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# TECHNICAL AND ECONOMIC CONSTRAINTS ON BOVINE PRODUCTION IN THREE VILLAGES IN THAILAND

A THESIS

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OF THE UNIVERSITY OF MINNESOTA

By

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# CONVERSION FACTORS

1 rai = 1600 square meters

= 0.16 hectares

= 0.395 acres

1 square kilometer = 247.1 acres

= 100 hectares

= 0.386 square miles

1 kilometer = .621 miles

1 kilogram = 2.2 pounds

1 metric ton = 1000 kilograms

= 2204.6 pounds

1 baht = U. S. $ 0.0476 (1970 exchange rate)

# Chapter I

# INTRODUCTION

## The Problem

Thailand is a Kingdom approximately the size of France lying in the center of the Indochinese peninsula. The population in 1970 was over 37 million and is increasing by about 3.2 percent per year. In common with most less developed nations, Thailand has a rapidly increasing and predominantly rural population with the vast majority of agricultural production undertaken by small scale family farms located in well defined villages units.

Major efforts toward development of the agricultural sector have been directed towards rice and upland crops. Uncertainty regarding long-term export demand for these commodities has produced a shift in emphasis towards the expansion of cattle and buffalo (hereafter referred to as bovines) production as a major goal of the agricultural sector (18, p. 54). Historically, bovine production has lagged behind the growth of the agricultural sector as a whole which in turn has lagged behind the growth of the general economy (Table 1.1.). Efforts to build up the national bovine herd must take into consideration the multiple roles or functions presently performed by large animals in Thai villages. These roles include use as draft animals, a form of capital accumulation, and the production of meat.

Delineation of multiple roles within an economic framework is necessary in order to (a) analyze the nature and severity of

Table 1.1 Index Numbers of Selected Economic Indicators in Thailand, 1950-1966.

| Year | Value, All Crops[a] | Index of Per Capita[b] Income | Cattle[a] Population | Buffalo[a] Population |
|---|---|---|---|---|
| 1950-1953 | 100 | 106 | 100 | 100 |
| 1954 | 96 | 107 | 93 | 104 |
| 1955 | 129 | 128 | 110 | 110 |
| 1956 | 139 | 131 | 104 | 108 |
| 1957 | 139 | 128 | 114 | 108 |
| 1958 | 142 | 129 | 115 | 119 |
| 1959 | 154 | 137 | 116 | 124 |
| 1960 | 194 | 152 | 119 | 125 |
| 1961 | 211 | 155 | 115 | 125 |
| 1962 | 201 | 164 | 124 | 130 |
| 1963 | 207 | 159 | 120 | 130 |
| 1964 | 211 | 177 | 118 | 128 |
| 1965 | 272 | 183 | 115 | 122 |
| 1966 | 337 | 210 | 115 | 130 |

a/ 1950-1953 = 100

b/ 1950 = 100

Source: Agricultural Statistics of Thailand. 1966 Edition. Division of Agricultural Economics, Under-Secretary of Agriculture, Ministry of Agriculture

restraints on expanded meat supplies for domestic consumption and export earnings, and (b) assess the impact of emerging trends in mechanization and meat consumption.[1/] At the base of this problem of role definition and analysis is an almost total lack of information relevant to the formulation of realistic bovine development policies. This gap extends from the economic functions that animals perform to the most basic technical data needed to assess village production possibilities.

---

1/ Chancellor (11) estimated that in 1968, 55 percent of total land in annual crops was being plowed by tractors on a single pass basis.

## Review of Previous Research

A recent study conducted by the Asian Development Bank (2) summarized the problems and prespects of the bovine industry in general. Factors favorable to bovine production included land, water, favorable climate, a large and well distributed population of indigenous animals and a large population of experienced farmers. Constraints were listed as (a) ineffective pest and disease control, (b) poor nutrition and overgrazing, (c) lack of suitable pastures, (d) substandard husbandry, (e) inbreeding, (f) theft, (g) inefficient marketing, and (h) restrictive legislation limiting the classes of animals which may be slaughtered and the choice of facilities available for slaughtering.

A cattle breeding and raising project was formulated to overcome some of these obstacles. Evaluation of such a project is severely handicapped by a lack of information on the severity of the constraints listed above, the resulting improvements in efficiency from relieving one or more of these constraints, the efficiency levels of existing production systems, and the rate of return on existing livestock production -- utilization systems. The percentage return on invested capital for the proposed cattle breeding and raising project was estimated as 9.5 percent per year. Yet no information was available to allow comparison of this rate with existing rates of return to bovines at the village level.

Methods for evaluating the technical and economic performance of bovine production have focused on only one particular aspect at a time. A framework for estimating draft animal demand in India was developed by Sethuraman (40). The capital accumulation role and its

place in traditional societies has been examined in Thailand by Nakajud (34) and Bhannasiri (5), in India by Singh and Parnekar (42), Whyte (45), and Harris (19) and in Africa by Deshler (12) and Schneider (41). Those studies indicated the presence of economic forces underlying traditional methods of cattle production and herding.

Technical aspects of buffalo production were examined briefly by Bhannasiri (5) and Buranamus (9). To date, the only comprehensive study of village level production systems was that of Rufener (39) carried out in Northeastern Thailand. Rufener's study identified existing productivity levels and problems for bovines in small scale village production units. In most instances, however, the results were not used in the evaluation of the economic performance of bovines as draft power, capital accumulation devices and sources of meat output.

Identification of factors limiting livestock development may be clarified by looking at farming systems rather than separate components of the system (31). The procedure of looking at a system of interactions is often used in studies of animals. Geographers, anthropologists, and recently, zoologists, have examined the role of animals as components of a system -- the system being cultural, biological, or environmental in nature (17, 35). The United Nations Indicative World Plan concluded that the great diversity of livestock enterprises found in the developing nations precluded recommendations for simple measures to improve their performance (15). Thus the economist must formulate his model to take account of the interactions -- both technical and economic -- in an attempt to identify constraints and resulting policy implications.

The two types of domesticated buffalo are the swamp buffalo and river buffalo. Swamp buffalo are distributed throughout Southern China, Southern Asia, the Philippines, Indonesia, and parts of the Indian sub-continent. River buffalo are found in India, Pakistan, Egypt, the Middle East, and Southern Europe (29). The present family (Bos bubalis) is descended from the wild buffalo (Bos arni) native to Southeast Asia. The average weight of a swamp buffalo is 500 and 400 kilograms for male and female, respectively (9, p. 3-4). Dressing percentages are low, ranging from 35 to 48 per cent (47, p. 261) with the latter figure generally used for estimation purposes in Thailand.

Sexual maturity is reached at about three years of age under village conditions. Gestation is 325-330 days. Although several breeds of river buffalo are commercial milk producers (42), the swamp buffalo cows are barely able to sustain their progeny (9, p. 5). Reproduction rates per time period are generally low under existing management levels. Slow maturity, a long gestation period, castration of all animals but those unfit for work, short periods in heat and difficulty of heat detection all make high turnover rates difficult to achieve. These disadvantages of buffalo are offset by their efficiency in utilizing low quality forage (27).

Origins of Thai native cattle are unclear. Great heterogeneity exists among the important characteristics of size of hump, length and erectness of ear, color, dewlap, navel and animal size. Mason (29, p. 82) classifies them as Zebu in breed and originating in Northern Malaysia. Rouse (38) describes them as nondescript, humped animals. The influence

of American Brahman bloodlines is now pronounced in certain areas. The composition of Thai cattle is best described as a mixture of zebu (Bos Indicus) and shorthorn (Bos brachyeeros) types (47, p. 140).

Gestation varies from 275 to 287 days depending on the breeds. Heat periods occur at 21-24 day intervals and are often very short for tropical breeds. Weights are lower and dressing percentages higher than for buffalo but are also more variable. Weights of native cattle seldom exceed 350 kilograms. Dressing percentage averages about 55% (8, p. 2).

## Objectives

The multiple role of bovines in Thai villages raises problems in the formulation of policy objectives to expand this sector of the agricultural economy. Given these problems, the overall objective of this thesis is to specify and analyze the technical and economic constraints on the expansion of cattle and buffalo production in selected case study villages in Thailand. The review of previous research has shown that there is little information available on livestock production at the village level. Specific objectives of this study therefore reflect the need for both an accurate description of small scale village production and an analytical framework for applying the results to specific development programs.

Specific objectives are:

(1) To describe village crop production.

(2) To describe village cattle and buffalo production.

(3) To test the economic efficiency of village crop, cattle and buffalo production.

(4) To define the relationship between the multiple uses of bovines as providers of draft inputs and producers of direct income through animal sales, and, once defined, quantitatively estimate the relationship.

(5) To estimate the severity of major technical and economic constraints on cattle and buffalo production and suggest methods for alleviating the constraints.

## Procedure

Village bovine production in Thailand is usually part of a food production — utilization complex. Crop production and the resulting utilization of crop residues thus play a major role. For this reason, a study must cover a full crop production cycle. Villages were chosen to represent major crop production systems since these logically influence the livestock production and utilization system present. Village selection proceeded in stages.

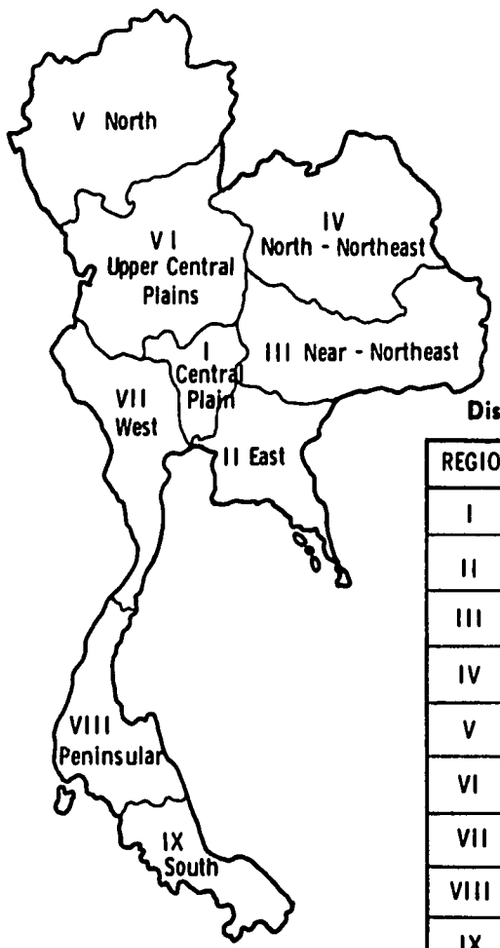
Livestock producing regions were delineated using the Department of Livestock Development's classification. Map 1.1. outlines the regions and their shares of bovine population in the Department's 1965 estimates. Travel considerations of the researcher ruled out the North, Peninsular, and South regions for inclusion in this study.

One village was selected in each of regions IV, VI, and VII. Village selection criteria included (a) the presence of both cattle and buffalo, (b) a major cropping system represented, (c) some mechanization present in at least one area, and (d) adequate variations in herd parameters, such as age-sex ratios.

Village selection began by consultations with Changwat (province) and Amphur (District) Livestock Development Department officials. Villages which adequately represented the cropping patterns, yields, and input usage of that region were identified. Those of manageable size for this study (100 families or less) were then visited to explain the study and solicit cooperation from the village headman and village families. Village selection decisions were made after initial trial inventory work established that the selection criteria were met. Data collection proceeded in three stages.

**Figure 1. 1.**

**DEPARTMENT OF LIVESTOCK DEVELOPMENT'S LIVESTOCK REGIONS IN THAILAND**




**Animal Population Distribution By Regions : 1965**

| REGION | CATTLE | % | BUFFALO | % |
|---|---|---|---|---|
| I | 188,734 | 3.7 | 561,607 | 8.4 |
| II | 152,046 | 3.0 | 464,643 | 6.9 |
| III | 1,166,963 | 22.9 | 1,480,750 | 22.1 |
| IV | 1,133,014 | 22.3 | 1,823,343 | 27.3 |
| V | 634,677 | 12.4 | 679,104 | 10.1 |
| VI | 400,091 | 7.8 | 856,881 | 12.9 |
| VII | 725,041 | 14.2 | 276,995 | 4.1 |
| VIII | 227,022 | 4.4 | 303,847 | 4.5 |
| IX | 476,266 | 9.3 | 243,953 | 3.7 |
| TOTAL | 5,103,854 | 100 | 6,691,103 | 100 |

Initial Inventory

An initial inventory of village crop and livestock production resources was carried out during March, 1970. Information was collected on all farmers in the village and included data on land use and location, 1969-1970 crop yields, family members and their occupations, bovine numbers, uses and characteristics, bovine production practices, estimated values. and animal measurements, when possible. Initial inventory was followed by selection of a random sample of farmers to participate in a year long study of land use, crop production practices and livestock production practices.

Monthly Visits

Beginning in April, 1970, each sampled farmer in each case study village was visited once a month for twelve months. Sampled farmers were given simple input recording forms to keep records of labor allocation by month plus cash expenses. These records were revised and updated each month during the field visits. Crop data collected on a monthly basis included labor and draft hours used per crop, other inputs used including cash costs plus crop yields, sales and prices. Bovine data included grazing areas, labor used for grazing and fodder gathering, births, deaths, sales, purchases, prices, and any other transactions reflecting a change in herd numbers.

Final Inventory

During the last of the twelve monthly visits (March, 1971) all of the farmers in each of the three case study villages were again interviewed. Crop production data were summarized for the entire village, a five year cropping history of each farmer was obtained, village grazing patterns were ascertained, each farmer's bovine herd was inventoried and

all changes in animal numbers were accounted for.

Three sources of data were used in the research reported in the following chapters. The first was that from the sampled farmers who participated in the twelve monthly visits and represents the data used in the analysis of crop production and resource productivities. The second source was from all farmers in the village who participated in the initial and final inventories. This included those sampled and those not sampled. Those data were used in analysis of village bovine herds, village land resources, and carrying capacities.

The third source of data was from additional survey work carried out in November, 1970. As data collection progressed in the case study villages, it became apparent that data on animal sizes, animal prices, herd compositions, birth and death rates, and village carrying capacities were, in some cases, inadequate for reliable estimates of herd performance. Therefore, additional survey work was carried out in the Northeast and Central Highlands regions where data were most urgently needed. The data on animal size estimated by tape measuring and animal prices in actual transactions were judged to be reliable and comparable with the case study villages in the respective regions. These items were pooled with case study data in obtaining certain estimates in Chapter IV, where noted. The other desired estimates were judged to be unreliable when collected by single survey procedures and were not used in any estimates that follow.

## Special Concepts Used in This Research

The readers of this thesis may include economists who are not familiar with certain concepts used in animal production and animal scientists who are not familiar with certain concepts of economics. Therefore, the concepts in both disciplines that form important parts of the analysis that follows are now briefly defined.

### Biomass

For certain procedures it was desirable to obtain estimates of herd size independent of animal numbers or animal type. The standard definition of one animal unit equal to one mature animal was inadequate since animal size varies greatly between cattle and buffalo and between villages for cattle, in particular. Therefore, the concept of biomass was used. Biomass is simply the weight of a mass represented by live animals at a point in time. This research uses total kilograms of the animal category under study as the measure of biomass. The measure of animal unit used in this research is a direct function of the biomass represented as animal units (AU) = $\frac{\text{Biomass in kilograms}}{\text{500 kilograms}}$.

Thus one animal unit represents one animal of 500 kilograms or 1100 pounds liveweight. In actual practice, this approximated the weight of a mature water buffalo. It is recognized that the biomass procedure does not adequately adjust for differences in nutritional requirements which are not a direct function of animal weight such as the increased energy required for draft animals or lactating females. Thus results using a simple measure of herd weight without consideration of functional

differences may bias the results somewhat. The measure is adequate, however, for the calculations of carrying capacity, herd accounting, and meat offtake estimates used.

Reproduction Rates

Birth rate is the most commonly used indicator. It is generally formulated as the t ` number of live births divided by the total number of females capable of reproduction. For this study, all female animals four years and older were included as the denominator. A related measure is the herd reproduction rate, which is a function of birth rate and herd composition. It is defined as the total number of live births divided by the total number of animals in the herd (excluding the live births). It represents the net addition to the total herd from births and indicates the ability of a herd to reproduce itself at present birth rates. A third measure of reproduction is herd reproductive capacity which is the herd reproductive rate assuming a 100 percent birth rate. This represents the potential of the herd to reproduce itself. For example, the reproductive capacity of a herd composed chiefly of castrated males used for draft purposes may be inadequate to maintain the herd at its present size without annual purchases of replacement stock.

Animal Production Technology

Evaluation of levels of technology existing in the villages and possible sources of improved productivity required a classification of livestock production technology. The classification developed for this research is outlined below in Table 1.2.

Efficiency

Two types of efficiency are relevant for this research. The first is allocative efficiency. Two versions of this concept are used

Table 1.2. Sources of Increased Bovine Productivity Through Production Technology

I. Genetic Improvements

A. Cattle
1. Exotic or crossbred males
2. Exotic or crossbred females
3. Artificial insemination with exotic or crossbred semen
4. Superior animal selection within own herd

B. Buffalo
1. Superior animal selection within own herd
2. Superior breeding animals imported into herd

II. Nutritional Improvements

A. Grazing
1. Improved grass and legume species
2. Fertilizer and crop rotations to improve fertility levels
3. Controlled grazing

B. Supplemental feedstuffs
1. Manufactured (mixed) whole ration feeds
2. Manufactured supplements
3. Stored roughages
4. Purchased concentrates

III. Animal Health Improvements

A. Prophylactic measures (serums and vaccines)

B. Therepentic measures (antibiotics, warming, dips, spraying)

C. Regular veterinary inspections

IV. Animal Housing and Management

A. Structures
1. Climatic protection
2. Predator protection

B. Feeding and watering facilities
1. Feed waste prevention
2. Continual availability
3. Feed and water sanitation

C. Other labor saving devices

D. Production evaluation techniques
1. Input records
2. Output records
3. Breeding records

in the following chapters. The first version examines input allocation in crop production; the relevant measure is equality of marginal value products to marginal factor costs. The second version examines the allocation of a resource bundle in producing two products; the relevant measure is equality of marginal rates of transformation to relative product prices.

The second type of efficiency examined is technical efficiency. Measures of technical efficiency are related to differences between actual and technically feasible output levels at given input levels. Firm output levels depend on how close they are to obtaining maximum outputs, feasible from a technical point of view, from a given configuration of inputs.

Rate of Return

Bovine production is analyzed as an investment. Consequently enterprise evaluation over time requires computation of a rate of return. The production -- utilization pattern is characterized by distinct periods of expenses and of revenues. By summing yearly expenses and revenues a yearly net cash flow can be computed. The internal rate of return is used for analysis of these cash flows over time and is equal to the rate which equalizes discounted positive and negative cash flows over time. This measure represents a rate of return to the investment from its inception.

Village

Decision making units in economics are typically defined as households and firms. For most Thai agricultural production decisions, the household is the relevant unit. The household has under its control a bundle of resources in the form of land, labor, draft animals, capital goods, seeds, and managerial ability. These resources are then allocated among various crops and work tasks to produce crops. For certain periods of the crop production process, the decision making unit may be expanded to include kin group participation and other forms of shared, voluntary labor (6, 32). This expands production only on a limited scale. The widespread practice of communal grazing and the use of communal pastures in Thai villages expands the decision making unit relevant for livestock production to the level of the village. The well known (by the villagers) boundaries of each village thus define the available livestock production resources since seasonal migration of animals and the importing of animal feed sources were very seldom

practiced. This implies that importing resources from outside the village boundaries is possible only through commercial transactions of animals, not through shared or communal use of resources with other villages.

Method of Planting Rice and Types of Rice

Rice grown by transplanting is first sown in a nursery two to four weeks prior to transplanting. The main fields are plowed and puddled as sufficient water becomes available. The seedlings are then uprooted and planted individually in rows in the prepared fields. For broadcast rice, the fields are plowed once or twice prior to heavy rains. When the farmer judges that sufficient rains are forthcoming, seed rice is broadcast by hand on top of the plowed ground where it sprouts.

Glutinous rice is non-translucent and becomes sticky when steamed or boiled. It is the staple food of Northern and Northeastern Thailand, Laos, and parts of Mainland China and North Vietnam. Non-glutinous rice grains are translucent and remain separated when cooked. This is the basic food of most of the rice consuming areas of the world and the type produced in the United States.

Ratooned Crops

Some crop species have the ability to ratoon or regenerate plant growth after the stalk has been severed. Sugarcane and sorghum are such crops. Sorthum was harvested by cutting off the heads; if moisture conditions were favorable, a second head of sorghum would be formed on a new tiller. Best results are obtained by cutting the sorghum stalk two to three inches above the earth. Similarly, sugarcane is cut close to the ground and proceeds to regenerate. The procedure

is repeated several years in succession. Before the roo tstocks were plowed under, a new set of cuttings were harvested for replanting.

Retting Kenaf

Retting refers to the process of separating the fibrous part of a plant from the woodlike stalk by soaking. Kenaf, a long fiber producing plant similar to jute, is processed by soaking the mature plants for seven to ten days until the fibrous outer layer slips off the stalk. It is then washed, dried, and bundled.

# CHAPTER II

# THE CASE STUDY VILLAGES

## Physical Characteristics

Villages were selected in three of the six distinct physiographic regions in Thailand (33). All villages lie between $14^{o}28'$ and $16^{o}28'$ north latitude and $100^{o}0'$ and $102^{o}90'$ east longitude. The six regions and the location of the three case study villages are shown in Figure 2.1.

Mapkhae village is situated on the eastern edge of the West Continental Highlands physiographic region and borders, but is not a part of, the Central Plains region. The West Continental Highlands consists of steep mountains along the Burmese border in the west descending to the flatter upland areas bordering the Central Plains. Mapkhae is generally flat and is located on recent alluvium soils raised above the valleu of the Suphanburi River. The rainfall distribution of this region, shown in Figure 2.2., indicates a marked increase in the September-October period. Forty-two percent of the yearly average of 1,116 m.m. occurs during these two months. This region was the driest of the three areas studied. Soils are low-humic gley and noncalcic brown on semi-recent alluvium. Productivity of these types is good with adequate water. Numerous sandy areas exist in this village, and scattered areas of mixed deciduous forest and bamboo thickets are common.

**Figure 2.1.**
**PHYSIOGRAPHIC REGIONS OF THAILAND**

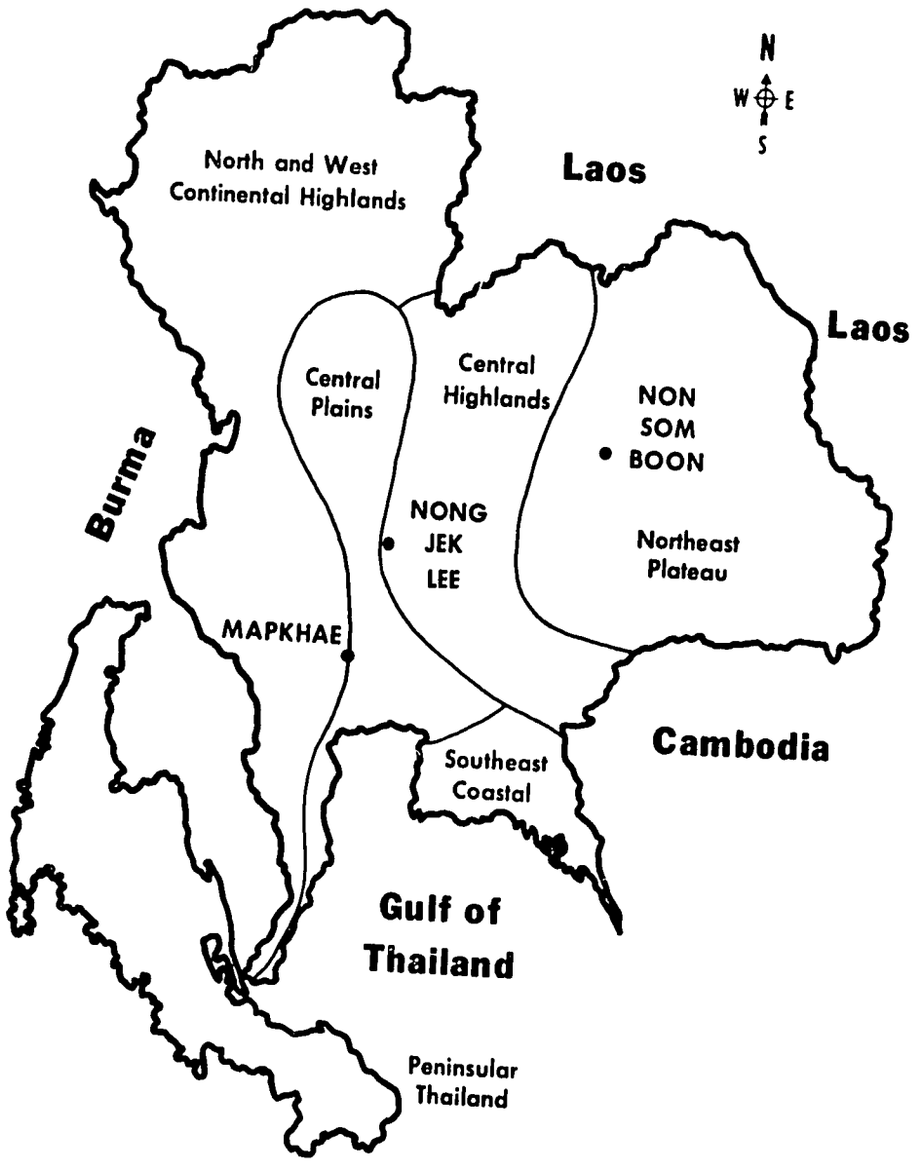
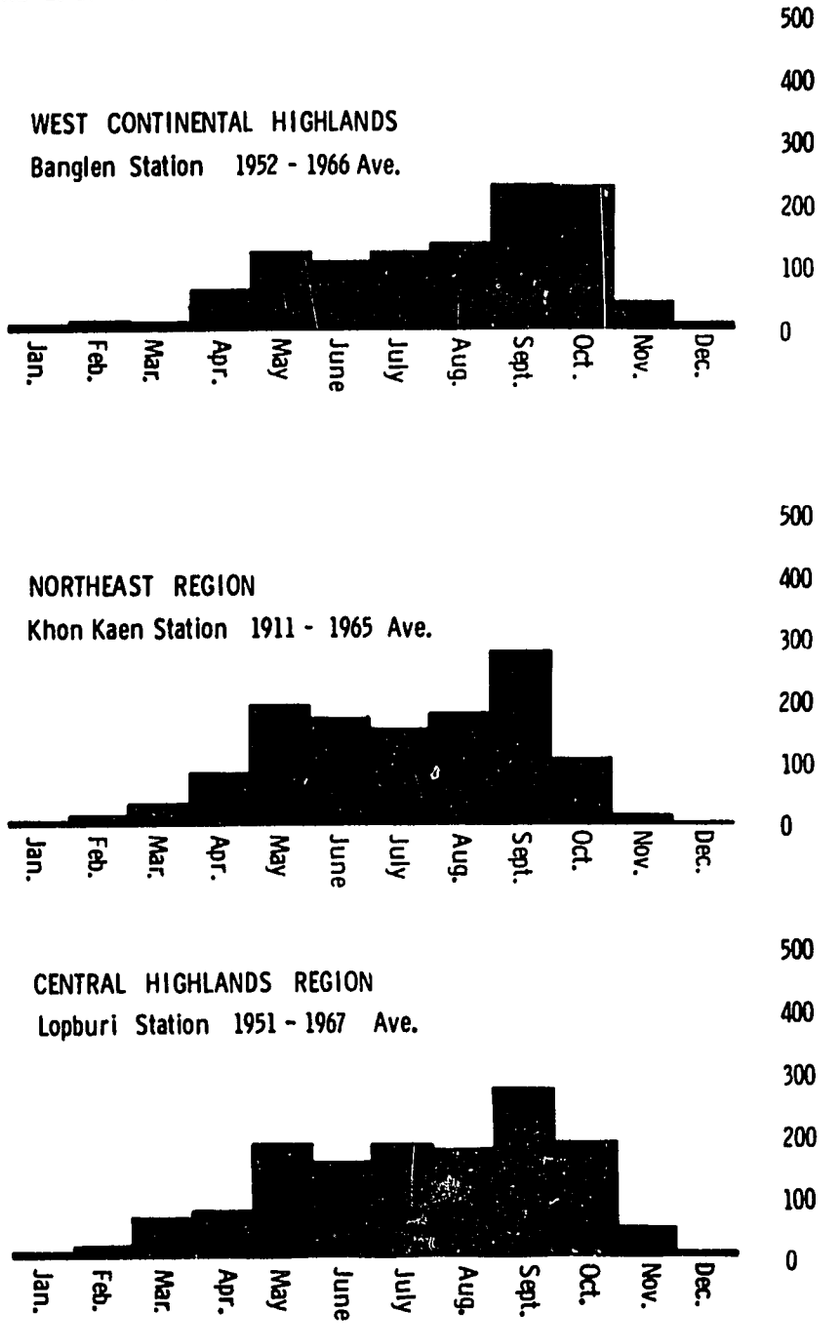


FIGURE 2. 2. MONTHLY RAINFALL AT SELECTED LOCATIONS



Non Som Boon village lies in the Northeast Plateau. Topography is gently undulating in the upland areas and flat in the river bottoms. The river bottoms of the Chi River form the western boundary of the village. Low-humic gley and gray podzolic soils dominate this area but some village fields are in alluvial river bottom soils. The upland areas are sandy and well leached. Eighty-seven per cent of the annual rainfall of 1,242 m.m. occurs in the May-October period. The normal pattern, shown in Figure 2.2., is a slight decrease in the annual monsoon rains in late June, sometimes extending into August. Natural vegetation consists of Dipterocarp forest, but most vegetation now consists of savannah and shrub regrowth on cutover crop land.

Nong Jek Lee is on the edge of the Central Highlands Region, an area characterized by gently undulating hills, low plateaus, gently sloping valleys and some steep rock out-croppings. Soils are grumosols and rendizas associated with limestone and basalt. The monthly distribution of rainfall at the Lopburi Station is given in Figure 2.2. The yearly average over the period was 1,369 m.m. with 84 percent occuring over the May-October period. Natural vegetation consists of mixed deciduous forests ascending into small savannah areas on the gentle slopes. Bamboo thickets and cocoanut palms are prevalent near household areas.

## Village Settlement Patterns

Mapkhae village is an example of the cluster pattern of village organization wherein a cluster of 4 to 6 houses (often consisting of related kin groups) are arranged together with the clusters being scattered throughout the village. The western boundary is the Nakhon Pathom-Suphanburi highway, the major road in the west-central region. The village lies about midway between these two major commercial centers and 13 kilometers west of the Suphanburi River. Figure 2.3., shows the location of the village in the region. Figure 2.4., shows the approximate land use within the village boundaries. Location of houses is not shown because they are scattered throughout the village area.

There is one major rice area in the northeastern part of the village, and other rice plots are scattered throughout the village. All rice fields are bunded and rainfed. The major rice area is primarily lowland rainfed and the other areas are upland rainfed. Limited areas of the lowland fields are subject to flooding by a stream which forms in the monsoon season.

Sugar cane is the dominant cash crop and rice is the predominate subsistence crop. Other cash crops of importance are corn, sorghum, taro, sweet potato, and dryland vegetable crops consisting of chili pepper, eggplant and cassava. The cash crops are grown in the better drained upland areas, although the flat topography makes the upland-lowland demarcation unclear in many instances and results in some periodic drowning of crops in portions of these fields.

The lowland rice fields are generally short on water and the rains often come too late to permit transplanting of all areas. Thus broadcasting of some or all of individual fields is common. Yellow-orange

**Figure 2. 3.**

# LOCATION OF MAPKHAE VILLAGE

MAPKHAE - NAKHON PATHOM 42 km.
MAPKHAE - SUPHAN BURI 60 km.

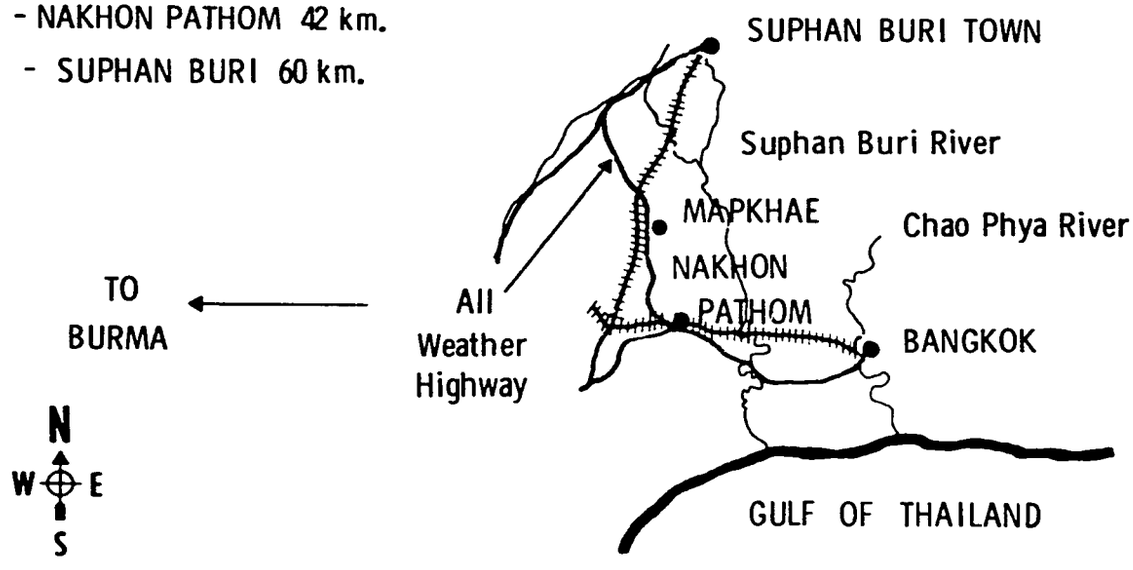
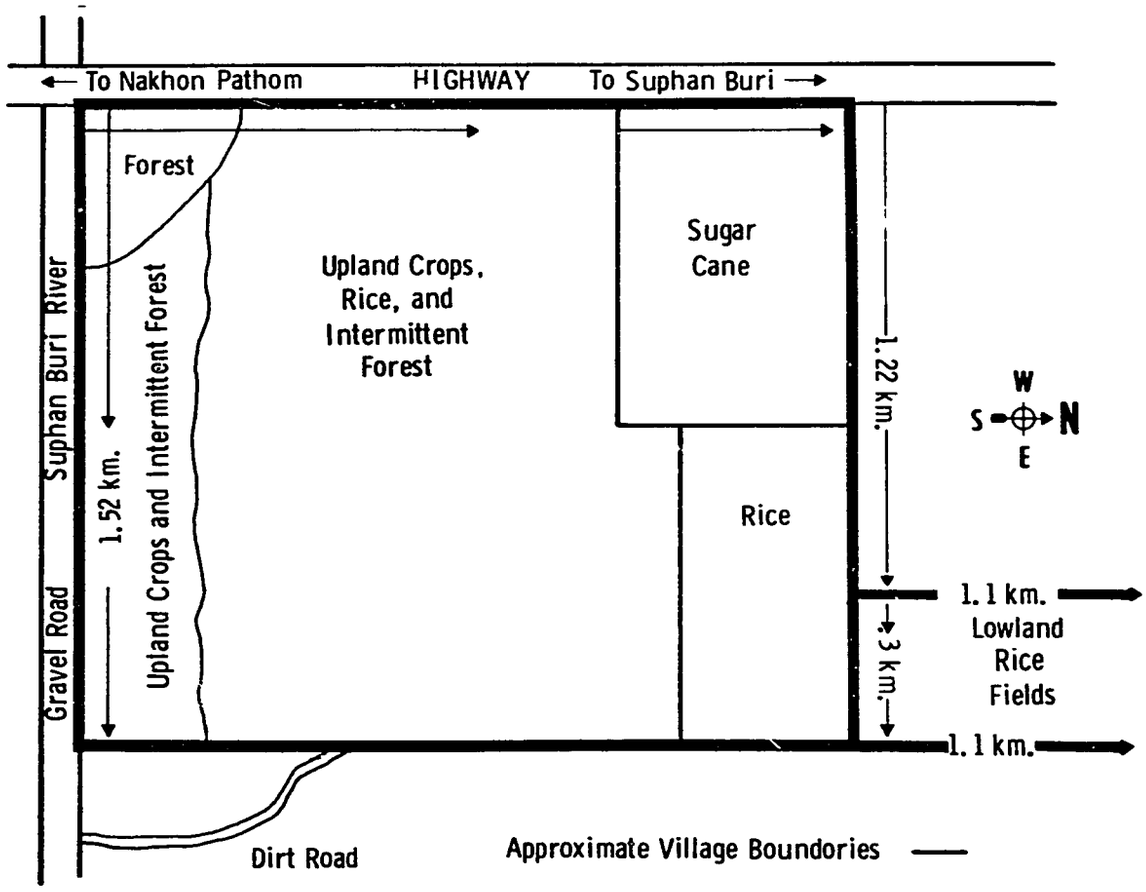


**Figure 2. 4.**

## MAP OF MAPKHAE VILLAGE



leaf virus has been severe in this area. This, coupled with inadequate rainfall for rice, has resulted in a series of rice crop failures. The areas of upland crops are generally too small to provide sufficient incomes and the proportion of families working as hired labor is substantial.

Non Som Boon village extends west to the Chi River lowlands and across the major North-South highway in the Northeast to the railroad tracks. The houses are arranged in the nuclear pattern (all in one location) which is typical of the Northeast. Figures 2.5., and 2.6., present the village's location in the Northeast and a detailed map of land use.

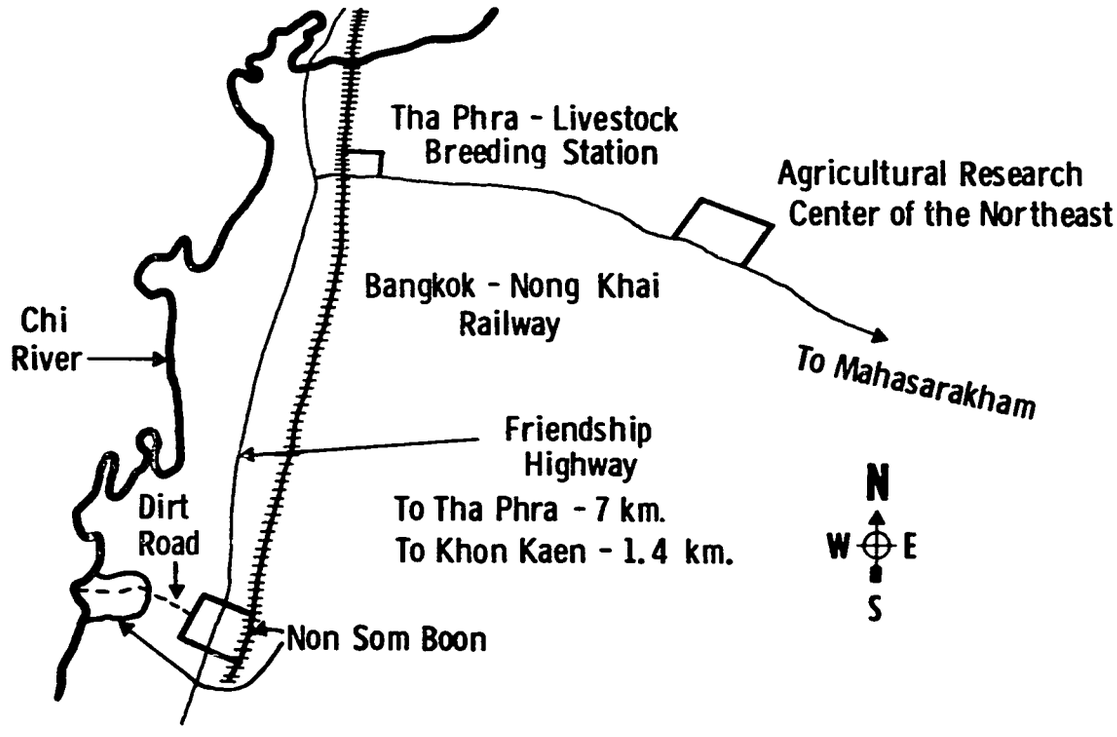
The village is near two major commercial centers. Khon Kaen, which is also the provincial capitol, is about 14 kilometers north and Baan Phai, a major commodity assembly and shipment point, is 30 kilometers south. A Department of Livestock Development Station and the Northeast Agricultural Research Center, both under the Ministry of Agriculture, are at Tha Phra, seven kilometers northeast.

The cropping patterns are more uniform than those of the other two case study villages. Every villager grew kenaf as a cash crop. Ten others grew watermelon for cash sales. Forty-two of the 52 village farmers grew glutinous rice, all for home consumption. Crop rotation follows the crop-fallow system for upland crops. Watermelon is occasionally double-cropped, but rice is not. Kenaf cannot be double-cropped because of its long growing period.

The lowland rice fields usually have adequate water for transplanting and are planted every year. The upland rice fields are transplanted if rainfall is adequate, otherwise they are left fallow. Often

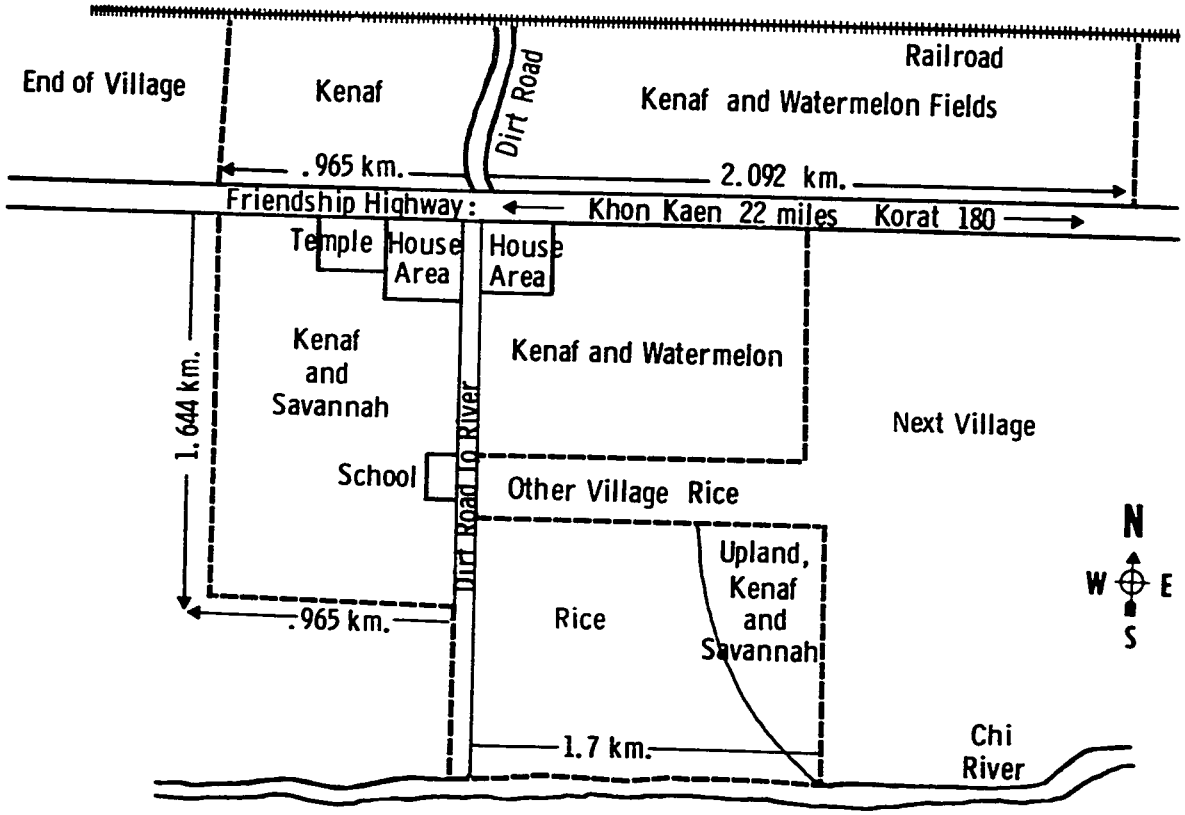
## Figure 2.5

# LOCATION OF NON SOM BOON VILLAGE



## Figure 2.6.

## MAP OF NON SOM BOON VILLAGE



these fields are partially planted, depending on rainfall conditions.

Nong Jek Lee village is organized in the string pattern with houses paralleling the irrigation canal and road. The village is located within a triangle of three major commercial centers served by all weather highways (Figure 2.7.). Barge transportation is available on the Chainat-Pasak Canal and a railroad station is located at Takhli. The fields span a transition area between the upland areas and the Central Plain region. The Chainat-Pasak Canal, a major irrigation structure eight years old, divides the village and the upland-lowland areas (Figure 2.8.). Two distinct cropping patterns are evident. Households on the lowland side of the canal grow primarily lowland rice and some second crop peanuts. Those on the upland side usually have a field of lowland rice plus one or more upland fields of corn or sorghum, which are often second-cropped to mungbeans.

**Figure 2.7.**

**LOCATION OF NONG JEK LEE VILLAGE**

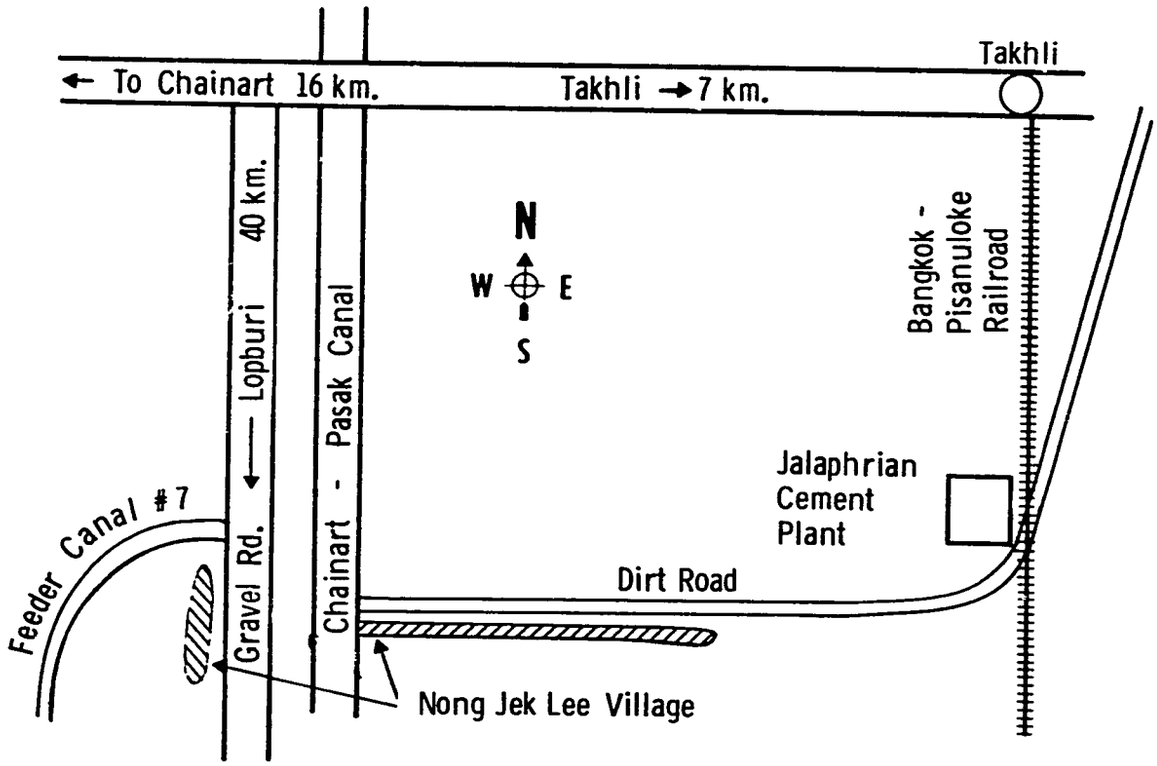
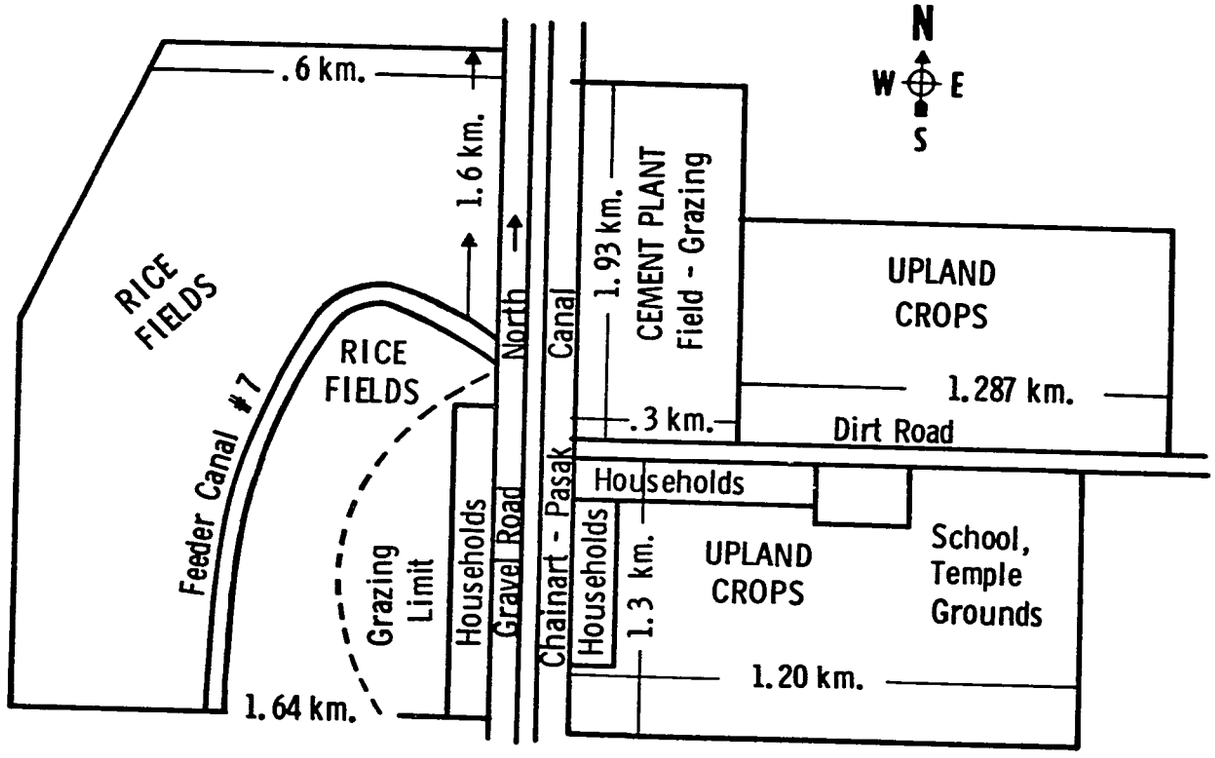


**Figure 2. 8.**

## MAP OF NONG JEK LEE VILLAGE



## Village Cropping Patterns

The sample farmers in Mapkhae practiced a diverse set of crop combinations, as shown in Table 2.1. However, rice and sugarcane were predominant, as shown in Table 2.2. Rice yields were very low in this village and rice prices were also low, so that 64 percent of the area planted by the sample farmers produced only 7 percent of their income. Sugarcane represented the other extreme, with 23 percent of the area producing 87 percent of the value of production. Village cropping patterns were fairly stable over the past 5 years, except for sugarcane which expanded rapidly. Part of the area for sugarcane expansion came from newly-cleared land and part from a decrease in area planted to sorghum.

In contrast to Mapkhae, sample farmers in Non Som Boon showed little variation in their choice of crops (Table 2.4.). Again, however, the proportion of the value of production from rice was considerably lower than the proportion of area planted to it (Table 2.5.). Distribution of village planted area among the three crops was relatively stable over the five years, with watermelon expanding rapidly during the past two years.

Nong Jek Lee sample farmers also concentrated on three crops (Table 2.7. and 2.8.). The contribution of area planted and value produced from each crop were more nearly equal in this village than in the other two. Distribution of area planted to each crop in the whole village was fairly stable over the past five years (Table 2.9.).

Table 2.1. Crop Combinations of 22 Sample Farms in 1970-71 in Mapkhae.

| Crops | Rice Only | Cane Only | Rice, Cane | Rice, Corn | Rice, Sorghum | Rice S. Pot. | Rice, Corn, Sorghum | Rice, Corn, S. Pot., Cane | Corn, Sorg., S. Pot., Cane | Sorg., Taro, Eggplant, Cane |
|---|---|---|---|---|---|---|---|---|---|---|
| No. of Farmers | 7 | 3 | 4 | 1 | 1 | 2 | 1 | 1 | 1 | 1 |

Table 2.2. Planted Area, Percent of Total Planted Area and Total Value, by Crop, of 22 Sample Farms in 1970-71 in Mapkhae.

| Crop | Rice | Cane | Corn | Sorghum | S. Pot., Taro, Eggplant | Total |
|---|---|---|---|---|---|---|
| Area (Rai)[1] | 368 | 133 | 26 | 15 | 34 | 576 |
| % Total Area | 63.89 | 23.09 | 4.51 | 2.60 | 5.90 | 100 |
| % Total Value of Crops Produced | 6.58 | 87.27 | 1.55 | 2.16 | 2.44 | 100 |

Table 2.3. Planted Area of Major Crops of All Village Farms, 1966-1970, in Mapkhae.

| Year | Major Crops (area in rai) Rice | Cane | Corn | Sorghum | S. Pot., Taro, Eggplant | Total Crop Area |
|---|---|---|---|---|---|---|
| 1966 | 496 | 12 | 9 | 64 | 36 | 617 |
| 1967 | 496 | 12 | 9 | 64 | 36 | 617 |
| 1968 | 515 | 12 | 9 | 66 | 31 | 637 |
| 1969 | 498 | 82 | 15 | 55 | 33 | 683 |
| 1970 | 512 | 132 | 22 | 24 | 34 | 724 |
| 1970 % of total | 70.72 | 18.23 | 3.04 | 3.31 | 4.70 | 100 |

Table 2.4. Crop Combinations of 26 Sample Farms in 1970-1971 in Non Som Boon.

| Crop Combinations | Kenaf Only | Rice, Kenaf | Rice, Kenaf, Watermelon |
|---|---|---|---|
| No. of Farmers | 1 | 15 | 10 |

Table 2.5. Planted Area, Percent of Total Planted Area and Total Value, by Crop, of 26 Sample Farms in 1970-71 in Non Som Boon.

| Crop | Rice | Kenaf | Watermelon | Total |
|---|---|---|---|---|
| Area-rai | 322 | 336 | 62 | 720 |
| % Total Area | 44.72 | 46.67 | 8.61 | 100 |
| % Total Value of Crops Produced | 18.21 | 69.67 | 12.12 | 100 |

Table 2.6. Planted Area of Major Crops of All Village Farms in 1966-1970 in Non Som Boon.

| Year | Major Crops (rai) Rice | Kenaf | Watermelon[1] | Total Area in Crops |
|---|---|---|---|---|
| 1966 | 573 | 531 | 0 | 1104 |
| 1967 | 573 | 550 | 0 | 1123 |
| 1968 | 571 | 577 | 5 | 1153 |
| 1969 | 574 | 557 | 37 | 1168 |
| 1970 | 563 | 591 | 66 | 1220 |
| 1970's total area | 46.15 | 48.44 | 5.41 | 100 |

(1) Watermelon totals are the sum of early and late crops.

Table 2.7. Crop Combinations of 36 Sample Farms in 1966-1970 in Nong Jek Lee.

| Crop Combinations | Rice Only | Rice, Corn | Rice,Corn Mungbean | Rice, Corn Sorghum | Corn Only | Corn, Mungbean |
|---|---|---|---|---|---|---|
| No. of Farmers | 8 | 2 | 23 | 2 | 0 | 1 |

Table 2.8. Planted Area, Percent of Total Planted Area and Total Value, by Crop, of 36 Sample Farms in 1970-1971 in Nong Jek Lee.

| Crop | Rice | Corn | Sorghum | Mungbean | Total |
|---|---|---|---|---|---|
| Area (rai) | 1014 | 428 | 11 | 334 | 1787 |
| % of Total Area of Crops Produced | 56.74 | 23.95 | 0.62 | 18.69 | 100 |
| % of Total Value of Crops Produced | 51.64 | 35.02 | 0.11 | 13.23 | 100 |

Table 2.9. Planted Area of Major Crops of All Village Farms in 1966-1970 in Nong Jek Lee.

| | Major Crops | | | | | Total Areas in Crops |
|---|---|---|---|---|---|---|
| Year | Rice | Corn | Sorghum | Mungbean | Peanut | |
| 1966 | 1603 | 694 | 0 | 556 | 38 | 2891 |
| 1967 | 1623 | 685 | 0 | 556 | 38 | 2902 |
| 1968 | 1625 | 732 | 0 | 623 | 41 | 3021 |
| 1969 | 1664 | 788 | 0 | 658 | 54 | 3164 |
| 1970 | 1608 | 730 | 11 | 649 | 50 | 3048 |
| 1970% total area | 52.76 | 23.95 | 0.36 | 21.29 | 1.64 | 100 |

Village Cattle and Buffalo Ownership Patterns

The patterns revealed in Figures 2.9. and 2.10. illustrate the diversity of cattle and buffalo ownership patterns among the three villages which reflect a combination of animal use patterns (analyzed in Chapter's III and IV) and the availability of resources for production (analyzed in Chapter IV.). Draft use patterns indicated a maximum of two to three buffalo or four cattle per farm necessary for power requirements. Herd sizes in excess of these numbers indicated production of animals for sale.

Mapkhae had few cattle owners but generally large herds. The owners used two to four males for power, the remainder of the herd was replacement animals and breeding females. Larger herd sizes were made possible by large areas of unplanted land. In Mapkhae, sixty percent of all cattle producers had herds larger than ten animals. Buffalo holdings, on the other hand, indicate smaller herd sizes and a smaller surplus of animals for herd replacement purposes. However, buffalo cows were often used for draft purposes while cattle cows were not, so the cattle breeding herd necessary to provide replacements had to be larger. No buffalo producers had over seven animals. Only twenty-four of the forty farmers in Mapkhae owned animals. This was a result of three factors: (a) tractor plowing making possible some elimination of the draft animal function; (b) manual labor being used extensively on upland crops; and (c) no cart hauling being used. Trucks hauled the large volume of sugar cane while hand and bicycle transportation handled the generally small volumes of the other crops. In Non Som Boon, cattle ownership was restricted to nineteen percent of all villagers. The

FIGURE 2.9 DISTRIBUTION OF CATTLE OWNERSHIP BY SIZE OF HERD IN THREE CASE STUDY VILLAGES.

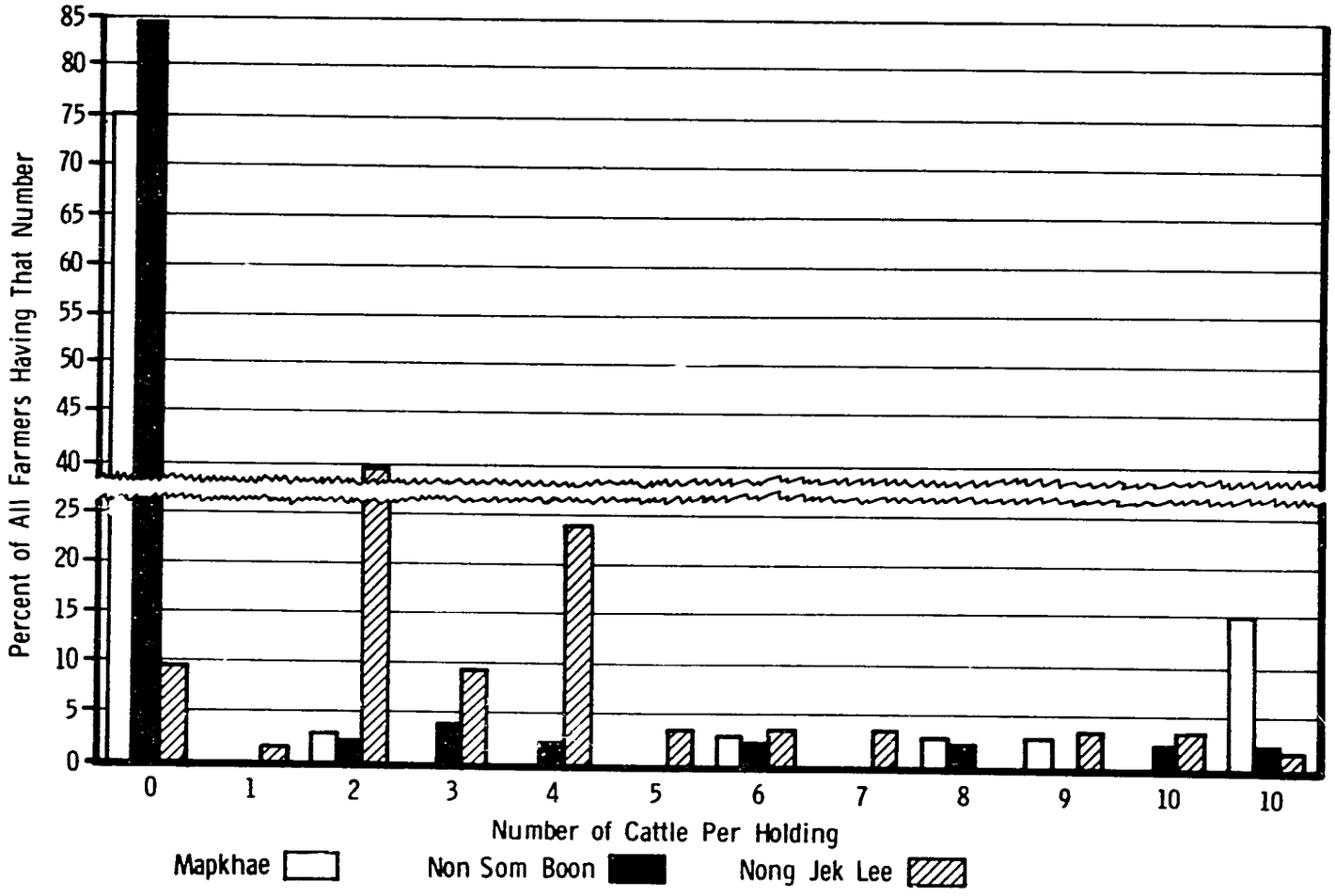
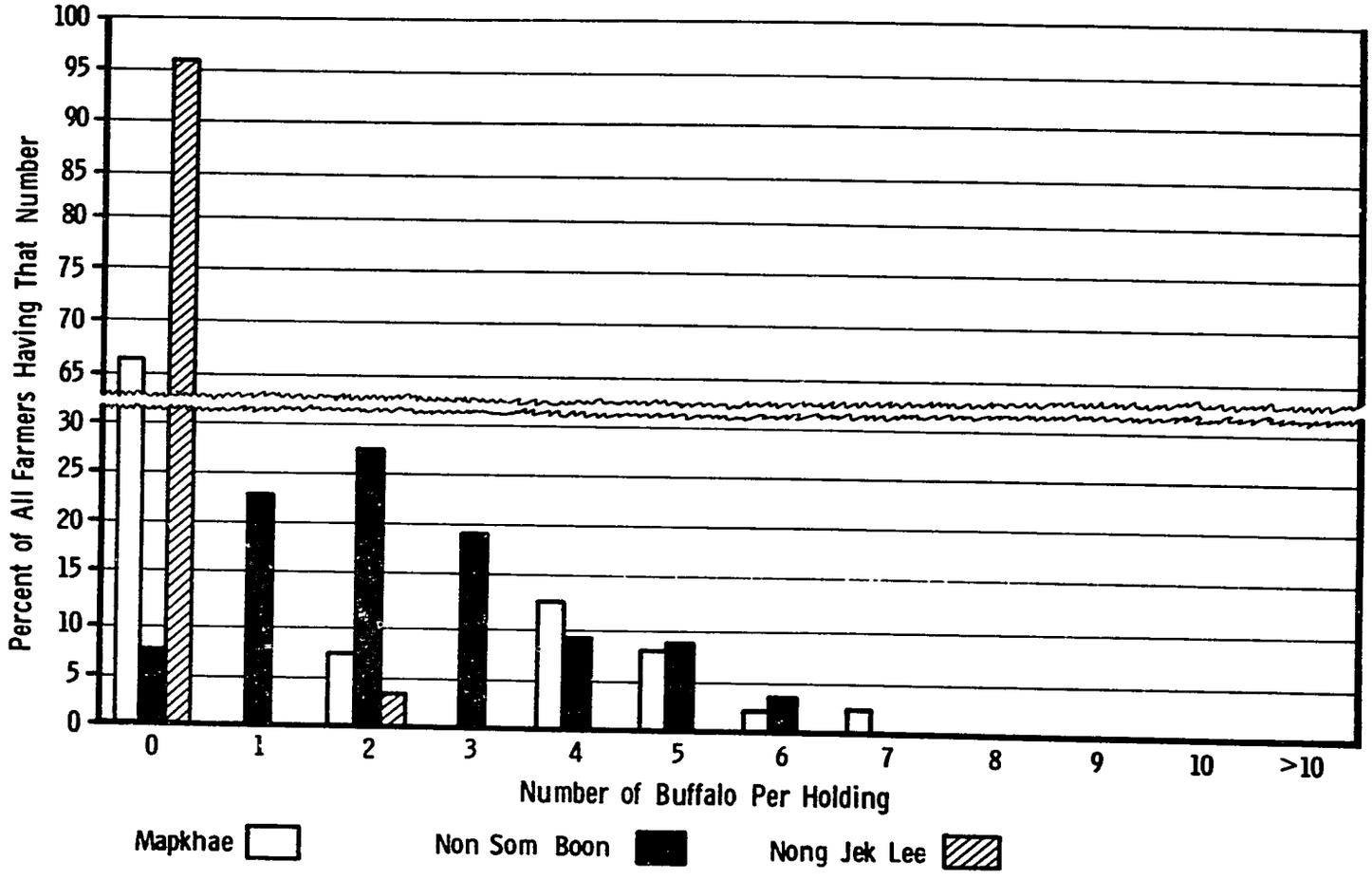


FIGURE 2. 10. DISTRIBUTION OF BUFFALO OWNERSHIP BY SIZE OF HERD IN THE CASE STUDY VILLAGES



apparent reasons were (a) resource restrictions in the form of a heavy buffalo biomass on a heavily cropped village area, and (b) large capital costs for starting a cattle-producing enterprise because of high prices for Brahmin crossbred cattle prevalent in the area. Since cattle were not used for draft purposes in Non Som Boon, all ten producers were producing for sale purposes. The village had almost universal buffalo ownership and those not owning buffalo rented or borrowed them. Water buffalo were the beast of burden and breeding was a secondary enterprise.

Nong Jek Lee cattle ownership patterns parallel those of Non Som Boon for buffalo (about 60% of all farmers holding two to four head) reflecting the prevalent draft power use patterns in each village. The lack of buffalo in Nong Jek Lee is striking. A marked preference for cattle as upland power plus long distances from the housing areas to suitable buffalo wallows was responsible. In Nong Jek Lee, 94 percent of the farmers had 2 or more cattle, even though the availability of tractor hire services was readily available. Cattle were a valuable input in crop production and most farmers still kept them. The small buffalo herd was for supplementing cattle power in rice fields and were always kept in addition to the farmers' cattle.

# Chapter III

# CROP PRODUCTION

## Crop Production Practices

### Mapkhae

The diversity in rice preparation procedures in Mapkhae was due primarily to the uncertainty of rainfall. Farmers who used tractor services for plowing began in April, while those using cattle or buffalo began in late May or early June. The farmers then waited for enough rainfall to begin transplanting. By July, 1970, the fields still were not adequately flooded for transplanting so the fields were plowed a second time by animal power and planting began. When the heavy rains came, the areas not already broadcast were plowed a third time, harrowed, and transplanted. This was not finished until late September by which time the seedlings were so old tillering was reduced. Several farmers never planted their rice fields.

Of the seventeen rice farmers sampled, seven initially plowed by tractor, seven by buffalo, and three by cattle. Although every farmer planted a portion of his land to broadcast rice, it was never done immediately following the first plowing by tractor, but the fields were always replowed by animals prior to planting. Weed growth and soil compaction occuring between initial plowing and planting time necessitated replowing.

Other production inputs were not used. The broadcast rice could not be weeded by hand and the transplanted fields did not require weeding as puddling the soil prior to transplanting achieved adequate weed control. Fertilizer and insecticides were not used on rice.

Rice harvest began in late December. The mature rice was cut by hand, bundled, and carried from the fields to the household areas by hand using sharpened bamboo poles extended across the shoulders. Threshing was by cattle or buffalo treading only. Winnowing was by machine. These simple methods were feasible because of the generally small size of the rice harvest. Carts, trucks, or tractors were not used for hauling. Since the fields were often one-half to one kilometer from the homesteads, hand hauling of a large crop would be impossible. Another reason was the lack of time constraints on other crops. Most sugar cane harvesting did not begin until January, and the harvest of other crops was finished before rice harvest began. Thus the opportunity cost of labor involved in hand transportation and cattle threshing was not high.

Sugar cane production was controlled by a factory quota system. The sugar mill which allocated production quotas in Mapkhae was located in Kanchanaburi. The mill had a number of factory representatives who each received a production quota for a producing area. The factory representative for the area containing Mapkhae was a wealthy woman from a neighboring village. Her functions were to (a) allocate quotas to each village in her area, (b) allocate quotas to individual farmers within each village, (c) set harvest dates, (d) arrange for the provision of cane cuttings for planting and tractor services, and (e) provide credit as needed and collect the debt plus interest at harvest time.

Sugar cane production practices depended on whether the cane was newly planted or ratooned. Seven of the ten cane farmers had some or all new plantings and three had only ratooned cane. The normal procedure for new plantings was field preparation beginning in April. The land was plowed twice by tractor using the standard disc plows. Then the fields were ridged by removing every other disc from the plow. Animal power was not used at any stage of sugar cane production.

Planting was done by cuttings from ratooned fields, one rai of cuttings being adequate for four rai of new plantings. Large labor forces were mobilized for setting the cuttings and for later cultivations by hoe. Setting continued into May and hand cultivation began immediately and continued into September. Fertilizer was applied during this period. The second and third year ratoon crops of cane required only cultivation and fertilization.

In 1970, cane cutting in Thailand began November first. The factory representative set cutting dates in Mapkhae. The two and three year old fields were cut first, followed by new plantings which could be harvested in March or April. Cutting, bundling, and loading on trucks were all done by hand labor. Cutting in this village began after rice production and major labor shortages were avoided.

The magnitude of cash outlays for cane production, particularly in the first year, was usually greater than the farmers' ability to meet them. In these cases, the factory representative would pay for plowing, cuttings, labor, and truck hire. Fertilizer was provided by the factory. As the individual farmer's cane was sold, these expenses were deducted and if all cash costs were paid by the factory representative, a ten baht per ton interest charge was also deducted. At the

1970-1971 cane prices, this was 7.31[1/] per cent interest per year.

Corn and sorghum production procedures were similar for the first crop after which the corn farmers raised a second crop of corn or sweet potato while sorghum farmers continued with a ratoon crop of sorghum. Tractor plowing was done by all farmers in April, followed soon after by hand planting using hoes. Cultivation was in July and August and was also by hand. Harvest began in August and required little hired labor as areas and yields were small. Three farmers in each group hired tractor shellers. Transportation to the merchants on the highway was by hand or bicycle. Animals were not used in any stage of the production process. The second corn crop was replanted immediately after the first by hand methods, cultivated by hoe once in September and harvested in November using the same procedure as the first crop. After the first sorghum crop was harvested, a ratoon crop was grown so animals had to be kept from the fields. The ratoon crop was smaller but required only harvesting and threshing inputs.

Sweet potatoes and taro, planted as a first crop, followed the same patterns. Plowing was by tractor in April, planting by hand in May or June followed by hoeing continuing into September and October. Harvest began in December and proceeded into February. The plants were dug up by spade and transported by basket to sheds where they were sold. Potatoes following corn did not require replowing but were planted by hoe in the corn stubble in August or September. Cultivation continued through November and harvest began in February. The entire corn fields generally were not replanted to sweet potatoes.

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1/ This rate is not an adequate reflection of capital costs because most of these expenses were carried only a fraction of the crop year.

Dryland vegetables were a small proportion of total cropland. Their input sequence followed that of potatoes and taro with initial tractor plowing, hand planting, cultivation, and harvesting.

Table 3.1. summarizes the major input categories and output levels for major crops grown in Mapkhae.

Crop budgeting and production function analyses are presented following the descriptions of the other two case study village crop production systems.

Table 3.1. Summary Measures of Major Crop Input and Output, 1970-71 Crop Season, Mapkhae, Thailand.

| Item | Unit | Rice | Corn | Sorghum | Sugar Cane | Vegetables[d] |
|---|---|---|---|---|---|---|
| | | per rai | | | | |
| Yield | kg. | 44 | 111 | 267 | --- | 514 |
| | m.t. | --- | --- | --- | 8.22 | --- |
| Value | baht | 31 | 108 | 269 | 1,125 | 129 |
| Labor | hours | 38.1 | 93.2 | 169.1 | 308.9 | 351 |
| Animal Power | hours | 20.4 | 0 | 0 | 0 | 0 |
| Cash Cost (a) | baht | 18.8 | 19.3 | 49.6 | 475.5 | 41.5 |
| Crop Capital Charge (b) | baht | 8.3 | 5.7 | 7.1 | 1.7 | 15.2 |
| Land Rent (c) | baht | 47.6 | 62.5 | 50.0 | 104.5 | 43.6 |
| | | per farmer who planted this crop | | | | |
| Area Planted | rai | 21.7 | 6.5 | 3.8 | 13.3 | 6.2 |
| Cane-Old | rai | | | | 8.1 | |
| Cane-New | rai | | | | 5.2 | |
| No. of Farmers | | 17 | 4 | 4 | 10 | 5 |

(a) Includes tractor hire, truck hire, fertilizer, and shelling costs. Excludes hired labor.

(b) Capital assets times a 15% discount rate plus a depreciation charge. This sum was allocated proportionately to crop areas and multiplied by the fraction of the year the crop was grown.

(c) Average land rent by crop time in 1970-1971 crop year at village rental rates.

(d) Sweet potato, taro, and eggplant only.

Non Som Boon

Rice field preparation began in June with the plowing and sowing of nursery fields. Main fields were initially plowed in July and August when the fields were sufficiently wet. Buffalo were used exclusively for all field work in this village. Both males and females were used and work rotation of animals was common, one working in the morning and another in the afternoon.

The second plowing, harrowing, and transplanting started in late July or August depending on the location of the field. Transplanting started in late July or August depending on the location of the field. Transplanting was completed in September. All fields with enough water were transplanted and fields with insufficient water were not broadcast but left fallow, and were grazed if access was available. Weeding and water control work after transplanting were not common and fertilizing and spraying were not done.

Harvesting began from October to late November, depending on the planting date and varietal maturity. No fields were finished before December. Rice was harvested standing upright and was laid in bunches on the stubble. As each field was completed, the bunches were gathered and bound into bundles. The bundles were then hauled by hand to the central threshing floor serving a group of farmers where they were stacked until all fields were done.

Threshing was done by hand exclusively. Northeastern Thai customs prohibit animals or women from rice threshing. The bundles were squeezed between two sticks bound by thongs at one end and slapped on the pile of threshed paddy. Threshed paddy was transported to the storage

sheds by truck. Depending on the size of the crop, one or two trips were made from the field to the house. The paddy was loaded and unloaded by 5 gallon water cans. The remaining space in the truck bed was loaded with rice straw for stacking at the house. The balance, if any, remained at the threshing floor. The truck hauling procedure speeded up the harvesting sequence and permitted easy hauling of the bulky rice straw. Kenaf cutting could then proceed sooner.

Kenaf production procedures were similar for all sampled farmers. Field preparation preceded that of rice. The same tillage implements were used. The initial plowing was followed by broadcast seeding and then a light harrowing to cover the seeds. Plowing began in April or early May and was done before June. Broadcasting and harrowing followed immediately. When the plants reached 4 to 6 inches in height, hand cultivation and thinning began and continued through July. This was the last input until cutting began after the completion of rice harvest in November and December.

Cutting began when the plants turned red, seed pods were fully formed, and the leaves had fallen. The stalks were cut individually, bound into bundles of twenty to thirty plants, and shocked until hauling began following transportation of the paddy. The shocked bundles were loaded on the trucks by the farmer and exchange labor. One truckload contained about 700 to 800 bundles. They were unloaded on the river bluffs by slings. Retting was done exclusively at the Chi River, giving these villagers a quality advantage in that fresh water was continuously available. Most Northeastern villages are dependent on ditches and ponds whose water supply is limited and the stagnant water soon reduces fiber quality.

After unloading, the bundles were again shocked to await retting. Retting proceeded in batches, with the size of the batch depending on the family and hired labor available, but usually was about one truckload. The bundles were hauled down the bank, lashed together into a raft, and sunk in the river by piling dirt on top of the raft. After ten to fourteen days, the raft was brought to the surface, hauled to shore, and fiber separation began. The fiber from a bundle of stalks was gathered in one hand and simultaneously pulled upward and off the core. The fiber was then folded and put in the river to soak until the batch was finished. After soaking, the small fiber bundles were washed in the river and hung to dry on bamboo drying racks for two days. Finally, the fiber was folded and tied into 200 kilogram bundles to await sale.

Watermelons were grown in two seasons. The early season was from April to June and the late season from September to December. Three farmers grew two crops in 1970. The other seven raised only the late season crop. Melons required purchased inputs consisting of seeds, spray, fertilizer, and hired labor. Tractors were not used for plowing as the fields were small enough for buffalo plowing. Tractors were not used for plowing as the fields were small enough for buffalo plowing. Tractors were used in neighboring villages, however, for the plowing of larger melon fields. Plowing for the early melon crop began in April. The soil was still dry, but melons were grown on sandy soils so buffalo plowing was possible. The planting and fertilizing were done in May. Initial fertilizing often included applications of buffalo manure; this was the only instance manure was used in any of the case study villages. After the plants were large enough, hand hoeing and spraying began. The first crop was ready by June. Melons were harvested by the farmer for sale at his home or sold unharvested in the field.

The second crop was planted the following October. Plowing was done during slack periods throughout the summer for the double crop farmers. The single crop farmers began in September and October, and did not fertilize. Planting was followed by cultivation and spraying in October and November. Harvest began early in December. Most late crop melons were sold unharvested in the field. Farmers who did their own harvesting transported the melons to the village or main road by baskets. Those sold in the field were loaded directly onto trucks hired by the merchants. A summary of cropping in Non Som Boon is given in Table 3.2.

Table 3.2. Summary Measures of Major Crop Inputs and Outputs. 1970-71 Crop Season. Non Som Boon, Thailand.

| Item | Unit | Rice | Kenaf Fiber | Watermelon |
|---|---|---|---|---|
| | | Per rai | | |
| Yield | kg. | 185 | 152 | --- |
| | melons | --- | --- | 883 |
| Value | baht | 95 | 347 | 331 |
| Labor | hr. | 88.4 | 141.9 | 51.3[a] |
| Animal Power | hr | 13.9 | 9.3 | 16.7 |
| Cash Costs | baht | 5.5 | 9.0 | 93.1 |
| Crop Capital Charge | baht | 6.0 | 0.9 | 0.3 |
| Land Rent | baht | 42.7 | 40.0 | 50.0 |
| | | per farmer who planted his crop | | |
| Area Planted | rai | 12.9 | 12.9 | 6.2 |
| No. of Farmers | no. | 25 | 26 | 10 |

[a] Watermelons were usually sold in the field so labor requirements are considerably less than if the melons were harvested by the farmers.

Nong Jek Lee

Cropping information was collected only for rice, corn, sorghum and mungbeans. Although some peanuts and soybeans were grown as a second crop following rice between the feeder canal and gravel road, the areas were small and were not harvested until well after the study was completed so they were excluded from analysis.

The rice land was idle beginning in January or May, the latter date being the case if peanuts followed rice. The presence of second crops restricted the paddy land for pasture use. The peanut fields were scattered throughout the lowland areas so access to paddy stubble by animals was often restricted and large, unsupervised grazing herds were uncommon.

Sixteen of the thirty-five sample farmers used tractors for the initial paddyland plowing, which began in April at the same time as corn plowing. Farmers initially plowing with animals began in May or early June. Nursery fields were replowed and harrowed predominantly with cattle teams, but two farmers used buffalo and one used a large tractor for puddling. The plowing and harrowing were done in the morning and transplanting followed in the afternoon of the same day. Farmers were not uniform in their use of other inputs. Eleven of the thirty-five fertilized and seven sprayed for insects. Most did limited amounts of weeding, grass cutting, and field irrigation after the completion of transplanting.

Harvest began in December in the drier rice fields and two weeks later for the others and continued into early February in the larger fields. Preparation for harvesting consisted of dragging a large bamboo pole over the rice to flatten it for easier harvest. Then

it was cut by hand scythe, bundled and transported to a central threshing floor at the field or at the farmer's house by tractor, truck or cattle drawn carts. The majority threshed in their fields and then transported the paddy and straw to their storage sheds. Threshing was done by cattle or tractors, but no clear indication of reasons for using one method or the other was found. Tractor threshing was much faster as a tractor was driven rapidly in a circle on the bundles until the paddy was removed, which required one and one-half to two hours for a tractor cart load. Then the straw was shaken out and piled at the edge of the threshing circle. Paddy was raked into a pile and scooped into a winnow machine which cleaned out dust, stones, and straw. Then it was stored. If threshing was done in the field, the rice was scooped into the tractor cart, truck or animal cart for transportation. The straw was loaded on top of the paddy or piled on the tractor platforms.

The first plowing for corn began at the same time as rice, and only two farmers did not use tractors. Soon after initial tractor plowing, most farmers replowed with a pair of cattle and planted directly behind the plow with a dibble stick. Cultivation began two weeks later, with the cattle plow and was often supplemented by hand hoeing. Harvest was in August or early September. Hand picking was followed by hauling with tractors if the area was dry or with cattle carts if the area was wet. The corn was partially dried in sheds, houses, or the village meeting house or on open cement floors or canvas tarps. Shelling was by tractor mounted, power take-off driven shellers or stationary rigs. Selling was usually done at the shelling area with further drying and handling done by the merchant.

Farmers who followed corn with mungbeans replowed the corn stubble immediately after picking. The seeds were then broadcast into the freshly plowed soil. Spraying followed in six weeks and was repeated once or twice at two week intervals. Animal power was used for hauling only in one case. In November, the plants were uprooted, gathered into bundles and placed on both ends of a sharpened bamboo pole for carrying across the shoulders. When all the farmers' bundles were assembled at the threshing floor, they were then scattered on the floor and threshed by tractor. The vines were shaken out and the beans winnowed by shaking wooden baskets suspended on tripods.

The summary data for the input and output in the 1970-1971 crop season is presented in Table 3.3.

Table 3.3. Summary Measures of Major Crop Input and Output, 1970-71 Crop Season, Nong Jek Lee, Thailand.

| Item | Unit | Rice | Corn | Sorghum[b] | Mung Beans |
|---|---|---|---|---|---|
| | | ----------per rai---------- | | | |
| Yield | kg. | 325 | 420 | 51 | 103 |
| Value | baht | 241 | 386 | 42 | 204 |
| Labor | hr. | 89.6 | 44.3 | 7.1 | 69.9 |
| Animal Power | hr. | 12.9 | 8.6 | 0 | 0.3 |
| Cash Costs | baht | 48.0 | 33.8 | 26.7 | 32.7 |
| Crop Capital Change | baht | 17.8 | 8.0 | 32.2 | 5.0 |
| Land Rent | baht | 75.1 | 53.4 | 60.0 | 27.0 |
| | | -----per farmer who planted this crop----- | | | |
| Area Planted | rai | 29.0 | 15.3 | 5.5 | 13.9 (a) |
| No. of Farmers | no. | 35 | 28 | 2 | 24 |

(a) Second crop after corn.

(b) Very low sorghum yields were the result of a serious shoot-fly infestation.

## Individual Crop Production Functions

### Functional Forms

Crop production inputs of the sampled farmers in each case study village were summarized in Tables 3.1., 3.2., and 3.3. Input data was compiled for each farmer and for each crop sown. Six major input categories were used. Planted crop area was total area sown as estimated by the farmers. Rent value by crop was estimated by farmers in most cases as almost all land was operator-owned and land rental markets were not well developed. Total labor inputs were in hours worked by all labor categories -- family, hired, relatives, and reciprocal labor. Draft animal inputs were hours worked per team for cattle and hours worked per individual animal for buffalo. All animal tasks were included. Cash costs included tractor and truck hire, fertilizer, spray, and shelling costs. It excluded hired labor, hired draft power, and land rent charges. Crop capital charges were computed from the inventory of crop production assets owned by each farmer. Typically, these assets included one or more wood, steel-tipped plows, a harrow, seed inventories, a winnowing device, and hand tools. In Hong Jek Lee, cart ownership was common and several farmers owned tractors, and tractor-mounted equipment. The capital inventory included two charges. The first was a capital charge equal to the present value of the asset multiplied by a 15 per cent interest rate. The second was a straight line depreciation charge applied to each asset. Tractors were charged as a cost only on the percentage of time used on the owner's fields.

Crop output for individual crop analysis was measured in total kilograms of harvested grain or vegetables except for watermelons, which were measured as a total number of harvested melons.

Means and standard deviations of the inputs and outputs on a per farm and per rai basis are summarized for each major crop in each village in Appendix A.

These data were then used for three purposes:

1. To measure the productivity of crop production inputs as a prerequisite for further analysis of the village livestock system;
2. To test if rational economic behavior was an adequate guide to behavior in the crop production sector; and
3. To construct crop budgets indicating the profitability of various crops to serve as a guide for comparisons of profitability between the crop and livestock production enterprises.

Analysis of the first two require a crop production function. The functional form was not specified a priori but instead several different functional forms were estimated using various groupings of the inputs. The two major input-output groupings for individual crop analysis were per farm observations and per unit of area observations. The first used totals of outputs and inputs as observations while the second divided inputs and outputs by planted area (in rai). Functions using the second grouping often included planted area as a variable to test for scale effects on per rai yields.

Functional forms were of the linear, quadratic, and Cobb-Douglas types. In general, each of these functions was fitted both with per farm and per unit of planted area observations.

The functional forms and variable groupings are presented below, excluding the land rent variable.

O = output, in kilograms of grain, fiber, or vegetables, or number of melons.

a = constant term.

L = rai planted.

N = labor hours.

A = animal team hours.

K = capital in baht.

C = cash cost in baht.

$U_c$ = random disturbance term, assumed to be independently distributed with zero mean and finite variance.

The representative functions are:

Linear per farm

$$O_c = a + b_1 L + b_2 N + b_3 A + b_4 K + b_5 C + U_c$$

Linear per rai

$$\frac{O_c}{L} = a + b_2 \frac{N}{L} + b_3 \frac{A}{L} + \frac{K}{L} + b_5 \frac{C}{L} + U_c$$

Linear per rai plus land

$$\frac{O_c}{L} = a + b_2 \frac{N}{L} + b_3 \frac{A}{L} + \frac{K}{L} + b_5 \frac{C}{L} + U_c$$

Cobb-Douglas per farm

$$O_c = a L^{b_1} N^{b_2} A^{b_3} K^{b_4} C^{b_5} U_c$$

Cobb-Douglas per rai

$$\frac{O_c}{L} = a \frac{N}{L}^{b_2} \frac{A}{L}^{b_3} \frac{K}{L}^{b_4} \frac{C}{L}^{b_5} U_c$$

$$\frac{O_c}{L} = a \frac{N}{L}^{b_2} \frac{A}{L}^{b_3} \frac{K}{L}^{b_4} \frac{C}{L}^{b_5} L^{b_6} U_c$$

Quadratic per Farm

$$O_c = a + b_1L + b_2L^2 + b_3N + b_4N^2 \ldots + U_c$$

The $\sum_{i=1}^{n} b_i$ for n factors is the returns to scale for the Cobb-Douglas function. On the "per rai" functions, it implies the percentage increase in output from increasing all inputs 1 per cent on the same amount of land.

Marginal productivities of the functions indicate the change in output forthcoming from a one unit increase in input use. For the linear functions it is $b_1, b_2, \ldots b_5$, for the Cobb-Douglas function it is $b_1 \frac{\overline{O}}{\overline{L}}, b_2 \frac{\overline{O}}{\overline{N}}, \ldots, b_5 \frac{\overline{O}}{\overline{C}}$ where the bars represent geometric means and for quadratic functions it is $b_1 + 2b_2\overline{L}, b_3 + 2b_4\overline{N}, \ldots, b_9 + 2b_{10}\overline{C}$ where the bars represent authentic means. Marginal value products are obtained by multiplying these marginal value productivity estimates by product prices.

Mapkhae

Results of the rice analysis were strongly influenced by drouth conditions over the study period and generally poor soils for rice production purposes. Scattered areas of rice were left unharvested due to the above factors plus infestations of yellow-orange leaf virus. Sugar cane provided high profits and resource productivities but expansion was limited by quota allocations. Corn also produced poorly relative to Nong Jek Lee in the Central Highland (111 kg/rai in Mapkhae compared to 420 kg/rai in Nong Jek Lee and a national average in 1966 of 275 kg/rai) while sorghum did much better (266 kg/rai in Mapkhae compare to 51 kg/rai in Nong Jek Lee and the 1966 national average of 264 kg/rai Sugar cane production averaged 8.22 tons per rai, well above the nationa average in 1966 of 5.0 tons per rai. Comparable national averages of Indonesia and the Philippines for the 1963-1967 period were 7.0 and 14.2 tons per rai of cane respectively.

Crop budgets are estimated in Table 3.4. Coefficients of selected production functions along with their standard errors, constant terms, and coefficients of multiple determination are given for Mapkhae crops in Table 3.5. The data for corn and sorghum were pooled with the data from Nong Jek Lee for production function analysis as the number of observations in Mapkhae were insufficient for reliable results.[1/] Corn and sorghum were analyzed together as the production process was similar. However, separate budgets were constructed for each crop in each village.

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[1/] Pooling the data was appropriate as it was judged that yield differences were a function of soil and environmental conditions rather than levels of inputs applied.

Table 3.4. Crop Budgets, Mapkhae.

| Crop | Rice | | Corn | | Sorghum (1) | | Sugar Cane | | Sweet Potato, Taro, Eggplant | |
|---|---|---|---|---|---|---|---|---|---|---|
| Unit | Baht | % | Baht | % | Baht | % | Baht | % | Baht | % |
| Land @ Rent Value | 47.64 | 29.47 | 62.50 | 34.59 | 50.00 | 16.90 | 104.50 | 11.46 | 72.50 | 15.10 |
| Labor @ baht 1/hr. | 38.08 | 23.56 | 93.22 | 51.59 | 189.11 | 63.93 | 308.88 | 33.88 | 351.01 | 73.11 |
| Draft Power @ baht 2.4/ hr. | 48.86 | 30.23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cash Cost | 18.80 | 11.63 | 19.28 | 10.67 | 49.61 | 16.77 | 475.46 | 52.15 | 41.46 | 8.64 |
| Crop Capital Charge | 8.27 | 5.11 | 5.68 | 3.15 | 7.10 | 2.40 | 22.89 | 2.51 | 15.17 | 3.15 |
| Total Cost per Rai | 161.65 | 100 | 180.68 | 100 | 295.82 | 100 | 911.73 | 100 | 480.14 | 100 |
| Total Revenue per Rai | 30.68 | --- | 107.57 | --- | 269.33 | --- | 1124.89 | --- | 129.46 | --- |
| Profit per Rai | -130.97 | --- | -73.11 | --- | 26.49 | --- | 213.16 | --- | -350.68 | --- |
| Total Cost per kg. (2) | 3.64 | --- | 1.623 | --- | 1.109 | --- | 110.92 | --- | 1.53 | --- |
| Price per kg.(2) | 0.69 | --- | 0.966 | --- | 1.01 | --- | 136.85 | --- | .43 | --- |
| Profit per kg. (2) | -2.95 | --- | -.657 | --- | -.099 | --- | 25.93 | --- | -1.10 | --- |

(1) Includes rattoon crop. (2) Per ton for sugarcane.

Table 3.5. Summary of Crop Production Functions, Mapkhae.

Mapkhae: Production Function Analysis Summary.

| Crop | Rice | Rice | Rice | Sugarcane | Sugarcane | Potato, Taro Eggplant | Potato, Taro, Eggplant |
|---|---|---|---|---|---|---|---|
| Functional Form | Linear Per Farm | Linear Per Farm | Cobb-Douglas per Farm | Cobb-Douglas per Rai + Planted Area | Cobb-Douglas per Farm | Linear per rai + Planted Area | Cobb-Douglas per Farm |
| $R^2$ | .71440 | .61037 | .89865 | .87387 | .92409 | .92174 | .95082 |
| Degrees of Freedom | 10 | 13 | 11 | 5 | 6 | 1 | 2 |
| Constant Term | 411.52 (1876.82) | 88.89 (248.97) | 486.10 (10.69) | 0 | 0 | -1721.68 (706.96) | 0 |
| Planted Area | 35.09(f) (35.63) | 19.458(d) (12.486) | 1.608(b) (.616) | 1.996(b) (.693) | 1.199 (1.403) | 115.54(e) (46.21) | |
| % Broadcast Rice of Total | -367.37 (1964.00) | | | | | | |
| Labor | .097 (.607) | .347(e) (.282) | -.050 (.428) | 2.205 (2.407) | 2.414(c) (1.059) | .699(d) (.204) | .761(c) (.211) |
| Draft Power | .970(d) (.671) | | -.462(f) (.485) | | | | |
| Capital Charge | .309 (.962) | .929(f) (.914) | .735(b) (.326) | -.669(f) (.604) | -.649(e) (.521) | | |
| Cash Cost | -1.486 (2.733) | | -.437(f) (.498) | .184 (1.85) | | 1.143 (3.177) | .919(c) (.308) |
| Rent | | | | | | 16.188(e) (5.711) | 4.596(c) (1.241) |
| Returns to Scale | n.a.(1) | n.a.(1) | 1.394 | 1.720 | 2.964 | n.a.(1) | 6.276 |

(1) n.a. = not applicable to this type of function.

(2) Probabilities the estimated coefficients are significantly different from 0 are as follows: a = .99, b = .95, c = .90, d = .80, e = .70, f = .60.

The budgets indicated the presence of losses on most crops when labor was valued at prices prevalent during peak demand periods. Since all of these crops, with the exception of broadcast rice, were relatively labor intensive, very low returns to labor when valued as a residual were expected. The production function analysis tended to bear this out. Also of interest was the limited use of draft animals in this area. All upland crops used tractors for initial plowing and further land preparation was then by hand tools.

A major shortcoming of budget construction was lack of accurate rental values. The predominant pattern of owner-operated farms made it difficult to estimate rents. When land was rented, the rent was often in kind and thus subject to commodity price fluctuations in the calculation of rents. An alternative was to assign rent value as a residual but this has several shortcomings.

Production function analysis of individual crops was of limited value in estimating resource productivities in Mapkhae. Number of observations on each crop was small and consequently the degrees of freedom were limited, particularly for the non-rice crops. Standard errors were large in most cases, particularly for cash costs. An attempt was made to adjust for lower yields of broadcast rice by including broadcast rice as a percentage of rice area planted as a variable. However, the coefficient was not significant.

Coefficients of linear functions can be interpreted as marginal physical products while coefficients of Cobb-Douglas functions represent production elasticities. Thus the second function estimated for rice in Table 3.5. indicates the addition of one rai of rice land

increases rice production by only 19.458 kilograms, an additional one hour of labor adds .347 kilograms of rice and an additional one baht of crop production capital investment increased rice output .929 kilograms. With rice prices less than one baht per kilogram, these results indicate excess use of inputs since input marginal value productivity (marginal physical product times output price) is less than input price. Cobb-Douglas results for rice were poor as three input groups had negative coefficients. Sugar cane functions indicated a negative relation between capital charges and output for both per rai and per farm functions. Labor was being efficiently used with marginal value productivities being close to one baht per hour (the wage rate). Labor use appears excessive for both vegetable functions although the small number of degrees of freedom make inferences from the results difficult. Cash costs would also appear excessive as marginal physical products were close to one, product price about one-half baht so marginal value products would be about one-half the wage rate. However, the use of family labor was particularly heavy on these crops and lower wage rates probably would be more relevant to adjust for children and women doing the bulk of hoeing and harvesting.

Non Som Boon

Table 3.6., the crop budgets, indicated a more even distribution of inputs between the three crops studied than in Mapkhae. Production costs per unit of output were more in line with historical prices received and the losses sustained on rice reflected a major drop in glutinous rice prices caused by several years of overproduction in the major producing areas. Kenaf profits were substantial with the good

Table 3.6. Crop Budgets, Non Som Boon.

| Crop | Rice | | Kenaf | | Watermelon | |
|---|---|---|---|---|---|---|
| Unit | Baht | % | Baht | % | Baht | % |
| Land @ Rent Value | 42.69 | 20.69 | 40.01 | 15.69 | 50.00 | 19.41 |
| Labor @ Baht 1.25 Per Hour | 110.48 | 53.55 | 177.38 | 69.54 | 64.09 | 24.88 |
| Draft Power @ Baht 3 Per Hour | 41.67 | 20.20 | 27.78 | 10.89 | 50.04 | 19.43 |
| Cash Costs | 5.47 | 2.65 | 8.99 | 3.52 | 93.10 | 36.15 |
| Crop Capital Charge | 6.01 | 2.91 | 0.90 | 0.36 | 0.33 | 0.13 |
| Total Cost Per Rai | 206.32 | 100 | 255.06 | 100 | 257.56 | 100 |
| Total Revenue Per Rai | 95.24 | --- | 346.62 | --- | 330.77 | --- |
| Profit Per Rai | -111.08 | --- | 91.56 | --- | 73.21 | --- |
| Total Cost Per Kg. (2) | 1.11 | --- | 1.68 | --- | 0.29 | --- |
| Price Per Kg. (2) | 0.51 | --- | 2.28 | --- | 0.37 | --- |
| Profit Per Kg. (2) | -0.60 | --- | 0.60 | --- | 0.08 | --- |

(1) Data includes early and late watermelon crops. (2) Per melon for watermelons.

price reflecting a strong world market. Watermelon profits per rai were large relative to the other crops grown.

Table 3.7. summarizes the results of the production function analysis. The production function coefficients were generally positive and significant. The negative coefficient for planted area in the per rai function for kenaf indicated diseconomies of scale as did the returns to scale figure, excluding the land variable. Draft power was an important input in all crops reflecting the absence of tractor plowing and villagers' dependence on their water buffalo for all land preparation purposes.

Rice yields were slightly under the all Northeast average, and kenaf yields are well above it, while no data for comparison were available for watermelons.

Labor productivities were low with the exception of watermelons. Marginal value productivities were .1 to .54 for rice and kenaf but 2.7 for watermelon. A similar pattern emerged for draft power and capital charges. This reflects the introduction of a new crop where resource use has not yet reached equilibrium levels. Cash cost productivities were high and reflected the general shortage of cash in this village.

The individual crop functions in Non Som Boon gave more reliable and plausible results than those in Mapkhae. More observations were available, crop production practices were more uniform, and yield variations were not as great.

Table 3.7. Summary of Crop Production Functions, Non Com Boom.

| Crop | Rice | Rice | Kenaf | Kenaf | Watermelon | Watermelon |
|---|---|---|---|---|---|---|
| Functional Form | Linear per Rai + Planted Area | Cobb-Douglas per Farm | Linear per Farm | Cobb-Douglas per Rai + Planted Area | Linear per Rai | Cobb-Douglas per Farm |
| $R^2$ | .67479 | .64150 | .88581 | .6804 | .39973 | .73357 |
| Degree of Freedom | 19 | 21 | 20 | 20 | 5 | 5 |
| Constant Term | -86.89 (75.70) | 4.58 (3.05) | 206.197 (178.742) | 26.40 (2.17) | -3002.74 (2361.79) | 3.37 (11.41) |
| Land | 5.30(c) (2.79) | .250(d) (.169) | 22.755(e) (17.985) | -.167(d) (.104) | | |
| Seed Cost | | | | | 173.01(e) (128.27) | .383 (.502) |
| Labor | .208 (.418) | .334(c) (.190) | .167(f) (.163) | .265(d) (.171) | 7.45 (12.84) | .021 (.718) |
| Draft Power | 3.64(d) (2.75) | .212(f) (.209) | 2.58(d) (1.59) | .101(f) (.115) | 27.56(e) (21.76) | .961(d) (.601) |
| Capital Charge | 6.01(d) 4.52 | | 11.85(f) (11.54) | .080(f) (.078) | 1426.95(e) (1216.29) | |
| Cash Cost | 8.69(d) (6.22) | .299(c) (.174) | 6.12(b) (2.54) | .313(b) (.148) | | |
| Rent | 1.16(f) (1.51) | | | | | .173 (.426) |
| Returns to Scale | n.a.(1) | 1.095 | n.a.(1) | .590 | n.a.(1) | 1.538 |

(1) n.a. = Not applicable to this type of function

(2) Probabilities the estimated coefficients are significantly different from 0 are as follows: a = .99, b = 95, c = 90, d = 80, e = 70, f = 60.

Nong Jek Lee

The crop budgets in Table 3.8. indicate generally higher levels of inputs and outputs in this village than the other two. Corn and mung beans were raised only for sale so the substantial areas in these crops coupled with the large revenue generated per rai meant large cash transactions within Nong Jek Lee.

The utilization of large tractors in the village for plowing, hauling, shelling, and threshing activities in addition to their non-uniform pattern of use between sampled farmers caused problems in production function estimation. This is apparent in the labor and capital coefficients obtained in the production function analysis, shown in Table 3.9. Generally yield per rai did not vary by size of farm, and so total output and hence total revenue per farm varied directly by size. Large farms tended to use tractors while small farms tended to use labor and animal power. Thus negative but significant labor coefficients and large positive capital coefficients resulted from the per farm functions. Estimating functions on a per unit of area basis did not improve results significantly. The allocation of tractors as capital, even after adjusting for hiring out of part of the tractor services, still caused large variations in the capital charge assigned to owners and non-owners of tractors and, in general, this variable was of little help in estimating production relationships.

Labor marginal value productivities were about equal to wage rates for the Cobb-Douglas functional forms but were much lower in the linear functions. The same pattern was found for draft power. Cash cost productivities were much higher for upland crops than for

Table 3.8. Crop Budgets, Nong Jek Lee.

| Crop | Rice | | Corn | | Sorghum[1] | | Mung Beans | |
|---|---|---|---|---|---|---|---|---|
| Unit | Baht | % | Baht | % | Baht | % | Baht | % |
| Land @ Rent Value | 75.14 | 23.93 | 53.40 | 28.50 | 60.00 | 46.30 | 27.00 | 15.84 |
| Labor @ Baht 1.50 Per Hour | 134.40 | 42.79 | 66.39 | 35.43 | 10.70 | 8.26 | 104.79 | 61.49 |
| Draft Power @ Baht 3 Per Hour | 38.73 | 12.33 | 25.80 | 13.77 | 0 | | 0.87 | 0.51 |
| Cash Costs | 48.01 | 15.29 | 33.75 | 18.01 | 26.73 | 20.62 | 32.72 | 19.20 |
| Crop Capital Charges | 17.77 | 5.66 | 8.04 | 4.29 | 32.17 | 24.82 | 5.04 | 2.96 |
| Total Cost Per Rai | 314.05 | 100 | 187.38 | 100 | 129.60 | 100 | 170.42 | 100 |
| Total Revenue per Rai | 240.90 | --- | 386.42 | --- | 42.00 | --- | 204.38 | --- |
| Profit Per Rai | -73.15 | --- | 199.04 | --- | -87.60 | --- | 33.96 | --- |
| Total Cost Per Kg. | 0.97 | --- | 0.45 | --- | 2.54 | --- | 1.65 | --- |
| Price Per Kg. | 0.74 | --- | 0.92 | --- | 0.82 | --- | 1.98 | --- |
| Profit Per Kg. | -0.23 | --- | 0.47 | --- | -1.72 | --- | 0.33 | --- |

(1) 2 observations only Crop not rattooned.

Table 3.9. Summary of Crop Production Functions, Nong Jek Lee.

| Crop | Rice | Rice | Corn, Sorghum | Corn, Sorghum | Mung Bean | Mung Bean |
|---|---|---|---|---|---|---|
| Functional Form | Linear per Farm | Cobb-Douglas per Farm | Linear per Rai + Planted Area | Cobb-Douglas per Farm | Cobb-Douglas per Farm | Linear per Rai + Planted Area |
| $R^2$, | .87990 | .61036 | .38208 | .85911 | .85092 | .65911 |
| Degrees of Freedom | 30 | 30 | 32 | 33 | 18 | 17 |
| Constant Term | -34.72<br>(978.97) | 28.00<br>(3.01) | 62.113<br>(90.249) | 28.21<br>(1.57) | 72.00<br>(8.28) | -13.196<br>(35.213) |
| Planted Area | 272.23[a]<br>(57.44) | | 4.91[c]<br>(2.57) | .278[d]<br>(.195) | | -.879[c]<br>(.506) |
| Labor | .072<br>(.532) | .350[c]<br>(.194) | .375[f]<br>(.433) | .113[e]<br>(.095) | -.067<br>(.128) | -.183[b]<br>(.087) |
| Draft Power | 1.70<br>(2.38) | .041<br>(.049) | 9.80[a]<br>(2.96) | .076[a]<br>(.027) | .023[e]<br>(.020) | 7.902[c]<br>(4.393) |
| Capital Charge | | | -1.70<br>(2.45) | | | -3.824[b]<br>(1.750) |
| Cash Cost | .531<br>(.817) | .198[d]<br>(.131) | 3.62[c]<br>(2.17) | .546[a]<br>(.122) | 1.02[a]<br>(.130) | 5.323[a]<br>(1.126) |
| Rent | | .223[d]<br>(.145) | | | -.726[e]<br>(.560) | |
| Returns to Scale | n.a.[1] | 0.812 | n.a.[1] | 1.013 | 0.250 | n.a.[1] |

(1) n.a. = Not applicable to this type of function.

(2) Probabilities the estimated coefficients are significantly different from 0 are as follows: a = .99, b = .95, c = .90, d = .80, e = .70, f = .60.

rice. Capital charge coefficients were negative for the functions in which they were included, reflecting problems outlined above. Draft power results were poor for rice since substantial substitution of tractors was occuring. Results were better for corn and sorghum while such small amounts of draft power were used for mung beans that draft power productivities have little meaning for this crop. Large draft power coefficients for corn and sorghum reflected increased yields occuring from animal cultivation.

## Whole Farm Production Functions

### Aggregation Procedures

A problem arose in estimating individual crop production relationships when other crops were simultaneously being produced. Because resources were being allocated between several enterprises, constraints arose more often in the use of one or more factors of production. An analysis of the value of draft animals must include their contribution to all enterprises. Thus a whole farm production function aggregating each farmer's total inputs and outputs was necessary. Inputs were aggregated over all crops and outputs were aggregated by total value. Input productivity measures for draft animals are examined in the following sections.

The procedure used was the estimation of the marginal value productivities (MVP) for each input. For the linear functions, MVP = $b_i$; for the quadratic function, MVP = $b_i + 2b_i\overline{X}_i$ where $\overline{X}$ is the arithmetic mean level of the i th input; and for the Cobb-Douglas function MVP = $b_i\overline{Y}\ \overline{X}_i$ where the means are geometric means. The MVP's are directly obtainable from the production function because the dependent variable is in value terms while the independent variables are in physical terms for land, labor and draft power and value terms for rent, capital, and cash cost (7).

Assuming cost minimizing behavior by the farmer and no resource constraints, each factor will be used up to the point at which the MVP of that resource equals its marginal factor cost (MFC), or price. The average price of the input in the village was used as the

marginal factor cost. If input restrictions are ignored, a ratio of one indicates the farmer has allocated the resource so its returns are just paying for its cost. A ratio less than one implies excess use of the resource and a ratio greater than one indicates a constraint on the resource preventing optional levels of use.

To test if the regression coefficients obtained were significantly different from b values which would give marginal physical products that equated MVP/MFC = 1, a t test was performed The required b values for the two functional forms, where X and Y are inputs and outputs and P are prices, are

Linear Function:

$$\frac{MPPx_i Py}{MFC} = 1, \text{ or}$$

$$b_i \frac{Py}{Px} = 1 \text{ so } b_i \text{ (required)} = \frac{Px}{PY}$$

Cobb-Douglas Function:

$$\frac{MPPx_1 Py}{MFC} = 1,$$

$$\frac{b_i(\overline{Y}/\overline{X})Py}{Px} = 1, \; b_i \text{ (required)} = (Px/Py)\,(\overline{X}/\overline{Y})$$

The appropriate t test was

$$t = \frac{b_i \text{ required} - b_i \text{ obtained}}{\sqrt{\text{var } b_i}}$$

where linear function variance = (standard error)$^2$ and Cobb-Douglas variance = $(\overline{Y}/\overline{X})^2$ (standard error)$^2$.

Mapkhae

Whole farm production functions were initially fitted using observations from all twenty-two farmers selected. The presence of high values produced on a per farm and a per rai basis by the sugar cane producers biased the results heavily toward labor and cash cost and gave negative productivities for land and draft power.

Therefore, functions were estimated by dropping farmers who used no animal inputs on any crop. This brought significant improvements in first order correlation matrices, regression results, and allocative efficiency analysis. A comparison of the correlation coefficient matrices for output-inputs and inputs-outputs is presented in Appendix B, Tables 1-4.

By eliminating farmers who used no animal power, correlations between total value produced and total draft power changed from -.25333 to .5114 and, in the per rai table, improved from -.51635 to .11069. A similar improvement occured between labor inputs and draft inputs as was expected because of the harrowing--transplanting relationship in rice production, the only animal-using crop enterprise.

Production functions of the arithmetic type gave more consistent results than the other functional farms in Mapkhae, both on a per farm and per rai basis. However, the negative land coefficients indicated per unit of area functions would be more logical. Quadratic functions also gave good results, but limited the degrees of freedom available. Linear per farm and quadratic per farm functions are summarized in Table 3.10., after non-users of draft animals were dropped from the analysis. Function two, a quadratic function adding capital and omitting

Table 3.10. Summary Measures of Efficiency Analysis, Maplkhae, 1 and 2.

1. Linear Per Farm: Only Farmers Using Draft Animal Power

$$(1) \quad V = 67.812 - 84.395L - .116N + 2.392A + 2.152C + .882R$$

$$R^2 = .95007$$

| Variable | Coeff. | S.e. | S.1.[1] | Ratio: $\frac{MVP}{MFC}$ | S.1.[2] |
|---|---|---|---|---|---|
| Planted Area (L) | -84.395 | 25.490 | 0.98 | -1.455 | 0.99 |
| Labor (N) | -0.116 | 0.584 | 0.10 | -0.116 | 0.90 |
| Draft Power (A) | 2.392 | 1.293 | 0.80 | 0.997 | 0.01 |
| Cash Cost (C) | 2.152 | 0.390 | 0.99 | 2.152 | 0.95 |
| Land Rent (R) | 0.882 | 0.461 | 0.90 | 0.882 | 0.01 |

[1] S.1. refers to the probability the estimated coefficient is significantly different from 0.

[2] S.1. here refers to the probability the coefficient required to equate MVP and MFC is not equal to the coefficient actually computed.

2. Quadratic Per Farm: Only Farmers Using Draft Animal Power

$$(2) \quad V = -126.317 + 39.277L - 1.157L^2 + .155N - .00015N^2 - 3.505A + .004A^2 + 3.465K - .008K^2 + 3.861C - .00043C^2$$

$$R^2 = .99575$$

| Variable | Coeff. | s.e. | s.1.[1] | Ratio: $\frac{MVP}{MFC}$ | s.1.[2] |
|---|---|---|---|---|---|
| Planted Area (L) | 39.277 | 93.706 | 0.20 | -.530 | not possible to compute in quadratic functions |
| Planted Area$^2$ | -1.157 | 0.991 | 0.60 | | |
| Labor (N) | 0.155 | 2.957 | 0.01 | -.348 | |
| Labor$^2$ | -0.00015 | 0.0007 | 0.10 | | |
| Draft Power (A) | -3.505 | 5.747 | 0.40 | .290 | |
| Draft Power$^2$ | 0.004 | .003 | 0.70 | | |
| Capital (K) | 3.465 | 5.514 | 0.40 | -.391 | |
| Capital$^2$ | -0.008 | 0.005 | 0.70 | | |
| Cash Cost (C) | 3.861 | 1.726 | 0.80 | 2.772 | |
| Cash Cost$^2$ | -0.00043 | 0.00037 | 0.60 | | |

land rent gave the highest $R^2$ values and the logically correct sign on all coefficients except draft power. However, poor significance levels on most coefficients and poor values of factor allocation ratios made the function of limited value.

The linear function obtained by converting the variables to a per unit of area basis gave the best results in the efficiency analysis, shown as function 4 in Table 3.11. This formulation avoided the negative productivity of the planted area variable found in equation 1 of Table 3.10. All marginal productivities were positive and all except animal power significantly different from 0 at the 70 per cent confidence level or higher. The improvement of results obtained by eliminating from the analysis non-users of draft animal power is illustrated by comparing equations 3 and 4, Table 3.11. Despite the loss of 9 degrees of freedom, the plausibility and reliability of the results improved.

The results obtained from function 4 were used as the basis for further analysis of resource productivities. The conclusions concurred with those expected. Labor and draft animals were being used relatively efficiently, though probably beyond the optimum cost minimizing mix, while cash costs were still not used up to their optimum level due to capital shortages and a general shortage of cash income in this village. Capital shortages were also indicated by the MVP/MFC ratio for capital derived from equation 2, Table 3.10. Land rent appears to reflect underlying land productivities well.

Table 3.11. Summary Measures of Efficiency Analysis, Mapkhae

(3) All Farmers: Linear Per Rai

$$(3)\quad \frac{V}{L} = -8.152 + .093\,\frac{N}{L} - 1.283\,\frac{A}{L} + 2.077\,\frac{C}{L} + .852\,\frac{R}{L}$$

$R^2 = .97981$

| Variable | Coeff. | s.e. | s.l.(1) | Ratio: $\frac{MVP}{MFC}$ | s.l.(2) |
|---|---|---|---|---|---|
| Labor/rai | 0.093 | 0.168 | 0.40 | 0.093 | 0.99 |
| Draft/rai | 1.283 | 1.942 | 0.40 | -0.535 | 0.90 |
| Cash Cost/rai | 2.077 | 0.104 | 0.99 | 2.077 | 0.99 |
| Rent/rai | 0.852 | 0.716 | 0.70 | 0.851 | 0.10 |

(4) Only Farmers Using Draft Power: Linear Per Rai

$$(4)\quad \frac{V}{L} = -84.952 + .550\,\frac{N}{L} + 1.206\,\frac{A}{L} + 1.686\,\frac{C}{L} + 1.014\,\frac{R}{L}.$$

$R^2 = .96354$

| Variable | Coeff. | s.e. | s.l.(1) | Ratio: $\frac{MVP}{MFC}$ | s.l.(2) |
|---|---|---|---|---|---|
| Labor/rai | 0.550 | 0.168 | 0.70 | 0.550 | 0.60 |
| Draft/rai | 1.206 | 1.942 | 0.60 | 0.503 | 0.60 |
| Cash Cost/rai | 1.686 | 0.104 | 0.99 | 1.686 | 0.95 |
| Rent/rai | 1.014 | 0.716 | 0.90 | 1.014 | 0.01 |

Non Som Boon

The functional form giving the most consistent results was a Cobb-Douglas function using per unit of area quantities as independent variables plus planted area as a scale indicator. The function, coefficients, variables, and results of the efficiency analysis are given in Table 3.12.

Land and labor both had a positive impact on value produced, land through a significant scale effect and labor through a large and highly significant production elasticity. Cash cost did not appear to be a major influence on value of output. This was because most of the farmers used a relatively fixed amount of cash costs in the form of truck hauling and the cost was in the form of a fixed charge per haul, regardless of how much was hauled. Thus it was a lumpy input and difficult to assess by regression techniques. Land rent was included as a proxy for land quality. The lack of a well-developed land rental market plus virtually uniform rent value estimates in the two land categories of lowland and upland contributed to its poor performance in the analysis.

The non-significance of the draft power variable was more difficult to explain. One possibility was that draft animal tillage reaches diminishing returns quickly and further tillage adds little or nothing to yields and therefore value produced per unit of area. In other words, draft power in this village was essentially a fixed input per unit of area.

Table 3.12 Summary Measures of Efficiency Analysis, Non Som Boon.

$$\frac{V}{L} = 15.27 \left(\frac{N}{L}\right)^{.579} \left(\frac{A}{L}\right)^{.016} \left(\frac{C}{L}\right)^{.078} \left(\frac{R}{L}\right)^{-.167} L^{.145}, \quad R^2 = .55843$$

| Variable | Coeff. | s.e. | s.1.(1) | Ratio: $\frac{MVP}{MFC}$ | s.1.(2) |
|---|---|---|---|---|---|
| Planted Area (L) | .145 | .135 | 0.70 | .744 | .001 |
| Labor (N) | .579 | .151 | 0.99 | .940 | .01 |
| Draft Power (A) | .016 | .137 | 0.05 | .106 | .001 |
| Cash Cost (C) | .078 | .099 | 0.50 | 1.487 | .001 |
| Land Rent (R) | -.167 | .128 | 0.70 | -.979 | .99 |

(1) Significance level here refers to the probability the actual coefficient is significantly different from 0.

(2) Significance level here refers to the probability the required coefficient (reauired to equate MVP and MFC) is not equal to the coefficient actually computed.

A minimum level was necessary for land preparation but additional increments added very little to output. Additionally, the value of kenaf per unit of area was much higher than that of rice (346.62 baht per rai for kenaf and 95.24 for rice), yet kenaf required, on the average, fewer hours of animal team power per rai (9.26 compared to 13.89 for rice). This was the most plausible explanation. The high significance level of the factor allocation analysis section for animal power must be interpreted with caution since the coefficient itself was not significant in the production analysis and the standard error was very large giving a large denominator in the t ratio calculations.

Labor and value of output were highly correlated as were cash cost and value of output. The first order correlations between the variables used in the whole farm analysis are given in Appendix B, Tables 5 and 6.

Nong Jek Lee

An arithmetic function quadratic in the labor and cash cost variables using per farm data gave the best results for Nong Jek Lee. Since all farmers used some draft power inputs, all observations were used. Transforming per farm variables to per unit of area variables was unnecessary as correlation between the total crop values produced and total crop areas planted were not considered excessive (.78800) Appendix B, Table 7). Unfortunately, significance levels cannot be calculated for the cost minimization analysis on the quadratic variables. The magnitude of both MVP/MFC ratios would indicate, however, that neither labor nor cash cost was being used at the optimum level, i.e. too much labor and too few cash costs. Again, the heavy labor input in transplanted rice and its low value produced per rai relative to corn (240 vs 360 baht per rai) would explain the negative marginal value productivity of labor. Rationing of cash costs also would explain its high productivity.

The equation and results of the analyses are presented in Table 3.13.

Both planted area and draft power appear highly profitable from the above analysis. The use of large tractors has allowed large acreages of corn and mung beans to be grown without diminishing returns to draft power setting in.

The high productivity of draft power stems from two sources. First, farmers transplanting rice achieved much higher yields and they inevitably used draft power for replowing and puddling their fields. Second, farmers cultivating their corn with cattle did better yieldwise, and cattle cultivation appeared profitable. These figures were used in further resource productivity analysis.

Table 3.13. Summary Measures of Efficiency Analysis, Non Jek Lee.

$$V = -4837.155 + 139.687\ L + .277\ N - .00016\ N^2 + 9.844\ A + 4.927\ C - .000287\ C^2$$

$$R^2 = .77864$$

| Variable | Coeff. | s.e. | s.l.(1) | Ratio: $\frac{MVP}{MFC}$ | s.l.(2) |
|---|---|---|---|---|---|
| Planted Area | 139.687 | 45.119 | 0.99 | 2.253 | 0.90 |
| Labor | 0.277 | 1.782 | 0.10 | -.604 | not possible |
| Labor$^2$ | -.00016 | .00014 | 0.70 | | |
| Draft | 9.844 | 3.747 | 0.99 | 3.281 | 0.90 |
| Cash Cost | 4.927 | 2.116 | 0.98 | 3.757 | not possible |
| Cash Cost$^2$ | -.000287 | .00024 | 0.70 | | |

Summary

As was anticipated, whole farm production functions gave better results than estimating individual crop production functions. There were more degrees of freedom available and the whole farm procedure allowed resource allocation between enterprises to be accounted for.

Transforming per farm variables to per unit of area variables gave the best results in Mapkhae and Non Som Boon while a per farm function worked best in Nong Jek Lee. The linear form was used in Mapkhae, Cobb-Douglas in Non Som Boon, and a semi-quadratic form gave best results in Nong Jek Lee. This tended to justify the earlier assumption that a priori specification of variable form or functional form was not feasible in a limited study of non-homogeneous areas.

Of the major input groupings, labor and draft power appeared to be used excessively in Mapkhae and close to equilibrium levels in Non Som Boon. The negative marginal value productivity of labor in Nong Jek Lee can best be explained by high values from mung beans being obtained by tractor plowing and broadcast seeding methods requiring a very small labor input. The negative labor productivities of labor in the mung bean production function (Table 3.9.) would tend to bear this out. The high marginal value productivities of Nong Jek Lee animal power resulted from large fields of rice and corn being worked by limited numbers of animals so a shortage of draft power still existed in this village.

The capital variable was of little value in explaining values produced in every village. Standard errors tended to be high

for this variable with most farmers having uniformly small amounts (wooden plow, wooden harrow and hand tools) and a few having large amounts (tractor, sheller, disc plow, cart, and winnow machine). In the villages without tractors, the level of capital equipment showed little variation. Cash costs were consistently significant variables explaining value produced and their marginal value productivities were also much higher than factor costs in every case. This implies credit shortages and considerable room for increasing outputs through the use of fertilizers, sprays, and hired machine services. Land rent as an indicator of land quality gave good results in Mapkhae, poor results in Non Som Boon and was of no value and thus not used in Nong Jek Lee.

Overall, the farmers tended to allocate their traditional inputs of labor and draft power at close to or exceeding cost minimizing levels while allocating newer, cash using inputs in less than optimum proportions. When we examine the returns to bovines in the next chapter, it is assumed the farmers allocated them relatively efficiently as a crop production input. Also, further investment in bovine production can now be measured against the opportunity cost of investing in cash expenditures on crop production which were found to be quite profitable.

# CHAPTER IV

# CATTLE AND BUFFALO PRODUCTION

The preceding chapter described and analyzed the input of animal power into village crop production systems, crop land use and seasonality of use, enterprise profitability, resource and productivity, and allocative efficiency of resource use. This chapter carries out a parallel development for the livestock production enterprise but the crop production system now serves as an input into the livestock production enterprise through the provision of pasture and supplementary feed resources. The carrying capacity of each such system is then analyzed in detail. Using somewhat different procedures, enterprise rates of return and the allocative efficiency of each type of livestock enterprise are examined. The chapter is divided into three sections: herd characteristics, bovine production resources, and an analysis of enterprise rates of return.

## Herd Characteristics

### Beginning and Ending Inventory

The basic inventory data for all farmers in each village are summarized in Tables 4.1. and 4.2. The biomass estimating procedure is described in Appendix C and was of necessity crude since weighing of animals was not possible and tape measuring was possible only on the more docile animals. Measurements of carrying capacity and herd output were made using biomass estimates because the concept of biomass is not biased by differences in animal sizes between ages, sexes and villages.

Table 4.1. Beginning Cattle and Buffalo Inventory

| Village | Total No. of Farmers | Animal Type | No. farmers with that type | Total animals | Total Males | Total Females | Biomass by animal type (kgs) | Total Herd Biomass (kgs) |
|---|---|---|---|---|---|---|---|---|
| Mapkhae | 40 | Cattle | 10 | 170 | 94 | 76 | 37,086 | 56,126 |
| | | Buffalo | 14 | 54 | 24 | 30 | 19,040 | |
| Non Som Boon | 52 | Cattle | 10 | 47 | 15 | 32 | 9,373 | 58,330 |
| | | Buffalo | 49 | 125 | 70 | 55 | 48,957 | |
| Nong Jek Lee | 62 | Cattle | 59 | 226 | 179 | 47 | 74,435 | 77,569 |
| | | Buffalo | 2 | 4 | 4 | 0 | 2,134 | |

Table 4.2. Cattle and Buffalo Biomass by Functional Groups (kgs).

| Mapkhae | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sex | Male | | | Female | | | Total | | |
| Age | 0-2 | 2-4 | Mature | 0-2 | 2-4 | Mature | 0-2 | 2-4 | Mature |
| Cattle | 4875 | 4463 | 12,175 | 2153 | 4410 | 9010 | 7028 | 8873 | 21,185 |
| Buffalo | 825 | 4230 | 3343 | 1085 | 2223 | 7334 | 1910 | 6453 | 10,677 |

| Non Som Boon | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sex | Male | | | Female | | | Total | | |
| Age | 0-2 | 2-4 | Mature | 0-2 | 2-4 | Mature | 0-2 | 2-4 | Mature |
| Cattle | 1125 | 1050 | 675 | 133 | 1680 | 4710 | 1258 | 2730 | 5385 |
| Buffalo | 2312 | 3862 | 23,148 | 1125 | 2858 | 15,652 | 3437 | 6720 | 38,800 |

| Nong Jek Lee | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Sex | Male | | | Female | | | Total | | |
| Age | 0-2 | 2-4 | Mature | 0-2 | 2-4 | Mature | 0-2 | 2-4 | Mature |
| Cattle | 1727 | 5462 | 56,299 | 1929 | 1959 | 7059 | 3656 | 7421 | 63,358 |
| Buffalo | 0 | 0 | 2134 | 0 | 0 | 0 | 0 | 0 | 2134 |

The inventory data of Tables 4.1. and 4.2. indicated major differences in the following herd characteristics:

1. Cattle numbers and biomass were higher for cattle than buffalo in two villages and much higher in one, Nong Jek Lee.
2. The male - female ratio was about one or greater than one where the herd's primary function was the provision of draft inputs into crop production. It was less than one where more female animals were used for reproductive purposes.
3. The total biomasses of two villages were about equal while that of Nong Jek Lee was one-third higher.
4. The biomasses estimated by functional group varied according to the herd's primary function. Reproducing herds have most of their biomass concentrated in young stock (0-2, 2-4 categories in the table) and mature cows. A draft herd has a high proportion of biomass in mature males.

Herd Growth Components

Changes in the cattle and buffalo inventories over the twelve month study period are shown in Table 4.3. These changes in numbers of animals in each category were converted into biomass changes and are shown in Table 4.4. In addition to correcting for differences in animal size by type, age, sex, and village, biomass estimates also permit estimation of the biomass increase through the biological growth of young animals.

Biological increases (births plus growth) in biomass of the cattle herds of Mapkhae, Non Som Boon, and Nong Jek Lee were 22, 32, and 8 percent, respectively, of the initial biomass. Transactions, theft, and death losses reduced biomass increase to 2, 18, and 5 percent, respectively. Farmers in Mapkhae and Non Som Boon had rapidly increasing herds which permitted substantial sales.

Buffalo herd management differed from that of cattle in the three villages. Biological increases were minus 22, plus 15, and zero percent for Mapkhae, Non Som Boon, and Nong Jek Lee respectively, with net biomass changes of minus 19, plus 9 and plus 19 percent respectively after deducting transactions and death losses. The Nong Jek Lee buffalo herd was too small to draw conclusions from. The substantial decline in the buffalo biomass in Mapkhae could be attributed to several causes. First, most rice farmers had buffalo. Very low family incomes as a consequence of poor rice yields resulted in many families selling some of their animals to purchase rice and other food. Second, tractor plowing was displacing some of the buffalo draft functions. Third, an

Table 4.3. Herd Accounting Sheet

**Cattle Inventory Changes**

| | Herd Increases | | | | | Herd Decreases | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Transactions | | | | Biological | Transactions | | | | | | |
| Village | Begin | Purchase | Rent In | Gift In, Loan In | Births | Sales | Gift In, Loan In | Rent In | Theft | Biological Death | Net Change | End |
| Mapkhae | 170 | 2 | 0 | 3 | 33 | 21 | 7 | 0 | 0 | 3 | +7 | 177 |
| Non Som Boon | 47 | 4 | 0 | 0 | 18 | 14 | 0 | 0 | 0 | 0 | +8 | 55 |
| Nong Jek Lee | 226 | 15 | 2 | 9 | 25 | 22 | 5 | 1 | 4 | 3 | +18 | 244 |

**Buffalo Inventory Changes**

| | Herd Increases | | | | | Herd Decreases | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Transactions | | | | Biological | Transactions | | | | | | |
| Village | Begin | Purchase | Rent In | Gift In, Loan In | Births | Sales | Gift In, Loan In | Rent In | Theft | Biological Death | Net Change | End |
| Mapkhae | 54 | 0 | 0 | 3 | 9 | 19 | 0 | 0 | 0 | 10 | -17 | 37 |
| Non Som Boon | 125 | 20 | 2 | 8 | 28 | 36 | 5 | 1 | 0 | 2 | +14 | 139 |
| Nong Jek Lee | 4 | 1 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | +1 | 5 |

Table 4.4. Biomass Accounting Sheet

Cattle Biomass Changes (in kgs.)

| | | Herd Increases | | | | | Herd Decreases | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Transactions | | | Biological | | Transactions | | | | | | |
| Village | Begin | Purchase | Rent In | Gift & Loan | Births | Animal Growth | Sales | Gift In, Loan In | Rent Out | Theft | Biol. Death | Net Change | End |
| Mapkhae | 37,086 | 793 | 0 | 628 | 3407 | 4865 | 6612 | 1631 | 0 | 0 | 528 | +922 | 38,008 |
| Non Som Boon | 9373 | 840 | 0 | 0 | 2210 | 805 | 2142 | 0 | 0 | 0 | 0 | +1713 | 11,086 |
| Nong Jek Lee | 74,435 | 5899 | 760 | 3476 | 3810 | 2427 | 8346 | 1464 | 380 | 1414 | 1032 | +3736 | 78,171 |

Buffalo Biomass Changes (in kgs.)

| | | Herd Increases | | | | | Herd Decreases | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Transactions | | | Biological | | Transactions | | | | | | |
| Village | Begin | Purchase | Rent In | Gift & Loan | Births | Animal Growth | Sales | Gift In, Loan In | Rent Out | Theft | Biol. Death | Net Change | End |
| Mapkhae | 19,040 | 0 | 0 | 833 | 1915 | 2276 | 6587 | 0 | 0 | 0 | 2098 | -3661 | 15,379 |
| Non Som Boon | 48,957 | 9108 | 1028 | 4102 | 4348 | 2896 | 14,304 | 2063 | 514 | 0 | 351 | +4250 | 53,207 |
| Nong Jek Lee | 2134 | 407 | 534 | 534 | 0 | 0 | 1068 | 0 | 0 | 0 | 0 | +407 | 2541 |

outbreak of haemorrhagic septicaemia caused an abnormally high death rate in the village buffalo herd.

The herd accounting sheets illustrate how the primary function of the herd affects the growth of the herd. Key indicators of herd function and management were proportion of males to females and proportion of herd biomass in each of the three functional categories. The number of breeding females placed a limit on the biological growth components of the herd while the number of mature males place a limit on the draft output of the herd. These principles served as the basis for construction of synthesized herds in Chapter V.

Reproductive Performance

The ability of a herd to provide sufficient offspring for replacement of culls plus a marketable surplus of animals is a function of (a) the proportion of the herd held as females capable of reproduction and (b) the actual birth rate. The reproductive rate and reproductive capacity of a herd, as defined at the end of Chapter I, take both of these factors into account. Herd composition, birth rate, reproductive rate and reproductive capacity of the herd by animal type and village are shown in Table 4.5.

Reproductive performances, with one exception, were surprisingly good considering the low levels of technology outlined later in this chapter. Cattle birth rates were slightly higher than buffalo when both types were present. Brahmin crossbred cattle in Non Som Boon had the highest birth rates and herd reproduction rates. Column 8 of Table 4.5 shows, at present birth rates, the proportion of the herd that could be sold or otherwise lost and still maintain a stable population. Offtakes higher than the rates in Column 8 deplete the herd while lower rates of offtake build up herd populations. Column 9 indicates potential offtakes

Table 4.5. Herd Composition and Reproductive Measures.

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Village | Type | Tot. animals, beg. of study | Aver. no. males & females | Aver. no. mature cows | % mat. cows of total herd | % mat. cows of mature animals | No. of births | Birth rate % | Herd reprod. rate % | Herd reprod. capacity % |
| Mapkhae | Cattle | 170 | 88 | 48 | 28.24 | 54.54 | 33 | 68.75 | 19.41 | 28.24 |
| | Buffalo | 54 | 28 | 16.5 | 30.56 | 58.92 | 9 | 54.54 | 16.67 | 30.56 |
| Non Som Boon | Cattle | 47 | 30 | 26 | 55.32 | 86.66 | 18 | 69.23 | 38.30 | 55.32 |
| | Buffalo | 125 | 87 | 40 | 32.00 | 45.97 | 26 | 65.00 | 20.80 | 32.00 |
| Nong Jek Lee | Cattle | 226 | 180 | 33 | 14.60 | 18.33 | 25 | 75.76 | 11.06 | 14.60 |
| | Buffalo | 4 | 4.5 | 0 | 0 | 0 | 0 | -- | 0 | 0 |

Calculations:

Column 4 = col. 3/col. 1
Column 5 = col. 3/col. 2
Column 7 = col. 6/col. 3
Column 8 = col. 6/col. 1
Column 9 = col. 3/col. 1

at a stable animal population using a 100 percent birth rate. The difference between columns 8 and 9 indicates potential offtake to be gained by higher birth rates. This potential was limited by the percentage of cows in the total herd, shown in column 4.

Another characteristic of bovine reproduction which affects performance is the seasonality of births. Good husbandry practices limit animal breeding to certain periods of the year to assure parturition when weather and feed conditions combine to produce optimum growing conditions for the offspring with minimum stresses on the cow. The resultant patterns of parturition are given in Figures 4.1. and 4.2. The patterns were consistent with those found in other studies when free breeding practices were followed (10,39). The concentration of conception over the January through May period was explained by Chantalakana, et, al. (10) as the cows attaining prime condition during this period which is the cool winter following the months of heaviest rainfall. They further hypothesized that the cows' reproductive efficiency has been disturbed by nutritional factors during the summer.

The herding patterns observed in all villages would tend to accentuate this pattern. Animals were herded in small groups when crops were planted to avoid trampling and crop damage. It was only after one of the major crops was harvested that animals from each farmer were combined into a large herd and the non-castrated males could circulate and breed. In most cases, this was the winter period beginning with rice harvest in December and January. The large percentages of conceptions in January-March resulted in the majority of calvings occurring over the October-December period for cattle and the November-January period for buffalo. Using the same reasoning, increased cattle births

**Figure 4. 1.**

**CATTLE PARTURITION SEASONALITY PATTERNS**

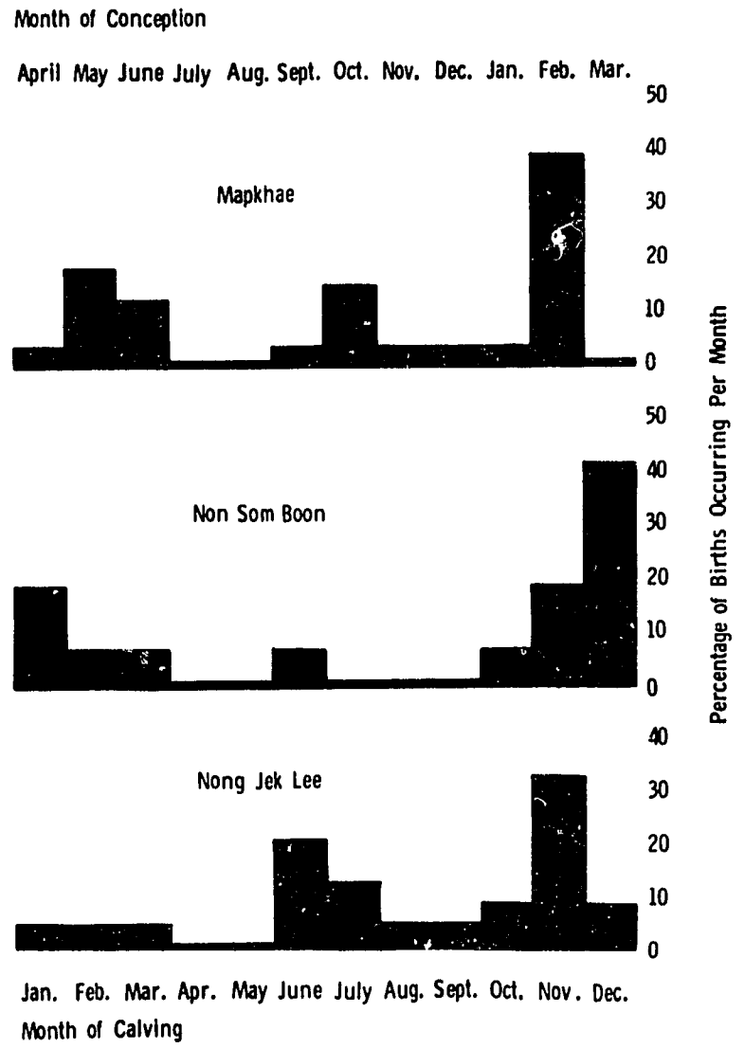
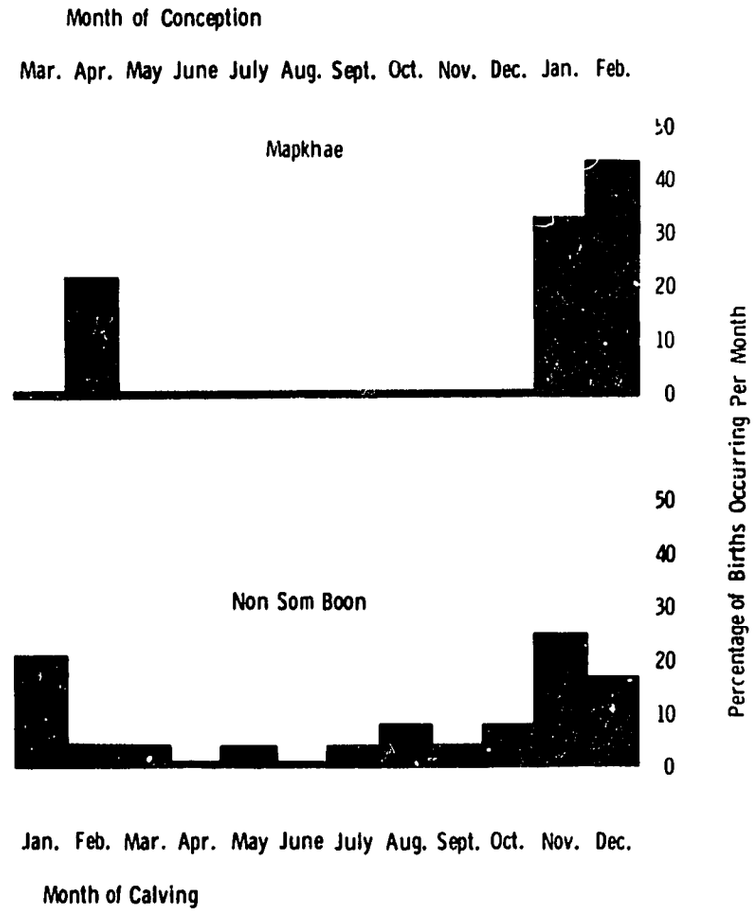


**Figure 4. 2.**
**BUFFALO PARTURITION SEASONALITY PATTERNS**



in June and July in Mapkhae and Nong Jek Lee would then correspond to corn harvest when some upland fields were grazed by larger herds of cattle in September and October, the months of conception corresponding to June and July births.

Three factors determined the desirability of this prevailing seasonal pattern--temperatures, rainfall, and crop residue availability. The lower mean maximum temperatures during the early part of the primary parturition period lessened physiological stresses on young animals. The very low rainfall during this period implied poor forage sources from natural pastures. This was counteracted, in part, by the major crop residue sources becoming available during the early part of this period. Toward the end of the primary parturition period, February and March, all of these factors were becoming unfavorable with rising temperatures, sparse rainfall, and, by this time, a depleted supply of crop residue. Births during this period were thus undesirable. Rufener's study (39) showed that all animal groups, except younger growing stock, lost 10 to 15 percent of their initial body weight during the January-April period.

Animal Value Estimates

Prices of animals were estimated from transactions recorded over the study period. The age of each animal was estimated by the farmer at the time of the transaction. The mean values at each age were then graphed and are given in Figures 4.3. through 4.6. The curves for the Northeast and Central Highlands used data from the case study village plus the two villages in each region surveyed in November, 1970. The

**Figure 4. 3.**

## MALE CATTLE VALUES

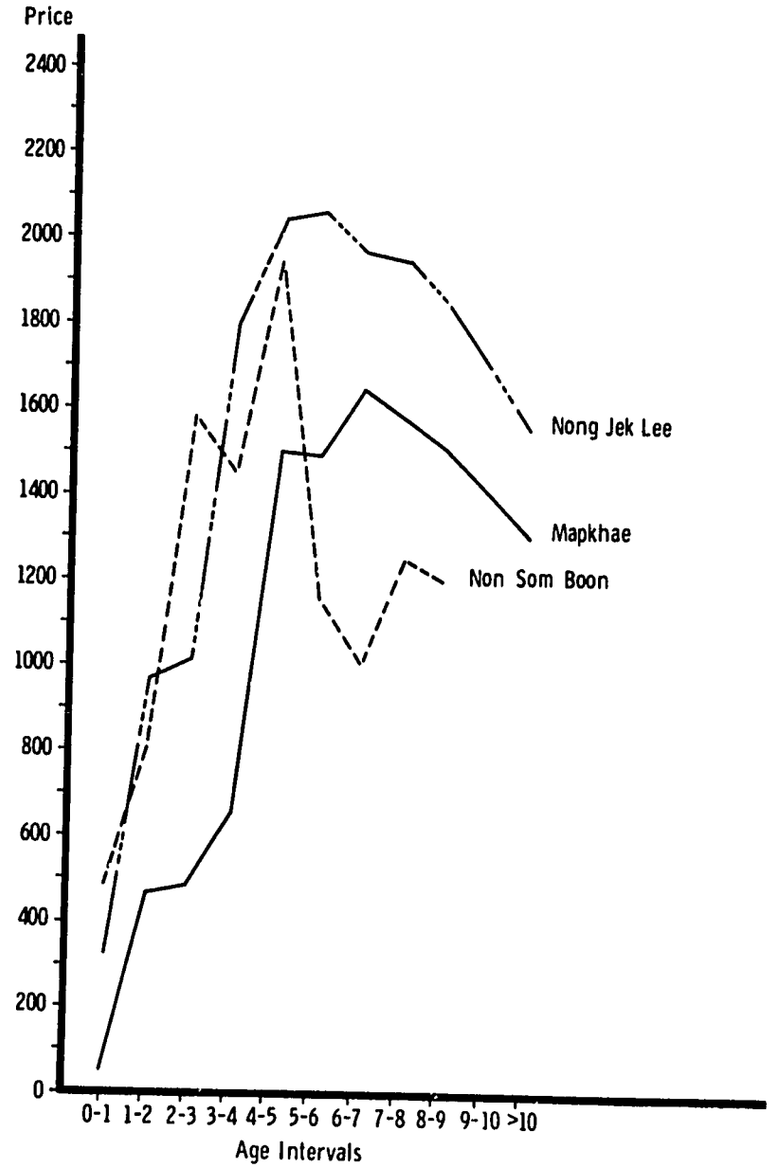


**Figure 4. 4.**

**FEMALE CATTLE VALUES**

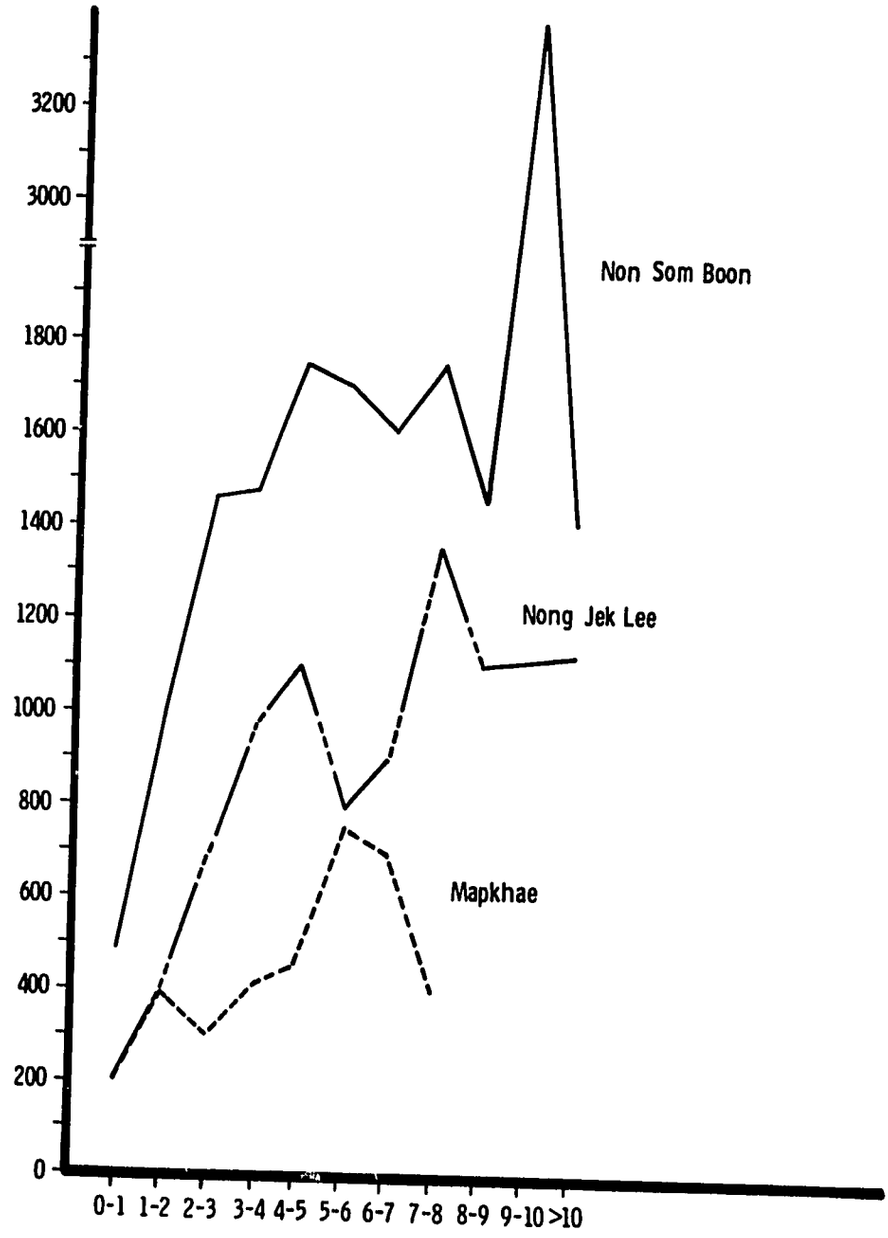


**Figure 4. 5.**

**MALE BUFFALO VALUES**

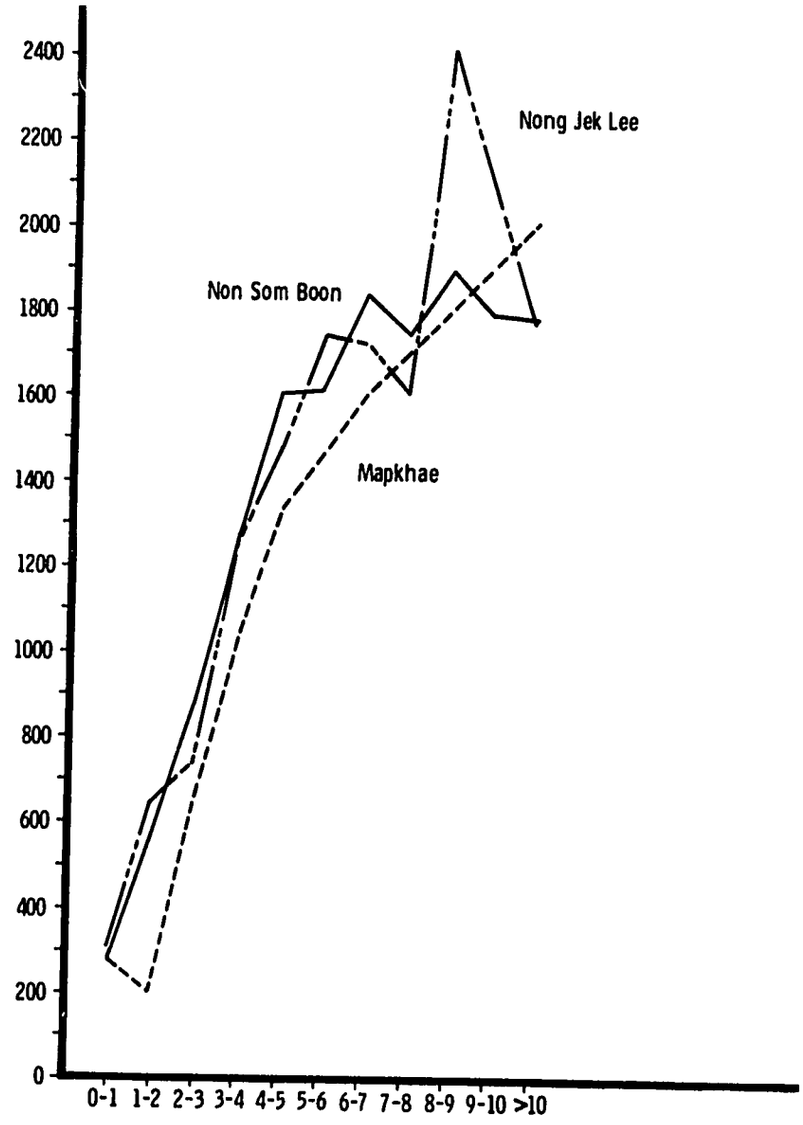
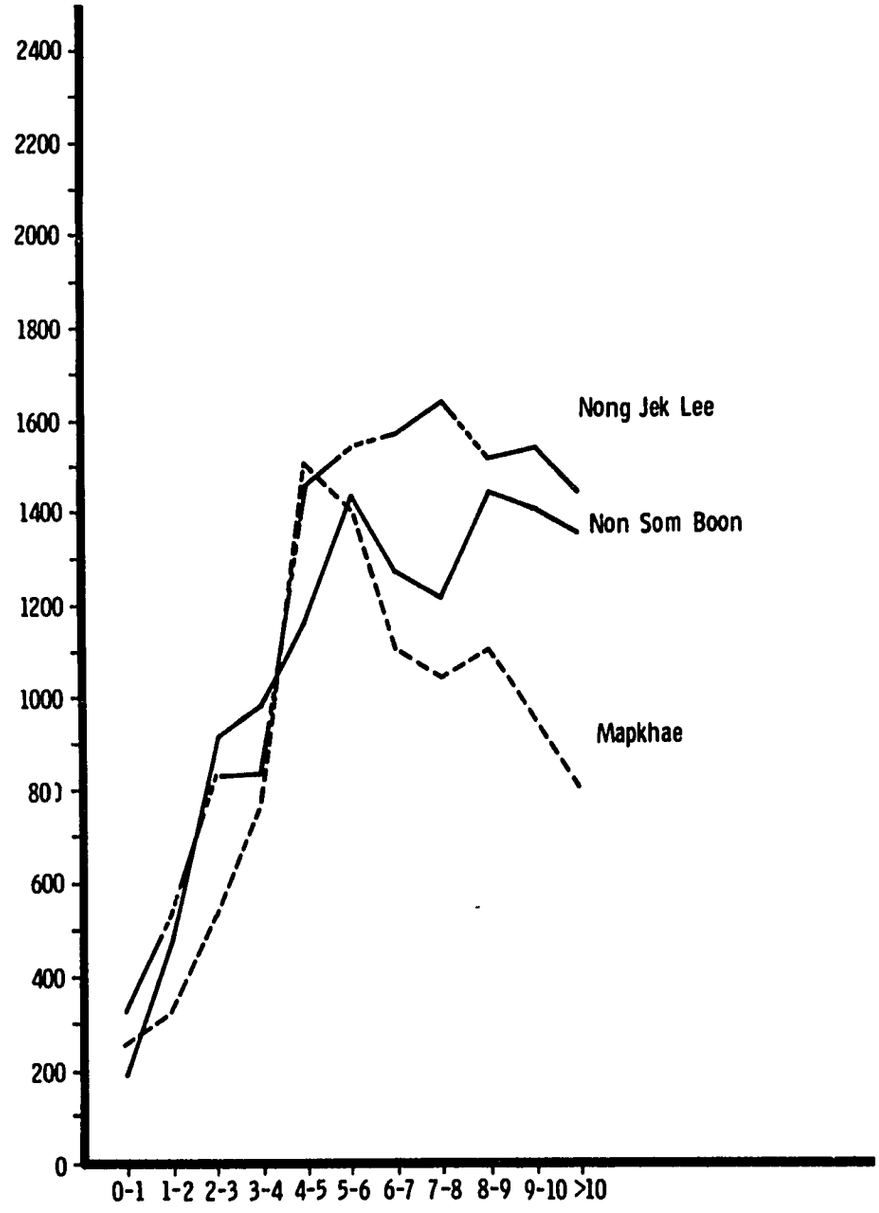


**Figure 4. 6.**

**FEMALE BUFFALO VALUES**



estimated values were consistent between the case study and surveyed villages within each region so the pooled estimates were used for value calculations in the Northeast and Central Highlands. Mapkhae estimates represent transactions from Mapkhae only.

Definite trends are apparent in Figure 4.3. through 4.6. Value increased rapidly up to maturity, remained about the same over the animals' productive lifespan (four to eight or nine years) and usually declined when the animal was no longer productive and could be sold as a cull for slaughter. These graphs indicated that a substantial increase in farm level prices for slaughter animals would have to occur before slaughter prices would equal or exceed prices dictated by the animals' productivity as draft power or breeding stock.

Production Technology

The potential sources of increased bovine productivity were outlined at the end of Chapter I. Evaluation of the technology levels existing in the case study villages indicated most measures were not available and those which were available were often not uniformly utilized. Table 4.6. gives the percentages of all farmers using some of the outlined measures which were thought to be available to Thai villagers.

The use of nutritional and housing technology reflected the presence of traditional production techniques. Variations in use within categories reflects individual farmer preferences and convenience factors rather than a change in technology.

Partial adoption of genetic and animal health technology

Table 4.6. Improved Livestock Production Technology Used in Case Study Villages in Thailand.

| Production Technology | Cattle | | | Buffalo | | |
|---|---|---|---|---|---|---|
| | Mapkhae | Non Som Boon | Nong Jek Lee | Mapkhae | Non Som Boon | Nong Jek Lee |
| | ---------- percent of owners using this technology ---------- | | | | | |
| I. Genetic | | | | | | |
| Exotic breeding stock | 10 | 100 | 0 | --- | --- | --- |
| II. Nutritional | | | | | | |
| Stored roughage (rice straw) | 20 | 10 | 47 | 7 | 27 | 50 |
| Fresh roughage (grass clippings) | 20 | 4 | 80 | 29 | 24 | 75 |
| III. Animal Health | | | | | | |
| Veterinary inspection at least once per year | 60 | 100 | 0 | 77 | 49 | 0 |
| IV. Animal Housing | | | | | | |
| Structures | | | | | | |
| Shade in grazing area | 20 | 0 | 18 | 0 | 0 | 0 |
| Pen under house for shade and theft protection | 100 | 100 | 100 | 100 | 100 | 100 |
| Feeding and watering facilities | | | | | | |
| Feed trough | 20 | 0 | 16 | 0 | 0 | 0 |
| Water trough (unsanitary) | 60 | 0 | 16 | 46 | 0 | 0 |

represented the only instance of non-traditional techniques being used. The non-uniform use of veterinary services reflects farmers choice of using or not using the veterinarian service when it arrived at the village for innoculations, not a pattern of discrimination among the veterinarians. The exotic stock was Brahmin bloodlines introduced on a significant scale in 1957 with the importation of 101 bulls and 30 heifers from the United States (37, p. 15). Non Som Boon is near the Department of Livestock Development Station where some of the stock was originally disseminated from.

Modern nutritional practices were not followed in the study villages. Variations in animal size, growth rates, and condition thus reflected primarily the nutritional levels provided from the village bio-system.

## Production Resources

### Procedure

A description of the major resources used in livestock production is given first. Then an analysis of each factor is conducted for each village.

Land resources.--Grazing was confined to two major classes of land(a) permanent pastures accessible to all animals; and(b) cropland which provided varying levels of pasture and supplementary feed resources. The procedure was to inventory and classify all land within each village for grazing use on either a permanent or seasonal basis. The land used

by the village herd was well-defined by village boundaries and grazing into other village areas was avoided.

Next, grazing patterns were recorded during the course of the monthly village visits. Primary areas grazed, approximate grazing hours, and identity of the herdsmen were recorded. Using these patterns plus the monthly data on the crop plantings and harvestings, estimates were made of monthly land use by the village herd and monthly carrying capacity of the village land.

Labor resources.--In all villages herding was the primary responsibility of village children. Occasionally the farmers' wives, relatives, or older people herded, but this was usually in slack periods of crop labor requirements. The farmers' major labor input was cutting grass and weeds for supplemental feeding, when practiced, plus stacking the rice straw which commonly served as a supplemental roughage source. Labor use was highest when all crops were planted and the animals had to be herded carefully. Labor use declined only slightly following harvest since villagers still watched their individual herds to prevent straying, theft, fighting and to aid in birth.

In estimating the contribution of labor to livestock production costs, several simplifying assumptions were made:

1. Adult labor was valued at its marginal value product as estimated by the whole farm production function.
2. All other types of labor used in livestock production were arbitrarily priced at fifty percent of the estimated marginal value productivity of adult labor.

3. Adjustment for seasonality in the price of livestock production labor was not made.

Capital resources.--Capital investments in livestock production were in facilities such as pens, corrals, rice straw, feeding equipment and watering troughs, and investments in the stock of animals. Facilities were assigned costs using straight line depreciation methods. Costs were determined by estimating costs of reproducing the facilities. In addition, a capital charge was also made equal to the estimated present value of the assets times a fifteen percent discount rate.

A capital charge was not assigned to the stock of animals because the method of evaluating the livestock production enterprise estimated the rate of return to the enterprise which equates positive and negative cash flows. This rate can also be interpreted as a capital charge which equates the enterprise cash flows. The estimation of rates of return is carried out in the last section of this chapter.

Land Use by Village

Mapkhae. -- Total land area of Mapkhae was estimated at 1574 rai (2.5184 square kilometers or .97235 square miles). This was close to the village headman's records showing 1600 rai in Mapkhae. Village grazing was limited to this area with the exception of one large cattle herd which migrated at the time of rice planting to a large pasture area outside the village. In addition to the cropland operated by the forty farmers included in the study (724 rai), some

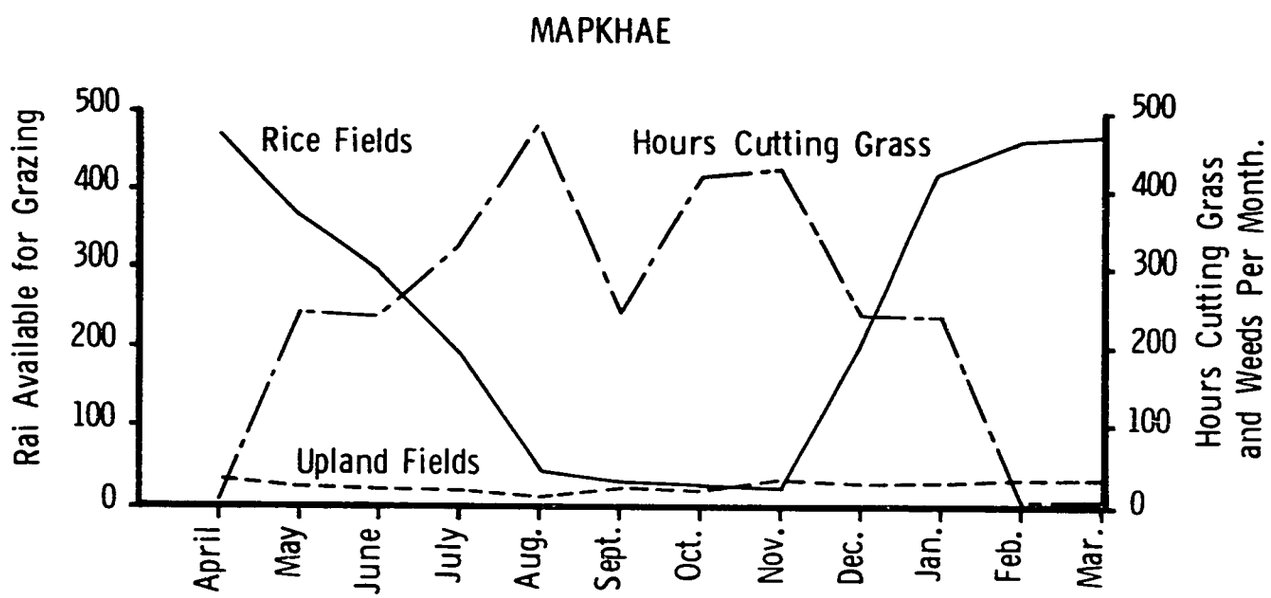
cropland was operated by farmers from surrounding villages. This rented-out cropland was available for village pasture after harvest. This increased total planted area to 1000 rai. Non-cropped land consisted of household areas (eighty rai), fallow cropland (ninety-eight rai) and scrub forests (396 rai). The 132 rai of sugarcane was never available as pasture and thus contributed nothing to livestock production. Adjusting cropland for monthly availabilities as pasture leaves a yearly average of 903 rai available for grazing out of the 1574 rai. The 903 rai, plus some limited grass cuttings and rice straw, supported an average combined biomass of 46,273 kilograms, (adjusted for the absence of the large herd for 7 months) or about 92.546 animal units. On an average basis over the year this was 9.757 rai per animal unit (about four acres per animal unit). This was about double the land per animal unit estimated in Rufener's study (39) and reflected a lower intensity of land use for grazing in Mapkhae.

Of equal significance was the seasonal variations in land availability. If all cropland was planted during some part of the year, non-cropped land plus supplemental roughage feeding had to support the entire herd. This may limit ultimate herd size more than the average area of grazing land available during the year.

Figure 4.7. is a summary of recorded cropland availabilities during the study year obtained during monthly interviews. Significant areas of sugarcane and other root crops could not be used for grazing at any time. The figures summarized in Figure 4.7. generally understated the cropland available because a complete record of grazing utilization for all herds was impossible to obtain. By adding the cropland available per month to non-cropped land plus forests, the carrying capacity varied from a high of 14.21 rai per animal unit in

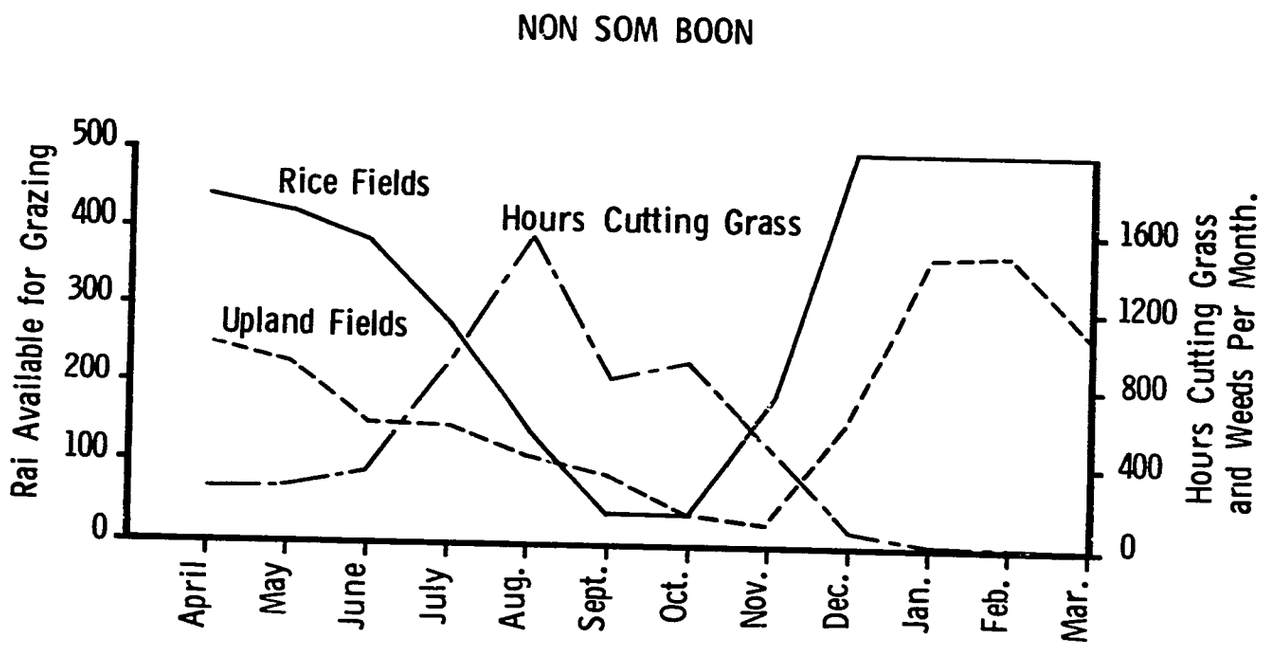
# Figure 4. 7. A.

# MONTHLY GRAZING AND SUPPLEMENTAL FEEDING



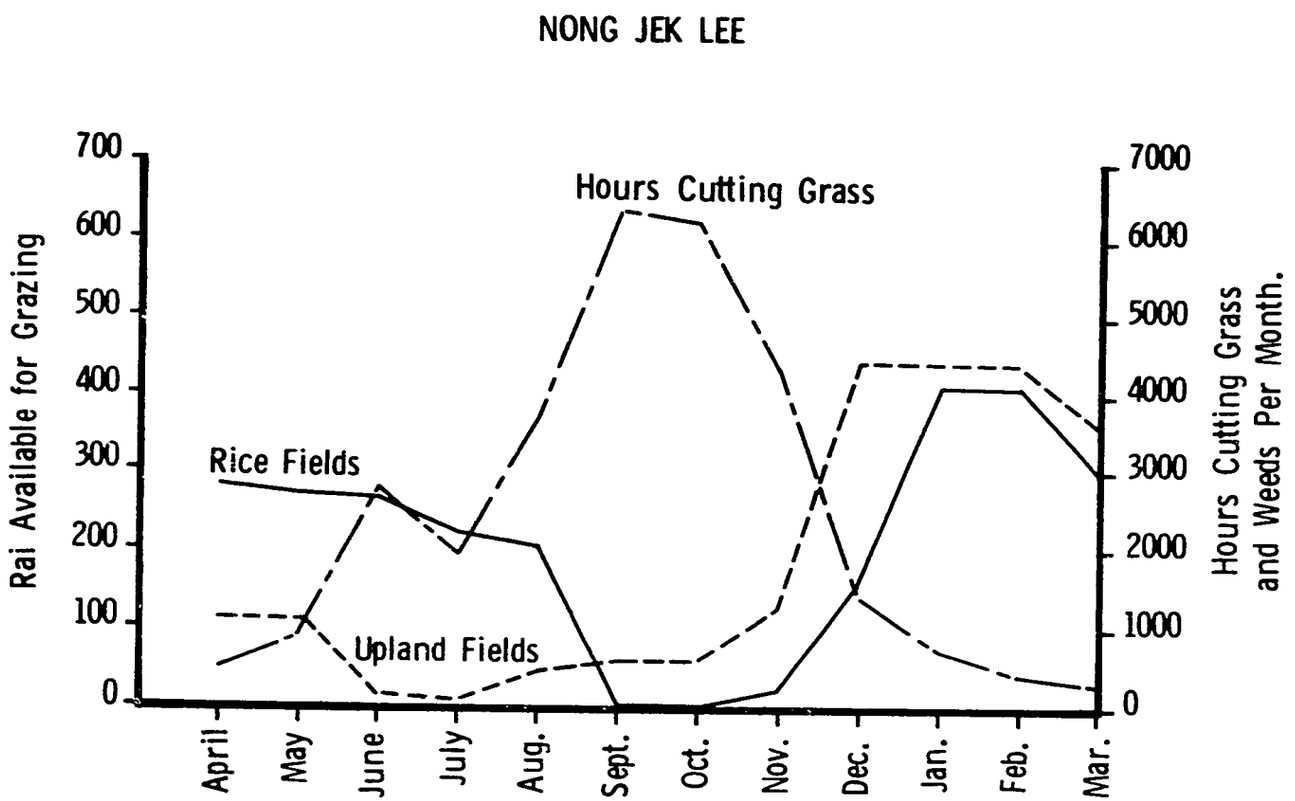
# Figure 4. 7. B.

## MONTHLY GRAZING AND SUPPLEMENTAL FEEDING



# Figure 4. 7. C.

# MONTHLY GRAZING AND SUPPLEMENTAL FEEDING



March and April after the large herd had left the village to a low of 5.96 rai (2.36 acres) per animal unit in October. The shortage of grazing resources during this period was alleviated by cutting grass on bunds and on areas where it was difficult to graze animals, and by cutting weeds from fields. Figure 4.7. shows effort expended on these tasks was inversely proportional to cropland availabilities. If rice straw was still available, it was fed during the July-November period but often the rice straw was consumed during the end of the dry season (February-April) when grass was again becoming scarce.

Non Som Boon. -- This village was intermediate in size, being about three times as large as Mapkhae and two-thirds the size of Nong Jek Lee. The upland areas pastured were much larger than in Mapkhae but available for only a short period each year since kehaf has a long growing period. Unlike many areas of the Northeast, fallowing of upland was not common.

Total area in Non Som Boon was 4,310 rai (6.9 square kilometers or 2.66 square miles). Of this, only 117 rai was in fields suitable for permanent pasture near the village. The other pasture was near the Chi River, in savannah areas bordering the rice fields and scattered areas of the upland fields. The rice field area was 563 rai while upland areas totaled 3,288 rai, not all of it cropped. Some upland areas were too distant from the village and water sources to be pastured.

After adjustments of the cropland areas for their monthly availabilities, the average land available over the year was 1,377 rai.

This supported an average combined biomass of 61,312 kilograms, or 122.26 animal units, an average of 11.13 rai per animal unit. Compared to the villages studied by Rufener (39), the bovines in this village were relatively well endowed with land resources.

Seasonality of grazing followed the pattern of the other areas. The data in Figure 4.7. understate the actual areas available since complete grazing records could not be obtained so actual areas of cropland available are considerably in excess of those shown over the December-March period. By assuming total village area was available for pasture during this period gave a carrying capacity of 35 rai per animal unit over this period. When almost all crop areas were planted, the carrying capacity dropped to 1.93 rai per animal unit. During this period, up to 200 man-days per month were spent cutting and hauling grass from paddies and field areas inaccessible to grazing herds. Rice straw was also kept in reserve for this period.

Nong Jek Lee. -- The village boundaries included 4,600 rai of rice fields of which only 1,608 were included in this study and 1,539 rai of upland crops with 741 included in this study. The other areas were operated by farmers in outlying areas of neighboring villages with some large rice tracts rented out to larger farmers. However, the areas included in this study defined the approximate grazing limits of village animals and were used in carrying capacity calculations rather than the larger areas which were not used by the village herd. Total village area grazed was thus 1,608 rai of rice, 741 rai of upland crops, and 622 rai of pasture and household area for a total of 2,971 rai. Adjusting

for seasonal availabilities of cropland resulted in an average of 1,263 rai available over the year. Average total biomass was 78,641 kilograms or 157.28 animal units giving an average carrying capacity of 8.03 rai per animal. Carrying capacity ranged from 16.68 rai per animal unit in January to 2.24 rai per animal unit in September and October.

A combination of factors alleviated pasture shortages during the short grazing land period. First, as Figure 4.7. indicates, up to 800 man days per month were used for forage gathering over the September-October period. Second, the permanent pasture available was of good quality with a good supply of water. Third, the large rice areas per farmer guaranteed an abundance of rice straw stored at the pens. Fourth, part of the corn fields were not resown to mung beans and became available during the late August-early September period.

Labor Use

The majority of the labor used was for herding. An exception was during the June-August period when forage gathering was also a major task. Labor inputs for castration, branding, parasite or disease control, and repair of facilities was negligible.

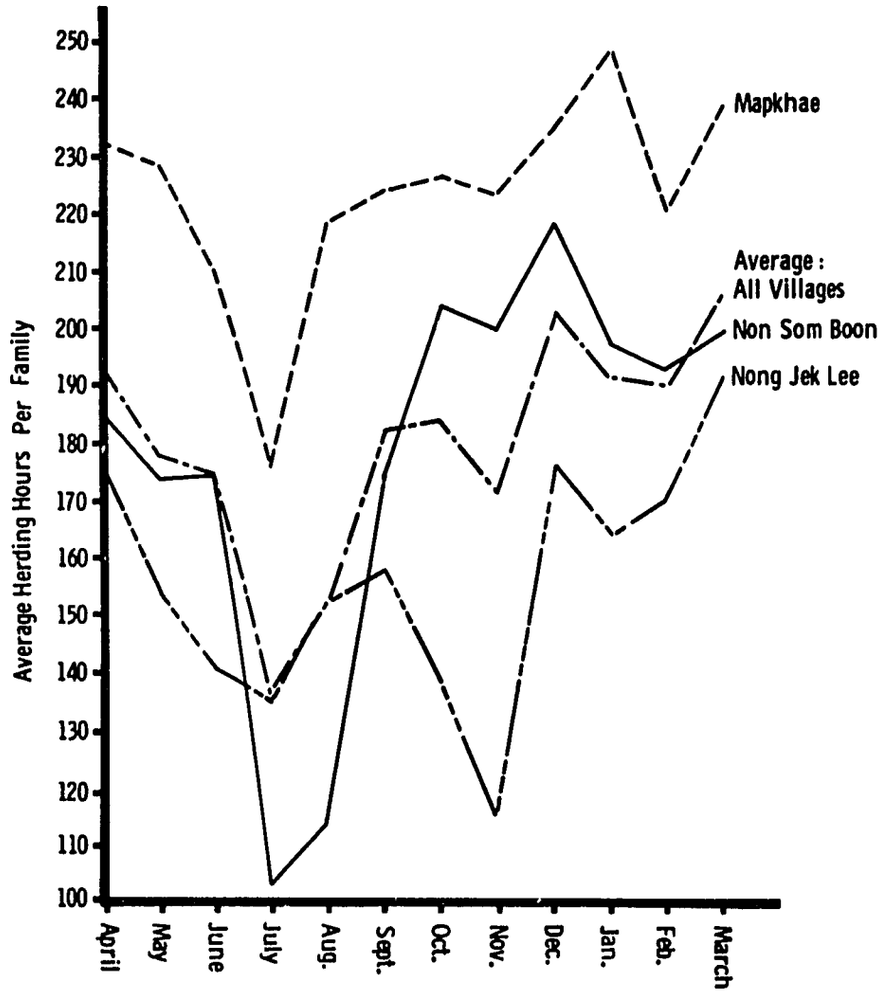
The herding labor aspect of bovine production was the most traditional of observed village tasks. Traditional in this sense implies labor makes a very limited or zero contribution to output (16), particularly after harvest of all crops when communal grazing on all village land was possible. However, several factors mitigated against reducing the large herding labor input. First, no fencing was available in any village to prevent animals from crossing village boundaries, straying into roadways,

or neighbors' housing compounds. Second, theft of animals or the threat of it was a major concern of all farmers and they were thus reluctant to leave their animals with anyone but members of their immediate family. Third, both bovine types needed daily water, and, in addition, buffalo needed a daily wallow to maintain their health. The farmer had to insure these functions were provided for all his animals on a daily basis. Fourth, since most parturition occured during this free grazing period, the herdsmen of each family were responsible for the prevention of trampling of newborn animals. These factors justified the assignment of positive wage rates to herding labor and helps explain why herding labor inputs were highest over the December-March period after fields were harvested and free grazing was possible. This was also the period of shortest water when the animals had to be driven longer distances to drink and wallow.

The seasonal pattern of bovine herding labor corresponded closely to the cropland availability in Figure 4.7. As the fields were planted, the smaller herds were staked out in the fields being worked or kept at home and fed cut grass or rice straw. Figure 4.8. indicates the seasonality of herding labor per family as recorded from the sampled farmers during the monthly visits. The decreasing labor from April to July corresponded to cropland preparation and planting. Herdsman labor increased as upland fields became available later in the summer but decreased in November when rice harvest began and most labor was mobilized for rice harvest, and increased from then on as the entire village area became available for grazing. The January-February decrease in herding labor corresponded to the availability of rice straw for

**Figure 4. 8.**

**SEASONAL HERDING LABOR PATTERNS**



feeding at home as availability of grazing dwindled.

Substantial economies of scale in the use of herdsman labor were realized by farmers with larger herds. In most cases, one child would tend each farmer's animals up to herd sizes of twenty animals when an adult or another child would assist. Assigning labor charges per animal made it necessary to know the herd size. Regression equations were estimated for total and average labor requirements per farmer as a function of each farmer's herd size. If cattle and buffalo were herded together, the total herd was defined as animals of both types.

Results of the regressions are given in Appendix D, Table 1. The regression results were used for two purposes. First, the average herding labor input per animal was estimated by substituting average herd size for the village herd into the equation. The resulting level of labor use was then used for cost estimation purposes. Second, the marginal herding labor cost for an additional animal being added by a birth was computed by substituting into the equation the average village herd size plus one and subtracting from this figure the labor used at the average herd size. Since economies of scale were substantial, this marginal increase in labor was well below average labor use in every village. The labor use estimates derived from this procedure are given in Table 4.7. for both the average herd levels in each village and the marginal increase in herding labor use by increasing average herd size by one animal.

Capital Use

Variations in capital charges for facilities were a function

Table 4.7. Herding Labor Use

| Total Labor Use per Animal at Mean Herd Size (hours per yr.) | | | |
|---|---|---|---|
| Village | Herding Labor | Grass and (a) Weed Gathering | Total Labor |
| Mapkhae | 562 | 13 | 575 |
| Non Som Boon | 785 | 31 | 816 |
| Nong Jek Lee | 452 | 125 | 577 |

| Total Labor Use per Additional Animal added at Mean Herd Size (hours per year) | | | |
|---|---|---|---|
| Village | Herding Labor | Grass and (a) Weed Gathering | Total Labor |
| Mapkhae | 146.2 | 1.4 | 147.6 |
| Non Som Boon | 52.0 | 8.9 | 60.9 |
| Nong Jek Lee | 39.9 | 32.1 | 72.0 |

(a) Grass and weed gathering labor was assumed to be increasing in proportion to the increase in herd size resulting from the one animal increase.

of the type and age of the structures. The charges were smallest in Mapkhae at fourteen baht per animal per year. This reflected the extensive type of production in this village. Outdoor corrals were the rule and since grass feeding was not prevalent, feeding and watering facilities were generally old and in poor condition. The poor rice harvests had provided very little rice straw and thus small inventories of feedstuffs.

Non Som Boon animals had an average capital charge of 42 baht per animal per year. Improvements in pens and feeding facilities among Brahmin cattle producers were a major factor as were substantial inventories of rice straw hauled in by the trucks.

The highest capital costs per animal were in Nong Jek Lee at 46 baht per year. Cattle often had both a pen and a corral plus feeding mangers. Some small fences had been constructed around the household areas. Finally, the large rice areas per farmer plus high yields provided large stacks of rice straw in the household areas.

Analysis of Rates of Return to Livestock Production Enterprises.

Procedure. -- The preceding sections outlined in detail the costs and returns for various types of livestock. Costs were labor and capital. Land was assumed free for several reasons. Permanent pasture was either communal village land, ditches along waterways or roadways, fallow cropland, or uncleared forested areas. The first two classes were not owned by individuals and were free goods to the village livestock producers. The last two classes were usually owned by farmers

but were assumed to have no costs to the livestock producers. Under existing levels of crop production technology, land which must be fallowed to regain its fertility had virtually no opportunity costs as a crop production resource during the fallow period. Similarly, forested areas were assumed to be unsuitable for crop production at existing levels of technology.

The other pasture resource was cropland lying idle between harvest and planting time. It too had a zero opportunity cost for crop production during the dry season since lack of irrigation facilities made cropping over this period infeasible.

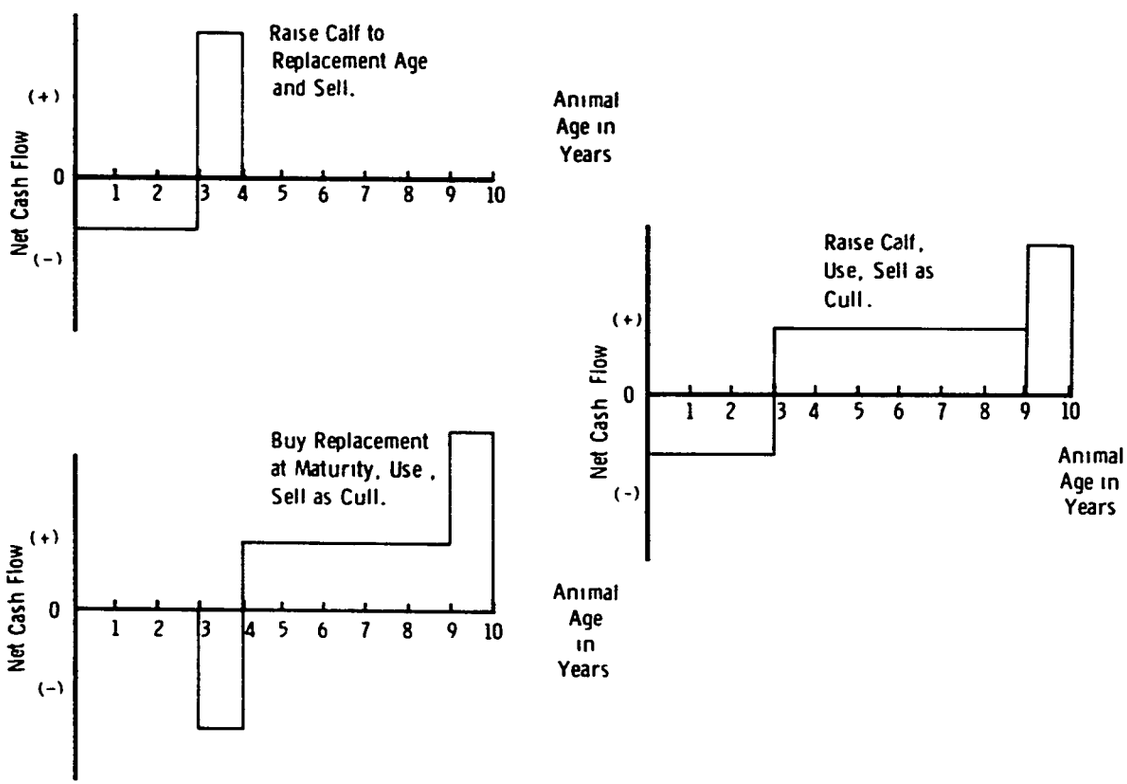
Returns to livestock enterprises flowed from the animals' contribution to crop production activities, the breeding of animals and resultant sale of offspring, and the final sale of cull animals.

The nature of the production and utilization processes suggested a rate of return approach to enterprise evaluation rather than a simple profit maximization framework (36). The animals had a non-productive period (birth until maturity) when their contribution, measured as a cash flow, was negative. After reaching maturity, the animal produced a stream of positive cash flows and, when culled, a lump sum of money. Figure 4.9. represents some costs and returns over the life of the major bovine enterprises of the villages. The net cash flow is returns minus costs at each point in time. It is negative until the animal contributes more to returns than costs.

Investments of this type can be analyzed by 3 measures: benefit-cost analysis, external rate of return, and the internal rate of return. The respective formulas for these measures are

**Figure 4. 9.**

## NET COSTS AND RETURNS IN BOVINE ENTERPRISES



(1) $\frac{B}{C} = PR + \frac{AFR/k}{CC}$

(2) $r = 100k \frac{B}{C}$

(3) $\underset{t-0}{} \frac{1}{(1 + i)^n} F_n = 0$

where B = benefits

C = costs

PR = cumulated past returns

k = the given rate of interest used to cumulate or discount returns

AFR = annual future returns

CC = cumulated costs

r = external rate of return, or the rate at which all future returns pay off

n = number of years for which the internal rate of return is relevent

$F_n$ = net cash flow in year n

i = an internally calculated rate of interest which makes the discounted present value of the flow of costs equal to the discounted present value of the flow of returns at a point in time

Equations 1 and 2 express the same measure while equation 3 has the advantage in that it is not dependent on the assignment of arbitrary discount rates.

A benefit-cost analysis is most applicable when the stream of benefits from an investment extend over a long period of time. It is also quite sensitive to the discount rate and the ratio of operating to capital costs. Measures one and two would be more appropriate for evaluation of a pasture improvement where the benefits extend over a long period (30).

For the purposes of this thesis, the internal rate of return was the most appropriate measure. If the enterprises had about the same capital intensity and gestation period, the results would be comparable between enterprises and villages and would provide estimates for judging livestock enterprise returns with those of alternative investments.

Calculation of discount rates which equalizes the areas under the curves in Figure 4.9. required a yearly accounting of net costs and benefits. This required data on average initial animal costs, yearly costs of labor and a charge on livestock production facilities, yearly returns for the enterprise in question, and a final cull price.

Costs were calculated from data on labor and capital inputs in livestock production. All initial animal costs were assumed to be 300 baht at weaning age. Breeding revenues were computed by arriving at a net value per calf raised to maturity and multiplying this by the birth rate for the animal class under consideration. This gave the average yearly revenue contribution of the cows. Sale prices were the prevailing village prices for animals destined for slaughter. The total time under consideration in a weaning to slaughter type of enterprise was ten years. Dual purpose (draft plus breeding) animals were assumed to work four years and breed six years. All animals began producing revenue during their fourth year.

Results. -- Based on these assumptions and the summary measures in Tables 4.8. through 4.10, internal rates of return were computed by an iterative process until the accumulated sum of net cash flows over the period under consideration was equalized. These are given in the final column of Table 4.11.

Table 4.8. Cost Data Used for Internal Rate of Return Calculations

| | Mapkhae | | Non Som Boon | | Nong Jek Lee |
|---|---|---|---|---|---|
| | Cattle | Buffalo | Cattle | Buffalo | Cattle |
| Herding Labor: Hours/ Animal | 562 | 562 | 785 | 785 | 452 |
| Fodder-Gathering Hours/Animal | 13 | 13 | 31 | 31 | 125 |
| Total Labor: Hours/Animal | 575 | 575 | 816 | 816 | 577 |
| Wage Rate/Hr. | .275[a] | .275[a] | .5875[a] | .5875[a] | .750[b] |
| Wage Bill | 158 | 158 | 479 | 479 | 433 |
| Capital Facilities Charge/ Animal | 14 | 14 | 42 | 42 | 46 |
| Total Cost/ Head per Year | 172 | 172 | 521 | 521 | 479 |
| Purchase Price: Male Replacement | 1500 | 1340 | 1940 | 1600 | 2030 |
| Purchase Price: Female Replacement | 460 | 1200 | 1740 | 1170 | 1100 |
| Calf Cost | 300 | 300 | 300 | 300 | 300 |

(a) Wage calculated at marginal value product of labor in crop production x .5.

(b) Wage calculated at actual wage for crop labor x .5.

Table 4.9. Returns Data Used for Internal Rate of Return Calculations

| Village | Animal Type | Hours of Draft Labor/yr. | Draft[a] Wage/ Hour | Power[a] Bill/Yr. | Breeding Returns Per Cow/ Year | Sale Price: Male Cull | Sale Price: Female Cull |
|---|---|---|---|---|---|---|---|
| Mapkhae | Cattle | 310 | 1.69[b] | 524 | 410 | 1500 | 400 |
| | Buffalo | 310 | .86[b] | 267 | 477 | 1800 | 1100 |
| Non Som Boon | Cattle | --- | --- | --- | 836 | 1200 | 1410 |
| | Buffalo | 333 | 2.1[c] | 700 | 673 | 1890 | 1440 |
| Nong Jek Lee | Cattle | 469 | 3.0[d] | 1407 | 550 | 1850 | 1350 |

(a) Returns per team for cattle and per animal for buffalo.

(b) Wage computed at marginal value product and adjusted for differences in draft output between types.

(c) Wage rate per hour computed at seasons rental rate.

(d) Wage rate actually paid per hour.

Table 4.10. Estimation of Net Returns per Breeding Female per Year.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| | Animal Age | | | | | | | | |
| | 0-1 | 1-2 | 2-3 | 3-4 | | | | | |
| Item | Cost | | | | Total Accum. Cost | Sale Price | Net Return per Calf | Birth Rate | Return per Breeding Female/Yr. |
| Mapkhae | | | | | | | | | |
| Cattle | 144.2 | 106.0 | 78.5 | 57.3 | 386 | 980 | 594 | .69 | 410 |
| Buffalo | 144.2 | 106.0 | 78.5 | 57.3 | 386 | 1270 | 884 | .54 | 477 |
| Non Som Boon | | | | | | | | | |
| Cattle | 235 | 173 | 128 | 93 | 629 | 1840 | 1211 | .69 | 836 |
| Buffalo | 235 | 173 | 128 | 93 | 629 | 1665 | 1036 | .65 | 673 |
| Nong Jek Lee | | | | | | | | | |
| Cattle | 311 | 229 | 169 | 124 | 833 | 1565 | 732 | .75 | 549 |

Calculations:

Column 1 through 4: Yearly costs are marginal costs of caring for one more animal at present average herd sizes, and are the same for cattle and buffalo but different for each village, i.e., Mapkhae = 42.15, Non Som Boon = 68.80, and Nong Jek Lee = 91. Each yearly cost is then multiplied by an accumulation factor, $(1 + r)^n$ where r = 36% and n = 4 for col. 1, n = 3 for col. 2, etc. Column accumulation factors are col. 1 = 3.421, col. 2 = 2.516, col. 3 = 1.862, and col. 4 = 1.360.

Column 6: Average price of 4-year-old males and females.

Column 9: Returns per calf times calves produced per year (birth rate).

Table 4.11. Estimates of Internal Rates of Return

| Village | Type | Sex | Enterprise | Internal Rate of Return |
|---|---|---|---|---|
| Mapkhae | Cattle | Male | Raised from birth to 4, used as draft from 4-11, sold at end of 11 years as culls. | 15 % |
| | Cattle | Female | Raised from birth to 4, bred from 4-11, sold at end of 11 years as culls. | 15.5% |
| | Buffalo | Male | Raised from birth to 4, used as draft from 4-11, sold at end of 11 years as culls. | 15.2% |
| | Buffalo | Female | Raised from birth to 4, used as draft from 4-8, used as breeding 4-11, sold at 11 years as culls. | 26.5%[a] |
| Non Som Boon | Cattle | Female | Raised from birth to 4, bred from 4-11, sold at end of 11 years as culls. | 8.2% |
| | Buffalo | Male | Raised from birth to 4, used as draft from 4-11, sold as end of 11 years as culls. | 6.1% |
| | Buffalo | Female | Raised from birth to 4, used as draft from 4-8, used as breeding 4-11, sold at 11 years as culls. | 10.9%[a] |
| Nong Jek Lee | Cattle | Male | Raised from birth to 4, used as draft from 4-11, sold at end of 11 years as culls. | 8.9% |
| | Cattle | Male | Purchase replacement males at 3, used as draft from 4-11, sold at end of 11 years as culls. | 16.0% |
| | Cattle | Female | Raised from birth to 4, bred from 4-11, sold at end of 11 years as culls. | -1.0% |

(a) Returns assumed power return = .5 of male draft animal and breeding returns equal to non-worked breeding females.

These rates served as excellent guides for assessing the farmers' ability to evaluate his investments. In most cases the rates were well below the 36 percent interest rate at which short term loans were available, but are near or slightly below commercial lending rates of 12 per cent. In 6 out of the 10 situations examined, returns from traditional production and utilization patterns exceeded the 9 percent rate of return the Asian Development Bank had estimated for its livestock improvement program (2).

The rates in Mapkhae do not indicate why cattle numbers are increasing and buffalo numbers declining. This is probably due to a major disease outbreak which resulted in large buffalo mortalities.

The high returns to dual purpose female buffalo should indicate a trend towards specialization in these animals. However, after farmers had their draft work requirements fulfilled, further female buffalo added revenue only as breeding stock since they were not demanded as rental stock and very few animals were ever rented in these villages. Thus their rates of return were greatly reduced when they moved from the dual to breeding category and became competitive with cattle for the breeding enterprise. The yearly revenues from cattle breeding were generally higher so the expansion of buffalo females was limited to the dual-purpose animals and no large buffalo breeding herds were present in any of the villages studied.

The negative return to the Nong Jek Lee cattle breeding enterprise resulted from higher production costs. This explained the relative smallness of this component of the total herd. The higher return to the cattle Buy-Draft-Meat enterprise explained why this is the predominant form of cattle enterprise in this village as high production costs worked against producing replacement workstock within the village

# CHAPTER V

# ALLOCATION OF BOVINE OUTPUT

Allocation of village resources was dealt with in Chapters III and IV. Chapter III examined the allocation of resource use in crop production, and, in particular, the use of draft animal inputs. Chapter IV discussed resources used in bovine production and the use of breeding stock. This chapter combines the two aspects of village bovine systems discussed previously--the size of the herd supported by the village resource base and the uses made of the herd--into a formal model allowing analysis of the underlying factors composing the system. Some concepts are now presented which may help clarify the various aspects of production and allocation to be discussed.

## Conceptual Framework

### Products

Several types of products are represented in the village crop and bovine production system. Village resources of land, labor, and capital are combined to produce five outputs.

$$Y_1 = f_1 (Y_4, X_1, X_2, X_3)$$

$$Y_2 = f_2 (Y_4, X_1, X_2, X_3)$$

$$Y_3 = f_3 (Y_2, Y_5, X_2, X_3)$$

$$Y_4 = f_4 (Y_2, Y_5, X_2, X_3)$$

$$Y_5 = f_5 (X_1, X_2)$$

where $Y_1$ = food and fiber crops output

$Y_2$ = fodder production (excluding grain)

$Y_3$ = meat

$Y_4$ = draft power

$Y_5$ = grazing production

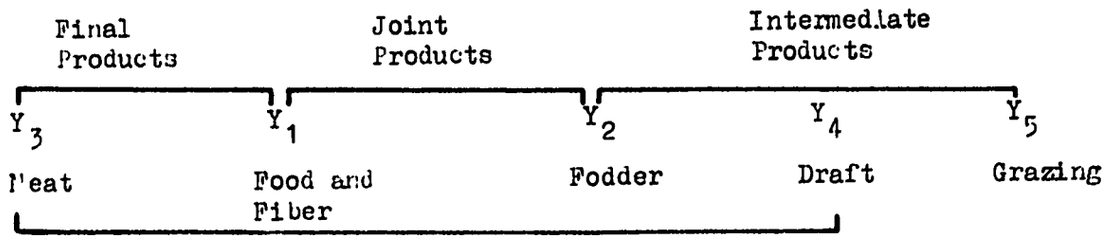
$X_1$ = land

$X_2$ = labor

$X_3$ = capital

The five outputs are comprised of three types of products. Food and fiber crops ($Y_1$) and meat ($Y_3$) are final products and are sold outside of the village or consumed within the village. Intermediate products are those which are not sold outside of the village, but instead are used as inputs in the production of the final products. Intermediate products in this model are fodder ($Y_2$) and grazing ($Y_5$) which are used as an input into bovine production ($Y_3$ and $Y_4$) and draft power ($Y_4$) used in the production of food and fiber crops ($Y_1$) and their fodder by-products ($Y_2$). The third type of products represented are joint products, or products produced in fixed proportions. The joint products assumed in crop production are food and fiber crops ($Y_1$) and fodder ($Y_2$).

In summary, the following products are represented in each village:



Flow Charts

Production relationships and resource-product flows are summarized in Figure 5.1. The evaluation of bovine costs and returns in Chapter IV was a simplified version in which costs were confined to labor and capital facilities and returns were confined to draft power and animal sales. The generalized model presented in this chapter allows the impact of exogenous forces to be traced through the system.

A fixed herd biomass level is set by the level of the intermediate products; fodder and grazing resources. This given level of biomass is allocated between use as draft power and use for meat production through breeding herds. Figure 5.2. illustrates the working of this portion of the village bovine system.

Replacements come from internally produced calves or from transactions with sources outside the village. The mature animals are allocated between power and breeding by relative rates of return to each enterprise. Offtakes are in the form of draft power, culls for slaughter and sales of animals in excess of replacement requirements.

Production Relationships

The resources and intermediate products are combined to produce the final products in the village. Three production relationships are present.

Factor-factor or resource substitution problems relate the use of two or more inputs to production levels of a product. The shape of the resulting isoquant reflects the substitution possibilities in input usage. The minimum cost of producing a given level of a product is at the level of input use where

**Figure 5. 1.**

**VILLAGE RESOURCE ALLOCATION**

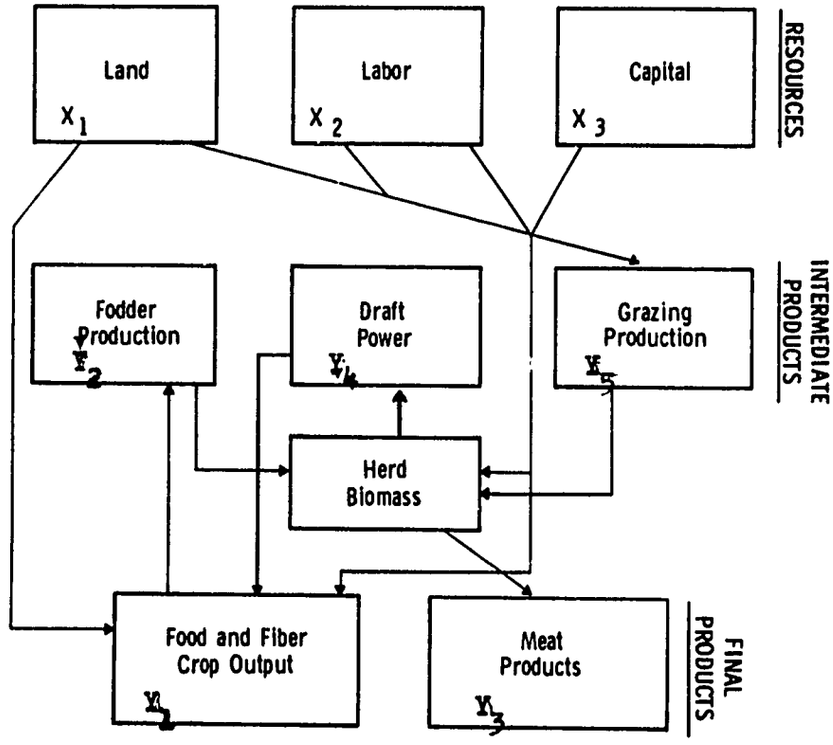
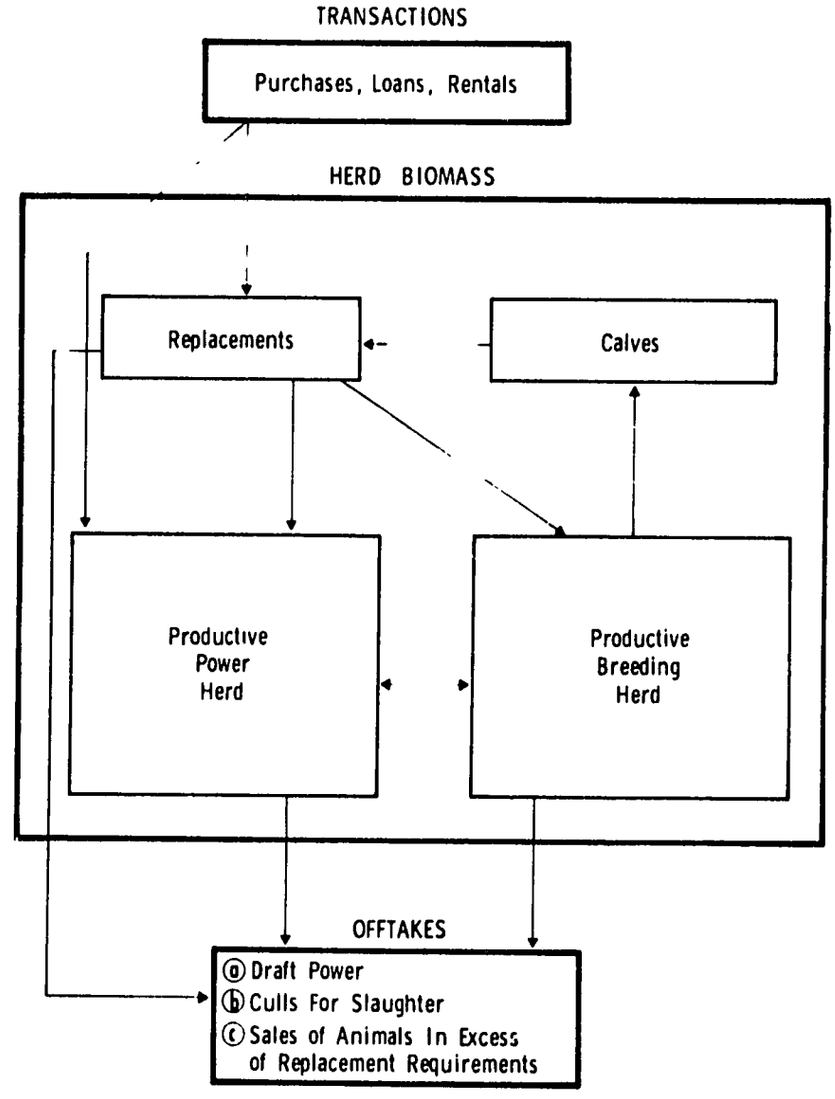


**Figure 5. 2.**

**BOVINE BIOMASS ALLOCATION**



$$\frac{MPPx_1}{Px_1} = \frac{MPPx_2}{Px_2} = \cdot \cdot \cdot = \frac{MPPx_n}{Px_n}$$

Profit is maximized when the levels of resource use are adjusted until the ratio of MVP's is equal to 1.0, i.e.

$$\frac{Py_1 \, MPPx_1}{Px_1} = \cdot \cdot \cdot \frac{Py_1 MPPx_n}{Px_n} = 1.0$$

Factor-product relationships, sometimes called production functions, specify the output levels forthcoming from alternative levels of variable input use. Inputs are classified as variable and fixed. The standard or classical representation of the production function has total product first increasing at an increasing rate, then increasing at a decreasing rate, and finally decreasing absolutely as increased levels of the inputs are applied. The increasing use of labor on a fixed supply of village land produces this phenomena.

The third concept is the product-product relationship which holds resource quantities constant and varies the quantities of output produced by this fixed bundle of resources. The rate at which one product can be transformed into another using the fixed resource bundle is called the marginal rate of product substitution (21, p. 239), the marginal rate of transformation (4, p. 27) or the rate of product transformation (22, p. 68). The rate at which rice output could be transformed into corn output using a fixed level of land, labor, and capital would define a product-product situation in the case-study villages. This concept will be used below in analyzing how the fixed biomass, set by fixed village resources, can be used to produce power, meat or so e combination of the two.

## A Model of Resource and Product Allocation

### Land Allocation and Biomass Support

The relationship of bovine production to resource use was complicated by the presence of intermediate products entering the production process. For example, the land resource produces two intermediate products, fodder and grazing; these in turn can produce animal power, a third class of intermediate product, which is also an input into the fodder production process. Fodder is a joint product produced with food and fiber, the final products. Because of these complex, interacting relationships, several simplifying assumptions must be made. However, these assumptions appear to be consistent with actual conditions in the three case study villages.

First, the total resource base of a village sets a limit on the bovine biomass that can be supported in that village. At the present state of knowledge about bovine nutrition, the author is hesitant to specify it precisely as TDN; therefore the limit will be referred to more generally as "nutritional." Of the three general classes of basic resources --- land, labor, and capital --- the land resource appear to set the nutritional limit. Given the low levels of technology employed in both crop and forage production, the total area of village land is assumed to produce a more or less constant quantity of animal nutrition (allowing for yearly fluctuations in the weather). This assumption implies that a rai of village pasture will support about the same kilograms of animal biomass as a rai of rice. This assumption seems feasible under the "roughage

only" type of feeding carried out at present in the villages. The biomass supported per unit of area varied between villages because of substantial differences in land quality, weather and drainage.

The one-to-one trade off between crop residue production and grazing resources is not valid when certain types of crops are introduced or substantial changes in biological and chemical inputs occur in crop production. The increase in sugar cane production takes land out of livestock production since the fields are never grazed and the crop residues are unusable for feed. Watermelon and root crops took land out of grazing and contributed very little to biomass support in the form of crop residues. In these cases, the model to be presented must be modified to account for changes in cropping patterns. The introduction of new chemical and biological inputs is examined later in the Chapter as one of a class of shifters in biomass support levels.

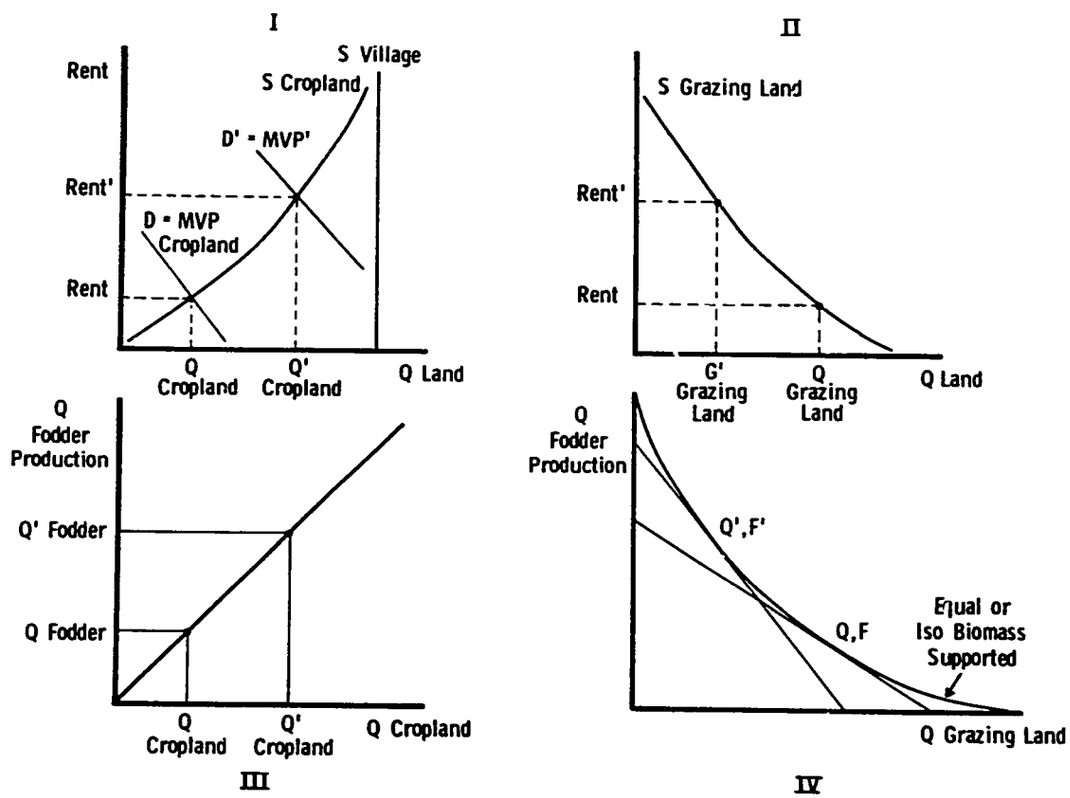
Labor is not felt to be a resource limiting the total size of biomass supported. The current labor stock employed in bovine production could be spread over a greater biomass for herding operations. Labor (particularly in management aspects) was assumed to influence breeding herd productivity, however. This enters as an assumption in the next section where large breeding herds perform less efficiently than smaller herds due to poor management and supervision. Capital was not felt to be limiting as long as the present practice of not transferring roughage between villages is maintained. Use of capital to purchase more animals would exceed the nutritional limit, reducing growth rates and animal sizes.

The working of the model is shown in the four interrelated diagrams in Figure 5.3. The demand for cropland is a function of the MVP of cropland in the production of food and fiber. Shifts in the demand curve for cropland are a function of the prices of food and fiber final products. The shifts are not a function of technological change in the food-fiber producing sector, the effects of which are examined in a later section of this chapter.

Part I of Figure 5.3. illustrates the demand and supply of village cropland in relation to total village land resources (supply of village land--3 village). The supply of cropland becomes increasingly inelastic as more marginal land is brought into crop production. The supply of grazing land (Graph II) is a mirror image of cropland supply because grazing land is treated as a residual, i.e., the supply of the village land (3 village) minus equilibrium levels of cropland use. Graph III assumes a direct, linear relationship between levels of cropland use and village fodder produced. This would not hold when non-fodder producing crops enter village cropping systems. Graph IV combines various levels of grazing and fodder into a type of "factor-factor" diagram, except the reader must keep in mind that the "factors" are intermediate products which were in turn produced by the basic inputs of land, labor, and capital. This graph illustrates the various combinations of these two intermediate products producing a given level of another intermediate product, village herd biomass. Two items are of interest. First, the relationship is primarily biological or technical in nature. Economics enters in only when

**Figure 5. 3.**

**LAND AND INTERMEDIATE PRODUCT ALLOCATION IN BOVINE PRODUCTION**



cropland demand shifts. Second, regardless of the cropland-grazing land mix, the level of biomass is fixed by village land supplies and the underlying productivities of (a) grazing land in supporting animals, and (b) cropland in producing fodder supplies. This fixed relationship is a consequence of the one-to-one trade off between crop residue production and grazing resources assumed earlier.

Bovine Production Possibilities

Following the determination of biomass levels, the next step is allocation of the animals between their various uses. Production from the biomass consists of an intermediate product (draft power) and a final product (meat). The capital accumulation role is disregarded for now. The analysis proceeds by allocating the products of the village herd biomass by means of a product - product relationship using a synthesized herd analysis of the primary flows of Figure 5.2.

Assumptions were as follows:

(1) One animal unit (AU) = 500 kilograms.

(2) Larger breeding herds had lower birth rates than smaller breeding herds because management of larger herds was more difficult and the provision of adequate bulls for larger herds was inadequate. Specifically, a seventy percent birth rate was assumed for herds of ten percent breeding females and birth rate decreased one percent for each two percent increase in breeding females percentage of total herd. Death rate was zero percent.

(3) Animals become productive for breeding or power at four years of age; were culled at eleven years of age, and replaced with four year old replacement stock. Thus one-seventh of the producing herd is replaced yearly to maintain a static level of

productive animals.

(4) Only males may be imported (purchased) from outside the village; female replacements are produced within the village. Male replacements are purchased at age three to train for work.

(5) Actual production is net of all purchased animals.

(6) No bulls for breeding are accounted for.

(7) All calves are held to age three. Younger animals were infrequently bought or sold and only at a discount. At age three they are retained as replacements or sold.

(8) Only cattle are analyzed.

Animals were classified into nine functional categories. These categories and their corresponding age groupings are presented for reference in Figure 5.4. The categories are as follows:

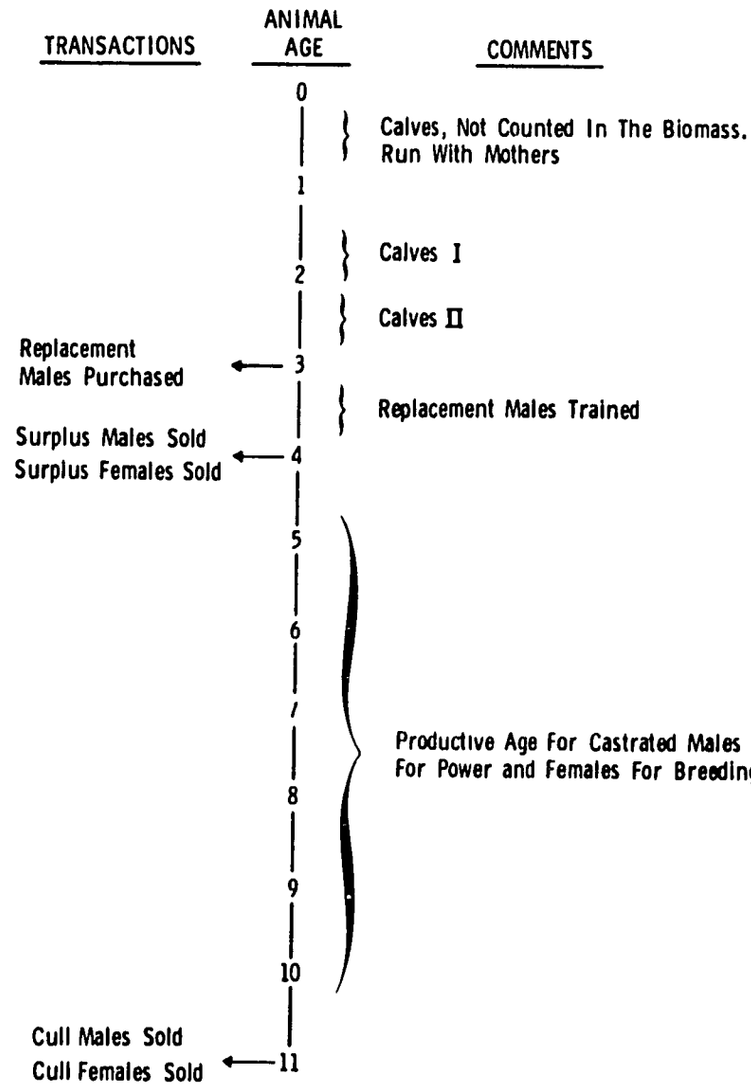
(1) Castrated males are workstock which become productive at age four, work through age ten, and are sold promptly at age eleven. One animal is equal to one animal unit. Each animal works 720 hours per year. They are evaluated economically as a team. Power output is in terms of total hours worked by each animal, not by hours per team. One-seventh of these are replaced annually.

(2) Breeding females become productive at age four, are sold at age eleven, and also are counted as one animal unit. If each female produces an average of .7 calves per year, over her productive lifespan of seven years, she then produces 4.9 calves.

(3) Replacement males (from herd) are three to four year old castrated males raised from birth from the village herd, and are counted as .75 animal units. They are being trained for work but contribute no power input. If no replacement males are purchased,

**Figure 5.4.**

## SYNTHETIC HERD CATEGORIES



the number of animals in this category must equal power culls being sold.

(4) Replacement males (purchased) have the same characteristics as (3) above except they are purchased from outside the village to supplement inadequate male replacements generated inter ally. In determining net herd output, these animals are subtracted from the cull power animal sales to produce a "net of purchases" output figure.

(5) Surplus replacement males have the same characteristics as (3) above except they are not being trained for power. A surplus of replacement males exists if draft power requirements are low or a large breeding herd is present.

(6) Replacement females (from herd) are three year old females produced by the breeding herd. They are equal to .75 AU's and become productive breeders at age four.

(7) Surplus replacement females have the same characteristics as (6) and are in excess of breeding herd replacement requirements.

(8) Calves II are two to three year old male and female calves which are generated from the breeding herd. They equal .5 AU. Their number equals breeding cows times the birth rate.

(9) Calves I are calves one to two years old generated by the breeding herd. They are assumed equal to .5 AU. Their numbers are equal to numbers of the Calves II category. Calves I and II are retained in the herd rather than sold at weaning for reasons presented in assumption seven above. Calves aged zero to one years were not

included as herd biomass in the calculations of Chapter IV to simplify calculations at this point.

Five different herd categories are assumed to represent various animal uses.

(1) "Strict power herd" represents the most specialized arrangement found in the villages. Three year old castrated males are purchased and trained for power to replace the culls. No breeding stock are kept. Output consists of power and a small net meat output since cull animals weighing 500 kilograms (one AU) are being replaced by three year old replacements weighing 375 kilograms (.75 AU's).

(2) "Import fraction of power herd" represents the presence of some breeding stock but these stock are inadequate to fully replace the yearly sale of power stock culls with male replacement stock from the village herd. Power replacements then come from both village-produced calves and purchases. Output consists of power plus sales of power culls, breeding herd culls, and surplus replacement females.

(3) "Static power herd" has a breeding herd large enough to produce all power replacements but not a surplus of replacement males. No purchases are necessary. Output categories are the same as (2) above.

(4) "Static power and breeding herd" has a smaller power herd and a larger breeding herd than herd classification one, two, and three. A surplus of both replacement males and females are produced in addition to power and culls.

(5) "Static breeding herd" has no castrated males present. All cull females are replaced and the surplus of replacement females are

sold. All males are surplus and sold at three years of age.

To interpret the results of the synthesized analysis, herd compositions are expressed as fractions. Thus .600 of total herd means 60 per cent of the herd is in this category, or sixty animals out of a 100-animal herd. Tables 5.1. and 5.2. represent herd compositions of the five herd situations discussed above. Table 5.1. represents a numerical breakdown while Table 5.2. expresses composition in biomass terms. The fractions are not equal because of different animal sizes in the various categories represented. Table 5.1. is interpreted as follows:

In the strict power herd, .875 of the total number of animals are working and one-seventh of these are replaced yearly (.125), which are the replacement males (purchased). Adjusting for biomass differences gives a biomass breakdown of .903 and .097 for the two categories in Table 5.2.

Importing part of the replacement males and producing the rest internally decreases the size of the power component to allow for some breeding activity. Power replacement requirements of the second herd category are .515 x 1/7 = .0735 and are met by male replacements from the herd (.052) and purchased males (.022). Breeding females produced .148 x .675 = .104 calves per year. Female calves were .104 x .5 = .052 and upon reaching replacement age, female calves were either used as breeding stock (.022) or were sold as surplus (.029).

Table 5.1. Composition of Synthetic Herds by Animal Numbers.

| Category by Animal Function | Age | Animal Units | Synthetic Herd Situations | | | | |
|---|---|---|---|---|---|---|---|
| | | | Strict Power Herd | Import Fraction of Power Herd | Static Power Herd | Static Power & Breeding Herd | Static Breeding Herd |
| Castrated Males for Draft | 4-10 | 1.00 | .875 | .515 | .436 | .259 | 0 |
| Breeding Females | 4-10 | 1.00 | 0 | .154 | .190 | .259 | .368 |
| Replacement Males (from herd) | 3 | .75 | 0 | .052 | .062 | .037 | 0 |
| Replacement Males (purchased) | 3 | .75 | .125 | .022 | 0 | 0 | 0 |
| Surplus Replacement Males | 3 | .75 | 0 | 0 | 0 | .043 | .106 |
| Replacement Females (from herd) | 3 | .75 | 0 | .022 | .027 | .037 | .053 |
| Surplus Replacement Females | 3 | .75 | 0 | .029 | .035 | .043 | .053 |
| Calves II | 2 | .50 | 0 | .103 | .125 | .161 | .210 |
| Calves I | 1 | .25 | 0 | .103 | .125 | .161 | .210 |
| Total | — | — | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

Table 5.2. Composition of Synthetic Herds by Biomass.

| Category by Animal Function | Age | Animal Units | Synthetic Herd Situations | | | | |
|---|---|---|---|---|---|---|---|
| | | | Strict Power Herd | Import Fraction of Power Herd | Static Power Herd | Static Power & Breeding Herd | Static Breeding Herd |
| Castrated Males for Draft | 4-10 | 1.00 | .903 | .613 | .536 | .342 | 0 |
| Breeding Females | 4-10 | 1.00 | 0 | .184 | .234 | .342 | .536 |
| Replacement Males (from Herd) | 3 | .75 | 0 | .046 | .057 | .036 | 0 |
| Replacement Males (purchased) | 3 | .75 | .097 | .020 | 0 | 0 | 0 |
| Surplus Replacement Males | 3 | .75 | 0 | 0 | 0 | .043 | .115 |
| Replacement Females (from herd) | 3 | .75 | 0 | .020 | .025 | .036 | .058 |
| Surplus Replacement Females | 3 | .75 | 0 | .026 | .033 | .043 | .058 |
| Calves II | 2 | .50 | 0 | .060 | .077 | .106 | .154 |
| Calves I | 1 | .25 | 0 | .031 | .038 | .052 | .077 |
| Total | --- | --- | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |

In the last three herd situations, the breeding component increased at the expense of power component. More surplus animals are thus forthcoming from the increased breeding component as the fractions indicate.

Production from the herds is presented as a fraction of total biomass (Table 5.3.) and then converted to actual quantities in Table 5.4. by assuming a herd biomass of 100 animal units. The fractions in Table 5.3. were multiplied by 100 to obtain animals produced and then multiplied by the kilograms appropriate to their animal units. The number of animals in each power herd was multiplied by 720 hours to arrive at hours of power produced.

The output combinations estimated for each herd category are plotted in Figure 5.5. Connecting these points outlines the product-product relationship discussed previously. The slope of the curve can be interpreted as the marginal rate of substitution of the intermediate product (power) for the final product (meat).

The line divides the quadrant of the graph into two sectors. Points to the right of the line represent herds in which the proportion of power animals is so high that an inadequate number of females are present to produce all the male replacement animals needed. Points to the left of the line represent herds in which the proportion of breeding animals is high enough to replace cull males and still produce a surplus of power stock replacement animals.

The curve in Figure 5.5. is a product - product relationship as defined previously. The curve is normally drawn concave to

Table 5.3. Net Meat Production of Synthetic Herds.

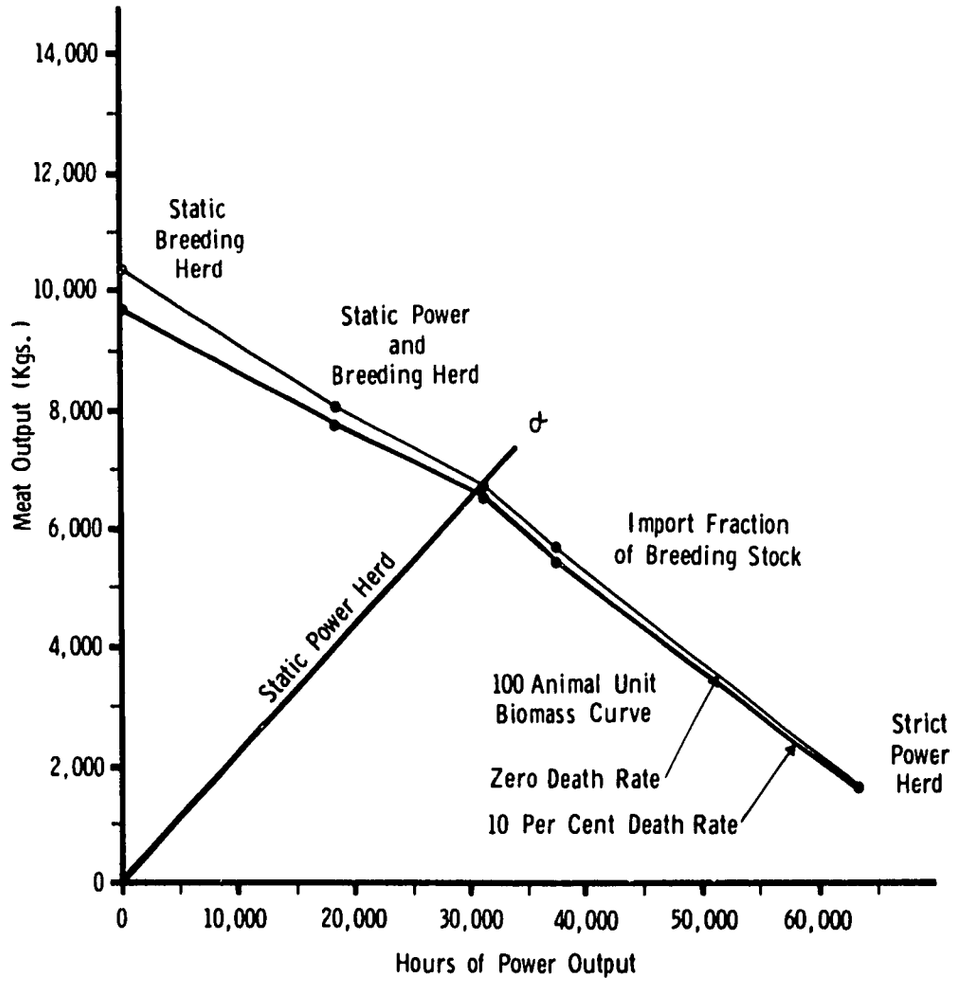
| Category by Animal Function | Age | Animal Units (meat) (terms) | Synthetic Herd Situations: Strict Power Herd | Import Fraction of Power Herd | Static Power Herd | Static Power & Breeding Herd | Static Breeding Herd |
|---|---|---|---|---|---|---|---|
| Cull Castrated Males | 11 | 1.00 | .032 | .068 | .077 | .048 | 0 |
| Surplus Replacement Males | 3 | 1.00 | 0 | 0 | 0 | .043 | .115 |
| Cull Breeding Females | 11 | 1.00 | 0 | .026 | .033 | .049 | .077 |
| Surplus Replacement Females | 3 | 1.00 | 0 | .026 | .032 | .043 | .058 |
| Total | --- | --- | .032 | .120 | .142 | .183 | .250 |

Table 5.4. Net Production of Power and Meat from a 100 Animal Unit Synthetic Herd

| Category by Animal Function | Age | Animal Units | Unit of Product | Synthetic Herd Situations: Strict Power Herd | Import Fraction of Power Herd | Static Power Herd | Static Power & Breeding Herd | Static Breeding Herd |
|---|---|---|---|---|---|---|---|---|
| Animal Power @ 720 hours per Animal/ Year | 4-10 | 1.00 | Hours | 63,000 | 37,080 | 31,392 | 18,648 | 0 |
| Cull Castrated Males | 11 | 1.00 | kgs. | 1,600 | 3,400 | 3,850 | 2,400 | 0 |
| Surplus Replacement Males | 3 | .75 | kgs. | 0 | 0 | 0 | 1612.5 | 4312.5 |
| Cull Breeding Females | 11 | 1.00 | kgs. | 0 | 1,300 | 1,650 | 2,450 | 3,850 |
| Surplus Replacement Females | 3 | .75 | kgs. | 0 | 975 | 1,200 | 1612.5 | 2,175 |
| Total Meat Output | --- | --- | kgs. | 1.600 | 6,000 | 7,200 | 9,800 | 13,700 |

**Figure 5. 5.**

## OUTPUT LEVELS OF 100 ANIMAL UNIT SYNTHETIC HERD



the origin reflecting differing factor intensities of the two products. However, variations in the shape of the curve in Figure 5.5. are a result of variations in herd performance, not factor intensities as the biomass is assumed to be supported by the same bundle of resources regardless of the use of the biomass. In either case, a constant substitution relationship along the curve does not prevail because of the second assumption which varied breeding rates along the curve. Several other factors would contribute towards making the curve more concave to the origin.

First, death rates are normally higher for breeding herds due to calving mortality. Death rates would also be expected to increase with larger breeding herds for reasons cited above. Higher death rates make less meat available from surplus animals remaining after replacement requirements are filled. The curve lying slightly below the zero death rate curve in Figure 5.5. was constructed assuming a ten percent mortality rate at calving.

Second, the use of dual purpose female buffalo for both draft and breeding purposes would push the center portion of the curve outward as both power and meat are being produced in greater quantities than under the "male only" draft situation described in Figure 5.5. at either end of the curve, however, the total contribution of dual purpose females declines as their function becomes more specialized.

Third, at higher draft animal levels, energy and feed requirements increase since draft animal energy expenditures rise rapidly during work. Thus less feed is available for non-draft

animals and the net effect is a reduction in the total animal units the village can support. Using the results of a Philippine study (26), the 720 hours worked per year assumed for synthetic herd animals would increase gross energy requirements of draft animals by about thirty percent per year. This would reduce meat output at high draft power levels because fewer animals could be supported by village feed resources.

A fourth factor not related to the technical factors underlying the shape of the curve, is transaction costs involved in converting from one system to another. These costs arise when animals are sold for a salvage value less than the acquisition price or less than the marginal value product of an asset in its primary function.

Power Demand and Meat Demand

The product - product diagram also represents product combinations produced by a given level of total costs since the same resource bundle was used in constructing the curve. Faced with this cost , the rational producer will attempt to maximize revenues (returns in this case) for these products. Multiplying quantities times prices at each product level produces a series of iso - revenue lines moving outward from the origin as the resource bundle is increased. The highest revenue obtainable for a given resource bundle is the point of tangency between the product - product and iso - revenue curves and is represented by points

e, f, g, and h in diagrams I and II, figure 5.6.

Diagram I represents a product - product curve where the rate of substitution is constant and a decrease of one draft animal allows a constant increase in meat to be produced at every point along the curve. Diagram II is more representative of village conditions where diminishing marginal rates of substitution of draft power for meat production holds. A change in relative rates of enterprise return would shift the revenue maximizing product mix from point e to point f. A shift of this type would occur over time in response to changes in technical and economic forces influencing livestock returns. Increased birth rates or more rapid animal growth rates would increase the returns to breeding enterprises and therefore increase meat production relative to power production at equal biomass levels. This would correspond to a shift from point e to point f on diagram II, Figure 5.6. Conversely, increased crop prices, ceteris paribus, would increase returns to draft animals and have the opposite effect.

A shift in consumer demand for beef is illustrated in diagram IV, Figure 5.6. Demand increases to D' increasing meat prices. Since meat is the primary product of the breeding enterprise, a shift from e to f occurs. The factor - factor diagram (diagram III, Figure 5.6.) illustrates the effect on animal power use of decreasing prices of tractor plowing services.[1/] The movement from a

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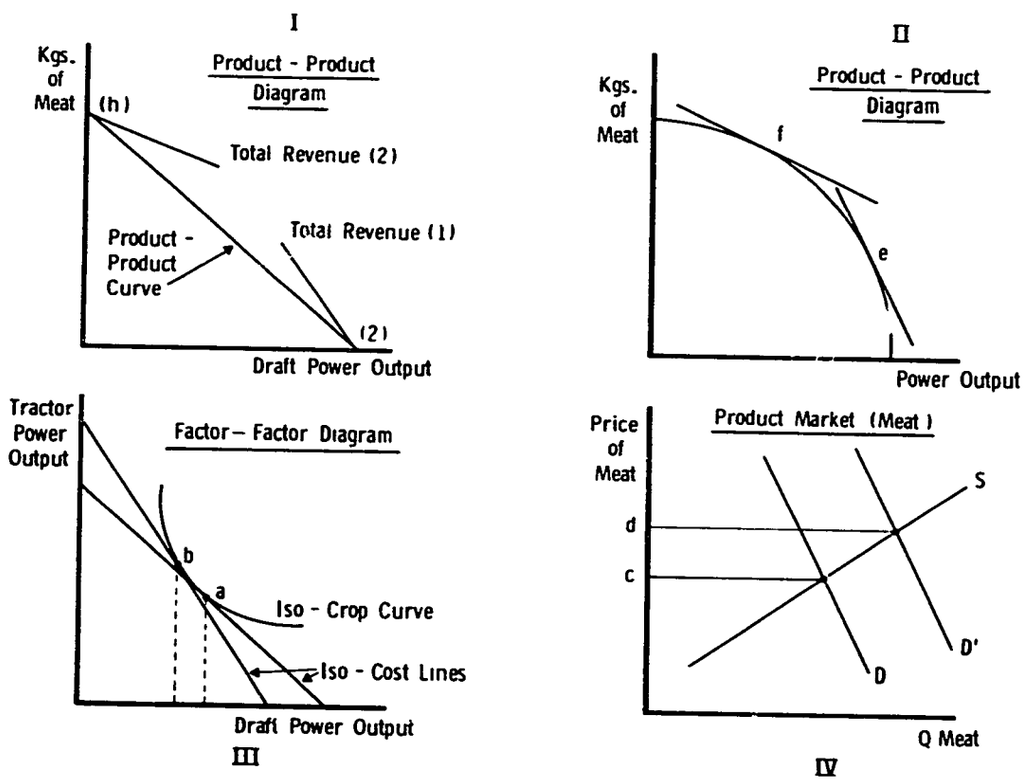
[1/] Chancellor (11, p. 79) estimated tractor service rates decreased an average of 7.2 percent per year over the 1965-1969 period.

**Figure 5. 6.**

**SOLUTION OF THE PRODUCT - PRODUCT DIAGRAM**



to b illustrates the substitution effect at existing crop output levels. If tractor plowing introduces a scale effect, the curve would shift outward and increase power demand on a per farm basis over that at point b. However, per unit of area use of draft animals would be less. This was the case in Nong Jek Lee where larger farm sizes and some double cropping has created a strong per farm demand for draft animals although per rai use of draft animals is generally less than those found in the other villages. A more detailed examination of the mechanization effects is carried out in Chapter VI.

Shifters of Biomass Production Levels

Offtakes from village herds increases when the biomass increases, when an existing level of biomass is used more efficiently, or both. Changes in crop and forage production technology allow biomass increases while improvements in livestock production technology allow increases in production from existing biomass levels.

Crop Production Technology

In order to substantially increase the biomass levels of a village, crop production levels must be increased and the subsequent forage produced must also increase proportionately. The planting of sugar cane on sorghum land would not increase available feed supplies but actually decrease these supplies. Neither would double cropping at low levels of technology necessarily increase biomass support levels since the land being replanted could also be used as a pasture source during the period of second cropping. The

role of improved crop production technology is to break the one - to - one feed supply relationship between cropland and pasture land so total feed supplies in the village are increased. The effect would be to shift the product - product curve of diagram II, Figure 5.6. outward and, assuming the new crop technologies increased animal power demand, shift the product mix in favor of a higher proportion of draft animals.

In actual practice, increases in crop production intensity in other countries has been accompanied by major structural shifts in bovine production. The increased resource productivities make crop production more profitable than bovine production at existing levels of bovine production technology and investments in resources flow into crop production. Increased cropping intensity has often led to increased mechanization which contributes further to this trend. Thus a major weakness of this model is the lack of a well defined relationship between changes in crop production technology and biomass support levels.

Forage Production Technology

Improved forage technology will be confined to improving the productivity of existing pastures and to programs of reseeding idle cropland to forage crops between harvesting and planting periods. There is no effect on level of the intermediate product, fodder production. The shift is in nutrition produced per unit of pasture. If the biomass is supported only by fodder production, no change in biomass is forthcoming. As more and more grazing land is substituted

for fodder, the same level of biomass can be supported by smaller levels of grazing land and fodder produced. Conversely, the same levels of these intermediate products can now support larger levels of biomass. Diagram V, Figure 5.7. illustrates the result. The higher biomass curve (100 AU) represents unimproved pastures. Improved pastures allow 100 animal units to be supported with fewer resources, or the higher curve would now become some level of biomass greater than 100 animal units. The effect is to shift the product-product curve outwards. Forage production technology alone would cause no change in enterprise rates of return so no shift along the product-product curve occurs.

Bovine Production Technology

The following improvements in bovine production technology are discussed together since they all have the same effect on the system:

(a) increase in birth rate or growth rate, or decrease in death rate;

(b) increase in maximum animal size at maturity;

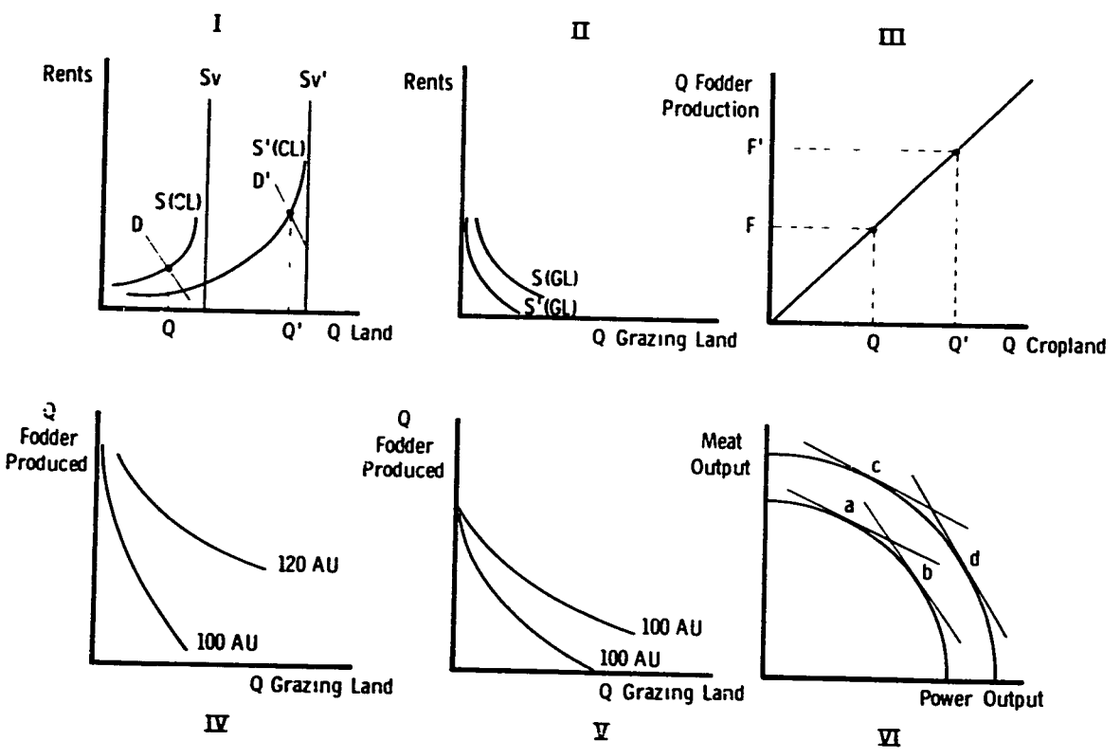
(c) disease control and prevention which can be analyzed under (a) and (b) above; and

(d) improved breeding stock and breeding practices which also effect (a) and (b) above.

Increased bovine productivity is not reflected in Diagrams I - V in Figure 5.7. The impact is on production of animal power and

**Figure 5. 7.**

## BOVINE BIOMASS SHIFTERS



meat from a given level of biomass. By referring back to the synthetic herd analysis, increases in the productivity levels assumed bring forth direct increases in output from the same level of biomass. Graphically, the product-product curve shifts out in Diagram VI, Figure 5.7., but the level of biomass remains constant; alternatively, the original output levels of curve ab can be produced by a smaller, more productive bovine herd.

# CHAPTER VI

# MAJOR RESTRAINTS OF OUTPUT EXPANSION

## Introduction

The discussion of problems surrounding bovine production in Chapter I indicated that bovine production has been unable to match the general growth of the economy. This indicates that constraints have arisen as the agricultural sector of the Thai economy has been subjected to the forces of modernization. A brief discussion of the traditional versus modernizing crop-livestock production system points out some problem areas where constraints to increased bovine production have arisen.

## Traditional Versus Modern Systems

An aggregate food production-consumption model for bovines would have population growth causing an increase in rice cropping area, which in turn would increase draft animal requirements and thus result in a larger total bovine population. The larger bovine population would result in a larger number of cull animals (meat supply) which would affect per-capita consumption levels of beef. In this simplified, traditional system, population growth gives impetus to the system. The historical pattern in pre-World War II Thailand was as follows:

1. Population growth was increasing without major rural to urban migration.

2. The increasing population settled new areas, expanding rice area roughly in proportion to population (24, p. 310).

3. Under traditional technology, draft animal requirements increased in proportion to rice areas cultivated as did the animal populations required to produce the draft animals.

4. The increasing bovine populations produced cull animals and thus meat supplies roughly in proportion to population growth. Per capita consumption levels would be static. Most animals were consumed in rural areas where the vast majority of the population lived. Pricing and marketing were not well-developed.

Post-World War II developments have seen substantial shifts in demand conditions and production relationships which have disrupted the traditional population expansion - meat supply model outlined above. First, population growth has accelerated and a rural to urban migration has begun. To maintain constant per capita consumption levels of cattle and buffalo meat, meat supplies, both in total and per producer, must expand at an increasing rate. Second, the expansion of rice area has slowed and the expansion of upland crops has increased but presently at a decreasing rate. These two factors plus the introduction of tractor plowing on a large scale (11) has altered the traditional rice-draft power linkage. The decreasing demand for draft power requirements plus the slowing down of crop area expansion appears to have dampened the growth rates of bovine populations. Consequently, cull animal production and meat supplies have not expanded sufficiently to maintain per capita consumption levels of cattle and buffalo meat on a nationwide basis.

This chapter proceeds by looking at bovine problems and production at two levels. At the macro level, production and price relationships are examined along with legislation, export and promotion policies. At the micro level, the results of this study are applied in an attempt to provide insights and answers to the major questions asked at the higher levels of planning, research, and policy implementation.

## Trends at the Macro Level

### Production and Prices

The most obvious question is, in the face of slow increases in cattle and buffalo numbers and a stagnant technology coupled with a rapidly increasing population and rising per capita incomes, why haven't retail beef prices shot upwards? Over the ten year period, 1957 to 1966, cattle numbers increased an average of .34 percent per year while wholesale Bangkok meat prices increased 1.34 percent per year (deflating prices would lower the rate of price increase moderately). The corresponding figures for buffalo were a 1.48 percent per year increase in numbers and a 1.61 percent per year in wholesale meat prices. Assuming an income elasticity of demand of one, demand increased by an average of 11.07 percent per year over this same period. Several explanations are possible.

First, the increases in bovine production could have been grossly underestimated such that the supply curve has been shifting at a more rapid rate than indicated by official statistics. The estimates given above were provided by the Department of Livestock Development, Ministry of Agriculture. In fact, the figures may over-

state actual animal numbers as the 1963 Census of Agriculture showed only 67.8 percent of the cattle numbers and 72.7 percent of the buffalo numbers reported for 1963 by the Department of Livestock Development. Reported slaughter estimates grossly underestimate total national slaughterings because of the widespread presence of illegal slaughtering. Data collected in a recent survey by the Division of Agricultural Economics, Ministry of Agriculture, should help improve national herd estimates. However, the Department of Livestock Development estimates are the best available at present and show no definite trend towards rapidly increasing animal numbers.

The second possibility is a highly skewed distribution of the increase in incomes over this period which decreases effective demand levels over those of a more evenly distributed income growth pattern. Over the 1961-1967 period, the total value of agricultural, forestry, and fisheries products increased an average of 1.98 percent annually while overall population increased at about 3.2 percent annually. Allowing for a limited amount of outmigration from the agricultural sector, the population of the rural areas (approximately 80 percent of the total population) has not shared the income growth of the Kingdom equally. A large proportion of income growth has occurred in Bangkok and the surrounding areas comprising less than ten percent of the total population. This appears to be one reason for a less rapid growth in demand that would seem warranted by a simple interpretation of aggregate data.

The third factor seems to be the rapid development of commercial hog and poultry enterprises near the major consumption centers. While the majority of the pig and poultry production is still of the village "backyard" type of operation (28), commercial production of breeding stock, feeder pigs and fattening operations plus factory-type broiler, egg, and duck-producing firms seem to have supplied increased amounts of meat at near constant prices over the past fifteen years. Over the 1955 to 1966 period, hog numbers increased 2.58 percent annually and prices by 1.46 percent annually. The corresponding average percentage increases for chicken were 1.87 percent for quantity while undeflated price stayed the same. In addition to the increases in numbers, annual extraction rates from the national swine herd and poultry flock probably increased significantly though the unreliable slaughter data do not permit extraction percentages. The introduction and cross-breeding of exotic swine and poultry breeding stock was rapid during this period. In addition, hog and poultry vaccinations became common and improved feed formulations were introduced. The sutstitution of poultry and pork (and possibly fish) for beef appears to be a major factor holding down beef shortages and price increases. If consumers regard beef as an inferior good vis a vis poultry or pork, the substitution of these for beef would be further accentuated over this period of rapid income growth.

## Legislation, Promotion, and Export Policies

Historically, the government has sought to maintain animal

numbers by the regulation of slaughtering practices. The Propagation and Conservation of Livestock and Beast of Burden Act was passed in 1949 to reduce slaughtering of draft animals in order that adequate power sources would be available for crop production purposes (34, p. 11). Under this act, all cattle and buffalo shipped for slaughter must meet one or more of the following requirements:

Being 8 to 10 years old or over.

If female, being over 15 years old.

Being lame or crippled.

Being over 5 years old and sterile.

Having poor specimen of offspring.

Having inherited contagious diseases.

In special cases, for religious purposes.

The prevalence of illegal abattoirs makes the act of little practical significance when the conditions which caused its formulation (meat shortages and wholesale slaughtering of stock) are not present. For example, in Chieng Mai, a major consumption center in Northern Thailand, no buffalo had been sent to the municipal slaughterhouse during 1970 although the previous year's estimate showed 178,929 buffalo in the province (3).

More recent trends in legislation have formulated policies to promote large-scale commercial production to meet local demands for high quality meat and develop export markets. In 1970, the Board of Investment, Ministry of National Development, announced that cattle farming, slaughtering and meat freezing were to be promoted industries.

Project conditions included a minimum capital of five million baht, excluding land and working capital, cattle to be slaughtered must be fed at the investor's own farm for at least three months, and operators may only store their own meat in their deep freeze storage facilities.

The first promotional certificate was granted to Chokchai Ranch Company in January, 1971 with a 62 million baht investment. Later, in 1971, the Department of Livestock Development began to require exporters to develop their own farms.

These trends indicate the tying of both slaughtering and exports to large-scale specialized production. The legislation was formulated to bypass several constraints. First, the major beef-importing countries, particularly Japan, do not permit imports from hoof-and-mouth-disease-infected countries. By tying exports to disease free commercial producers, the government hopes to get around this obstacle. Secondly, a general rise in cattle and buffalo prices is undesirable for consumers and for the Kingdom's stock of draft animals. If a major export program developed and commercial production was not kept separate from the village production, domestic prices would rise towards world prices. Brisbane saleyard prices had been averaging $25 to $27 per hundredweight over the study period while Bangkok saleyard prices were in the $9 to $10 range for cattle and $7 to $7.50 range for buffalo.[1/] If Thai exporters could get world prices, there would be a enormous incentive for exporters to buy

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1/ It should be noted that the quality and dressing percentages would be much lower for the Thai animals at village level conditions.

village culls and export their meat. Given the problems of export control which have plagued Thailand (43, 45), the required segregation of markets would be difficult to achieve.

Adoption of New Technology: Bovine Production Versus Poultry and Hog Production

Examination of price and production relationships for bovines in an earlier section of this chapter indicated sustained increases in poultry and pork production and development, and in certain circumstances, of factory-type production systems employing improved technology. Through a combination of circumstances, a parallel trend may be developing in cattle production. Three questions arise. First, why was improved hog and poultry technology adopted prior to its use in bovine production? Secondly, why did it lead to factory-type systems, albeit still on a limited scale? Third, will the adoption of improved bovine technologies necessarily follow a similar pattern.[2]

The first phenomena is widely observed in tropical countries and is partially related to productive efficiency and the environmental modifications necessary to achieve high production levels. Early successful transfers of genotypes to Thailand occurred when exotic breeds were able to increase animal productivity without substantial modifications of the environment being necessary. Duroc and Yorkshire

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[2] Discussion of these three questions is based heavily on conversations and correspondences with Dr. James E. Johnston, Animal Scientist, The Rockefeller Foundation, Bangkok.

hogs are an example. Brahmin cattle have also been readily accepted by Thai farmers but large increases in animal growth and size have not been achieved without some improvements in environmental conditions. In this respect, disease control may be crucial. Duckman and Lasefield (13) distinguish between two main classes of livestock with respect to this transferability.

> . . . In the first class, which includes pigs and poultry, temperate genotypes can be transferred to most tropical environments with complete success. In the second class (cattle, sheep, goats) this is not usually possible until the environment has been modified, at least by the control of diseases (p.45).

More recently Santa Gertrudis cattle have been introduced but have not proven feasible to produce under village conditions as they require a much improved environment which village farmers are as yet unable to provide for their cattle.

Another factor influencing adoption is the traditional function of the animal. Generally, pigs and poultry have been kept primarily for production of meat and eggs and the introduction of more productive genotypes increased productivity of these types although some improvements in animal environment were usually required. Cattle are traditionally kept for the draft purpose and only secondarily for use as meat. The Brahmin is superior in both respects and has been adopted whereas the Santa Gertrudis, an even better meat producer, has not been accepted because the Brahmin is a superior draft animal.

A third factor is vastly different replacement costs and availabilities. For the cost of an imported cow the farmer could purchase several thousand chicks or forty exotic weaner gilts. The

investment costs of establishing an improved enterprise are much greater while the ability to supply additional improved stock is much less in the case of bovines.

The second question must be qualified by what is meant by a factory-type production situation in the Thai setting. An operational definition would be a producer having one or more pure-bred boars and five or more brood sows while a factory-type poultry system would have a minimum of 100 to 200 birds in a confined, controlled situation. The term factory-type, when applied to Thai large scale cattle producers, does not imply intensive operations of the confined feeding type but instead more extensive type of improved grazing operations under generally better environmental conditions than are found in the villages. They are factory-type only in that large quantities of meat are produced, slaughtered, and processed in an integrated operation.

The second question is partially explained by the above discussion. The small investment per animal required by pig and poultry operations allows easier and more rapid expansion towards larger systems. Returns to the initial investment begin earlier allowing re-investment to begin sooner. The factory-type system in egg production tended to be imported as an entire technology package (animals, building designs, cages, feed formulas, vaccines, and management practices) and very little local technology was required. This was true to a lesser extent for broiler and pig production and adoption has proceeded more slowly. In the case of cattle, major gaps in technology still exist - particularly in the areas of pasture production, management, and animal health - before factory-type systems can be widely adopted. In summary, the major difference

between hog-poultry factory-type operations and a factory-type cattle operation as proposed by the Board of Investment guidelines is the much greater amounts of land and capital required in the latter. Thus a trend toward a factory-type system in the hog-poultry sector and the bovine sector has vastly different meanings regarding entry conditions into the industry and interpretation of a trend in the one industry has little significance for evaluating possible production organizations in the other.

The third question is the most difficult to answer until practical and locally adapted nutritional and animal health sources are readily available. However, the nature of bovine production systems cause them to be more capital intensive than hog-poultry operations. The tying of exports to promotion privileges accentuates this tendency. The only way to avoid large-scale operations having an advantage over village farmers in access to new technology would be intensive research on improving productivity of present forms of crop livestock systems simultaneously and the provision of adequate capital and knowledge to use the improved production technology at the village level. Presently, most countries which have efficient beef industries combine a low cost system of producing feeder calves with an intensive finishing operation based on pasture (Australia) or grain (USA - Europe). Feeder calf production may be through use of low cost grazing areas for cow herd maintenance or the use of dairy bull calves. These technologies are not suited to Thailand t the present time.

## Insights at the Micro Level

### Technology

An additional implicit assumption behind current investment privileges is that commercial bovine producers (presently only cattle are being produced commercially) will be able to emulate the successful adoption of improved technology carried out by commercial poultry and hog producers. The requirement of large capital investment (in addition to land) plus the provision of slaughtering and freezing facilities will require levels of technology and management far beyond those found in the villages. Whether costs will be sufficiently reduced to compete with traditional village production systems remains to be seen. If the traditional and large scale are kept separate and a substantial export market develops, costs in large scale operations need not approach village levels to still show profits.

The official approach appears to assume improved bovine production technology is available (at least for cattle). At this point, three questions seem relevant. First, is improved technology really available to Thai bovine producers? Second, if it is available, for which species is it available, has it been adopted, and if not, why not? Third, what new technologies or modifications of existing technologies are needed at the village level? The sources of improved productivity outlined in Chapter I included genetic improvements, nutritional improvements, animal health improvements and better housing and management.

Genetic Improvements.-- Improved breeding stock was available in certain areas of the Kingdom, particularly regions of the Northeast near the Department of Livestock Development Stations. These

were Brahmin crossbreeds and adoption seemed uniform where breeding stock was available. Under good nutritional and management conditions, maximum animal size increased dramatically.[3/] The large-scale promoted farms were using Brahmin and Charolais purebred and crossbred animals in their breeding programs. The problems at the village level of poor nutrition, pest control, and management were making it impossible to achieve the productive potentials of the crossbred cattle. The price differential reflected speculative or status factors rather than differences in animal size or vigor in virtually every instance.

Breed improvement of buffalo is possible by selective breeding. Within the villages, buffalo sizes were more uniform than cattle reflecting more uniform breeding and management practices. Given the difficulties of detecting female buffalo in heat and mating difficulties, the provision of specialized buffalo breeding stock in the villages was not feasible. Buffalo breeding was totally haphazard whereas Brahmin sires for cattle were available at stud for a fee in Nong Bom Boom and almost every village visited in the Northeast. Thus, for cattle, breeding technology is available in some areas and is expanding to other parts of the Kingdom. It appears profitable and a market has arisen which reflects this. Further improvements will be from the introduction and crossbreeding of better adapted, more productive exotic varieties and provision of the necessary environmental modifications. The genetic improvement potential of buffalo appears limited at prese

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3/ A pair of matched Brahmin crossbred steers were tape measured in the Northeast and their estimated weights were over 1600 pounds each. The largest native animal measured was 1100 pounds.

Nutritional Improvements. --A limited set of improved forages are available including Para Grass, Hybrid Napier, Guinea Grass, and several clover varieties. Concentrates are available in the form of rice bran, corn and sorghum. Manufactured supplements for hogs are available locally. Concentrates and supplements are clearly unprofitable at present bovine price levels. Although some forage varieties are available for free at several Department of Livestock Development Stations, use has been negligible. The reasons are two. The necessary forage management techniques are not available nor is the capital necessary for fencing. Second, land preparation and forage planting offers low gross income per unit of land area. The synthetic cattle herd kept strictly for breeding produced 137 kilograms of meat per animal unit per year. If improved pastures could double the best carrying capacity found in the case study villages, two rai of land could support one animal unit with some fodder also provided. With a village price of 3.5 baht per kilogram, gross value produced per rai would be 240 baht per year per rai. A 350 kilogram per rai rice crop sold at one baht per kilogram would gross 350 baht per rai while corn would increase the gross to 400 to 500 baht per rai. Nutritional improvements would have even less effect on buffalo as the buffalo digestive system can readily utilize rice straw and other cheap, low-quality forages very efficiently (27). Successful nutritional improvements will require a combination of (a) better adapted forage varieties than are presently available, (b) improved management techniques including the ability to fit a forage system into present patterns of crop production, (c) improved breeding to utilize the potential of the

forages, (d) improved sources of intermediate term credit for fencing and land clearing costs, and (e) higher village level bovine prices.

Animal Health Improvements. -- Animal health technology is generally unavailable at the village level. Serums and vaccines are available from the Provincial Veterinary Officers but the knowledge of when or how to administer them is lacking. The normal pattern is one visit per year by the veterinary officer. Only a general outbreak of a fatal disease brings additional visits. Under existing levels of nutrition, improvements in animal health would most likely have a minimal effect. Thailand's bovines are well adapted to local disease conditions, which are partly dictated by climatic conditions. Water buffalo have developed some resistance to ticks, foot and mouth disease, rinderpest, anthrax, and haemorrhagic septicemia (although the latter still causes most buffalo deaths from disease) (47, p. 264). A limited ability to dissipate heat is compensated for by wallowing during the hottest part of the day. Thai cattle are smaller and maintain slower growth rates than cattle in temperate zones, thus reducing feed requirements and maintaining their health. They have strong, long legs for walking long distances to feed and water sources. They attract fewer ticks than temperate breeds. Their "comfort zone" is 50° F. to 80° F. as contrasted with 30° F. to 60° F. for temperate types. The temperature at which their thermoregulative mechanisms begin to fail is 95° contrasted to 80° for temperate types (47, p. 9-10). In body temperature trials, Zebu

animals have always had the highest heat tolerance coefficient (48, p. 319).[4/]

Housing and Management Improvements. --Present structures provide adequate protection from weather, thieves, and predators for small herds. Intensive feeding of larger herds would require substantial changes in traditional structures. Structures appear to be the least crucial constraint at this stage of village livestock development.

Management of small scale cattle and buffalo herds is adequate in most respects. Seasonal supplies of nutrition are adjusted for to avoid serious losses during short forage periods. Breeding is not managed, except when stud bulls are present but this does not appear to have serious consequences for cows or calves (refer to seasonality of parturition discussion in Chapter IV). In general, animals are managed as a part of a system in which their primary goal is to supply draft power. The management function changes when herds are kept exclusively for the breeding of animals for sale. It is here that a management constraint appears most serious. The inability of Non Som Boon cattle breeders to significantly improve birth rates, animal sizes, general animal health, and to provide adequate nutrition over the mixed breeding-draft systems of the other two villages highlights this problem. In a number of other villages

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[4/] Heat tolerant animals have slow growth rates and late maturity, conditions which are necessary to avoid being placed under undue stress by harsh environments. The heat tolerance coefficient has an inverse relationship to productivity. Thus, overall environmental improvements allow more productive animals to be introduced even though they are less heat tolerant (correspondence with Dr. James B. Johnston).

overall efficiency of large breeding herds of cattle appeared to be lower than for smaller herds of breeding-draft-type animals. The ability to provide adequate nutrition for the larger herds was a major problem. Increased live birth rates also seem difficult to achieve with present levels of management as do improved health measures such as dips, oilers, or worming procedures.

In summary, the genetic, animal health, housing and management constraints become serious only after improved nutrition becomes available. With improved nutrition, exotic crossbreeds will grow faster and attain larger maximum sizes (10). With improved nutrition, feed utilization becomes crucial so animal health must be improved, particularly reduction of internal parasite loads. Similarly, improved management and housing would be necessary to take advantage of higher herd offtakes, increased levels of market transactions and capital investments, and better housing of larger herds.

Mechanization

Major structural changes in village bovine herds would occur if tractors rapidly replaced draft animal functions. Currently, tractor use is concentrated in the initial plowing function where cost and timeliness factors have been most pronounced. Budgets constructed from a larger study (44, p. 130) indicated net income for a 21 rai paddy farm would be increased 33 baht per rai by the use of tractor plowing in place of the water buffalo. The more limited results of the case study village crop production analysis tended to confirm cost savings in most cases from tractor plowing. For paddy land plowing, animal costs were 26 baht per rai in Mapkhae, 42 baht per rai in Non Som Boon, and 28 baht per rai in Hong Jek Lee

while tractor plowing costs were 14 baht per rai in Mapkhae, 33-35 baht per rai in Non Som Boon (rate taken from (44) as no tractor plowing was done in this village), and 20 baht per rai in Nong Jek Lee. Upland animal plowing was cheaper in Non Som Boon (27 baht vs. 37 baht for animal and tractor, respectively) but more expensive in Nong Jek Lee (34 baht by cattle vs. 20 baht by tractor). Given declining tractor service charges per unit of area cited by Chancellor (11), the cost advantages should continue to increase.[1/]

Despite the cost advantages, draft use continued to be an important input in most cases. Tractor power has permitted substa tial expansion of cropped area. Thus, even though per rai use of animals is reduced by tractor plowing, per farm use of animals remains high since farm size has expanded.

Another major factor has been an easing of peak period human and draft power demands plus the timeliness of operations which has permitted increased cropping intensity to take place. Chancellor (11) summed up his findings on Thailand as

> Almost every farmer hiring tractor service combined the time saved and other resources to produce additional income. Although the enterprises were quite varied, 65 percent in Thailand---chose enterprises based on agricultural intensification of the type which would <u>not</u> displace labor from rural to urban areas (p.2.).

Further mechanization effects include under-utilization

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[1/] Cost advantages of tractors tend to be exaggerated however. Village animal rental rates seemed higher than actual supply prices because farmer who rented animals always would have preferred to own them. Due to some misfortune, however they had lost their draft animals.

of draft animals and a possible shift in relative rates of crop versus livestock returns. Under-utilization would occur since the difference between draft animal acquisition price and salvage value was ubstantial. Thus the animal would continue to be used as long as the marginal value product exceeded the salvage value of the animal (25). This phenomena helps explain why no dramatic decrease in draft animal numbers has occured as mechanization progressed.

During the study year, two factors made certain crops a good investment relative to livestock. The crops using zero or moderate amounts of draft power inputs, such as sugar cane, kenaf, corn and mung beans, were highly profitable during the study year. Rice, the heaviest user of draft power lost money in every case due primarily to a precipitous drop in rice prices. If rice budgets were evaluated using historical price levels or price levels which would have historically prevailed in the absence of the rice premium (a form of export tax which depresses domestic price levels), rice enterprises would have been moderately profitable.

The use of tractors has undoubtedly fostered this trend as they permitted rapid increases in the highly profitable upland crops which would have been difficult to achieve using traditional draft power sources and implements. Thus, given capital constraints on enterprise expansion, investment has been towards upland crop production expansion rather than on bovine enterprise improvement and expansion. This is certainly the case in Pong Jek Lee where idle pasture and rice straw is not utilized by expanding the village herd. Upland production is a better investment than an expanded breeding herd. This would appear to be true also in Ma,khae where

the farmers getting a sugar cane quota have promptly sold their livestock and began cane cultivation. Mechanization has not yet entered Non Som Boon (with the exception of truck hauling) and all crops require substantial draft animal inputs so this phenomena has not yet occured.

Farmers' Attitudes

The farmers' attitudes towards his bovines seemed to correspond to the degree of modernization attained in their crop production activities. Large cash crop farmers using tractors, sprayers and corn shellers in Nong Jek Lee responded as follows:

> If the price of cattle looks good this fall, I'll sell them all and try and purchase cheaper animals next spring for my fieldwork. I like to buy and sell livestock to see if a better deal is possible.

More traditional Northeastern farmers in Non Som Boon tended to look on their animals not as pure commodities but as an integral part of their system. Nakajud described the prevailing attitude well (34).

> Students of culture and rural sociology would find that cattle and water buffalo are not commodities or ordinary possessions, but are part of the stream of life for the rural people. Cattle and buffalo are often given auspicious names, such as Ekum (support) or Aikum (beneficial), either because they feel such animals would produce a large number of offspring, or it would help produce a bumper crop in the manner of the Thai kings who similarly named their war elephants, steeds, or swords, which brought victory to them (p. 10).

Even in Non Som Boon, however, the source of a new and profitable technology, exotic breeding stock, is breaking down the cultural attitudes towards cattle and buffalo.

Old cultural attitudes are being replaced by new status

symbols, however, The ownership of a matched pair of white, humped bullocks for cart pulling has become a social symbol where Brahmin sires are common. Rufeurer found this prevalent in his case study villages (39).

> In contrast to only a few years ago, when Brahmin cattle were not accepted by farmers (57), a great deal of pride is now attached to ownership of such animals. Farmers in Village I were not satisfied with their ox teams until they had acquired a matched pair of humped and spirited animals. Both villages had an apparent surplus of Brahmin sires . . . (p. 145).

This status symbol might be interpreted in light of the traditional status role animals play in many African societies. Detailed economic investigations in Africa have shown the presence of underlying economic factors such as capital accumulation, the leveling out of seasonal income patterns, and speculation purposes (12,41). Although wealth accumulation through animals is not widespread in Thailand, the underlying motivations, particularly among traditional farmers, may be similar to those observed in Africa.

Undoubtedly, the introduction and expansion of upland crops has led to increased monetarization of the economy. Profitability now becomes a relevant decision making variable for the farmer and there seems no clear cut reason why the same criteria will not be applied to livestock production as it is applied to crop production. In fact, results of the analysis carried out in Chapters III and IV indicated farmers' attitudes have not created a dual structure in which modernizing crop production exists side by side with a traditional livestock production sector. In fact, both crop and livestock

production have responded to changes while maintaining, with some minor exceptions, economically efficient combinations of resources and products.

In summary, farmers' attitudes do not appear to be a major restraint towards expanding their livestock production.

# CHAPTER VII

# SUMMARY AND CONCLUSIONS

## Review of the Study

Cattle and water buffalo production have contributed less than proportionately to an otherwise expanding agricultural economy in present-day Thailand. A number of reasons have been offered but identification of key inter-relationships and variables has been lacking. This thesis hypothesized that village bovine production must be analyzed in terms of a food-producing-consuming complex of which bovines were one of the major components. Objectives were formulated in terms of identifying several types of crop-livestock production systems, estimating present levels of economic performance and operative constraints, and, by using results of the description and analysis of village bovine systems, suggest levels at which policy must be formulated and specific components which policy decisions must deal with.

The village was chosen as the relevant unit of enquiry. The study involved a one-year case study of three villages, each in a distinctly different physiographic region of Thailand. The study period was April, 1970 through March, 1971. Data were collected by means of beginning and ending inventories, monthly visits to sampled farmers for crop production recording, and some further survey work in surrounding villages.

Data from the study were used to look at three aspects of village bovines:

(1) utilization and efficiency of bovine use as crop production inputs;

(2) bovine production procedures, the relationship of bovine production to crop production, and aspects of bovine production efficiency; and

(3) construction of a model representing the functioning of the village bovine system.

## Summary of the Results

Bovines were used for draft power in every village. Use among farmers varied considerably as did use between crops in each village and for the same crop in different villages. Draft power inputs in rice production were 30.2 percent of total cost in Mapkhae, 20.2 percent in Non Som Boon and only 12.3 percent in Nong Jek Lee, where tractor plowing of rice land was prevalent. On upland crops, draft power as a percent of total costs was 10.9 percent for kenaf and 19.4 percent for watermelon in Non Som Boon and 13.8 percent for corn in Nong Jek Lee. The draft power input in mung beans was less than 1 percent of total costs. There did not appear to be any clear relationship between animal use as draft power and crop enterprise profitability. Production functions were estimated by aggregating inputs into several categories. Functions were estimated for individual crops and on a whole farm basis by aggregating value produced per farm. Several functional forms were estimated with the variables defined on a per farm or a per rai basis. The individual crop analyses

gave fair to poor results with a few exceptions. Very low rice yields in Lapkhae made analysis of draft power productivity difficult. Productivities were generally high for Non Som Boon upland crops but much lower for rice. The same pattern appeared in Hong Jek Lee.

Whole farm production function results were generally more satisfactory in terms of the size, sign, and reliability of the estimated production coefficients. High values produced per farm and per unit of area in Lapkhae for sugar cane production necessitated estimation of a function using data only from farms which used draft animals. Large yield variabilities reflecting drouth conditions again caused high standard errors. Non Som Boon results were good as were those for Hong Jek Lee with the exception of labor productivity. An efficiency analysis using a cost minimization framework was performed. Results indicated that resources not seriously constrained such as labor and draft power were being used close to their cost minimizing combinations while those which were often seriously constrained such as cash expenditures and capital investments were being used in less than optimum proportions. On the whole, draft power was being allocated efficiently in the crop production enterprise.

The use of animals for draft power provided the basis for the herd classification developed in Chapter IV. Herds being utilized primarily as draft power had a male-female ratio of about one and a high proportion of total herd biomass was concentrated in mature males. The converse situation occurred where the herd was engaged in producing offspring as the primary revenue generating function. These herd characteristics were reflected in herd growth and herd transactions

incurred over the study period.

Reproductive performances showed little variation between animal types or villages. Distinct seasonality patterns were observed and related to crop production patterns which governed herd grazing and breeding. The present parturition pattern did not seem to be a major restraint on increased bovine production.

The next step was an analysis of bovine production resources and costs. Herding and forage gathering labor requirements showed definite seasonal patterns corresponding to crop production patterns. Land use as pasture and in providing fodder resources was analyzed in terms of carrying capacities which indicated large season to season fluctuations. Carrying capacities between villages were similar and in the neighborhood of ten rai per animal unit.

Costs were assigned to bovine production inputs and an internal rate of return analysis was performed to test for significant misallocations between animal types and herd uses. An analysis was performed using an average herd as the reference point and using the existing enterprises represented in each village. Returns for each animal type-enterprise combination represented were found to be quite close to other combinations within that village and between villages, and, in most instances, were close to prevailing institutional interest rates.

Chapter V combined the framework and results of Chapter III and Chapter IV into an explanatory model representing interactions of the food-fiber production sector with bovine production and utilization. The model emphasized the interdependence of the system on the level of animals in the village and the allocation of these animals among

competing purposes. The model illustrated some areas of policy decisions relevant to increasing the size of the national bovine herd and increasing the output from a given level of national herd.

## The Village System

### A Review of the System

The analyses of Chapters III and IV and the model of Chapter V illustrate how closely the bovine production system of a village is tied to the crop production system of the same village. Under a traditional system of very limited technological change, the only impetus to the system is population growth leading to expansion of village areas and livestock numbers roughly in proportion to population growth. The introduction of new crops has led to sharp increases in production and exports but has not, with minor exceptions, led to major increases in productivity in either the crop or livestock sector. Because of the interrelationships involved, sustained increases in bovine herd sizes and outputs can come from two sources: (1) changes in crop production technology, and (2) changes in bovine production technology.

### Policy Conclusions from the System

The first conclusion from this study is that efforts to increase village level bovine production must focus on farming systems. Approaches treating animals as an individual and distinct farm enterprise overlooks the following characteristics revealed in this study:

1. Bovine returns take several forms and these returns are dependent on variables in both the crop and livestock enterprises.

2. Nutritional restraints must be analyzed in terms of the land resources of the entire village, not of individual farmers.

3. Grazing improvement programs, as distinct enterprises, do not appear profitable unless they can be integrated with present crop production methods.

4. There do not appear to be any major sources of economic inefficiencies of production resources which could be tapped to increase animal populations at given levels of technology in the villages studied.

Rapid advances in crop technologies which would alter the system have not occured with the exception of widespread tractor use. Tractor use has not increased the productivities of crop production resources but has decreased draft power plowing requirements. The discussion of Chapter VI indicated this has probably not caused dramatic decreases in animal numbers even where plowing is widespread. The impact of new technologies generally associated with the "Green Revolution" has been minimal in Thailand and indications are that their impact will be gradual.

The rapid adoption of upland crops observed in Thailand and found in all the case study villages represent new crops produced using traditional inputs plus tractors. They have not replaced the traditional crop, rice, nor have they required technical assistance or extension activities. Given this background of minimal technical change in the food and fiber section, it is not surprising that bovine production technology is still at very low levels, although the farmers are using their herds quite efficiently at the present level of production possibilities.

The following policy implications seem relevant to the facts brought out by this thesis.

First and foremost, research and other efforts to invoke technological change among village livestock producers must analyze farming systems. Analysis of individual components and constraints may be misleading and unproductive.

Second, the relevant decision-making level must be made explicit. In some types of research, decisions can be made only by the village as a whole while the farmer has control of certain production decisions. The making of certain production decisions by the village (all villagers do not castrate their animals) may retard the adoption of improved bovine technology by an individual farmer (controlled breeding program).

Third, distinctions must be made between policies to increase the biomass (by improved pastures) and those designed to increase the offtake from a given biomass (increased birth rate). Sometimes the two policies are related, but not in every case. The two means of increasing meat supplies may have much different costs and capital requirements. Furthermore, the decision-making unit may be different between the policies.

Fourth, well-designed research on crop production systems and technologies must consider their impact on the village bovine herds. National grain and fiber policies may well run into conflicts with meat production and export goals. The use of short straw rice varieties with high silica content of the fiber could lead to serious feeding problems for the villagers' cattle and buffalo as could the green manuring of corn stubble.

Fifth, forage research at the village level should aim towards integration into the present farm system, not towards creating a separate sector of feed supplies by permanent pastures. The planting of quick growing forages after harvest or planting of fallow upland areas between plantings are examples.

Sixth, more work is needed on the impact of mechanization on animal use, profitability of draft animals, and the effect on animal numbers and herd compositions where tractor use has been widespread.

Seventh, the study neglected the demand side of both markets, draft and meat and the rates of growth in these demand functions have obvious policy implications in terms of the model developed.

## Looking Ahead

### Future of Cattle

A combination of economic development and technological considerations indicate that cattle numbers should reverse the historical trend and begin to increase faster than the water buffalo population. As the economic development of Thai agriculture progresses, water buffalo draft requirements will lessen and farmers will switch to cattle for a variety of reasons. First, more breeding females can be supported on a given resource base with cattle than with buffalo because of the size differences. Second, breeding performances of cattle can be increased more rapidly than with buffalo because of difficulties in buffalo mating characteristics. Third, cattle meat brings a higher price in the market and the differential will widen with increasing income levels. Finally, modern production technologies which are available have been developed primarily for cattle production.

Future of Water Buffalo

As the previous paragraph indicated, only some unusual market developments plus a concentrated research effort would serve to maintain water buffalo numbers under a rapid growth and development of Thai agriculture. The domestic market is limited and preferences for cattle beef over buffalo meat as incomes increase will dampen demand increases. The export market is limited to neighboring countries plus Hong Kong and again appears limited.

Rapid increases in water buffalo productivity appear limited due to breeding problems and the lack of exotic breeding stock to increase their genetic potential. Water buffalo growth response to improved nutrition, animal health, or management is unknown.

A different situation would occur under a stagnating agriculture, however. Water buffalo are very efficient animals under present village levels of draft usage and water buffalo production. Without significant change in the rural sector, the water buffalo will be very difficult to dislodge as the farmers' most valuable asset.

Past Trends and Future Goals

Table 1.1. of Chapter I indicated water buffalo numbers were increasing faster than cattle numbers through 1966. This would indicate major shifts in village holdings between the two types has not yet occured in response to the factors just discussed.

Recognition of Thailand's agricultural potential and concentrated efforts towards increased crop production through the

utilization of increased inputs combined with new technology can be expected to yield results which would change this situation.

Increasing use of irrigation and water control and the introduction and dissemination of improved crop varieties will lead to increasingly commercialized crop operations. Increased levels of livestock productivity will be necessary to maintain their competitive position vis a vis crop production. Given the limited scope for technological improvements for water buffalo, emphasis for longer run programs must concentrate on cattle. However, short run programs must pay greater attention to water buffalo which are still the major bovine species represented nationally.

Crisis or Transition

The livestock situation in Thailand at the present time is often spoken of in terms of impending crises. Anticipated shortages of beef have not occured nor have prices risen out of proportion. The reasons were examined in Chapter VI. This should not be construed to mean that this sector of the agricultural economy is not a problem or that significant benefits to the country and to producers are not being realized. Rather, it means that crisis measures need not be imposed and planning, policy making, and policy implementation can proceed on a transition path to achieve several goals.

This thesis indicated some considerations in planning research for and some restraints currently operating on village producers in selected case study villages in Thailand. The results should be integrated into more comprehensive studies of village farming systems and the impact of technological change on these systems in both a short run and long run context.

# APPENDIX A

## MEANS AND STANDARD DEVIATIONS OF MAJOR CROP INPUTS AND OUTPUTS FOR THE CASE STUDY VILLAGES

Table 1. Means and Standard Deviations, Mapkhae.

| | | Rice | | Corn | | Sorghum | |
|---|---|---|---|---|---|---|---|
| Variable | Units | Mean | s.d. | Mean | s.d. | Mean | s.d. |
| Area Planted | Rai | 21.65 | 18.34 | 6.50 | 7.05 | 3.75 | 2.36 |
| Area New Cane | --- | --- | --- | --- | --- | --- | --- |
| Area Old Cane | Rai | --- | --- | --- | --- | --- | --- |
| Total Yield | Kg. | 962.35 | 919.81 | 723.50 | 268.70 | 1000.00 | 558.27 |
| Yield per Rai | Kg. | 44.45 | 28.87 | 111.31 | 139.07 | 266.67 | 308.68 |
| Tot. Val. Prod. | Baht | 664.32 | 620.97 | 699.23 | 384.45 | 1010.00 | 548.15 |
| Tot. Val. Prod. per Rai | Baht | 30.68 | 21.49 | 107.57 | 165.39 | 269.33 | 306.27 |
| Total Labor | Hours | 824.41 | 811.10 | 605.94 | 405.54 | 709.17 | 464.58 |
| Tot. Labor per Rai | Hours | 38.08 | 24.18 | 93.22 | 120.81 | 189.11 | 120.08 |
| Animal Power | Hours | 440.82 | 436.52 | 0 | 0 | 0 | 0 |
| Animal Power per Rai | Hours | 20.36 | 12.92 | 0 | 0 | 0 | 0 |
| Cash Costs | Baht | 407.12 | 401.56 | 125.30 | 84.62 | 186.05 | 100.28 |
| Cash Costs per Rai | Baht | 18.80 | 10.52 | 19.28 | 24.59 | 49.61 | 15.04 |
| Crop Capital Chg. | Baht | 178.99 | 210.68 | 36.93 | 24.51 | 26.62 | 21.55 |
| Crop Capital Chg. per Rai | Baht | 8.27 | 6.84 | 5.68 | 7.84 | 7.10 | 11.41 |
| Land Rent | Baht | 1031.41 | 469.59 | 406.25 | 81.25 | 187.50 | 41.89 |
| Land Rent per Rai | Baht | 47.64 | 21.69 | 62.50 | 12.50 | 50.00 | 11.17 |

Table 1. (Cont.) Means and Standard Deviations, Mapkhae.

| Variable | Units | Sugar cane Mean | Sugar cane s.d. | Potato, Taro, Eggplant Mean | Potato, Taro, Eggplant s.d. |
|---|---|---|---|---|---|
| Area Planted | Rai | 13.30 | 7.23 | 5.17 | 3.43 |
| Area New Cane | Rai | 8.10 | 7.88 | --- | --- |
| Area Old Cane | Rai | 5.20 | 6.20 | --- | --- |
| Total Yield | Kg. | 109.27 (tons) | 80.18 | 1623.83 | 1221.20 |
| Yield per Rai | Kg. | 8.22 (tons) | 4.08 | 314.33 | 140.50 |
| Total Value Prod. | Baht | 14,960.99 | 11,065.89 | 669.30 | 540.87 |
| Total Value Prod. per Rai | Baht | 1124.89 | 557.83 | 129.46 | 67.02 |
| Total Labor | Hours | 4108.10 | 2797.31 | 1813.33 | 2123.90 |
| Total Labor per Rai | Hours | 308.88 | 113.92 | 351.01 | 314.68 |
| Animal Power | Hours | 0 | 0 | 0 | 0 |
| Animal Power per Rai | Hours | 0 | 0 | 0 | 0 |
| Cash Costs | Baht | 6323.70 | 4994.71 | 214.33 | 173.37 |
| Cash Costs per Rai | Baht | 475.46 | 203.56 | 41.46 | 17.84 |
| Crop Capital Chg. | Baht | 22.89 | 27.69 | 78.36 | 59.58 |
| Crop Capital Chg. per Rai | Baht | 1.72 | 1.07 | 15.17 | 11.44 |
| Land Rent | Baht | 1389.85 | 294.82 | 225.36 | 124.24 |
| Land Rent per Rai | Baht | 104.50 | 22.17 | 43.59 | 16.82 |

APPENDIX A (cont.)

Table 2. Means and Standard Deviations, Non Som Boon.

| Variable | Units | Rice | | Kenaf | | Watermelon | |
|---|---|---|---|---|---|---|---|
| | | Mean | s.d. | Mean | s.d. | Mean | s.d. |
| Area Planted | Rai | 12.88 | 6.57 | 12.92 | 7.52 | 6.20 | 5.79 |
| Total Yield | Rice, Kenaf:kg. Watermelon:melons | 2387.31 | 1822.53 | 1964.19 | 1153.45 | 5472.00 | 10,074.50 |
| Yield per Rai | Rice, Kenaf:kg. Watermelons:melons | 185.35 | 102.90 | 151.99 | 69.12 | 882.58 | 959.42 |
| Total Value Produced | Baht | 1226.73 | 918.81 | 4478.43 | 2669.69 | 2050.75 | 2481.16 |
| Total Value Produced per Rai | Baht | 95.24 | 51.52 | 346.62 | 152.01 | 330.77 | 237.20 |
| Total Labor | Hours | 1138.31 | 603.73 | 1834.19 | 1380.44 | 317.90 | 264.55 |
| Total Labor per Rai | Hours | 88.38 | 59.81 | 141.9 | 77.51 | 51.27 | 28.90 |
| Animal Power | Hours | 178.89 | 84.29 | 119.62 | 90.76 | 103.40 | 77.11 |
| Animal Power per Rai | Hours | 13.89 | 8.09 | 9.26 | 4.46 | 16.68 | 19.93 |
| Cash Costs | Baht | 83.31 | 31.46 | 116.15 | 82.13 | 577.20 | 452.45 |
| Cash Costs per Rai | Baht | 5.47 | 3.56 | 8.99 | 5.24 | 93.10 | 49.21 |
| Crop Cap. Chg. | Baht | 77.36 | 53.20 | 11.61 | 9.72 | 2.07 | 2.17 |
| Crop Cap. Chg. per Rai | Baht | 6.01 | 4.64 | 0.90 | 0.61 | 0.33 | 0.29 |
| Land Rent | Baht | 549.85 | 247.42 | 517.02 | 349.57 | 310.00 | 85.31 |
| Land Rent per Rai | Baht | 42.69 | 19.21 | 40.01 | 27.06 | 50.00 | 13.76 |

Table 3. Means and Standard Deviations, Nong Jek Lee (cont.).

| Variable | Units | Sorghum | | Mung beans | |
|---|---|---|---|---|---|
| | | Mean | s.d. | Mean | s.d. |
| Area Planted | Rai | 5.50 | 2.12 | 13.92 | 11.85 |
| Total Yield | Kgs. | 280.00 | 113.14 | 1434.04 | 1460.98 |
| Yield per Rai | Kgs. | 51.00 | 1.01 | 103.04 | 43.89 |
| Total Value Produced | Baht | 231.00 | 80.61 | 2844.98 | 2833.31 |
| Total Value Produced per Rai | Baht | 42.00 | 1.67 | 204.38 | 74.76 |
| Total Labor | Hours | 39.20 | 4.33 | 972.29 | 809.58 |
| Total Labor per Rai | Hours | 7.13 | 2.12 | 69.86 | 92.52 |
| Animal Power | Hours | 0 | 0 | 4.04 | 10.30 |
| Animal Power per Rai | Hours | 0 | 0 | 0.29 | 1.69 |
| Cash Costs | Baht | 147.03 | 40.98 | 454.91 | 430.07 |
| Cash Costs per Rai | Baht | 26.73 | 3.09 | 32.72 | 5.27 |
| Crop Capital Charge | Baht | 176.91 | 173.79 | 70.20 | 93.26 |
| Crop Capital Charge per Rai | Baht | 32.17 | 47.54 | 5.04 | 3.62 |
| Land Rent | Baht | 330.00 | 77.83 | 379.60 | 29.37 |
| Land Rent per Rai | Baht | 60.00 | 14.15 | 27.00 | 2.11 |

APPENDIX A (cont.)

Table 3. Means and Standard Deviations, Nong Jek Lee.

| Variable | Units | Rice Mean | Rice s.d. | Corn Mean | Corn s.d. |
|---|---|---|---|---|---|
| Area Planted | Rai | 28.97 | 25.58 | 15.29 | 14.22 |
| Total Yield | kgs. | 9414.29 | 8536.26 | 6419.07 | 8341.32 |
| Yield per Rai | Kgs. | 324.97 | 114.41 | 419.82 | 206.02 |
| Total Value Produced | Baht | 6978.86 | 5963.70 | 5908.34 | 7385.16 |
| Total Value Produced per Rai | Baht | 240.90 | 98.15 | 386.42 | 185.03 |
| Total Labor | Hours | 98.15 | 386.42 | 185.03 | 42.00 |
| Total Labor per Rai | Hours | 89.60 | 57.01 | 44.26 | 38.35 |
| Animal Power | Hours | 374.14 | 333.89 | 131.47 | 132.65 |
| Animal Power per Rai | Hours | 12.91 | 13.60 | 8.60 | 11.18 |
| Cash Costs | Baht | 1390.59 | 1799.37 | 515.99 | 538.57 |
| Cash Costs per Rai | Baht | 48.01 | 27.98 | 33.75 | 14.09 |
| Crop Capital Charge | Baht | 514.70 | 819.40 | 819.40 | 122.95 |
| Crop Capital Charge per rai | Baht | 17.77 | 11.84 | 8.04 | 6.40 |
| Land Rent | Baht | 2176.81 | 128.63 | 816.49 | 119.57 |
| Land Rent per Rai | Baht | 75.14 | 4.44 | 53.40 | 7.82 |

# APPENDIX B

## Zero Order Correlation Coefficient

## Matrices for Whole Farm Crop Production Function Variables

Table 1. All Observations on Per-Farm Basis, Mapkhae

| | Planted Area | Value Output | Labor | Draft | Capital | Cash Cost | Rent |
|---|---|---|---|---|---|---|---|
| Planted Area | 1 | | | | | | |
| Value Output | .03231 | 1 | | | | | |
| Labor | .06395 | .83725 | 1 | | | | |
| Draft | .62588 | -.25333 | -.25535 | 1 | | | |
| Capital | .47809 | -.20327 | -.12719 | .62251 | 1 | | |
| Cash Cost | .04820 | .42602 | .43252 | .53469 | -.20882 | 1 | |
| Rent | .69947 | .42602 | .43252 | .53469 | .41855 | .38998 | 1 |

Table 2. All Observations on Per-Unit-of-Area Basis, Mapkhae

| | Value/Rai | Labor/Rai | Draft/Rai | Capital/ Rai | Cash Cost/ Rai | Rent/Rai |
|---|---|---|---|---|---|---|
| Value/Rai | 1 | | | | | |
| Labor/Rai | .65298 | 1 | | | | |
| Draft/Rai | -.51635 | -.63188 | 1 | | | |
| Capital/Rai | -.40240 | .02727 | .14741 | 1 | | |
| Cash Cost/Rai | .98764 | .62118 | -.49141 | -.43457 | 1 | |
| Rent/Rai | .53234 | .52217 | -.20238 | -.12547 | .49455 | 1 |

APPENDIX B (cont.)

Table 3. Animal Users Only on Per-Farm Basis, Mapkhae.

| | Planted Area | Value Output | Labor | Draft | Capital | Cash Cost | Rent |
|---|---|---|---|---|---|---|---|
| Planted Area | 1 | | | | | | |
| Value Output | .12787 | 1 | | | | | |
| Labor | .39772 | .75178 | 1 | | | | |
| Draft | .58928 | .51114 | .67959 | 1 | | | |
| Capital | .43252 | .07486 | .26397 | .54147 | 1 | | |
| Cash Cost | .21473 | .90714 | .72908 | .33801 | .09509 | 1 | |
| Rent | .66842 | .61634 | .62915 | .73776 | .49840 | .50942 | 1 |

Table 4. Animal Users Only on Per-Unit-of-Area Basis, Mapkhae.

| | Value Output/Rai | Labor/Rai | Draft/ Rai | Capital/ Rai | Cash Cost | Rent/ Rai |
|---|---|---|---|---|---|---|
| Value Output/ Rai | 1 | | | | | |
| Labor/Rai | .81694 | 1 | | | | |
| Draft/Rai | .11069 | .18287 | 1 | | | |
| Capital/Rai | -.22674 | -.17754 | .22233 | 1 | | |
| Cash Cost/ Rai | .95118 | .78908 | -.08257 | -.28738 | 1 | |
| Rent/Rai | .52074 | .24631 | .39186 | .15497 | .34843 | 1 |

APPENDIX B (cont.)

Table 5. All Observations on Per-Farm Basis, Non Som Boon.

| | Planted Area | Value Output | Labor | Draft | Capital | Cash Cost | Rent |
|---|---|---|---|---|---|---|---|
| Planted Area | 1 | | | | | | |
| Value Output | .83271 | 1 | | | | | |
| Labor | .68518 | .89853 | 1 | | | | |
| Draft | .75969 | .80540 | .72846 | 1 | | | |
| Capital | .43295 | .61801 | .60215 | .54704 | 1 | | |
| Cash Cost | .77792 | .85622 | .78150 | .85332 | .52896 | 1 | |
| Rent | .82229 | .59184 | .49139 | .57353 | .23503 | .52942 | 1 |

Table 6. All Observations on Per-Unit-of-Area Basis, Non Som Boon.

| | Value/Rai | Labor/Rai | Draft/Rai | Capital/ Rai | Cash Cost/ Rai | Rent/ Rai |
|---|---|---|---|---|---|---|
| Value Output/ Rai | 1 | | | | | |
| Labor/Rai | .65029 | 1 | | | | |
| Draft/Rai | .28936 | .49811 | 1 | | | |
| Capital/Rai | .20203 | .16319 | .06740 | 1 | | |
| Cash Cost/ Rai | .44840 | .27008 | .36492 | -.07748 | 1 | |
| Rent/Rai | -.07412 | .16926 | .10429 | -.02439 | -.11111 | 1 |

APPENDIX B (cont.)

Table 7. All Observations on Per-Farm Basis, Nong Jek Lee.

| | Planted Area | Value Output | Labor | Draft | Capital | Cash Cost | Rent |
|---|---|---|---|---|---|---|---|
| Planted Area | 1 | | | | | | |
| Value Output | .7880 | 1 | | | | | |
| Labor | .55193 | .46552 | 1 | | | | |
| Draft | .13980 | .22594 | .52804 | 1 | | | |
| Capital | .63656 | .44033 | .42799 | -0.08928 | 1 | | |
| Cash Cost | .79503 | .75036 | .61311 | -0.04103 | .70834 | 1 | |
| Rent | .98141 | .71521 | .56593 | .11687 | .65741 | .79375 | 1 |

Table 8. All Observations on Per-Unit-of-Area Basis

| | Value/Rai | Labor/Rai | Draft/ Rai | Capital/ Rai | Cash Cost/ Rai | Rent/ Rai |
|---|---|---|---|---|---|---|
| Value/Rai | 1 | | | | | |
| Labor/Rai | .17056 | 1 | | | | |
| Draft/Rai | .20194 | .57887 | 1 | | | |
| Capital/Rai | .11404 | -.16996 | -.11681 | 1 | | |
| Cash Cost/ Rai | .27810 | .37309 | -.23494 | .28313 | 1 | |
| Rent/Rai | .06214 | .08287 | .12394 | .06602 | .02780 | 1 |

# APPENDIX C

## Village Biomass Estimation Procedures

Weighing or even tape measuring all village bovines was not possible. Thus any biomass estimates were indirect and less accurate. The problem was further complicated by a lack of reliable animal age estimates.

Given these limitations, the procedure was to tape measure as many animals as possible. Then, using a well-defined heart girth circumference-weight relationship, each animal's weight was estimated. The animals were then grouped into 3 categories: (1) calves (0-2 years); (2) replacement stock (2-4 years); and (3) mature animals. Average weights were then assigned to each category for each animal type in each village. The village biomass was then determined by assigning each village animal to a category and multiplying the number of animals in each category by the assigned average weight for that category. If the animals in each category had a normal distribution of weight around the average established by the measuring procedure, reasonably accurate estimates would be obtained assuming that the interviewers consistently distinguished between calves, replacements, and mature animals.

The equations used for estimating weight by heart girth measurements were derived by Rufener (39) in his study of Northeastern villages and are as follows:

Weight - Heartgirth Estimates of Rufener in Northeastern Thai Villages.

Male Cattle: $\log_{10} \text{wt.} = -3.7789 + 2.8354 \log_{10} \text{H.G.}$

Female Cattle: $\log_{10}$ wt. = -4.1070 + 2.9929 $\log_{10}$ H.G.

Male Buffalo: $\log_{10}$ wt. = -3.8276 + 2.8371 $\log_{10}$ H.G.

Female Buffalo: $\log_{10}$ wt. = -4.0302 $\pm$ 2.9227 $\log_{10}$ H.G.

An inadequate number of observations in Non Som Boon and Nong Jek Lee necessitated further tape measurings in surrounding villages. By assuming the cattle and buffalo in the surrounding villages were of the same confirmation as those in the villages studied, they can be incorporated into the weight estimates for each category. The weights assigned to each functional category for cattle and water buffalo are given in Table 1.A. and 1.B.

Table 1. Weights (in kgs.) assigned to Functional Categories

A. Cattle

| | Male Cattle | | | Female Cattle | | |
|---|---|---|---|---|---|---|
| Age Group | 0-2 | 2-4 | Mature | 0-2 | 2-4 | Mature |
| Mapkhae | 125.0 | 262.5 | 320.4 | 102.5 | 210.0 | 265.0 |
| Non Som Boon | 125.0 | 262.5 | 337.5 | 132.7 | 210.0 | 204.8 |
| Nong Jek Lee | 157.0 | 273.1 | 380.4 | 148.4 | 244.9 | 271.5 |

B. Buffalo

| | Male Buffalo | | | Female Buffalo | | |
|---|---|---|---|---|---|---|
| Age Group | 0-2 | 2-4 | Mature | 0-2 | 2-4 | Mature |
| Mapkhae | 165.0 | 352.5 | 477.5 | 155.0 | 317.5 | 458.4 |
| Non Som Boon | 210.2 | 321.8 | 514.4 | 140.6 | 317.5 | 411.9 |
| Nong Jek Lee | 165.0 | 352.5 | 533.8 | 155.0 | 317.5 | 406.7 |

# APPENDIX D

## Herding Labor Analysis

Table 1. Herding Labor Regression Results

| | | |
|---|---|---|
| Mapkhae | $H/Y = 968.563\ B/Y^{.19923}$ | $R^2 = .31120$ |
| Mapkhae | $H/M/B = 132.421\ B/Y^{-.801}$ | $R^2 = .87949$ |
| Non Som Boon | $H/Y = 243.769\ B/Y^{.574}$ | $R^2 = .58790$ |
| Non Som Boon | $H/M/B = 76.675\ B/Y^{-.426}$ | $R^2 = .43909$ |
| Nong Jek Lee | $H/Y = 572.131\ B/Y^{.232}$ | $R^2 = .13188$ |
| Nong Jek Lee | $H/M/B = 84.874\ B/Y^{-.768}$ | $R^2 = .62453$ |

all coefficients significantly different from 0 at the 95% confidence level.

H = hours of herdsman labor per household

Y = year

B = average bovine numbers per household

M = month

# APPENDIX E

MONTHLY RAINFALL AT SELECTED LOCATIONS

| MONTH | BANGLEN[a] | KHONKAEN[b] | LOPBURI[c] |
|---|---|---|---|
| January | 6.1 | 4.6 | 9.4 |
| February | 15.1 | 22.4 | 17.0 |
| March | 13.4 | 39.7 | 61.7 |
| April | 68.6 | 60.9 | 78.7 |
| May | 124.9 | 170.6 | 181.7 |
| June | 109.5 | 156.0 | 151.2 |
| July | 122.6 | 142.0 | 181.3 |
| August | 138.8 | 171.5 | 173.1 |
| September | 234.2 | 276.1 | 275.5 |
| October | 231.0 | 101.6 | 187.4 |
| November | 43.4 | 11.5 | 44.9 |
| December | 8.4 | 1.3 | 7.3 |
| Yearly Mean | 1116.4 | 1165.35 | 1150.2 |

[a] 1952-1966 Averages

[b] 1951-1967 Averages

[c] 1951-1967 Averages

Source: Unpublished records, Meteorological Department, Office of the Prime Minister, Royal Thai Government.

# APPENDIX F

## DISTRIBUTION OF CATTLE AND BUFFALO HOLDINGS

Distribution of Cattle Holdings

| No. per holding | Mapkhae | | Non Som Boon | | Nong Jek Lee | |
|---|---|---|---|---|---|---|
| | No. of farmers | Percent-age | No. of farmers | Percent-age | No. of farmers | Percent-age |
| 0 | 30 | 75 | 44 | 84.7 | 5 | 8.1 |
| 1 | 0 | 0 | 0 | 0 | 1 | 1.6 |
| 2 | 1 | 2.5 | 1 | 1.9 | 24 | 38.8 |
| 3 | 0 | 0 | 2 | 3.9 | 6 | 9.7 |
| 4 | 0 | 0 | 1 | 1.9 | 15 | 24.2 |
| 5 | 0 | 0 | 0 | 0 | 2 | 3.2 |
| 6 | 1 | 2.5 | 1 | 1.9 | 2 | 3.2 |
| 7 | 0 | 0 | 0 | 0 | 2 | 3.2 |
| 8 | 1 | 2.5 | 1 | 1.9 | 0 | 0 |
| 9 | 1 | 2.5 | 0 | 0 | 2 | 3.2 |
| 10 | 0 | 0 | 1 | 1.9 | 2 | 3.2 |
| Over 10 | 6 | 15 | 1 | 1.9 | 1 | 1.6 |
| Total | 40 | 100 | 52 | 100 | 62 | 100 |

Source: Initial Inventory Surveys

APPENDIX F (cont.)

DISTRIBUTION OF CATTLE AND BUFFALO HOLDINGS

Distribution of Water Buffalo Holdings

| No. per holding | Mapkhae | | Non Som Boon | | Nong Jek Lee | |
|---|---|---|---|---|---|---|
| | No. of farmers | Percent-age | No. of farmers | Percent-age | No. of farmers | Percent-age |
| 0 | 27 | 67.5 | 4 | 7.7 | 60 | 96.8 |
| 1 | 0 | 0 | 12 | 23.1 | 0 | 0 |
| 2 | 3 | 7.5 | 15 | 28.9 | 2 | 3.2 |
| 3 | 0 | 0 | 10 | 19.2 | 0 | 0 |
| 4 | 5 | 12.5 | 5 | 9.6 | 0 | 0 |
| 5 | 3 | 7.5 | 4 | 7.7 | 0 | 0 |
| 6 | 1 | 2.5 | 2 | 3.8 | 0 | 0 |
| 7 | 1 | 2.5 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| Over 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 40 | 100 | 52 | 100 | 62 | 100 |

Source: Initial Inventory Surveys

APPENDIX G

DISTRIBUTION OF CATTLE AND WATER BUFFALO PARTURITION

| Month of birth | Cattle parturition | | | | | | Water buffalo parturition | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mapkhae | | Non Som Boon | | Nong Jek Lee | | Mapkhae | | Non Som Boon | |
| | No. births | Per-cent | No. births | Per-cent | No. births | Per-cent | No. births | Per-cent | No. births | Per-cent |
| January | 1 | 3.0 | 3 | 16.6 | 1 | 4.0 | 0 | 0 | 6 | 21.4 |
| February | 6 | 18.2 | 1 | 5.6 | 1 | 4.0 | 2 | 22.2 | 1 | 3.6 |
| March | 4 | 12.1 | 1 | 5.6 | 1 | 4.0 | 0 | 0 | 1 | 3.6 |
| April | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| May | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3.6 |
| June | 1 | 3.0 | 1 | 5.6 | 5 | 20.0 | 0 | 0 | 0 | 0 |
| July | 5 | 15.2 | 0 | 0 | 3 | 12.0 | 0 | 0 | 1 | 3.6 |
| August | 1 | 3.0 | 0 | 0 | 1 | 4.0 | 0 | 0 | 2 | 7.1 |
| September | 1 | 3.0 | 0 | 0 | 1 | 4.0 | 0 | 0 | 1 | 3.6 |
| October | 1 | 3.0 | 1 | 5.6 | 2 | 8.0 | 0 | 0 | 2 | 7.1 |
| November | 13 | 39.5 | 3 | 16.6 | 8 | 32.0 | 3 | 33.3 | 8 | 28.6 |
| December | 0 | 0 | 8 | 44.4 | 2 | 8.0 | 4 | 44.5 | 5 | 17.8 |
| Total | 33 | 100 | 18 | 100 | 25 | 100 | 9 | 100 | 28 | 100 |

Source: Case study village monthly surveys and ending inventory.

APPENDIX H

BOVINE VALUE ESTIMATES

| Animal class | Average Male cattle values | | | Average Female cattle values | | | Average Male buffalo values | | | Average Female buffalo values | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age inter-vals | Map-khae | Non Som Boon | Nong Jek Lee | Map-khae | Non Som Boon | Nong Jek Lee | Map-khae | Non Som Boon | Nong Jek Lee | Map-khae | Non Som Boon | Nong Jek Lee |
| 0-1 | 50 | 488 | 325 | - | 481 | 200 | 275 | 275 | 305 | 250 | 180 | 324 |
| 1-2 | 464 | 813 | 697 | 383 | 995 | 382 | 200 | 558 | 640 | 320 | 476 | 533 |
| 2-3 | 486 | 1579 | 1019 | 300 | 1458 | 682 | 640 | 878 | 731 | 533 | 911 | 825 |
| 3-4 | 650 | 1450 | 1795 | 405 | 1472 | 969 | 1025 | 1272 | 1262 | 770 | 980 | 831 |
| 4-5 | 1500 | 1940 | 2035 | 450 | 1742 | 1100 | 1340 | 1610 | 1457 | 1500 | 1168 | 1460 |
| 5-6 | 1490 | 1150 | 2056 | 750 | 1706 | 793 | - | 1618 | 1736 | 1400 | 1433 | 1536 |
| 6-7 | 1640 | 1000 | 1967 | 694 | 1605 | 900 | 1600 | 1836 | 1720 | 1100 | 1267 | 1563 |
| 7-8 | - | 1250 | 1948 | 400 | 1741 | 1350 | - | 1746 | 1600 | 1040 | 1210 | 1631 |
| 8-9 | 1500 | 1200 | 1944 | - | 1468 | 1100 | - | 1890 | 2400 | 1100 | 1435 | 1511 |
| 9-10 | - | - | - | - | 3375 | - | - | 1790 | 2100 | - | 1400 | 1533 |
| Over 10 | 1300 | - | 1559 | - | 1414 | 1128 | 2000 | 1780 | 1770 | 800 | 1356 | 1440 |
| n= | 66 | 85 | 211 | 35 | 269 | 120 | 22 | 313 | 91 | 32 | 347 | 171 |

Source: Mapkhae - case study village only.
Non Som Boon and Nong Jek Lee - case study village plus additional survey work in November, 1970.
Note: n refers to the number of observations of value estimates in each category.

APPENDIX I

MONTHLY GRAZING AND GRASS FEEDING PATTERNS

| | | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mapkhae | Rice | 457 | 356 | 288 | 196 | 45 | 25 | 25 | 15 | 191 | 422 | 457 | 457 |
| | Upland | 27 | 22 | 20 | 20 | 10 | 10 | 20 | 24 | 27 | 27 | 27 | 27 |
| | Feeding labor | 0 | 248 | 240 | 328 | 496 | 240 | 408 | 424 | 248 | 248 | 0 | 0 |
| ********** | | | | | | | | | | | | | |
| Non Som Boon | Rice | 439 | 422 | 388 | 277 | 136 | 45 | 44 | 167 | 500 | 500 | 500 | 500 |
| | Upland | 262 | 238 | 146 | 144 | 108 | 88 | 45 | 32 | 160 | 374 | 374 | 270 |
| | Feeding labor | 240 | 248 | 360 | 976 | 1588 | 813 | 897 | 408 | 80 | 0 | 0 | 0 |
| ********** | | | | | | | | | | | | | |
| Nong Jek Lee | Rice | 280 | 270 | 266 | 220 | 204 | 0 | 0 | 20 | 157 | 421 | 421 | 292 |
| | Upland | 104 | 125 | 14 | 7 | 46 | 57 | 29 | 125 | 445 | 445 | 445 | 351 |
| | Feeding labor | 480 | 992 | 2640 | 1976 | 3744 | 6436 | 6352 | 4430 | 1472 | 744 | 429 | 248 |

Note: Rice and upland figures are areas (in rai) per month.
Feeding labor is hours spent cutting and hauling grass per month.

Source: Monthly visits, case study villages.

APPENDIX J

SEASONAL HERDING LABOR PATTERNS

| | Average herding hours per month per family | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. |
| Mapkhae | 232 | 229 | 210 | 176 | 218 | 224 | 226 | 234 | 234 | 248 | 220 | 238 |
| Non Som Boon | 185 | 174 | 175 | 103 | 114 | 174 | 203 | 200 | 218 | 197 | 193 | 199 |
| Nong Jek Lee | 176 | 154 | 141 | 135 | 152 | 158 | 138 | 115 | 176 | 164 | 170 | 191 |
| Weighted Ave., All villages | 193 | 178 | 175 | 136 | 154 | 183 | 184 | 171 | 203 | 191 | 190 | 207 |

Source: Monthly visits, case study villages.

# LIST OF REFERENCES


1. Aliclusan, L.C. 1964. The Rate of Substitution of Man Hours by Animal or Machine Horsepower - Hours in Rice Production. Mimeo University of Philippines College of Agriculture, Los Banos.

2. Anonymous. 1972. Cattle Industry Lags Behind. Financial Post, Volume 3, No. 6. Bangkok.

3. 1970. Where Are All These Buffaloes? Bangkok Post, September 17.

4. Bator, Francis M. 1957. The Simple Analytics of Welfare Maximization. American Economic Review 43: pp. 22-23.

5. Bhannasiri, Tim. 1970. Primary Study of Water Buffaloes in the Northeastern Part of Thailand. Department of Livestock Development, Ministry of Agriculture, Bangkok. (In Thai).

6. Blanchard, Wendell. 1958. Thailand. Human Relations Area Files. Yale University Press, New Haven, Connecticut.

7. Bradford, Lawrence A. and Johnson, G.L. 1953. Farm Management Analysis. John Wiley and Sons, New York.

8. Brooks, E.R. 1961. A Pasture and Forage Program for Thailand. Agency for International Development, USOM, Thailand.

9. Buranamus, Prasob. 1963. A Survey of the Buffalo in Thailand. Monograph, Kasetsart University. Bangkok.

10. Chanalokhana, C. et al. 1968. Crossbreeding of Thai Local Cattle with Hereford, Charolais, and Red Sindhi. Kasetsart University -- University of Hawaii, Project No. 2. Bangkok.

11. Chancellor, William J. 1970. Survey of Tractor Contractor Operations in Thailand and Malaysia. Agricultural Engineering Department, University of California, Davis.

12. Deshler, W.W. 1965. Native Cattle Keeping in Eastern Africa in Economic Transition in Africa, ed. by M.J. Herskovits and H. Harwitz. Northwestern University Press, Evanston, Illionois.

13. Duckham, A. N. and Masefield, G.B. 1969. Farming Systems of the World. Praeger Publishing Co., New York.

14. Egbert, Alvin C. and Reutlinger, Shlomo. 1965. A Dynamic Long-Run Model of the Livestock-Feed Sector. Journal of Farm Economics, Vol. 47, No. 5.

15. FAO. Target, Policies and Inputs for Livestock Production. 1970. Chapter 5 of the Provisional Indicative World Plan for Agricultural Development. Rome.

16. Fei, J.C.H. and Ranis, Gustav. 1964. Development of the Labor Surplus Economy: Theory and Policy. Yale University, Economic Growth Center. Irwin Co., Homewood, Illinois

17. Geertz, C. Agricultural Involution: The Process of Ecological Change in Indonesia. University of California Press, Berkeley, California.

18. Government of Thailand. 1967. Evaluation of the First Six-Year Plan (1961-1966).

19. Harris, M. 1965. The Myth of the Sacred Cow in Man, Culture, an Animals, ed. by Anthony Leeds and Andrew P. Vayda, Publication No. 78 of the American Association for the Advancement of Science, Washington, D.C.

20. Hayami, Yujiro and Vuttan, Vernon W. 1971. Agricultural Development: An International Perspective. The Johns Hopkins Press, Baltimore, Md.

21. Heady, E.O. 1952. Economics of Agricultural Production and Resource Use. Prentice Hall, Inc. Englewood Cliffs, N.J.

22. Henderson, James M. and Quandt, Richard B. 1958. Microeconomic Theory. McGraw-Hill Book Co., New York.

23. Hildreth, Clifford G. and Jarrett, F.G. 1955. A Statistical Study of Livestock Production and Marketing. John Willy and Son, Inc., New York.

24. Hsieh, S.C. and Ruttan, V.W. 1967. Environmental, Technological, and Institutional Factors in the Growth of Rice Production: Philippines, Thailand, and Taiwan. Food Research Institute Studies, Vol. VII, No. 3.

25. Johnson, Glenn L. 1962. The Overproduction Trap in U.S. Agriculture. Unpublished Manuscript, Michigan State University.

26. Lantin, M.S. 1964. Energy Expenditure and Work Capacity of the Philippines Carabao While Pulling Loads. Unpublished Master's Thesis, University of Philippines College of Agriculture, Los Banos.

27. MacGregor, R. 1941. The Domestic Buffalo. Veterinary Record 53: 443-450.

28. Maner, Jerome. 1970. Observations on Swine Production in Thailand and the Swine Program of Kasetsart Universtiy and Suggestions for Improvement. Mimeo. Rockefeller Foundation, Bangkok.

29. Mason, I.L. 1969. A World Dictionary of Livestock Breeds, Types, and Varieties. Technical Commission No. 8, Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh.

30. McLintock, G.T. 1970. The Economics of Pasture Improvement for Beef Production in the Northern Territory: A Summary. Quarterly Review of Agricultural Economics 23: No. 2. pp. 82-96.

31. McPherson. W.W. and Johnston, Bruce F. 1967. Distincitive Features of Agricultural Development in the Tropics in Agricultural Development and Economic Growth, ed. by Herman M. Southworth and Bruce F. Johnston. Cornell University Press, Ithica, New York.

32. Moerman, Michael. 1968. Agricultural Change and Peasant Choice in a Thai Village. University of California Press, Berkeley, California.

33. Moorman, F.R. and Rajanasoonthon, S. 1968. Soils of Thailand. Report. No. 72, Soil Survey Division, Ministry of National Development, Bangkok.

34. Nakajud, Arb. 1962. Livestock Trade in Thailand (Cattle, Buffaloes, and Hogs). Kasetsart Economic Report No. 10. Faculty of Economics and Business Administration, Kasetsart University, Bangkok.

35. Odum, H.T. 1967. Energetics of World Food Production in the World Food Problem. Vol. 3, pp. 55-94. A Report of the President's Science Advisory Committee, Washington, D.C.

36. Peterson, Willis L. 1969. The Returns to Investment in Agricultural Research in the United States. University of Minnesota Department of Agricultural and Applied Economics Staff Paper Series. P 69-5.

37. Rife, D.C. 1960. Livestock Breeding in Thailand. Agency for International Development. USOM, Thailand.

38. Rouse, J.E. World Cattle, Volume II. 1969. University of Oklahoma Press, Norman, Oklahoma.

39. Rufener, W.H. 1971. Cattle and Water Buffalo Production in Villages of Northeast Thailand. Unpublished Ph.D. thesis, University of Illinois.

40. Sethuraman. S.V. 1970. Long Run Demand for Draft Animals in Indian Agriculture. Unpublished Ph.D. thesis, University of Chicago.

41. Schneider, H.K. 1964. Economics in East Africa Aboriginal Societies in Economic Transition in Africa, edited by M.J. Herskovits and H. Harwitz. Evanston, Northwestern University Press, Evanston, Illinois.

42. Singh, Harbans and Parmerkar, Y.M. 1966. Some Basic Facts about Cattle Wealth and Allied Matters. Central Council of Gosamvardhava, New Delhi.

43. Smith, Eldon D. 1970. Effects of Thai Kenaf Pricing on the Development of the Industry, Northeast Agricultural Research Center Technical Paper No. 1.

44. Thailand: Farm Mechanication and Farm Machinery Market - An Appraisal of the Degree of Farm Mechanization and Equipment Market. 1970. Royal Thai Government, Industrial Finance Corporation of Thailand, and U.S. Operations Mission to Thailand. USOM Private Enterprise Division, Bangkok, Thailand.

45. Tongpan, Sopin. 1970 Thai Corn Export Problems. Paper presented at workshop on Some Emerging Issues Accompanying Recent Breakthroughs in Food Production, Cornell University, March 30-April 3.

46. Whyte, R.O. 1968. Land, Livestock, and Human Nutrition in India. Frederick A. Praeger, New York.

47. Williamson, S. and Payne, J.A. 1959. An Introduction to Animal Husbandry in the Tropics Longmans, Green and Co., London.

48. Wrigley, G. 1961. Tropical Agriculture. B.T. Batsford Co., London.