource is the amount of resource available to farm in 1974-75.

[b]This column specifies the names of activities or resources that would change as the result of applying the resource beyond its stability limits.

[c]UL = upper limit. In this case UL indicates the resource or activity that would increase to the upper limit (or enter the solution).

[d]LL = lower limit. In this case LL indicates the resource or activity that would decrease to the lower limit (or leave the solution).

(A301 or PRGO) will decrease to the zero level. For the operating capital, the initial level is 3,800 baht. Beyond the lower limit, less than 579 baht of operating capital, the glutinous rice production activity (A 802) will decrease to zero level. Beyond the upper level, more than 4,344 baht, paddy land will be used to the upper limit level (25.5 rai).

Zone 02

Paddy land is the limiting resource and its initial level is 27 rai. The range of constant MVP is between 26 and 31 rai. Below the lower level of 26 rai kenaf selling activity (A 1402) would decrease to the zero level. Beyond the upper level, 31 rai, peanut, selling activity (A 1202) would leave the optimum solution. The stability limits of the upland area is between 2.6 and 7.0 rai. Kenaf production activity (A 802) would leave the optimum solution if the amount of upland were to be reduced below 2.6 rai. The kenaf selling activity (A 1202) would leave the solution if the upland could be increased above 6.9 rai. The range limits of operating capital is from 3,346 to 3,910 baht. Kenaf selling activity (A 1202) or kenaf production activity (A 802) would leave the solution if the operating capital were reduced to less than 3,356 baht or increased to more than 3,910 baht, respectively.

Zone 03

The initial level of the paddy land (PDL) is 24 rai. The lower limit and the upper limit are 21.7 and 30.6 rai, respectively. Below the lower limit of 21.7 rai, the peanut selling activity (A 903) will decline to zero. Above the upper limit of 30.6 rai, the cassava selling activity A 1003) would leave the optimum solution. The range limits of the upland

area in Zone 03 is from 5 to 11 rai. The activities that would be affected by decreasing or increasing beyond this range are the peanut selling activity (A 903) or cassava selling activity (A 1003), respectively. Both would be reduced to the zero level. Any reduction in the operating capital (OCAP) below 3,133 baht, the lower limit, (A 1003), the cassava selling activity, would drop from the optimum solution. The upper limit of OCAP is 4,027 baht and the peanut selling activity would drop from the solution if the OCAP could be increased above 4,027 baht.

Zone 04

The initial level of the paddy land is 26.6 rai with the lower and upper limit equal to 0 and 33.7 rai, respectively. This means that any changes in the amount of paddy land between 0 and 33.7 rai will not change the value of MVP of paddy land. In other words the MVP is relevant under this range. If paddy land is reduced to the zero level "sell nonglutinous rice" (A 704) will be removed. However, if the paddy land could increase beyond the upper limit, the farrow to finish activity would be removed. The stability limits for the upland area is between 0 and 5.7 rai. A 1004, "sell cassava," will be removed if no upland area is available. However, the "farrow to finish" activity (A 1304) will be dropped if the upland area increased over 5.7 rai. The range limits for the operating capital (OCAP) is wide, from 3,183 baht at the lower level to 90,334 baht at the upper level. Any reduction of the operating capital below 3,183 baht would cause "farrow to finish" activity to drop from the solution. If an increase in the capital is more than 90,334 baht, there

would be more demand for the May-August labor (LAB 2) and this labor would become the limiting factor.

Zone 05

The stability limits for the upland area is 10 rai for the lower level and 15.7 rai for the upper limit level. Reduction of the upland area below 10 rai, "sell cassava" will be removed. However, if the upland area increases beyond 15.7 rai, "peanut production" (A 605 would be removed. The initial level of the operating capital (OCAP) is 3,800 baht with the lower and upper limits equal to 3,483 baht and 4,048 baht, respectively. If the operating capital were less than 3,483 baht, more paddy land would be used for production. If the capital were more than 4,048 baht, "sell cassava" would be removed. The initial level of the May-August labor (LAB 2) is 3,060 man hours with the lower and upper limits equal to 2,680 and 3,301 man hours, respectively. If the availability of this labor were lower than the lower limit, "sell cassava" (A1305) would be removed. But if there were more than 3,301 man hours of LAB 2 available, then the paddy land would be used up to the 18.4 rai.

F. EFFECTS OF INCREASING CAPITAL ON THE OPTIMUM ORGANIZATION

One of the most limiting resources for small farmers in Northeast Thailand is operating capital. This was demonstrated by the high MVP's for operating capital calculated for the agro-economic zone. The high value of MVP's for operating capital indicates the possibility of increasing farm incomes by acquiring more operating capital.

The increase in farmers' operating capital in this case was assumed to be obtained by borrowing from the Bank for Agriculture and Agricultural Cooperatives. Two alternatives were considered. The first was Alternative A, the model which allowed farmers to have short-term credit, with 60 percent of the value of crops and livestock producing in 1974-1975 as a source of additional capital.[3] All other resources and input-output coefficients remain unchanged. The second was Alternative B, the model in which it was assumed that a combination of short-, medium-, and long-term credit was available to farmers with the maximum amount being 30,000 baht. All other resources and input-output coefficients remained the same. The results of the analysis are shown in Table 6-4 to 6-8.

It should be noted that the optimum base plan was included in the table to facilitate comparison.

Zone 01

Table 6-4 shows that net return over variable costs increases from 4,004 to 5,065 baht, or 26.5 percent as credit increases from 0 to 2,403 baht in Alternative A. If 30,000 baht of credit were loaned to the farmer, the net income would be increased to 10,765 baht, or 168.8 percent of the base plan income. When more capital was available, the net return was improved because the farmer could utilize his resources more efficiently. For example, when capital was made available, the use of paddy land increased from 21.8 rai of the base plan to 25.5 rai, and nonglutinous paddy was substituted for glutinous paddy in both Alternatives A and B. More family labor was utilized in farm production, especially for swine

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[3]Short-term credit for Zone 01 is 2,043 baht; Zone 02, 3,476 baht; Zone 03, 3,705 baht; Zone 04, 2,826 baht; and Zone 05, 6,167 baht.

Table 6-4. Optimum Organization of Plan Alternative A and B for Zone 01

Item	Unit	Base[a] Plan	Alternative A	Alternative B
Net Return over Variable Cost	baht	4,004.24	5,064.90	10,764.60
Resources Used				
Paddy land	rai	21.81	25.49	25.49
MVP of Paddy Land	baht	0	83.49	83.49
Upland Area	rai	4.51	4.51	4.51
MVP of Upland Area	baht	166.12	228.50	228.50
Operating Capital	baht	3,800.00	3,800.00	3,800.00
MVP of Operating Captial	baht	.86	.37	.37
Total Labor	hour	2,769.64	3,255.85	4.236.02
Labor 1	hour	179.54	184.56	511.28
Labor 2	hour	1,570.37	1,910.74	2,237.46
Labor 3	hour	1,018.38	1,159.20	1,458.92
Credit	baht	-	2,402.54	30,000.00
MVP of Credit	baht	-	.21	.21
Crop Production				
Nonglutinous Paddy	rai	-	25.49	25.49
Glutinous Paddy	rai	21.81	-	-
Corn	rai	-	-	-
Cassava	rai	-	-	-
Kenaf	rai	4.51	4.51	4.51
Swine Production				
Market Hogs	kg.	-	44.05	2,593.60
Feeder Pigs	head	-	-	-
Feed Used	kg.	-	207.01	12,200.37

[a]Base plan is included to facilitate the comparison.

Table 6-5. Optimum Organization of Plan Alternative A and B for Zone 02

Item	Unit	Base[a] Plan	Alternative A	Alternative B
Net Return over Variable Cost	baht	5,793.13	6,603.96	12,081.97
Resources Used				
Paddy Land	rai	27.00	27.00	27.00
MVP of Paddy land	baht	17.75	111.44	111.44
Upland Area	rai	3.00	3.00	3.00
MVP of Upland Area	baht	234.51	489.08	489.08
Operating Capital	baht	3,800.00	3,800.00	3,800.00
MVP of Operating Capital	baht	1.21	.37	.37
Total Labor	hour	2,388.91	2,526.31	3,466.57
Labor 1	hour	18.54	39.59	353.01
Labor 2	hour	1,402.84	1,479.86	1,793.28
Labor 3	hour	967.52	1,006.85	1,320.27
Credit	baht	-	3,476.00	30,000.00
MVP of Credit	baht	-	.20	.20
Crop Production				
Nonglutinous Paddy	rai	27.00	27.00	27.00
Glutinous Paddy	rai	-	-	-
Corn	rai	-	-	-
Peanuts	rai	2.41	3.00	3.00
Cassava	rai	-	-	-
Kenaf	rai	.59	-	-
Swine Production				
Market Hogs	kg.	-	309.54	2,759.92
Feeder Pigs	head	-	-	-
Feed Used	kg.	-	1,456.08	12.982.75

[a]Base plan is included to facilitate the comparison.

Table 6-6. Optimum Organization of Plan Alternative A and B for Zone 03

Item	Unit	Base[a] Plan	Alternative A	Alternative B
Net Return Over Variable Cost	baht	6,173.79	6,959.27	12,389.98
Resources Used				
Paddy Land	rai	24.00	24.00	24.00
MVP of Paddy Land	baht	109.01	117.97	117.97
Upland Area	rai	6.00	6.00	6.00
MVP of Upland Area	baht	301.32	325.46	325.46
Operating Capital	baht	3,800.00	3,800.00	3,800.00
MVP of Operating Capital	baht	.86	.37	.37
Total Labor	hour	3,801.70	3,921.04	4,853.18
Labor 1	hour	590.87	832.73	1,143.44
Labor 2	hour	1,890.47	1,896.17	2,206.88
Labor 3	hour	1,356.23	1,228.13	1,538.84
Credit	baht	-	3,705.00	30,000.00
MVP of Credit	baht	-	.21	.21
Crop Production				
Nonglutinous Paddy	rai	24.00	24.00	24.00
Glutinous Paddy	rai	-	-	-
Peanuts	rai	1.52	-	-
Cassava	rai	4.48	6.00	6.00
Kenaf	rai	-	-	-
Swine Production				
Market Hogs	kg.	-	318.45	2,747.68
Feeder Pigs	head	-	-	-
Feed Used	kg.	-	1,498.01	12,925.16

[a]Base plan is included to facilitate the comparison.

Table 6-7. Optimum Organization of Plan Alternative A and B for Zone 04

Item	Unit	Base[a] Plan	Alternative A	Alternative B
Net Return Over Variable Cost	baht	4,709.64	5,293.30	10,095.55
Resources Used				
Paddy Land	rai	26.60	26.60	26.60
MVP of Paddy Land	baht	99.62	99.62	99.62
Upland Area	rai	3.40	3.40	3.40
MVP of Upland Area	baht	191.05	191.05	191.05
Operating Capital	baht	3,800.00	3,800.00	3,800.00
MVP of Operating Capital	baht	.37	.37	.37
Total Labor	hour	3,982.89	4,083.06	5,046.36
Labor 1	hour	1,109.55	1,142.94	1,464.04
Labor 2	hour	1,898.05	1,931.44	2,252.54
Labor 3	hour	975.29	1,008.68	1,329.78
Credit	baht	-	2,826.00	30,000.00
MVP of Credit	baht	-	.21	-
Crop Production				
Nonglutinous Paddy	rai	26.60	26.60	26.60
Glutinous Paddy	rai	-	-	-
Corn	rai	-	-	-
Cassava	rai	3.40	3.40	3.40
Swine Production				
Market Hogs	kg.	64.73	325.81	2,836.24
Feeder Pigs	head	-	-	-
Feed Used	kg.	304.50	1,532.61	13,341.75

[a]Base plan is included to facilitate the comparison.

Table 6-8. Optimum Organization of Plan Alternative A and B for Zone 05

Item	Unit	Base[a] Plan	Alternative A	Alternative B
Net Return Over Variable Cost	baht	10,277.59	11,714.75	16,241.88
Resources Used				
Paddy Land	rai	13.46	9.06	6.26
MVP of Paddy Land	baht	0	0	0
Upland Area	rai	11.40	11.40	11.40
MVP of Upland Area	baht	247.58	430.86	430.86
Operating Capital	baht	3,800.00	3,800.00	3,800.00
MVP of Operating Capital	baht	1.42	.35	.35
Total Labor	hour	6,235.38	6,236.29	6,595.57
Labor 1	hour	753.38	281.54	565.77
Labor 2	hour	3,060.00	3,060.00	3,060.00
MVP of Labor 2	baht	.67	1.40	1.40
Labor 3	hour	2,049.55	2,324.74	2,399.78
Credit	baht	-	6,167.00	30,000.00
MVP of Credit	baht	-	.19	.19
Crop Production				
Nonglutinous Paddy	rai	-	-	-
Glutinous Paddy	rai	13.64	9.07	6.26
Corn	rai	-	-	-
Peanuts	rai	7.46	11.40	11.40
Cassava	rai	3.94	-	-
Kenaf	rai	-	-	-
Swine Production				
Market Hogs	kg.	-	548.73	2,770.96
Feeder Pigs	head	-	-	-
Feed used	kg.	-	2,581.24	13,034.65

[a]Base plan is included to facilitate the comparison.

production. Hog production increases from 0 kilograms in the base plan to 44 and 2,594 kilograms in Alternative A and B, respectively. The utilization of family labor increases from 2,770 man hours in the base plan to 3,256 man hours in Alternative A and 4,236 man hours in Alternative B.

Zone 02

As shown in Table 6-5, the net return over variable costs increases from 5,793 to 6,603 baht as credit increases from 0 baht in the base plan to 3,476 baht in Alternative A. If 30,000 baht of credit were loaned to the farmer, the net return over variable costs in Alternative B would be increased to 12,082 baht or about 108.5 percent over the base plan. The use of family labor increased over the base plan by 5.7 and 45.1 percent for Alternatives A and B, respectively. The increase in the use of capital results in changes in crop enterprises, e.g., kenaf production dropped from the optimum solution in the Alternatives A and B and all upland area would be used for peanut production. About 309 kilograms of hogs were produced in Alternative A and 2,760 kilograms in Alternative B as a result of increasing the use of credit in Zone 02.

Zone 03

The net return over variable costs increases from 6,174 to 6,959 baht as credit increases from 0 baht in the base plan to 3,705 baht in Alternative A. When credit increases to 30,000 baht in Alternative B, the net return over variable costs increases to 12,390 baht. All 6.0 rai of the unland area is used for cassava production in both Alternative A and B. The swine enterprise enters the optimum solution, 318 kilograms

of market hogs would be produced under Alternative A and 2,748 kilograms under Alternative B (Table 6-6).

Zone 04

An increase in the use of credit from 0 baht in the base plan to 2,826 baht in alternative would result in an increase in net return over variable costs from 4,710 to 5,293 baht. As the credit increases to 30,000 baht in Alternative B, the net return over variable costs would increase to 10,906 baht. The total market hog production would increase from 65 kilograms in the base plan to 326 kilograms in Alternative A and 2,836 kilograms in Alternative B. As a result of increasing swine production, the employment of family labor increases from 3,983 man hours in the base plan to 4,083 man hours in Alternative A and 5,046 in Alternative B. All other enterprises stay the same as they were in base plan (Table 6-7).

Zone 05

Table 6-8 shows that net return over variable costs increases from 10,278 to 11,715 baht as credit increases from 0 in the base plan to 6.167 baht in Alternative A. If 30,000 baht of credit were made available to the farmer in Alternative B. The net return over variable costs would increase to 16,242 baht. As a result of increasing the use of credit in Zone 05, glutinous paddy production is reduced from 13.6 rai in the base plan to 9.1 rai in Alternative A and 6.3 rai in Alternative B. This is because the paddy enterprise competes with the swine and the upland crop enterprises for the May-August labor supply. Cassava production would drop from the optimum solution while peanut production would increase

from 7.5 rai in the base plan to 11.40 rai in both Alternatives A and B. Hog production would increase from 0 in the base plan to 549 kilograms in Alternative A and 2,771 kilograms in Alternative B.

G. STABILITY LIMITS OF THE ACTIVITIES INCLUDED IN THE OPTIMUM SOLUTION WITH RESPECT TO PRICES AND VARIABLE COSTS FOR PLAN ALTERNATIVE A

The enterprises included in the optimum plan can be reorganized by changing the prices and/or variable costs per unit of activity. Table 6-9 shows the lower and upper limits of variable costs and prices beyond which the optimum plan, Alternative A, will change. The importance of this analysis is to know how much prices and/or costs would have to change before the optimum should be changed. The net effect of the changes are listed under the columns "Entering Variable" in Table 6-9. Discussions are as follows:

Zone 01

At the optimum solution, "produced nonglutinous new variety" (PNRN) is grown on 25.49 rai with initial variable costs equal to 193 baht per rai. The stability limits for the nonglutinous rice (new variety) production ranges between 205 and 0 baht per rai. If the variable costs were higher than 205 baht per rai, glutinous rice native variety (PGRO), would substitute for the nonglutinous rice; so, the activity, "produced glutinous rice native variety" (PGRO), is the entering variable. If the cost of producing the new variety of nonglutinous rice were lower

Table 6-9. Activities Included in the Optimal Solution and Their Stability Limits with Respect to Prices or Variable Costs for Plan Alternative A

Zone	Activity	Unit	Level	Unit	Stability Limits				
					Initial cost[a] or price	Lower[a] limit	Entering variable	Upper[a] limit	Entering variable
01	PNRN	rai	25.49	฿/rai	-192.83	-204.62	PGRO	+inf	NONE
	PKNF	rai	4.51	฿/rai	-128.47	-180.26	PCON	+inf	NONE
	SNGR	kg.	6,768.97	฿/kg.	1.31	1.26	PGRO	5.40	PNRO
	SNKF	kg.	822.04	฿/kg.	2.22	1.93	PCON	+inf	NONE
	FEED	kg.	207.21	฿/kg.	-2.00	-2.31	PCON	-1.47	PNRO
	PFF	sow	0.03	฿/sow	-176.61	-658.89	PPF	3,562.72	PNRO
	SSLH	kg.	44.05	฿/kg.	13.06	11.56	PCON	14.93	PPF
	SPIG	head	0.0	฿/hd.	240.00	209.87	PPF	311.79	PFP
	BORO	baht	2,402.54	฿/baht	-0.21	-0.32	BORO[b]	+inf	NONE
02	PNRO	rai	27.00	฿/rai	-111.24	-140.11	PGRO	+inf	NONE
	PPNT	rai	3.00	฿/rai	-302.29	-460.58	PKNF	+inf	NONE
	SNGR	kg.	4,884.12	฿/kg.	1.47	1.31	PGRO	4.63	PNRN
	SPNT	kg.	903.54	฿/kg.	3.00	2.47	PKNF	+inf	NONE
	FEED	kg.	1,546.09	฿/kg.	-2.00	-2.48	BORO[b]	-0.29	PKNF
	PFF	sow	0.21	฿/sow	-176.61	-658.89	PPF	11,885.57	PKNF
	SSLH	kg.	309.54	฿/kg.	13.06	10.82	BORO[b]	21.08	PPF
	SPIG	head	0.0	฿/hd.	240.00	209.87	PPF	311.79	PFP
	BORO	baht	3,476.00	฿/baht	-0.12	-0.33	BORO[b]	+inf	NONE
03	PNGO	rai	24.00	฿/rai	-100.28	-149.36	PGRO	+inf	NONE
	PCAS	rai	6.00	฿/rai	-271.04	-284.35	PPNT	+inf	NONE
	SNGR	kg.	4,827.60	฿/kg.	1.27	1.02	PGRO	+inf	NONE
	SCAS	kg.	12,667.26	฿/kg.	0.33	0.32	PPNT	+inf	NONE
	FEED	kg.	1,498.02	฿/kg.	-2.00	-2.48	BORO[b]	1.82	PPNT
	PFF	sow	0.21	฿/sow	-176.61	-658.89	PPF	1,103.35	PPNT

Table 6-9 (Continued)

Zone No.	Activity	Unit	Level	Unit	Stability Limits: Initial cost[a] or price	Lower[a] limit	Entering variable	Upper[a] limit	Entering variable
	SSLH	kg.	318.45	฿/kg.	13.06	10.82	BORO[b]	13.91	PPNT
	SPIG	head	0.0	฿/hd.	240.00	209.87	PPF	311.79	PFP
	BORO	baht	3,705.00	฿/baht	-0.12	-0.33	BORO[b]	+inf	NONE
04	PNRO	rai	26.60	฿/rai	-86.36	-109.07	PNRN	+inf	NONE
	PCAS	rai	3.40	฿/rai	-206.65	-451.70	UPL[b]	+inf	NONE
	SNGR	kg.	4,602.86	฿/kg.	1.26	1.00	PGRN	4.22	PNRN
	SCAS	kg.	4,661.56	฿/kg	0.40	0.26	UPL[b]	+inf	NONE
	FEED	kg.	1,532.61	฿/kg.	-2.00	-2.47	BORO[b]	-0.52	UPL[b]
	PFF	sow	0.22	฿/sow	-176.61	-658.89	PPF	10,322.37	UPL[b]
	SSLH	kg.	325.81	฿/kg.	13.06	10.82	BORO[b]	14.93	PPF
	SPIG	head	0.0	฿/hd.	240.00	209.87	PPF	311.79	PFP
	BORO	baht	2,826.00	฿/baht	-0.12	-0.33	BORO[b]	+inf	NONE
05	PGRO	rai	9.07	฿/rai	-69.44	-72.75	PNRN	-0.34	PCAS
	PPNT	rai	11.40	฿/rai	-259.65	-327.04	PCAS	+inf	NONE
	SGR	kg.	1,698.74	฿/kg.	1.26	1.24	PNRN	1.63	PCAS
	SPNT	kg.	3,988.18	฿/kg.	3.00	2.81	PCAS	+inf	NONE
	FEED	kg.	2,581.24	฿/kg.	-2.00	-2.11	PNRN	0.15	PCAS
	PFF	sow	0.36	฿/sow	-176.61	-605.23	PPF	15,020.63	PCAS
	SSLH	kg.	548.73	฿/kg.	13.06	12.54	PNRN	23.17	PPF
	SPIG	head	0.0	฿/hd.	240.00	213.18	PPF	313.85	PFP
	BORO	baht	6,167.00	฿/baht	-0.12	-0.31	BORO[b]	+inf	NONE

Table 6-9 (Continued)

[a]Initial cost or price means the cost or price in 1975. Entries with negative signs indicate variable cost per unit of activity or purchasing price and entries with no signs indicate selling price.

[b]Leaving variable.

Source: Computed.

than 193 baht per rai, or even as low as 0, nothing would be changed. The same interpretation can be applied to the other crops.

For the feed buying activity (FEED), the optimal amount of feed used is 207 kilograms with the initial price equal to 2.00 baht per kilogram. The stability limits for the feed buying activity ranges between 2.31 and 1.47 baht per kilogram. If the feed price were higher than 2.31 per kilogram, "produced corn activity" (PCON) would enter the solution. If the price of feed were lower than 1.47 baht per kilogram, "produce nonglutinous native variety rice" (PNRO) would enter the solution.

For the "sell market hog" activity, the optimum amount of hogs to produce to sell is 44 kilograms and the initial selling price equals to 13.06 baht per kilogram. The stability limits for the "sell market hog" range between 11.56 and 14.93 baht per kilogram. If the hog price were lower than 11.56 baht per kilogram, "produce corn" activity would substitute for hogs. If the hog price were higher than 14.94 baht per kilogram, "produce finishing" activity would enter the solution. The same interpretation can be applied to the other zones.

H. EFFECTS OF INCREASING LAND AND CAPITAL ON THE OPTIMUM ORGANIZATION

In addition to capital, land is also an important limiting factor inhibiting production on farms in Northeast Thailand. This is indicated by the high value the MVP is for land. In this section, the effect of increasing both land and capital resources on the optimum farm organization are examined.

The results of the analysis are reported in Tables 6-10 through 6-14. Plan Alternative I allowed farmers to increase their agricultural land base by 50 percent and given only a short-term credit made available to farmers.[4] Plan Alternative II assumed that farmers could increase their land by 50 percent and at the same time can obtain credit up to 30,000 baht. All other resources and coefficients remain the same. The results are discussed zone by zone as follows:

Zone 01

After allowing the agricultural land base to increase by 50 percent, the total available upland area in Zone 01 increased from 4.5 to 6.3 rai. At the same time available paddy land increased from 25.5 to 38.7 rai. Only 34.6 rai of paddy land was used to produce glutinous paddy under Plan I and 37.1 rai of paddy land was used to produce non-glutinous paddy under Plan II. All 6.3 rai of upland area was used to produce kenaf in both Plan I and II. The net return over variable costs for Plan I was 5,826 baht and for Plan II, 12,146 baht. When agricultural land was increased by 50 percent and 30,000 baht of credit made available, man hours of labor in May-August became the limiting factor in increasing production under Plan II. No swine was produced under Plan I while 2,344 kilograms of market hogs were produced under Plan II (Table 6-10).

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[4]Short-term credit for each zone is equal to 60 percent of the total value of the agricultural products produced in 1974-75 season. In this case, short-term credit for Zone 01 is 2,403 baht; Zone 02, 3476 baht; Zone 03, 3,705 baht; Zone 04, 2826 baht; and Zone 05, 6,167 baht.

Table 6-10. Optimum Organization of Plan Alternative I and II for Zone 01

Item	Unit	Plan Alternative I	Plan Alternative II
Net Return over Variable Cost	baht	5,825.98	12,145.88
Resources Used			
Paddy Land	rai	34.56	37.10
MVP of Paddy Land	baht	-	-
Upland Area	rai	6.31	6.31
MVP of Upland	baht	166.12	164.29
Operating Capital	baht	3,800.00	3,800.00
MVP of Capital	baht	.86	.35
Total Labor	hour	4,248.59	5,570.69
Labor 1	hour	251.20	549.75
Labor 2	hour	2,446.35	3,060.00
MVP of Labor 2	baht	-	1.32
Labor 3	hour	1,549.14	1,959.04
Credit	baht	2,402.54	30,000.00
MVP of Credit	baht	.63	.19
Crop Production			
Nonglutinous Paddy	rai	-	-
Glutinous Paddy	rai	34.56	37.11
Corn	rai	-	-
Cassava	rai	-	-
Kenaf	rai	6.31	6.31
Swine Production			
Market Hogs	kg.	-	2,334.14
Feeder Pigs	head	-	-
Feed Used	kg.	-	10,979.85

Table 6-11. Optimum Organization of Plan Alternative I and II for Zone 02

Item	Unit	Plan Alternative I	Plan Alternative II
Net Return over Variable Cost	baht	8,841.98	14,319.99
Resources Used			
Paddy Land	rai	40.50	40.50
MVP of Paddy Land	baht	111.44	111.44
Upland Area	rai	4.50	4.50
MVP of Upland	baht	489.08	489.08
Operating Capital	baht	3,800.00	3,800.00
MVP of Operating Capital	baht	.37	.37
Total Labor	hour	3,651.31	4,591.57
Labor 1	hour	13.34	236.75
Labor 2	hour	2,173.74	2,487.16
Labor 3	hour	1,464.23	1,777.64
Credit	baht	3,476.00	30,000.00
MVP of Credit	baht	.21	.21
Crop Production			
Nonglutinous Paddy	rai	40.50	40.50
Glutinous Paddy	rai	-	-
Corn	rai	-	-
Peanuts	rai	4.50	4.50
Cassava	rai	-	-
Kenaf	rai	-	-
Swine Production			
Market Hogs	kg.	104.28	2,554.67
Feeder Pigs	head	-	-
Feed Used	kg.	490.55	12,017.21

Table 6-12. Optimum Organization of Plan Alternative A and B for Zone 03

Item	Unit	Plan Alternative I	Plan Alternative II
Net Return over Variable Cost	baht	9,351.30	14.697.17
Resources Used			
Paddy Land	rai	36.00	35.28
MVP of Paddy Land	baht	117.97	0
Upland Area	rai	9.00	9.00
MVP of Upland Area	baht	325.46	261.87
Operating Capital	baht	3,800.00	3,800.00
MVP of Operating Capital	baht	.37	.37
Total Labor	hour	5,739.35	6,592.93
Labor 1	hour	1,201.70	1,513.37
Labor 2	hour	2,796.86	3,060.00
MVP of Labor 2	baht	0	1.78
Labor 3	hour	1,794.80	2,073.54
Credit	baht	3,705.00	30,000.00
MVP Credit	baht	.21	.18
Crop Production			
Nonglutinous Paddy	rai	36.00	35.28
Glutinous Paddy	rai	-	-
Peanuts	rai	-	-
Cassava	rai	9.00	9.00
Kenaf	rai	-	-
Swine Production			
Market Hogs	kg.	107.08	2,543.87
Feeder Pig	head	-	-
Feed Used	kg.	503.69	11,966.45

Table 6-13. Optimum Organization of Plan Alternative I and II for Zone 04

Item	Unit	Plan Alternative I	Plan Alternative II
Net Return over Variable Cost	baht	6,938.55	12,378.11
Resources Used			
Paddy Land	rai	39.95	38.22
MVP of Paddy Land	baht	99.62	0
Upland Area	rai	5.05	5.05
MVP of Upland Area	baht	191.05	183.72
Operating Capital	baht	3,800.00	3,800.00
MVP of Operating Capital	baht	.37	.35
Total Labor	hour	6,002.64	6,726.33
Labor 1	hour	1,671.87	1,933.13
Labor 2	hour	2,858.15	3,060.00
MVP of Labor 2	baht	0	1.44
Labor 3	hour	1,372.62	1,733.20
Credit	baht	2,826.00	30,000.00
MVP of Credit	baht	.20	.19
Crop Production			
Nonglutinous Paddy	rai	39.95	38.22
Glutinous Paddy	rai	-	-
Corn	rai	-	-
Cassava	rai	5.05	5.05
Swine Production			
Market Hogs	kg.	159.62	2,685.77
Feeder Pigs	head	-	-
Feed Used	kg.	750.88	12.633.94

Table 6-14. Optimum Organization of Plan Alternative A and B for Zone 05

Item	Unit	Plan Alternative I	Plan Alternative II
Net Return over Variable Costs	baht	14,100.05	18,433.36
Resources Used			
Paddy Land	rai	0	0
MVP of Paddy Land	baht	0	0
Upland Area	rai	17.10	17.10
MVP of Upland Area	baht	308.55	308.55
Operating Capital	baht	3,800.00	3,800.00
MVP of Operating Capital	baht	.34	.34
Total Labor	hour	6,661.83	7,088.55
Labor 1	hour	518.89	1,200.96
Labor 2	hour	3,060.00	3,060.00
MVP of Labor 2	baht	2.09	2.09
Labor 3	hour	2,280.31	2,168.77
Credit Use	baht	6,167.00	30,000.00
MVP of Credit	baht	.18	.18
Crop Production			
Nonglutinous Paddy	rai	-	-
Glutinous Paddy	rai	-	-
Corn	rai	-	-
Peanuts	rai	16.05	13.18
Cassava	rai	1.05	3.92
Kenaf	rai	-	-
Swine Production			
Market Hogs	kg.	452.35	2,693.75
Feeder Pigs	head	-	-
Feed used	kg.	2,127.85	12,671.47

Zone 02

The total agricultural land for Zone 02 was assumed to be increased by 50 percent, from 30 rai to 45 rai, with 40.5 rai being paddy land and 4.5 rai being upland area. All 40.5 rai of paddy land was used to produce nonglutinous paddy in both Plan I and Plan II. Both Plan I and II used all 4.5 rai of upland area to produce peanuts. The net return over variable costs for Plan I was 8,842 baht and for Plan II, 14,320 baht. The total hog production was 104 kilograms for Plan I and 2,555 kilograms for Plan II (Table 6-11).

Zone 03

After allowing agricultural land to increase 50 percent, the maximum land area for the representative farm in Zone 03 increased form 30.0 rai to 45.0 rai consisting of 36.0 rai of paddy land and 9.0 rai of upland area. All 36.0 rai of paddy land and 9.0 rai of upland area were used to produce nonglutinous paddy and cassava, respectively, under Plan I. All 9.0 rai of upland area was used to produce cassava. When total land was increased by 50 percent and 30,000 baht of credit made available, man hours of labor in May-August became the limiting factor to increasing production under Plan II. The nonglutinous paddy production decreased from 36.0 rai in Plan I to 35.3 rai in Plan II. The net return over variable costs for Plan I was 9,351 baht and for Plan II 14,697 baht. Market hog production at the optimum solution for Plan I was 107 kilograms and for Plan II 2,544 kilograms (Table 6-12).

Zone 04

After allowing agricultural land to increase 50 percent, the total available upland area for the representative farm in Zone 04 increased from 3.4 to 5.0 rai and the available paddy land increased from 26.6 to 40.0 rai. All 40 rai of paddy land and 5 rai of upland area were used to produce nonglutinous paddy and cassava, respectively, under Plan I. Under Plan II, 38.2 rai of paddy land was used to produce nonglutinous paddy and all 5.0 rai of upland area was used to produce cassava. The net return over variable costs for Plan I was 6,939 baht and for Plan II was 12,378 baht. Market hog production for Plan I was 160 kilograms and for Plan II 2,686 kilograms. When total available land was increased by 50 percent and 30,000 baht of credit made available, man hours of labor in May-August became the limiting factor to increasing production under Plan II (Table 6-13).

Zone 05

After allowing agricultural land to increase 50 percent, the total available upland area of the representative farm in Zone 05 increased from 11.4 to 17.1 rai and the available paddy land increased from 18.6 to 27.9 rai. As a result of increasing land 50 percent, and with 6,167 baht of short-term credit made available, man hours labor in May-August became the limiting factor to increasing production under Plan I and the paddy enterprise became unprofitable compared to upland crop and swine enterprises. At the optimum solution for Plan I, 16.0 rai of peanuts, 1.0 rai of cassava and 452 kilograms of market hogs were produced. The total

net return over variable costs for Plan I was about 14,100 baht. In Plan II, man hours labor in May-August was also the limiting factor in increasing production. At the optimum solution for Plan II, 13.2 rai of peanuts, 4.9 rai of cassava and 2,694 kilograms of market hogs were produced yielding 18,433 baht of net return over variable costs (Table 6-14).

I. EFFECTS OF VARYING FEED PRICES ON THE OPTIMUM PLAN

Feed is the most important factor in swine production. Any change in feed prices affect the swine industry. In this section, the effect of varying feed prices, from 1.00 to 3.00 baht per kilogram, are examined. It is assumed that only short-term credit is available to farmers.

Zone 01

Table 6-15 shows the optimum farm organization when feed prices vary from 1.00 to 3.00 baht per kilogram and when 2,403 baht of short-term credit is being provided. All other resources and input-output coefficients remain the same. When the feed price varied between 1.00 to 1.25 baht per kilogram, no paddy land was used because swine production became more profitable than paddy (rice) production. Paddy (glutinous) production, however, entered the optimum solution when feed price was 1.50 baht per kilogram. At this point, swine production dropped from 889 to 219 kilograms. The net return dropped from 7,293 baht when feed price was 1.25 baht per kilogram to 5,470 baht when feed price was 1.50 baht per kilogram. When feed price was 1.75 baht per kilogram, nonglutinous paddy became more profitable to produce than glutinous paddy. Swine

Table 6-15. Optimum Farm Organization for Zone 01 with 2,402.54 Baht of Credit and Varying Feed Price from ฿ 1.00-3.00 per Kilogram

Item	Unit	Feed Price per Kilogram (Baht)								
		1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
Net return over variable costs	baht	10,072.83	7,239.42	5,470.43	5,145.92	5,064.90	5,001.68	4,998.90	4.998.90	4,998.90
Resources used										
Paddy land	rai	-	-	25.49	25.49	25.49	25.49	25.49	25.49	25.49
Upland land	rai	4.51	4.51	4.51	4.51	4.51	4.51	4.51	4.51	4.51
Operating Capital	baht	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00
Total labor	hour	1,181.13	1,097.88	3,193.00	3,260.00	3,257.71	3,257.71	3,224.18	3,224.18	3,224.18
Labor 1	hour	321.07	293.32	207.54	185.97	185.18	184.56	169.74	169.74	169.74
Labor 2	hour	368.73	340.99	1,825.14	1,912.16	1,911.36	1,910.74	1,940.10	1,940.10	1,940.10
Labor 3	hour	489.96	463.22	1,159.50	1,160.61	1,159.82	1,159.20	1.113.36	1,113.36	1,113.36
Credit	baht	2,402.54	2,402.54	2,402.54	2,402.54	2,402.54	2,402.54	2,402.54	2,402.54	2,402.54
Crop Production										
Nonglutinous rice	rai	-	-	-	25.49	25.49	25.49	25.49	25.49	25.49
Glutinous rice	rai	-	-	25.49	-	-	-	-	-	-
Corn	rai	-	-	-	-	-	-	1.27	1.27	1.27
Peanut	rai	-	-	-	-	-	-	-	-	-
Cessava	rai	-	-	-	-	-	-	-	-	-
Kenaf	rai	4.51	4.51	4.51	4.51	4.51	4.51	3.23	3.23	3.23
Swine Production										
Market hogs	kg.	1,106.47	889.51	218.93	50.25	44.05	39.21	-	-	-
Feeder pigs	head	-	-	-	-	-	-	-	-	-
Feed Used	kg.	5,204.88	4,184.29	1,029.84	236.40	207.21	184.44	-	-	-

production left the optimum solution when feed price reached 2.50 baht per kilogram.

Zone 02

Table 6-16 shows the optimum farm organization for the representative farm in Zone 02 when feed price varied from 1.00 to 3.00 baht per kilogram. When feed price was at 1.00 baht per kilogram, 1,351 kilograms of hogs and 3.0 rai of kenaf were produced in the optimum solution. At 1.25 baht feed price per kilogram, 27.0 rai of nonglutinous rice enter the optimum solution and peanuts substituted for kenaf. Swine production dropped from 1,351 to 492 kilograms. Swine production dropped from the solution when feed price was 2.50 baht per kilogram. At this point, only 125 baht of credit was used.

Zone 03

Table 6-17 shows the optimum solution of the representative farm in Zone 03 when feed prices varied from 1.00 to 3.00 baht. Six rai of kenaf production and 1,359 kilograms of market hogs were in the optimum solution when the feed price was at 1.00 baht per kilogram. Peanuts were substituted for kenaf and 24 rai of nonglutinous rice entered the optimum solution at 1.25 baht per kilogram of feed. Swine production decreased from 1,359 to 655 kilograms. When the feed price was 2.00 baht per kilogram and higher, cassava production substituted for peanuts and swine production declined steadily. Swine production became unprofitable when the feed price reached 2.50 baht per kilogram. Only 258 baht of credit was used when the feed price was 2.50 baht or higher.

Table 6-16. Optimum Farm Organization for Zone 02 with 3,476.00 Baht of Credit and Varying Feed Price from ฿ 1.00-3.00 per Kilogram

Item	Unit	Feed price per Kilogram (Baht) 1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
Net return over variable costs	baht	11,836.35	8,982.02	7,929.43	7,173.35	6,603.96	6,159.71	5,911.96	5,911.96	5,911.96
Resources used										
Paddy land	rai	-	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00
Upland land	rai	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Operating capital	baht	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00
Total labor	hour	880.19	2,596.17	2,565.25	2,543.24	2,526.31	2,513.25	2,407.53	2,407.53	2,407.53
Labor 1	hour	267.62	62.88	52.57	45.17	39.59	35.24	-	-	-
Labor 2	hour	259.79	1,503.15	1,492.84	1,485.44	1,479.86	1,475.51	1,440.27	1,440.27	1,440.27
Labor 3	hour	352.76	1,030.14	1,019.83	1,012.43	1,006.85	1,002.50	967.26	967.26	967.26
Credit	baht	3,476.00	3,476.00	3,476.00	3,476.00	3,476.00	3,476.00	125.40	125.40	125.04
Crop Production										
Nonglutinous rice	rai	-	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00
Glutinous rice	rai	-	-	-	-	-	-	-	-	-
Corn	rai	-	-	-	-	-	-	-	-	-
Peanut	rai	-	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Cassava	rai	-	-	-	-	-	-	-	-	-
Kenaf	rai	3.00	-	-	-	-	-	-	-	-
Swine Production										
Market hogs	kg.	1,351.43	491.63	411.03	353.14	309.54	275.52	-	-	-
Feeder pigs	head	-	-	-	-	-	-	-	-	-
Feed Used	Kg.	6,357.19	2,312.63	1,933.50	1,661.17	1,456.09	1,296.07	-	-	-

Table 6-17. Optimum Farm Organization for Zone 03 with 3,705.00 Credit and Varying Feed Price from ฿ 1.00-3.00 per Kilogram

Item	Unit	Feed price per Kilogram (Baht)								
		1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
Net return over variable costs	baht	12,587.12	10,046.73	8,644.80	7,637.78	6,959.27	6,502.22	6,247.34	6,247.34	6,247.34
Resources Used										
Paddy land	rai	-	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
Upland land	rai	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Operating capital	baht	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00
Total labor	hour	1,731.12	4,096.84	4,055.65	4,026.06	3,921.04	3,907.61	3,798,84	3,798.84	3,798.84
Labor 1	hour	491.90	83.75	70.62	60.16	832.73	828.26	792.00	792.00	792.00
Labor 2	hour	465.62	2,077.13	2,063.40	2,053.54	1,896.17	1,891.70	1,855.44	1,855.44	1,855.44
Labor 3	hour	773.60	1,935.95	1,922.22	1,912.36	1,228.13	1,223.66	1,187.40	1,187.40	1,187.40
Credit	baht	3,705.00	3,705.00	3,705.00	3,705.00	3,705.00	3,705.00	257.91	257.91	257.91
Crop Production										
Nonglutinous rice	rai	-	24.00	24.00	24.00	24.00	24.00	24.00	24.00	24.00
Glutinous rice	rai	-	-	-	-	-	-	-	-	-
Corn	rai	-	-	-	-	-	-	-	-	-
Peanut	rai	-	6.00	6.00	6.00	-	-	-	-	-
Cassava	rai	-	-	-	-	6.00	6.00	6.00	6.00	6.00
Kenaf	rai	6.00	-	-	-	-	-	-	-	-
Swine Production										
Market Hogs	kg.	1,359.11	654.80	547.45	470.34	318.45	283.46	-	-	-
Feeder pigs	head	-	-	-	-	-	-	-	-	-
Feed Used	kg.	6,393.29	3,080.19	2,575.23	2,212.51	1,498.02	1,333.40	-	-	-

Zone 04

Table 6-18 shows the optimum solution of the representative farm in Zone 04 when feed price varied from 1.00 to 3.00 baht. When feed price was at 1.00 baht per kilogram, 1,304 kilograms of market hogs were produced and the net return over variable cost was 10,403 baht at the optimum solution. As feed price increased to 1.25 baht per kilogram, 2.6 rai of nonglutinous paddy was produced and hog production decreased from 1,304 to 665 kilograms and the net return over variable costs decreased from 1,403 to 7,862 baht. When feed price increased to 1.50 baht per kilogram 26.6 rai of glutinous rice, 3.4 rai of cassava were produced. Hog production decreased from 665 to 443 kilogram and the net return over variable costs declined from 7,862 to 6,688 baht. When feed price increased from 1.50 to 2.75 baht per kilogram, hog production decreased from 438 to 47 kilograms. The net return over variable costs decreased from 6,688 to 4,481 baht while nonglutinous paddy and cassava productions remained unchanged. As feed price increased to 2.50 baht per kilogram or higher, no credit was used. When feed price increased to 3.00 baht per kilogram, hog production dropped from the solution.

Zone 05

The effects of varying feed price on the optimum organization for the average farm in Zone 05 are shown in Table 6-19. When the feed price was as low as 1.00 baht per kilogram, 18.6 rai of glutinous paddy, .8 rai of peanuts, 10.6 rai of cassava, and 1,234 kilograms of market hogs were produced. When feed price increased to 1.25 baht, glutinous paddy production dropped to 8.6 rai and swine production declined to 876

Table 6-18. Optimum Farm Organization for Zone 04 with 2,826 Baht of Credit and Varying Feed Price from ฿ 1.00-3.00 per Kilogram

Item	Unit	Feed Price per Kilogram (Baht)								
		1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
Net return over variable costs	baht	10,403.37	7,861.51	6,688.44	5,892.62	5,293.30	4,825.71	4,542.23	4,481.16	4,480.85
Resources used										
Paddy land	rai	-	26.60	26.60	26.60	26.60	26.60	26.60	26.60	26.60
Upland land	rai	-	-	3.40	3.40	3.40	3.40	3.40	3.40	3.40
Operating capital	baht	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,183.38
Total labor	hour	500.34	4,024.48	4,134.06	4,100.68	4,083.06	4,069.33	3,977.97	3,976.18	3,958.05
Labor 1	hour	166.78	1,034.17	1,166.61	1,148.81	1,142.94	1,138.36	1,107.91	1,107.31	1,101.27
Labor 2	hour	166.78	1,945.76	1,945.11	1,937.32	1,931.44	1,926.87	1,896.41	1,895.82	1,889.77
Labor 3	hour	166.78	1,044.55	1,022.34	1,014.55	1,008.68	1,004.10	973.65	973.05	967.01
Credit	baht	2,826.00	2,826.00	2,826.00	2,826.00	2,826.00	2,826.00	-	-	-
Crop Production										
Nonglutinous rice	rai	-	26.60	26.60	26.06	26.60	26.60	26.60	26.60	26.60
Glutinous rice	rai	-	-	-	-	-	-	-	-	-
Corn	rai	-	-	-	-	-	-	-	-	-
Peanut	rai	-	-	-	-	-	-	-	-	-
Cassava	rai	-	-	3.40	3.40	3.40	3.40	3.40	3.40	3.40
Kenaf	rai	-	-	-	-	-	-	-	-	-
Swine Production										
Market hogs	kg .	1,303.93	665.23	432.63	371.70	325.81	290.00	51.91	47.23	-
Feeder pigs	head	-	-	-	-	-	-	-	-	-
Feed Used	kg.	6,133.13	3,129.26	2,035.12	1,748.48	1,532.61	1,364.19	244.20	222.20	-

Table 6-19. Optimum Farm Organization for Zone 05 with 6,167.00 Baht of Credit and Varying Feed Price from ฿ 1.00-3.00 per Kilogram

Item	Unit	Feed Price per Kilogram (Baht)								
		1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
Net return over variable costs	baht	18,855.09	15,895.30	14,039.23	12.711.55	11,714.75	10,991.94	10,692.09	10,692.09	10,692.09
Resources used										
Paddy land	rai	18.60	8.65	8.84	8.97	9.07	11.15	11.82	11.82	11.82
Upland land	rai	11.40	11.40	11.40	11.40	11.40	11.40	11.40	11.40	11.40
Operating capital	baht	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00	3,800.00
Total labor	hour	6,583.64	6,289.25	6,265.73	6,248.92	6,236.29	6,217.96	6,147.55	6,147.55	6,147.55
Labor 1	hour	1,822.44	323.44	291.53	281.54	267.26	211.36	211.36	211.36	211.36
Labor 2	hour	3,060.00	3,060.00	3,060.00	3,060.00	3,060.00	3,060.00	3,060.00	3,060.00	3,060.00
Labor 3	hour	1,659.77	2,335.80	2,330.00	2,327.38	2,324.74	2,320.90	2,306.19	2,306.19	2,306.19
Credit	baht	6,167.00	6,167.00	6,167.00	6,167.00	6,167.00	6,167.00	6,167.00	6,167.00	6,167.00
Crop Enterprises										
Nonglutinous rice	rai	-	-	-	-	-	11.15	11.82	11.82	11.82
Glutinous rice	rai	18.60	8.65	8.84	8.97	9.07	-	-	-	-
Corn	rai	-	-	-	-	-	-	-	-	-
Peanut	rai	.83	11.40	11.40	11.40	11.40	11.40	11.40	11.40	11.40
Cassava	rai	10.57	-	-	-	-	-	-	-	-
Kenaf	rai	-	-	-	-	-	-	-	-	-
Swine Production										
Market hogs	kg.	1,234.54	876.31	730.87	626.83	548.73	435.50	-	-	-
Feeder hogs	head	-	-	-	-	-	-	-	-	-
Feed Used	kg.	5,807.29	4,122.17	3,438.03	2,948.66	2,581.23	2,048.60	-	-	-

kilograms of market hogs. Glutinous rice production increased from 8.8 to 9.1 rai as feed price increased from 1.25 to 2.00 baht per kilogram. Peanuts substituted for cassava when the feed price was equal to 1.25 baht or higher. When the feed price increased to 2.25 baht, nonglutinous paddy entered the solution and glutinous paddy dropped out. Swine production dropped from the optimum farm organization when the feed price reached 2.50 baht.

J. EFFECTS OF VARYING SWINE PRICES ON THE OPTIMUM PLAN

The purpose of this analysis is to determine the changes in swine production relative to the changes in swine prices. The results are shown in Tables 6-20 through 6-24.

Zone 01

Table 6-20 shows that as swine price increased from 13 (base plan) to 15 baht per kilogram, the optimum organization was not changed. When the swine price increased to 16 baht, swine production increased to 165 kilograms of market hogs and glutinous paddy substituted for non-glutinous paddy in the optimum organization. The optimum organization was not changed as swine price increased from 16 to 17 baht per kilogram. Paddy production dropped from the optimum solution when the swine price was increased to 18 baht and swine production increased to 560 kilograms of market hogs. The solutions were not changed as swine price increased from 18 to 20 baht.

Zone 02

Table 6-21 shows that there was no change in swine production for the representative farm as swine price increased from 13 to 20 baht

Table 6-20. Optimum Organization with Varying Swine Prices from ฿ 13.06-20.06 per Kilogram Zone 01

Item	Unit	Base[a] Plan	Swine Price Per Kilogram (baht) 14.06	15.06	16.06	17.06	18.06	19.06	20.06
Net Return Over Variable Cost	baht	5,064.90	5,108.95	5,153.00	5,259.06	5,423.93	5,737.04	6,297.10	6,857.16
Resources Used									
Paddy land	rai	25.49	UNCHANGED	UNCHANGED	25.49	UNCHANGED	0	UNCHANGED	UNCHANGED
Upland area	rai	4.51			4.51		4.51		
Operating capital	baht	3,800.00			3,800.00		2,800.00		
Total Labor	hour	3,257.71			3,172.80		971.45		
Labor 1	hour	185.18			200.63		251.18		
Labor 2	hour	1,911.36			1,818.23		298.84		
Labor 3	hour	1,159.82			1,152.58		420.07		
Credit	baht	2,402.54			2,402.54		2,402.54		
Crop Production									
Nonglutinous paddy	rai	25.49			-		-		
Glutinous paddy	rai	-			25.49		-		
Corn	rai	-			-		-		
Cassava	rai	-			-		-		
Kenaf	rai	4.51			4.51		4.51		
Swine Production									
Market Hogs	kg.	44.05			164.87		560.06		
Feeder Pigs	head	-			-		-		
Feed Used	kg.	207.21			775.54		2,634.53		

[a] Base Plan is Plan Alternative A in the previous section (Table 6-4, page 57). Unchanged means all solutions are the same as the previous column.

Table 6-21. Optimum Organization with Varying Swine Prices from ฿ 13.06-20.06 per Kilogram Zone 02

Item	Unit	Base[a] Plan	Swine Price Per Kilogram (baht) 14.06	15.06	16.06	17.06	18.06	19.06	20.06
Net Return Over Variable Cost	baht	6,603.96	6,913.50	7,223.04	7,532.58	7,842.12	8,151.66	8,461.20	8,770.74
Resources Used									
Paddy land	rai	27.00	UNCHANGED	UNCHANGED	UNCHANGED	UNCHANGED	UNCHANGED	UNCHANGED	UNCHANGED
Upland land	rai	3.00							
Operating capital	baht	3,800.00							
Total labor	hour	2,526.31							
Labor 1	hour	39.59							
Labor 2	hour	1,479.86							
Labor 3	hour	1,006.85							
Credit	baht	3,476.00							
Crop Production									
Nonglutinous paddy	rai	27.00							
Glutinous paddy	rai	-							
Corn	rai	-							
Peanuts	rai	3.00							
Cassava	rai	-							
Kenaf	rai	-							
Swine Production									
Market Hogs	kg.	309.54							
Feeder Pigs	head	-							
Feed Used	kg.	1,456.09							

[a] Base Plan is Plan Alternative A in the previous section (Table 6-5, page 58). Unchanged means all solutions are the same as the previous previous column.

Table 6-22. Optimum Organization with Varying Swine Prices from ฿ 13.06-20.06 per Kilogram Zone 03

Item	Unit	Base[a] Plan	Swine Price per Kilogram (baht) 14.06	15.06	16.06	17.06	18.06	19.06	20.06
Net Return Over Variable Cost	baht	6,959.27	7,291.68	7,703.95	8,116.23	8,528.51	8,940.78	9,353.06	9.765.34
Resourced Used									
Paddy land	rai	24.00	24.00	UNCHANGED	UNCHANGED	UNCHANGED	UNCHANGED	UNCHANGED	UNCHANGED
Upland land	rai	6.00	6.00						
Operating capital	baht	3,800.00	3,800.00						
Total labor	hour	3,921.54	4,003.78						
Labor 1	hour	832.73	52.73						
Labor 2	hour	1,896.17	2,046.11						
Labor 3	hour	1,228.13	1,904.93						
Credit	baht	3,705.00	3,705.00						
Crop Production									
Nonglutinous paddy	rai	24.00	24.00						
Glutinous paddy	rai	-	-						
Peanuts	rai	-	6.00						
Cassava	rai	6.00	-						
Kenaf	rai	-	-						
Swine Production									
Market Hogs	kg.	318.45	412.28						
Feeder Pigs	head	-	-						
Feed Used	kg.	1,498.02	1,939.36						

[a]Base Plan is Plan Alternative A in the previous section (Table 6-6, page 59). Unchanged means all solutions are the same as the previous column.

Table 6-23. Optimum Organization with Varying Swine Prices from ฿ 13.06-20.06 per Kilogram Zone 04.

Item	Unit	Base[a] Plan	Swine Price per Kilogram (baht)						
			14.06	15.06	16.06	17.06	18.06	19.06	20.06
Net Return Over Variable Cost	baht	5,293.30	5,619.11	5,914.92	6,270.73	6,596.54	6,922.35	7,248.16	7,575.63
Resources Used									
Paddy land	rai	26.60	UNCHANGED	UNCHANGED	UNCHANGED	UNCHANGED	UNCHANGED	UNCHANGED	26.60
Upland area	rai	3.40							-
Operating capital	baht	3,800.00							3,800.00
Total labor	hour	3,551.08							3,397.96
Labor 1	hour	1,142.94							1,002.66
Labor 2	hour	1,931.44							1,914.24
Labor 3	hour	1,008.68							1,013.03
Credit	baht	2,826.00							2,826.00
Crop Production									
Nonglutinous paddy	rai	26.60							26.60
Glutinous paddy	rai	-							-
Corn	rai	-							-
Cassava	rai	3.40							-
Swine Production									
Market Hogs	kg.	325.81							418.84
Feeder Pigs	head	-							-
Feed Used	kg.	1,522.61							1,970.25

[a] Base Plan is Plan Alternative A in the previous section (Table 6-7, page 60). Unchanged means all solutions are the same as the previous section.

Table 6-24. Optimum Organization with Varying Swine Prices from ฿ 13.06-20.06 per Kilogram Zone 05

Item	Unit	Base[a] Plan	Swine Price per Kilogram (baht) 14.06	15.06	16.06	17.06	18.06	19.06	20.06
Net Return Over Variable Cost	baht	11,714.75	12,263.48	12,812.21	13,360.94	13,909.67	14,458.40	15,007.13	15,555.86
Resources Used									
Paddy land	rai	9.07	UNCHANGED	UNCHANGED	UNCHANGED	UNCHANGED	UNCHANGED	UNCHANGED	UNCHANGED
Upland area	rai	11.40							
Operating capital	baht	3,800.00							
Total labor	hour	6,236.29							
Labor 1	hour	267.26							
Labor 2	hour	3,060.00							
Labor 3	hour	2,324.74							
Credit	baht	6,167.00							
Crop Production									
Nonglutinous paddy	rai	-							
Glutinous paddy	rai	9.07							
Corn	rai	-							
Peanuts	rai	11.40							
Cassava	rai	-							
Kenaf	rai	-							
Swine Production									
Market Hogs	kg.	548.73							
Feeder Pigs	head	-							
Feed Used	kg.	2,581.23							

[a]Base Plan is Alternative A in the previous section (Table 6-8, page 61). Unchanged means all solutions are the same as the previous column.

per kilogram. The results are consistent with the stability analysis shown in Table 6-9, page 65 which indicated that the stability limits for swine price were between 11 and 21 baht per kilogram.

Zone 03

Table 6-22 shows the effects of varying swine price on the optimum organization for the representative farm in Zone 03. As swine price increased to 14 baht per kilogram, hog production increased from 318 to 412 kilograms and in the production system peanuts were substituted for kenaf. Increasing swine prices from 14 to 20 did not change the optimum farm solution.

Zone 04

Table 6-23 shows the results of increasing the swine price in the optimum farm organization in Zone 04. The optimum solution changed as the swine price increased to 20 baht. At this price, swine production increased from 326 to 419 kilograms and cassava dropped from the solution.

Zone 05

Table 6-24 shows the changes in swine price from 13 to 20 baht did not change the optimum farm organization plan in Zone 05. In Table 6-9, page 65, it was indicated that the optimum organization would not be changed unless the price was increased to 23 baht or more kilogram.

CHAPTER VII

SUMMARY

The objectives of this study were: (1) to assess the capability of small family farms to increase swine production through increased efficiency in resource use; (2) to determine the effect of variation in selected management and efficiency factors in swine production on income potentials for a representative farm situation; and (3) to interpret the findings as they relate to agricultural policy for the Northeast Thailand livestock industry. The findings should be of value to the Thai government because they provided needed information upon which to base decisions concerning policies for agricultural development in Northeast Thailand.

A. PROBLEM AND DATA SUMMARY

The Northeast region of Thailand is the least developed region within the Kingdom. About 79 percent of the households in the Northeast are engaged in agriculture, and farm incomes in this region are lower than in other regions. Poverty in the Northeast has resulted in a slow down in economic development and has contributed to the political instability of the country. Improving farm incomes in the region by improving crop production is a difficult task because of inherent climatic conditions and low soil fertility.

Livestock is an important enterprise for northeast farmers and improvements in the productive processes can improve farm incomes. The study of potential livestock (swine) production on small farms in Northeast

Thailand will provide additional knowledge and information for the Thai government, the northeast region farmers, and to other interested persons who are concerned about the economic development of Northeast Thailand.

The General Farm Survey Data which were collected by the Division of Agricultural Economics (DAE), Ministry of Agriculture and Cooperatives (MOAC), Government of Thailand, were used for the study. Fifteen provinces in the northeast region were grouped into five agro-economic zones. The data were synthesized by the five zones to form a representative farm situation for each zone.

Linear programming techniques were used to examine the organization of farm resources that would maximize farm income under limited resource situations, varying capital arrangements, different land resource mixes, and varying feed and swine prices. The objective function to be maximized was the net farm return over variable costs.

The model was constructed to include crop production and selling activities, feed buying activity, feeder pig buying activity, swine production and selling activities, and a capital borrowing activity.

B. SUMMARY OF RESULTS

A summary of the results are:

(1) With existing farm resources, the optimum organization of four out of five representative farms produced zero livestock.

(2) Capital and land were the most limiting factors.

(3) With existing farm resources and short-term credit, farmers in every zone could increase their net income by producing swine.

(4) By providing 30,000 baht of credit to farmers, the net returns to the representative farms in Zones 01, 02, 03, and 04 would increase by more than 100 percent, resulting from substantial increases in swine production.

(5) Increasing both capital and land resulted in increases to net returns. Increasing both the capital and land resources yielded higher net returns than increasing capital alone.

(6) An increase of 30,000 baht of credit and 50 percent more land resulted in the May-August labor requirements becoming the limiting production factor.

(7) Swine production was very sensitive to variation in feed prices. As feed prices increased to 2.50 baht per kilogram, swine production in 01, 02, 03, and 05 Agro-economic Zones dropped from the optimum solution.

(8) Swine production was not sensitive to variation in swine prices.

(9) Capital was the most limiting factor affecting the swine enterprise. Increasing capital resulted in increased swine production and greater net farm incomes.

The results of this study show that there is considerable potential to improve farm incomes in Northeast Thailand by increasing swine production. Increased use of capital shifted the swine supply curve to the right indicating the importance of credit to small farmers. Feed is the most important factor that affects swine production. Small changes in the feed price causes considerable change in swine production. Under

present technology and price conditions, swine becomes an unprofitable enterprise if the feed price increases to 2.50 baht per kilogram.

Peanuts and cassava are the upland crops produced in Zones 02, 03, 04, and 05. Kenaf is the only upland crop grown in Zone 01. Paddy is grown in all zones in the Northeast.

Under the assumed input-output coefficients, input costs, and available resources, swine production responded very little to increases in the price of swine.

High marginal value products of capital and land indicate the limitation of these resources. This also suggests that farmers could improve their incomes by borrowing money and/or renting land, if available.

C. POLICY IMPLICATIONS

An important conclusion is that farm income and swine production could be increased by increasing the capital and land resource base. At low levels of capital use but with more land, farmers would substitute cropping enterprises for the swine enterprise, but when more capital becomes available, swine production would increase to the point where labor becomes the restricted resource (e.g., May-August man hours labor). Therefore, policy makers should be aware of the potential values of capital and land resources. Livestock enterprises are usually identified to be more labor intensive than crop enterprises. This has implications for employment policy. Increasing swine production implies that more labor is needed all year round and thus it would help alleviate the problem of seasonal unemployment. Better nutrition would be available to the Thai people if swine production were increased. Increasing the supply of

swine would also create a demand for better processing plants, would create job opportunities, and would help distribute the effect of income changes over other sectors of the economy.

Swine production responded sensitively to variations in feed price but did not respond nearly as sensitively to increases in the price of swine. This implies that if policy makers want to increase swine production, swine price support is not the desirable procedure. Subsidies, on the other hand, to reduce the cost of feed would lead to increase in swine production.

D. SOME LIMITATIONS OF THE STUDY

This study was designed to assess the potential of swine production as a means to increase farm income on small family farms in Northeast Thailand by reallocating existing resources and by acquiring new ones. The results are not intended to be predictions of what would occur under actual conditions but rather to provide an estimate of what might happen under a series of assumed conditions relating to price and resource availability.

The lack of information on feed that farmers use for swine production may lead to a bias in the estimation of feed conversion and feed price ratios.

BIBLIOGRAPHY

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BIBLIOGRAPHY

1. Anaikas, L., "Potential Livestock Production Adjustment on Family Farms in Central Macedonia, Greece." Michigan State University, Unpublished Ph.D. dissertation 1975.

2. Baumol, William J., *Economic Theory and Operations Analysis*, Prentice-Hall Inc., Englewood Cliffs, N. J., 1965.

3. Beneke, Raymond R. and Ronald Winterboer, *Linear Programming Applications to Farm Planning*, Ames, Iowa: Iowa State University Press, 1970.

4. Brannon, Russell H., Chumnarn Sirirugsa, and Benjamin T. Dean. "Testing of Research Station Results at the Farm Level: Lessons From a Swine Feeding Trail in Northeast Thailand." Northeast Regional Office of Agriculture, Tha Phra, Khan Kaen, Thailand, 1974. (Mimeograph).

5. Cashdollar, Parker Ditmore, "An Economic Analysis of Crops and Land Use Localizations in the Tungabhadra Irrigation Project of Mysore State, India," The University of Tennessee, Unpublished Ph.D. dissertation, 1971.

6. Colyer, Dale and George D. Irwin, *Beef, Pork, and Feed Grains in Cornbelt: Supply Response and Resource Adjustments*, University of Missouri Agricultural Experiment Station Research Bulletin 921, 1967.

7. Cooper, Leon and David Steinberg, *Method and Applications of Linear Programming*, W. B. Saunders Company, Philadelphia, 1974.

8. Cowan, William Butler, Jr. "Variations in Land-Labor and Optimum Enterprise Organizations of Farms in the Brown Soil Area of West Tennessee." Unpublished M.S. thesis, The University of Tennessee, 1964.

9. DAE, "Report on the Survey of Incomes and Expenditures of Farmers in Thailand 1970." *Agricultural Economic Bulletin No. 66, 1973*, Division of Agricultural Economics, MOAC, Bangkok, Thailand, 1973.

10. DAE, *Agricultural Statistics of Thailand*, Crop Year 1972-73. Division of Agricultural Economics, MOAC Bangkok, Thailand, 1974.

11. DAE, Input-Output Section, "Case Study on Swine," Division of Agricultural Economics, MOAC, Bangkok, Thailand, 1975 (Mineograph).

12. DAE, *Agricultural Statistic Bulletin No. 18, March 1976*. Division of Agricultural Economics, MOAC, Bangkok, Thailand, 1976.

13. DAE, *Farm Management Hand Book 1975*, Division of Agricultural Economics, MOAC, Bangkok, Thailand, 1976.

14. DAE, *Thailand's Fourth Five Year Agricultural Development Plan, BE 2524-Guidelines,* Division of Agricultural Economics, MOAC, Bangkok, Thailand, 1976.

15. DAE, *Selected Economic Indicators Relating to Agriculture,* Division of Agricultural Economics, MOAC, Bangkok, Thailand, February 1977.

16. Heady, Earl O. and Winfield Candler, *Linear Programming Methods,* The Iowa State College Press, Ames, Iowa, 1969.

17. IBM, "Introduction to Mathematical Programming System--Extended (MPSX), Mixed Interger Programming (MIP) and Generalized Upper Bounding (GOB)" GH20-0849-3

18. IBM, "Mathematical Programming System--Extended (MPSX) and Generalized Upper Bounding (GUB), Program Description" SH20-9068-1.

19. Kasetsart University, "The Report of the Sixth National Conference on Agricultural Science At Kasetsart University, February 1967," Kasetsart University, Bangkok, Thailand, 1967.

20. Libbin, James D., Charles A. Moorhead and Neil R. Martin, Jr., "A User's Guide to the MPSX Linear Programming Package Part I--Small Models. AE 4316," Department of Agricultural Economics, College of Agriculture, University of Illinois, 1973.

21. Manowalailao, Koset, Supote Tajatech and Somnuk Striplung, "Livestock and Economic Problem," *Agricultural Economics Bulletin No. 46, 1971,* Division of Agricultural Economics, MOAC, Bangkok, Thailand, 1971.

22. Nisar, A. K. and J. G. Elterich, "Optimum Organizations of Medium-Sized Dairy Farms on the Delmarva Peninsula." University of Deleware, Bulletin 390, Newark (March 1972).

23. _____, "Changing Input-Output Relationships and Optimum Organizations of Large-Scale Dairy Farms on the Delmarva Peninsula." University of Delaware, Bulletin 397, Newark (April 1973).

24. Price, Edwin Chappel Jr., "Aggregate Bovine Supply in Northeast Thailand." Lexington: University of Kentucky, Unpublished Ph.D. dissertation, 1973.

25. Rogers, Keith D.,"Thailand Agricultural Sector Analysis Project." *End of Tour Report,* Division of Agricultural Economics, MOAC, Bangkok, Thailand, October 1975.

26. Smith, Eldon D., Edwin C. Price Jr., Barry B. Bobst, and Mary L. Lagema, "Economic Potential of the Cattle and Buffalo Industry in Northeast Thailand," Department of Agricultural Economics, College of Agriculture, University of Kentucky and Division of Agricultural Economics, Ministry of Agriculture, Thailand, Cooperating, 1974.

27. Striplung, Somnuk and Koset Manowalailao. "Agro-Economic Zones and Agricultural Development Planning." Agricultural Economic Research Bulletin No. 65," Division of Agricultural Economics, MOAC, Bangkok, Thailand, 1972.

28. Trede, Larry D. and Sidney E. James, "Which Swine Production System for You?" Iowa State University, Ames, Iowa, March 1969.

29. Vandermeulen, Daniel C., *Linear Economic Theory*, Prentice-Hall Inc., Englewood Cliffs, N. J., 1971.

APPENDICES

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APPENDIX A

Table A-1. Crop Budgeting for Zone 01

Name of Crop	Yield (Kg/rai)	Price (฿/Kg)	Gross Return (Baht)	Variable Cost (฿/rai)	Net Return (฿/rai)	Labor Required (Hour)[a] Lab-T	Lab-1	Lab-2	Lab-3
Nonglutinous Rice (NA)[b]	281.81	1.31	369.78	252.67	117.11	-	68.76	46.65	115.41
Nonglutinous Rice (N)[c]	265.55	1.31	348.45	192.83	155.62	-	65.85	31.61	97.46
Glutinous Rice (NA)	215.89	1.27	275.06	147.68	127.38	-	61.59	30.72	92.31
Glutinous Rice (N)	265.55	1.27	338.33	195.45	142.88	-	65.85	31.61	97.46
Corn	505.84	1.59	804.28	457.73	346.56	32.12	77.35	45.23	154.70
Cassava	1,087.24	0.37	402.44	275.58	126.88	32.52	47.32	8.24	88.08
Kenaf	182.27	2.22	404.63	128.47	276.16	39.81	50.88	77.26	167.75

[a]See Appendix B.

[b]NA = Native Variety.

[c]N = New Variety.

Source: DAE General Farm Survey.

Table A-2. Crop Budgeting For Zone 02

Name of Crop	Yield (Kg/rai)	Price (฿/Kg)	Gross Return (Baht)	Variable Cost (฿/rai)	Net Return (฿/rai)	Labor Required (Hour)[a]			
						Lab-T	Lab-1	Lab-2	Lab-3
Nonglutinous Rice (NA)[b]	179.65	1.47	264.93	111.24	153.69	72.25	-	43.04	29.21
Nonglutinous Rice (N)[c]	189.43	1.47	279.49	144.52	134.97	118.42	-	86.01	32.41
Glutinous Rice (NA)	165.89	1.38	230.10	106.75	123.35	82.52	-	55.05	27.47
Glutinous Rice (N)	189.43	1.38	262.76	146.91	115.85	119.42	-	86.01	32.41
Corn	582.51	1.42	827.16	475.05	352.11	127.82	29.09	63.90	34.83
Peanut	301.18	3.00	903.54	302.29	601.25	152.26	-	72.73	59.33
Cassava	1,322.20	0.39	515.65	318.74	196.91	124.14	91.19	32.95	-
Kenaf	163.60	2.78	487.52	114.32	373.20	120.54	31.59	28.98	59.97

[a]See Appendix B.

[b]NA = Native Variety

[c]N = New Variety

Source: DAE General Farm Survey.

Table A-3. Crop Budgeting for Zone 03

Name of Crop	Yield (Kg/rai)	Price (฿/Kg)	Return (Baht)	Variable Cost (฿/rai)	Net Return (฿/rai)	Labor Required (Hour)[a]			
						Lab-T	Lab-1	Lab-2	Lab-3
Nonglutinous Rice (NA)[b]	201.15	1.27	255.64	100.28	155.36	113.28	-	67.49	45.89
Nonglutinous Rice (N)[c]	200.99	1.27	255.44	254.21	1.13	153.16	-	89.92	63.24
Glutinous Rice (NA)	164.44	1.26	212.07	103.63	108.44	109.59	-	73.11	36.48
Peanut	159.39	3.00	478.17	121.09	357.08	187.81	-	62.27	125.54
Cassava	2,111.21	.34	633.36	271.04	362.32	186.02	132.00	39.28	14.14
Kenaf	146.20	2.67	390.35	84.58	305.77	201.60	53.10	48.63	99.96

[a]See Appendix B.

[b]NA = Native Variety.

[c]N = New Variety.

Source: DAE General Farm Survey.

Table A-4. Crop Budgeting for Zone 04

Name of Crop	Yield (Kg/rai)	Price (฿/Kg)	Return (Baht)	Variable Cost (฿/rai)	Net Return (฿/rai)	Labor Required (Hour)[a]			
						Lab-T	Lab-1	Lab-2	Lab-3
Nonglutinous Rice (NA)[b]	173.04	1.26	218.90	88.36	135.54	121.70	35.68	69.95	36.07
Nonglutinous Rice (N)[c]	180.71	1.26	228.60	109.51	119.09	119.73	-	76.19	43.54
Glutinous Rice (NA)	154.97	1.15	179.38	100.53	78.85	140.74	40.66	89.56	10.52
Glutinous Rice (N)	181.71	1.15	209.17	112.05	97.12	133.10	-	89.56	43.54
Corn	461.94	1.30	600.52	446.97	153.52	106.70	22.25	53.25	31.10
Cassava	1,391.05	0.40	548.42	260.65	287.77	55.54	44.76	8.56	2.22

[a]See Appendix B.

[b]NA = Native Variety.

[c]N = New Variety.

Source: DAE General Farm Survey.

Table A-5. Crop Budgeting For Zone 05

Name of Crop	Yield (Kg/rai)	Price (฿/Kg)	Return (Baht)	Variable Cost (฿/rai)	Net Return (฿/rai)	Labor Required (Hour)[a] Lab-T	Lab-I	Lab-2	Lab-3
Nonglutinous Rice (NA)[b]	170.23	1.33	227.10	73.30	153.86	152.25	-	102.41	49.84
Nonglutinous Rice (N)[c]	195.49	1.33	260.80	107.56	153.24	145.25	-	83.67	61.58
Glutinous Rice (NA)	187.35	1.26	236.70	69.44	107.26	175.71	-	101.33	74.58
Glutinous Rice (N)	195.49	1.26	246.98	106.32	140.66	145.25	-	83.67	1.58
Corn	396.43	1.36	539.14	294.85	244.29	147.91	6.56	91.41	49.94
Peanut	439.84	3.00	1,319.52	259.65	1,059.87	338.66	18.54	181.67	138.45
Cassava	1,946.80	.36	700.85	164.42	536.43	238.00	156.00	82.00	-
Kenaf	144.14	2.53	364.67	59.16	305.51	125.28	16.73	28.30	80.25

[a]See Appendix B.

[b]NA = Native Variety.

[c]N = New Variety.

Source: DAE General Farm Survey.

Table A-6. Farrow to Finish Budget. Estimated Returns and Expenses Per Sow and 2 Litters of Pigs (1 sow unit)

Item	Description	Quantity (Kg)	Price (Baht)	Amount (Baht)
Revenue				
Market Hogs[a]	13.67 hd @ 110 Kg.	1,503.70	13.06	19,638.32
Cull Sow[b]	.33 of a sow	62.50	13.06	816.25
Death Loss	2 percent of 14 mkt hog			(402.00)
			Total	20,052.57
Expenses				
Feed	Mixed Feed	7,073.44	2.0	14,146.88
Pig	Breeder Pig Cost ฿ 400/hd.			400.00
Medicine				289.13
Water				98.73
Service Charge	Two times Service Charge for Breeding ฿ 200			200.00
			Total	15,134.74
Net Return Over Variable Expenses				4,917.83
Labor Required				
Jan-Apr (hour)			192.33	
May-Aug (hour)			192.33	
Sept-Dec (hour)			192.33	
Total (hour)				576.99

[a].33 pig per year will be kept for sow replacement.

[b]Sow will be culled after 6 litters or 3 years of age.

Table A-7. Feeder Pig Budget. Estimated Returns and Expenses Per Sow and 2 Litters of Pigs

Item	Description	Quantity (Kg)	Price (Baht)	Amount (Baht)
Revenue				
Feeder pigs[a]	13.67 feeder pigs (head)	13.67	240.00	3,280.80
Cull Sow[b]	.33 of a sow (Kg)	62.5	13.00	816.25
Death Loss	2 percent of 14 pigs			67.20
			Total	4,029.85
Expenses (Variable)				
Feed	Feed for sow, and and replacement (Kg)	1,509.00	2.00	3,018.12
Pig	Breeder Pig Cost ฿ 400			400.00
Medicine				294.13
Water				10.39
Service Charge				200.00
			Total	3,922.64
Net Return Over Variable Expenses				107.21
Labor Required				
Jan-Apr (hour)			192.33	
May-Aug (hour)			192.33	
Sept-Dec (hour)			192.33	
Total (hour)				576.99

[a]Assumes 7 pigs per litter or 14 pigs per year are weaned with .33 pig retained as replacement leaves 13.67 head available for marketing.

[b]Assumes the average sow will produce 6 litters before she is replaced.

Table A-8. Finishing Budget. Estimated Returns and Expenses for Finishing Purchased Feeder Pig

Item	Description	Quantity (Kg)	Price ฿	Amount ฿
Revenue				
Market Hogs	110 Kilograms	110.00	13.06	1,436.60
Death Loss	5 percent of Market Hogs			71.83
			Total	1,364.77
Expenses				
Feeder Pig			250.00	250.00
Feed	Mixed Feed	436.8	2.00	873.60
Medicine				14.83
Water				5.97
			Total	1,144.40
Net Return Over Total Variable Cost				220.37
Labor Required (Hour)				
Jan-Apr			9.66	
May-Aug			9.66	
Sept-Dec			9.66	
Total				28.98

APPENDIX B

APPENDIX B

EXPLANATION OF ABBRIVIATIONS USED IN THE MATRIX

Table B-1. Resources (Rows)

Row No.	Abbreviation	Complete Heading
1	POL	Paddy Land
2	UPL	Upland Area
3	OCAP	Operating Capital
4	LABT	Total Farm Labor
5	LAB1	The January-April Labor
6	LAB2	The May-August Labor
7	LAB3	The September-December Labor
8	NGR	Nonglutinous Rice Account
9	GR	Glutinous Rice Account
10	CORN	Corn Account
11	PNUT	Peanut Account
12	CASA	Cassava Account
13	KNAF	Kenaf Account
14	FEED	Feed Account
15	PIG	Feeder Pig Account
16	SLH	Slaughter Hog Account
17	BORO	Borrowing Money

Table B-2. Activities (Columns)

Column No.	Abbreviation	Complete Heading
1	PNRO	Produce Nonglutinous Rice (native)
2	PNRN	Produce Nonglutinous Rice (new variety)
3	PGRO	Produce Glutinous Rice (native)
4	PGRN	Produce Glutinous Rice (new variety)
5	PCON	Produce Corn
6	PPNT	Produce Peanut
7	PCAS	Produce Cassava
8	PKNE	Produce Kenaf
9	SNGR	Sell Nonglutinous Rice
10	SGR	Sell Glutinous Rice
11	SCOW	Sell Corn
12	SPNT	Sell Peanut
13	SGAS	Sell Cassava
14	SKNF	Sell Kenaf
15	BFEED	Buy Feed
16	BPIG	Buy Pig
17	PFF	Produce Farrow to Finish
18	PFP	Produce Feeder Pig
19	PPF	Produce Finishing
20	SSLH	Sell Market Hog
21	SPIG	Sell Feeder Pig
22	BORO	Capital Borrowing

APPENDIX C

Table C-3. Input-Output Coefficient Matrix of Linear Programming for Zone 01

Row	Resources	Unit	Row Type	RHS	Crop Production Activities							Crop Selling Activities					Bureau Activities		Bureau Production Activities			Bureau Selling Activities		Capital Recovering Activities
					XT01 PWRD	X2WH PWRH	A3WF PORD	A4DT PORH	A5DT PORN	A6DT PCAS	X7DT PCWF	A8DT A8WR	A9DT 3WR	X1CDT 3CRH	X1TDT 3CAS	X2ZDH A8WF	X1JDT AFRER	X1KDT BFRG	X1SDT PFF	X1UDT PFZ	X1TDT PFF	AT4DT BBLH	AT5DH APBG	A2DDT BBRD
1	C	baht	N		-252.67	-192.83	-147.68	-195.45	-467.73	-275.55	-128.47	1.31	1.27	1.59	.37	2.22	-2.00	-250.00	-176.61	-88.27	-21.13	13.06	240.0	-.12
2	PBL	rai	L	25.49	1.00	1.00	1.00	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	WPL	rai	L	6.51	-	-	-	-	1.00	1.00	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-
4	OCAP	baht	L	3,800.00	252.67	192.83	147.68	195.45	467.73	275.55	128.47	-	-	-	-	-	2.00	250.00	176.61	88.27	21.13	-	-	-.88
5	LABT	hour	L	9,100.00	115.47	97.46	92.31	97.46	154.70	88.08	167.75	-	-	-	-	-	-	-	576.99	186.37	28.98	-	-	-
6	LAB1	hour	L	3,060.00	-	-	-	-	32.12	32.52	39.81	-	-	-	-	-	-	-	192.33	61.79	9.66	-	-	-
7	LAB2	hour	L	3,060.00	68.76	65.85	61.59	65.85	77.35	47.32	50.68	-	-	-	-	-	-	-	192.33	61.79	9.66	-	-	-
8	LAB3	hour	L	3,060.0	46.65	31.61	30.72	31.61	45.23	8.24	77.26	-	-	-	-	-	-	-	192.33	61.79	9.66	-	-	-
9	NGR	kg.	L	0	-281.81	-265.55	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-
10	GR	kg.	L	0	-	-	-215.89	-265.55	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-
11	CORN	kg.	L	0	-	-	-	-	-505.84	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-
12	CASA	kg.	L	0	-	-	-	-	-	-1,887.67	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-
13	KWAF	kg.	L	0	-	-	-	-	-	-	-182.27	-	-	-	-	1.00	-	-	-	-	-	-	-	-
14	FEED	kg.	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-1.00	-	-	-	-	-	-	-
15	PIG	head	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-1.00	-	-	-	-	-	-
16	FEED	kg.	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7,073.44	1,509.06	436.80	-	-	-
17	PIG	head	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-13.67	1.00	-	1.00	-
18	SLW	kg.	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-1,503.70	-	-110.0	1.00	-	-
19	BORD	baht	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00

Table C-2. Input-Output Coefficient Matrix of Linear Programming for Zone 02

Row No.	Resources	Unit	Row Type	RHS	Crop Production Activities								Swine Production Activities			Swing Selling		Capital Borrowing Activity	Crop Selling Activities						Buying Activities	
					A102 PNRO	A202 PNRN	A302 PGRO	A402 PGRN	A502 PCOR	A602 PPNT	A702 PCAS	A802 PKNF	A1702 PFF	A1802 PFP	A1902 PPF	A2002 SSLH	A2102 SP1G	A2202 BORO	A902 SNGR	A1002 SGR	A1102 SCOR	A1202 SPNT	A1302 SCAS	A1402 SKNF	A1502 BFEED	A1602 BPIG
1	C	baht	N		-111.24	-144.52	-106.75	-146.91	-475.05	-302.29	-318.74	-114.32	-176.61	-88.27	-21.13	13.86	240.00	-.12	1.47	1.38	1.42	3.00	.39	2.98	-2.00	-250.00
2	PDL	rai	L	27.10	1.00	1.00	1.00	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	UPL	rai	L	2.90	-	-	-	-	1.00	1.00	1.00	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	OCAP	baht	L	3,800.00	111.24	144.52	106.75	146.91	475.05	302.29	318.74	114.32	176.61	88.27	21.13	-	-	-.88	-	-	-	-	-	-	2.00	250.00
5	LABT	hour	L	9,180.00	72.25	118.42	82.52	119.42	127.82	152.26	124.14	120.54	576.99	185.37	28.98	-	-	-	-	-	-	-	-	-	-	-
6	LAB1	hour	L	3,060.00	-	-	-	-	29.09	-	91.19	31.59	192.33	61.79	9.66	-	-	-	-	-	-	-	-	-	-	-
7	LAB2	hour	L	3,060.00	43.04	86.01	55.05	86.01	63.90	92.73	32.95	28.98	192.33	61.79	9.66	-	-	-	-	-	-	-	-	-	-	-
8	LAB3	hou r	L	3,060.00	29.21	32.41	27.47	32.41	34.83	59.33	-	59.97	192.33	61.79	9.66	-	-	-	-	-	-	-	-	-	-	-
9	NGR	kg.	L	0	-179.56	-189.43	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-	-
10	GR	kg.	L	0	-	-	-165.89	-189.43	-	-	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-
11	CORN	kg.	L	0	-	-	-	-	-582.51	-	-	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	-
12	PNUT	kg.	L	0	-	-	-	-	-	-301.18	-	-	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-
13	CASA	kg.	L	0	-	-	-	-	-	-	-1 322.20	-	-	-	-	-	-	-	-	-	-	-	1.00	-	-	-
14	KNAF	kg.	L	0	-	-	-	-	-	-	-	-163.60	-	-	-	-	-	-	-	-	-	-	-	1.00	-	-
15	FEED	kg.	L	0	-	-	-	-	-	-	-	-	7,873.44	1,509.44	436.80	-	-	-	-	-	-	-	-	-	-1.00	-
16	PIG	head	L	0	-	-	-	-	-	-	-	-	-	-13.68	1.00	-	1.00	-	-	-	-	-	-	-	-	-1.00
17	SLH	kg.	L	0	-	-	-	-	-	-	-	-	-1,588.7	-	-110.00	1.00	-	-	-	-	-	-	-	-	-	-
18	BORO	baht	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-

Table C-3. Input-Output Coefficient Matrix of Linear Programming for Zone 03

No.	Resources	Unit	Type	RHS	Crop Production Activities						Crop Selling Activities					Buying Activities		Swine Production Activities			Swine Selling		Capital Borrowing Activity
					AT03 PNRO	A203 PNRN	A303 PGRO	A403 PPNT	A503 PCAS	A603 PKNG	SNGR	SGR	SPNT	SCAS	SKNG	BFEED	BPIG	PFF	PFP	PFF	SSLH	SPIG	BORO
1	C	baht	N		-100.28	-254.21	-103.63	-121.09	-271.04	-84.58	1.27	1.26	3.00	0.34	2.67	-2.00	-250.00	-176.61	-88.27	-21.13	-	-	-.12
2	PBL	rai	L	24.00	1.00	1.00	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	BPL	rai	L	6.00	-	-	-	1.00	1.00	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-
4	OCAP	baht	L	3,800.00	100.28	254.21	103.63	121.09	271.04	84.58	-	-	-	-	-	2.00	250.00	176.61	88.27	21.13	-	-	-.00
5	LABT	hour	L	9,180.00	113.26	153.16	109.59	187.81	186.02	201.60	-	-	-	-	-	-	-	576.99	185.37	28.98	-	-	-
6	LAB1	hour	L	3,060.00	-	-	-	-	132.00	53.10	-	-	-	-	-	-	-	192.33	61.79	9.66	-	-	-
7	LAB2	hour	L	3,060.00	67.49	89.92	73.11	62.27	39.28	48.63	-	-	-	-	-	-	-	192.33	61.79	9.66	-	-	-
8	LAB3	hour	L	3,060.00	45.79	63.24	36.48	125.54	14.14	99.96	-	-	-	-	-	-	-	192.33	61.79	9.66	-	-	-
9	NGR	kg.	L	0	-201.15	-200.99	-	-	-	-	1.00	-	-	-	-1	-	-	-	-	-	-	-	-
10	GR	kg.	L	0	-	-	-167.44	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-
11	PBNT	kg.	L	0	-	-	-	-159.39	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-
12	CASA	kg.	L	0	-	-	-	-	-2311.21	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-
13	OSAF	kg.	L	0	-	-	-	-	-	-146.20	-	-	-	-	1.00	-	-	-	-	-	-	-	-
14	FEED	kg.	L	0	-	-	-	-	-	-	-	-	-	-	-	-1.00	-	7,073.44	1,509.06	436.80	-	-	-
15	PIG	kg.	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-1.00	-	-13.66	1.00		1.00	-
16	SLA	kg.	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-1,503.70	-	-110.00	1.00	-	-
17	BORO	baht	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00

Table C-8. Input-Output Coefficient Matrix of Linear Programming for Zone 04

Row No.	Resources	Unit	Row Type	RHS	Crop Production Activities						Crop Selling Activities				Buying Activities		Swine Production Activities			Swine Selling Activities		Capital Borrowing Activities
					A104 PHRO	A204 PHRH	A304 PHRB	A404 PHRR	A804 PCRR	A804 PCRS	AT804 SHRR	AB04 SRR	AC04 SCRR	AT804 SCAS	AT104 BFEED	AT204 BPIG	AT304 PPF	AT404 PPP	AT804 PPF	AT804 SSLH	AT704 SPIG	AT804 BBRR
1	C	baht	N		-86.36	-109.61	-108.53	-112.05	-446.97	-260.65	1.26	1.15	1.30	0.04	-2.00	-250.00	-176.61	-88.27	-21.13	13.06	240.00	-.12
2	PDL	rai	L	26.60	1.00	1.00	1.00	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	UPL	rai	L	3.40	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
4	OCAP	baht	L	3,800.00	86.36	109.61	108.53	112.05	446.97	260.65	-	-	-	-	2.00	250.00	176.61	88.27	21.13	-	-	-.88
5	LABT	hour	L	9,100.00	141.70	119.73	140.74	133.10	108.70	55.54	-	-	-	-	-	-	576.99	185.37	28.98	-	-	-
6	LAB1	hour	L	3,060.00	35.68	-	40.66	-	22.25	44.76	-	-	-	-	-	-	192.33	61.79	9.66	-	-	-
7	LAB2	hour	L	3,060.00	69.95	76.19	89.56	89.56	53.35	8.56	-	-	-	-	-	-	192.33	61.79	9.66	-	-	-
8	LAB3	hour	L	3,060.00	36.07	43.54	10.52	43.54	31.10	2.22	-	-	-	-	-	-	192.33	61.79	9.66			-
9	NGR	kg.	L	0	-173.04	-180.71	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-
10	GR	kg.	L	0	-	-	-154.97	-181.71	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-
11	CORN	kg.	L	0	-	-	-	-	-461.94	-	-	-	1.00	-	-	-	-	-	-	-	-	-
12	CASA	kg.	L	0	-	-	-	-	-	-1,371.05	-	-	-	1.00	-	-	7,073.44	1,509.05	436.80	-	-	-
13	FEEH	kg.	L	0	-	-	-	-	-	-	-	-	-	-	-1.00	-						-
14	PIG	head	L	0	-	-	-	-	-	-	-	-	-	-	-	1.00	-	-13.66	-1.00	-	1.00	-
15	SLH	kg.	L	0		-	-	-	-	-	-	-	-	-	-	-	-1,503.70	-	-110.0	1.00	-	-
16	BORO	baht	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00

Table C-6. Input-Output Coefficient Matrix of Linear Programming for Zone 05

Row No.	Resources	Unit	Row Type	RHS	Crop Production Activities								Crop Selling Activities						Buying Activities		Swine Production Activities			Swine Selling Activities		Capital Borrowing Activities
					A105 PNRO	A205 PNRM	A305 PSRO	A405 PSRM	A505 PCOM	A605 BPNT	A705 PCAS	A805 PKNF	A905 SNGR	A1005 SGR	A1105 SCOM	A1205 SPWT	A1305 SCAS	A1405 SKNF	A1505 BFEED	A1605 BPIG	A1705 PFF	A1805 PFP	A1905 PPF	A2005 SSLH	A2105 SPIG	A2205 BORO
1	C	bshc	B		-73.30	-107.56	-69.44	-106.32	-294.85	-259.65	-164.42	-59.16	1.33	1.26	1.36	3.00	.36	2.53	-2.00	-250.00	-176.61	-88.27	-21.13	13.06	240.00	-.12
2	PRL	rod	L	18.40	1.00	1.00	1.00	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	RPL	rod	L	11.60	-	-	-	-	1.00	1.00	1.00	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	GRRP	bshc	L	3,888.00	73.30	107.56	69.44	106.32	294.85	259.65	180.42	59.16	-	-	-	-	-	-	2.00	250.00	176.61	88.27	21.13	-	-	-.88
5	LABT	hour	L	9,180.00	152.25	146.25	175.71	145.25	147.91	338.66	238.00	125.28	-	-	-	-	-	-	-	-	576.99	185.37	28.98	-	-	-
6	LAB1	hour	L	3,060.00	-	-	-	-	6.56	18.54	156.00	16.73	-	-	-	-	-	-	-	-	192.33	61.79	9.66	-	-	-
7	LAB2	hour	L	3,060.00	102.41	83.67	101.33	83.67	91.41	181.67	82.00	28.30	-	-	-	-	-	-	-	-	192.33	61.79	9.66	-	-	-
8	LAB3	hour	L	3,060.00	49.84	61.58	74.58	61.58	49.94	138.45	-	80.25	-	-	-	-	-	-	-	-	192.33	61.79	9.66	-	-	-
9	MIR	kg.	L	0	-170.23	-195.49	-	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-
10	CR	kg.	L	0	-	-	-187.35	-195.49	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-
11	CRR	kg.	L	0	-	-	-	-	-396.43	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-	-
12	PRR	kg.	L	0	-	-	-	-	-	-439.84	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-	-
13	CASA	kg.	L	0	-	-	-	-	-	-	-1,946.80	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-	-
14	RRNF	kg.	L	0	-	-	-	-	-	-	-	-144.14	-	-	-	-	-	1.00	-	-	-	-	-	-	-	-
15	FEED	kg.	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-1.00	-	7,073.44	1,589.06	436.80	-	-	-
16	PIG	head	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-1.00	-	-13.66	1.00		1.00	-
17	SLH	kg.	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-1,983.70	-	-110.00	1.00		-
18	BORO	bshc	L	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00

VITA

Chumnar Sirirugsa, son of Mr. and Mrs. Lun Sirirugsa, was born in Songkhla, Thailand, August 7, 1942. He graduated from Nontree High School in 1962. He received a Bachelor of Science degree in Economics and Cooperative Science from Kasetsart University, Bangkok, Thailand in 1967.

After graduation, he worked as an Assistant Researcher for the Division of Agricultural Economics (DAE), Ministry of Agriculture and Cooperatives, Royal Thai Government. In 1969, he entered Graduate School at the University of Kentucky and received the Master of Science degree with a major in Agricultural Economics in August 1971. After he received the master degree, he went back to Northeast Thailand to serve as Chief of the Agricultural Economics Branch at the Northeast Agricultural Research Center, Khon Kaen, Thailand.

He entered Graduate School at the University of Tennessee in January 1975. He received the Ph.D. in Agricultural Economics in December 1978.

He is married to the former Jaruporn Prabnasakdi. They have one daughter, Chiya.