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**The evaluation of alternative decision models: A case of crop
rotation in northern Thailand**

Suppapanya, Pramote, Ph.D.

University of Hawaii, 1994

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THE EVALUATION OF ALTERNATIVE DECISION MODELS:
A CASE OF CROP ROTATION IN NORTHERN THAILAND

A DISSERTATION SUBMITTED TO THE GRADUATE DIVISION OF THE
UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF

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ABSTRACT

Economic evaluations of multi-location testing results at the Thailand Farming Systems Research Institute have not been sufficient in terms of whole-farm decision planning. If no risk is involved in farm decision planning, farmers should act as profit maximizers. Since risk is inherent in agriculture, farmers should be concerned with risk when they make decisions on farm investments. Therefore, it is hypothesized that risk decision making models predict northern Thai rice farmers' behaviors better than profit maximization models.

Two elements in the mean-variance (E-V) decision analysis are farmer's risk preferences and risk perceptions. A quadratic function is used to represent farmer's attitudes to risk. Farmer's risk perceptions concerning crop production are measured by farmer's expectations of yields and prices. The expected mean-variance (E-V) efficiency frontier for each farmer is derived by a quadratic programming algorithm. The E-V efficiency frontier together with the utility function are used to derive optimal farm plans. The Target MOTAD model, using a linear programming algorithm, is included as an alternative decision model, which involves safety-first considerations (i.e., cash cost and variable cost as a target income level).

The results show that the expected utility maximization model predicts actual farmers' behavior more accurately than the expected profit maximization model. Moreover, the Target

MOTAD model performs quite well and better than the expected profit maximization model in predicting actual farmers' behavior when the selected target income level portrays their risk preferences and goals, such as variable cost of farm investment. The results suggest the importance of risk in farm decision making.

Investment decisions of farmers concerning the amount of land allocated to mungbean production preceding the rice crop in the yearly rotation are significantly affected by competition from alternative crops for limited farm resources, such as land, labor and cash capital. Therefore, formulation of programs or policies, such as the integration of a new crop into farmer's existing cropping systems, should take risk and interdependency among cropping enterprises into consideration.

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CHAPTER I
INTRODUCTION

Although Thailand is changing to an industrialized country, agriculture still plays a major role in terms of its economic and social contribution. The agricultural sector contributes about fifteen percent of the gross domestic product (GDP). More than fifty percent of the country's population of fifty seven million people in 1990 were directly engaged in farming. Most farmers own small plots of land averaging about 26 rai¹ (Office of Agricultural Economics 1991). They grow rice mainly for family consumption with any surplus being sold in the nearest marketplace.

Thailand's growth in agricultural production has been impressive over the past two decades. This growth has been due primarily to rapid expansion in cultivated area rather than to increases in productivity per unit of land. For instance, rice production increased about 35 percent, from 15,068,000 metric tons in 1976-77 to 20,601,000 metric tons in 1989-90. There was about a 20 percent increase in growing area, from 53,595,000 rai to 64,439,000 rai, but production per unit of land increased only 13 percent, from 281 kilogram/rai to 320 kilogram/rai during the same period. Thailand, however, will not be able to sustain this pattern of agricultural development in the long run. Overtime, new land for cultivation will become increasingly less available. The

¹ 1 Rai = 0.4 Acre.

latest survey indicates that only about 28 percent of forest lands remain (Office of Agricultural Economics 1991). Furthermore, some of the arable land is used for roads and urban infrastructure. Future agricultural growth must be through increasing land productivity, or the intensification of agriculture on the existing land area, for example through multiple cropping.

The Thai government recognized the importance of using limited land and other resources in agriculture more efficiently. Because of this interest, the Farming Systems Research Institute (FSRI) was founded in 1982. This institute implements farming systems research approaches that are problem-oriented, interdisciplinary and adaptive. The emphasis has been given to rice farmers with low incomes in rainfed areas. The FSRI has conducted multi-location testing to examine the feasibility of growing several crops in rainfed areas. The purpose is to increase and stabilize farm productivity, which translates into a higher and more stable income for rice farmers. This can be fulfilled by integrating additional crops into the existing cropping systems or introducing alternative cultural practices to rice farmers.

Economic evaluations of multi-location testing results by the FSRI have been lacking. Many evaluations without economic perspective have been conducted in terms of yield, such as comparison of crop varieties. A basic economic evaluation (i.e., partial or enterprise budgets) is not sufficient in a situation where interactions between new crops and other

activities on farms exist. Alternative farm enterprises compete for the farmer's limited stock of land, labor and capital and will also be interdependent if included in the plan. Therefore, whole-farm planning problems using mathematical programming models are more appropriate for assessment of integrating crops into existing cropping systems, planning in resources allocation and evaluating returns on farm investments.

1.1 Statement of Problem

Many studies testing economic rationality of resource allocation decisions by farmers use Cobb-Douglas production functions fitted to cross-section data (Hopper 1965 and Yotopoulos 1968). Such studies generally conclude that farmers in developing countries appear to act as profit maximizers within their technological and institutional constraints. A major criticism of this traditional production function theory is its omission of risk and risk aversion (Dillon and Anderson 1971 and Wolgin 1975).

Ignoring risk in farm decision planning models may lead to results that are either unacceptable to farmers or bear little relation to actual farmer decisions. In agricultural models, this can lead to important overstatements of the output levels of risky enterprises and to overly specialized cropping patterns. Other consequences may be overestimation of the value of important resources, such as land and irrigation water, and incorrect prediction of technology choices (Hazell

1986). More comprehensive analyses of farmer decision making can be implemented by decision making models which incorporate risk.

Anderson, et al., 1977 and Roumasset, et al., 1979 state that an important decision making consideration for many farmers is risk. According to Mapp, et al., 1979, risk and uncertainty always exist in agricultural decision making. Three major causes of risk are a) environment, b) market, and c) government policy. Farm production depends upon environmental conditions, such as soil type, rainfall distribution and disease and insect infestations. Output prices fluctuate due to changes in demand and supply conditions. If policy-makers formulate policies without fully understanding the technology introduced and how farmers are being affected, they may mandate policies that induce even greater risks to farmers.

In farm decision making analysis under risk, three classes of decision models can be identified with respect to the concept and measure of risk (Barry 1984). The expected utility maximization model uses variance of expected returns or profits as a measure of risk. Another, the safety-first model describes risk as a chance of loss. A third, a decision model requiring no probability information, expresses risk in terms of a minimax loss or maximin gain, minimax regret, etc. This model is not normally used in modern decision analyses because it ignores subjective probability of the decisionmaker

or objective information about the probability distribution of outcomes (Halter and Dean 1971).

Bernoullian decision theory or expected utility theory plays a key role in analyzing decisions under uncertainty. This theory was first postulated by Daniel Bernoulli in 1738. Its potential went unrecognized until the work on utility by von Neumann and Morgenstern in 1944. In addition, Savage (1954) advanced the theory through his work on subjective probability concepts and their relationship to expected utility. The theory is based on two components, the decisionmaker's personal valuation (or utility) of potential consequences and personal strengths of belief (or subjective probability) about the occurrence of uncertain events. It implies that decisionmakers should act as expected utility maximizers in choosing between risky prospects.

There are other methods for analyzing decision making under risk (Anderson et al. 1977). One such method is the mean-variance approach which was proposed by Markowitz in 1959. For this approach, the decisionmaker selects a portfolio based on a decision rule that minimizes the variance of returns for a given level of expected return. Another method in modelling decision making under risk is a safety-first approach. This approach specifies that the decisionmaker first satisfies a preference for safety or a risk constraint, in selecting among action choices or activities, and then follows a profit-oriented objective. The lexicographic utility approach is normally introduced when the decisionmaker is

faced with choice among multiple goals and is not prepared to allow tradeoffs between these goals. Lexicographic utility refers to sequential ordering of multiple goals in which the safety-first rule is commonly used. However, no theoretical base or set of axioms guides the ordering of these goals. The highest priority goal must be achieved at a threshold level before considering the second goal, and so on.

The various decision making models compete with one another on the basis of their relative power to explain and predict reality. This relative power depends upon the assumptions on which the competing models rest.

1.2 Research Setting and Justification

In northern Thailand, a mungbean-rice rotation is physically and biologically feasible in many areas (Pookpakdi and Chantkam 1985). Mungbean is a short-duration crop which requires low levels of moisture. It is a legume that increases soil fertility and yield of the following rice crop. This production complementarity increases output and income to the farmers. Mungbean-rice technology, for a mungbean preceding rice in the rotation, has been recommended by the FSRI to farmers in rainfed areas that have bi-modal types of rainfall patterns, with the first peak in May and the second peak in September. Details of the technological package of the mungbean before rice rotation are shown in Appendix A. It comes as a package that includes an improved seed variety, seed treatment (rhizobium and insecticide), planting space

recommendations, pest control chemicals, and other cultural practices.

Before dissemination of guidelines for mungbean-rice technology, the method was tested for economic viability and social acceptability to farmers. Appendix B shows the estimated benefits and costs of the new technology, using a simple enterprise budget compiled by the FSRI in 1986. The budget indicates that farmers will gain additional income when the mungbean price is higher than 5.06 Baht per kilogram. Researchers have assessed many socio-economic factors that might impede the farmers' adoption, such as land tenure, labor and credit availability, market prices, and access to inputs and markets. The Mungbean-rice technology has been approved as a "matured technology²" since 1986 and the government encourages farmers to adopt this technology on a larger scale through extension and seed exchange programs.

Mungbean-rice technology has been demonstrated to be profitable to farmers. If no risks are involved in the production process, profit maximization would be an appropriate action by farmers. Although, the government has tried to remove some constraints that hinder technology adoption, such as limited access to information by extension programs and some costs with the seed exchange program, widespread use of mungbean-rice technology does not occur

²The term is defined by the Farming Systems Research and Development Committee of the Department of Agriculture. It means that the technology has been proven to be agro-climatically feasible, economically viable and sociologically acceptable by the farmers and is ready for extension.

among all farmers in a particular area or farmers in similar agro-ecological areas. This situation can partly be explained by the fact that different farmers are faced with unique decision making environments in terms of physical as well as economic characteristics. Individual farmers have differences in soil structure, land characteristics and other physical aspects of their farm environment; the amount of labor available and access to the labor market; opportunities and access to financial credits; input and output prices; market conditions; and human capital, such as formal education and experience. The interaction of these factors creates a unique decision making environment for the application and analysis of input-output relationships in production for individual farmers before and after technological innovation is introduced by the government. The various decision making environments all involve risk.

Unfortunately, the FSRI has no ongoing research concerned with risk and uncertainty in the whole-farm decision making. The FSRI does not employ either agricultural economists or economists due to administrative reasons and their organizational structure. The FSRI was formed under the Department of Agriculture and most of its personnel are agronomists, plant pathologists, soil scientists and other physical and biological scientists. The FSRI researchers often act as intermediaries for a broad array of activities such as on-farm trials, socio-economic analyses, contacts with farmers and agricultural extension personnel in the field, private

companies and other government related agencies. Collaboration among government agencies is very difficult due to priorities set by different agencies, and complexities of budget and workforce allocations.

1.3 Hypothesis

In farm decision making, maximizing profit would be an appropriate action by farmers, if no risk is involved. Since risk is inherent in agriculture, farmers should be concerned with risk when they make decisions on farm investments. Therefore, the hypothesis is that decision making models involving risk predict northern Thai rice farmers' behaviors better than profit maximization models.

1.4 Objective

The objective of this study is to compare the performance and accuracy of decision making models in predicting farmers' behaviors involving risk and uncertainty with utility maximization, profit maximization and lexicographic utility (safety-first) models. The procedures are as follows:

- 1) Develop alternative whole-farm decision making models including mungbean-rice in cropping patterns for northern Thai farmers,
- 2) Empirically estimate the parameters of the models for predicting northern Thai farmers' behaviors, and
- 3) Compare the performance of the alternative models, utility maximization model, profit maximization

model and lexicographic utility (safety-first) model in predicting farmers' behaviors.

1.5 Structure of the Dissertation

The dissertation is divided into 5 chapters. A general background of Thailand agriculture and statement of the problem are discussed in the first chapter. The research setting, justification and objectives are also presented in this chapter.

Chapter II reviews and discusses the theoretical background for analyzing farmer decision making processes under risk and uncertainty. Analytical tools for whole-farm plan decision making and procedures for testing the predictive power of the farmer's behavior are also presented in this chapter. Chapter III describes the decision making environment of farmers in the study sites.

Chapter IV presents the empirical results of the analysis developed in the previous chapter. Conclusions of the study and recommendations for further research are summarized in Chapter V.

CHAPTER II
ANALYZING DECISIONS UNDER UNCERTAINTY

Risk and uncertainty inherently exist in agriculture. They involve natural hazards, market fluctuations and changes in government policy. Crop production depends on weather, particularly in rainfed areas. Small farmers are price-takers and production prices are formed by demand and supply of products both in domestic and international markets. Government agricultural policies also affect risk levels perceived by farmers. Therefore, farmers are inevitably faced with risky choices because they are not absolutely certain about the consequences of their decisions.

2.1 Decision Making under Uncertainty

Risk and uncertainty were defined by Frank H. Knight (1921) as follows: risk refers to a situation where alternative outcomes exist with known probabilities and uncertainty refers to the case where the probabilities are unknown. The work by Savage in 1954 on a theory of consistent preferences under uncertainty resulted in the elimination of the differentiation between risk and uncertainty. Subjective or personal probability is a concept used in modern decision analysis. Subjective probability is a personal degree of belief or strength of conviction an individual has about a proposition such as the occurrence of a state of nature.

The elements in the decision making process consist of actions, states of nature, outcomes that are expressed in payoffs and probability distributions, and a decision criterion for ordering the actions. Decisionmakers normally choose one action out of all possible actions available to them so as to maximize expected return or utility (Dillon 1971).

Risk is considered an important factor in the study of farmer's decision making. Explaining or predicting decisionmakers' behavior under uncertainty requires the knowledge of decisionmakers' willingness to bear risk or risk preferences. Risk can be represented by the concept and measurement of variance which reflects the variation of expected returns. Other risk concepts are specified in term of probability of loss and size of the maximum possible loss. Three decision criteria classifying these three risk concepts are: 1) expected utility maximization, 2) safety-first model, and 3) decision rules requiring no probability information.

Under the expected utility maximization model, risk is specified as a vector of moments of the probability distribution (i.e., variance). The probability of loss is a risk concept that is often described by a safety-first model. The examples of decision rules requiring no probability information are minimax loss or maximin gain, Hurwicz α index, and LaPlace principle of insufficient reason (Halter and Dean 1971). These decision rules are not suggested in modern decision analysis because they ignore probability information.

2.2 Decision Making in a Whole-farm Context

Whole-farm planning models are normally used for three purposes (Brink and McCarl 1978): 1) to help farmers plan for land allocation, 2) to help farmers budget returns to investments, and 3) to help policy makers predict farmer responses to policy decisions. If a new technology or crop is accepted by the farmer, it will change the farmer's production and financial plan throughout the cropping year, since there are interrelationships among inputs required and activities for the new crop. The constraints to technology adoption and expansion, such as farmers' attitudes and perceptions, capital, land and labor can be identified using whole-farm analysis. Moreover, income risk from price and yield variability facing farmers can be analyzed through the use of quadratic risk programming and Target MOTAD programming models.

2.2.1 Portfolio Selection and the E-V Model

In whole-farm planning under uncertainty, it is possible to use a portfolio choice model (Markowitz 1959), which utilizes a tradeoff between an expected return and a measure of risk. This is in contrast to the usual linear programming farm-planning model that maximizes return without explicit consideration of risk. The mean-variance (E-V) approach is applicable if a decisionmaker's utility function reflects preferences only toward mean and variance of expected returns or if he regards uncertain outcomes as normally distributed.

An efficient set of portfolios results from investment plans providing minimum variance of expected returns for various levels of returns. This can be derived by a quadratic programming algorithm. The efficient expected E-V frontier together with the well-defined classes of farmers' utility functions can be used to determine optimal farm plans (Robinson and Brake 1979). Mean-variance models are frequently used because of the simplified way in which portfolio theory identifies efficient investment plans. However, portfolio theory may have some limitations, such as when decisionmakers cannot find their preferred plan in the E-V set or the decisionmaker's preference cannot be solely represented by expected return and variance.

Markowitz (1990) argued that the single period utility function depends only on portfolio returns, under certain assumptions. A number of experiments with a variety of utility functions and historical or synthetic distributions of returns have confirmed the efficacy of the mean-variance approximation (see Grauer 1986, Tew and Reid 1987). Moreover, the finding of the expected utility-maximizing portfolio typically requires many times more computational resources than does the critical line algorithm for tracing out a mean-variance efficient frontier. The relative simplicity and reasonableness of results suggest the E-V approach will continue in use for analysis of firm-level decisions (Perry et al. 1989).

2.2.2 Profit and Utility Maximization and Whole-farm Analysis

Under certainty, finding the preferred plan is simple. Each plan has a single outcome, so as long as decisionmakers prefer more to less, they prefer the profit-maximizing plan. But under uncertainty, each investment plan has many possible outcomes that should be considered. Therefore, an index is needed to rank investment plans according to the expected value of each investor's utility function (Robinson and Brake 1979). Moreover, utility maximization is more theoretically attractive than profit maximization because it can explain why two individuals, faced with exactly the same situation, might rationally respond quite differently, and it does not exclude profit maximization but rather includes it as a special case of Bernoullian utility.

Lin, Dean, and Moore (1974) tested the hypothesis that Bernoullian and Lexicographic utility models are more accurate predictors of farmers' behavior than profit maximization. The E-V analysis was used by Mohayidin (1981) to compare different farm plans that maximize expected utility, expected profit, and expected accounting profit (using shadow prices). The studies' results showed that expected utility maximization models have performed better than profit maximization models in terms of the accuracy in explaining actual farm plans (see also the work by Herath, Hardaker, and Anderson 1982).

2.2.3 Target MOTAD

Peter Fishburn (1977) stated that decisionmakers in investment contexts very frequently associate risk with failure to attain a target return. This implies that decisionmakers do not attach disutility to positive income deviations from a target level. The E-V model measures risk as deviations (positive and negative) from the mean or expected return. The E-Semivariance model has been proposed in which risk is measured as deviations below the average return level or mean. Since the average return level varies across activities, it may not be a good risk reference point. Target MOTAD defines risk as the absolute value of negative deviations from a target level which standardizes the risk reference point across all activities considered (Watts, Held, and Helmers 1984). Hence the Target MOTAD approach was incorporated into this study as an alternative analysis for the whole-farm plan.

Target MOTAD addresses the issue that decisionmakers often wish to maximize expected returns but are concerned with net returns falling below a critical target. This approach was suggested by Tauer in 1983 and Helmers et al. in 1984. The objective of this approach is to maximize expected income subject to the sum of negative deviations below a fixed or nonfixed target, and resource constraints. The solutions of this approach are proven to satisfy second-degree stochastic dominance (SSD) by Tauer. Fishburn (1977) and Holthausan (1981) show that this approach is congruent with the actual

behavior of decisionmakers, von Neumann-Morgenstern utility functions, and stochastic dominance relationships. The alternative farm plans under different target income and risk levels can be projected and presented to decisionmakers for selection according to their risk attitudes. Moreover, this approach implies safety-first considerations when expected return is maximized subject to a given negative deviation from the target level (Helmers et al. 1984, and Vandever et al. 1989).

The formulation of the appropriate target level is an important step in using the Target MOTAD approach. It is a subjective choice and depends upon the context and circumstances of the individual decisionmakers. The target level might be formulated as a firm's longrun survival, as ruinous return, as the zero profit return, as the return available from an insured safe investment, or as a target which reflects a general attitude toward acceptable performance of the farm. This implies the importance of understanding the nature and distribution of decisionmakers' attitudes toward risk.

In recent studies for agriculture on risk-return analysis, the Target MOTAD approach has been widely used by many researchers in a variety of situations. The approach was used for marketing strategies selection by Curtis et al. 1987, McKinnell et al. 1990, and Bauer 1991. This approach was also applied for scheduling of farm activities and farm financial management (Misra and Spurlock 1991, and Prevatt et al. 1992).

In multiple cropping analysis, the benefits of crop rotations, including crop diversification for managing production variability and cropping systems sustainability, were investigated by using the Target MOTAD approach (see Vandever et al. 1989, Zwingli et al. 1989, and Novak et al. 1990).

2.3 Measurement of Attitudes Toward Risk

2.3.1 Expected Utility Theory

A Bernoullian utility or expected utility model is suitable for the study of individual decision making under uncertainty (Anderson, Dillon and Hardaker 1977). It clearly delineates between the decisionmaker's perception of and attitude toward risky prospects. The decisionmaker's perception expresses the amount of uncertainty involved through the concept of subjective probabilities. The amount of uncertainty and other characteristics associated with risky prospects are valued by decisionmaker's preference. Therefore, risky prospects can be ordered according to the preferences or attitudes of the decisionmaker. A risky prospect refers to an act or a possible choice that has a probability distribution of outcomes. The most preferred prospect is the one that possesses the highest expected utility.

The set of three axioms listed below are a sufficient basis for deducing Bernoulli's principle or the expected utility theorem. The axioms have been formulated in a variety of ways and under a variety of names. They are often referred

to as the von Neumann-Morgenstern axioms due to their proof of this theorem in 1944.

- 1) Ordering and transitivity. A person either prefers one of two risky prospects a_1 and a_2 or is indifferent between them. The logical extension of ordering is the transitivity of orderings for more than two prospects, e.g., a_1 , a_2 , and a_3 . This implies that if a person prefers a_1 to a_2 (or is indifferent between them) and prefers a_2 to a_3 (or is indifferent between them), he will prefer a_1 to a_3 (or be indifferent between them).
- 2) Continuity. If a person prefers a_1 to a_2 to a_3 , a subjective probability $P(a_1)$ exists other than zero or one such that he is indifferent between a_2 and a lottery yielding a_1 with probability $P(a_1)$ and a_3 with probability $1 - P(a_1)$.
- 3) Independence. If a_1 is preferred to a_2 , and a_3 is any risky prospect, a lottery with a_1 and a_3 as its outcomes will be preferred to a lottery with a_2 and a_3 as outcomes when $P(a_1) = P(a_2)$. In other words, preferences between a_1 and a_2 are independent of a_3 .

There are difficulties with these axioms. For instance, it is difficult to discriminate between prospects in the real world with complex situations. Experimental psychologists have demonstrated that people are not always perfectly transitive in their choices. Continuity axioms may have operational difficulties when the prospects consist of disparate

alternatives, such as life or death. Even with its drawbacks, the expected utility theory is generally being used by researchers and considered valid for the study of decisionmaker's behavior under uncertainty (Barry 1984).

If a decisionmaker follows the above three axioms, a utility function can be formulated that reflects the decisionmaker's preferences (Hey 1979). Utility is defined on an arbitrary scale in which cardinal values can be assigned to expected outcomes. Moreover, its properties are not changed under a positive linear transformation. The utility function yields a reliable ordering of decisionmaker's risky prospects.

The shape of the utility function portrays decisionmaker's attitude toward risk. A risk-neutral decisionmaker has a linear utility function as shown in Figure 2.1a, where the expected utility $EU(X)$ is equal to the expected monetary value \bar{X} . Thus the risk-neutral decisionmaker chooses among alternatives to maximize his expected monetary values, such as profits.

Figure 2.1b shows the concave utility function of the risk-averse decisionmaker. Expected utility $EU(X)$ is a linear combination of $U(X_1)$ and $U(X_2)$. In this case, the utility of a certain \bar{X} exceeds the expected utility of a risky action with \bar{X} as the expected monetary value. This can be recognized where $U(\bar{X})$ is higher than $EU(X)$. The risk-averse decisionmaker would not buy the risky action at \bar{X} , because the concave utility function would translate the zero monetary gain into a utility loss. Thus, the risk averter would be willing to pay a premium

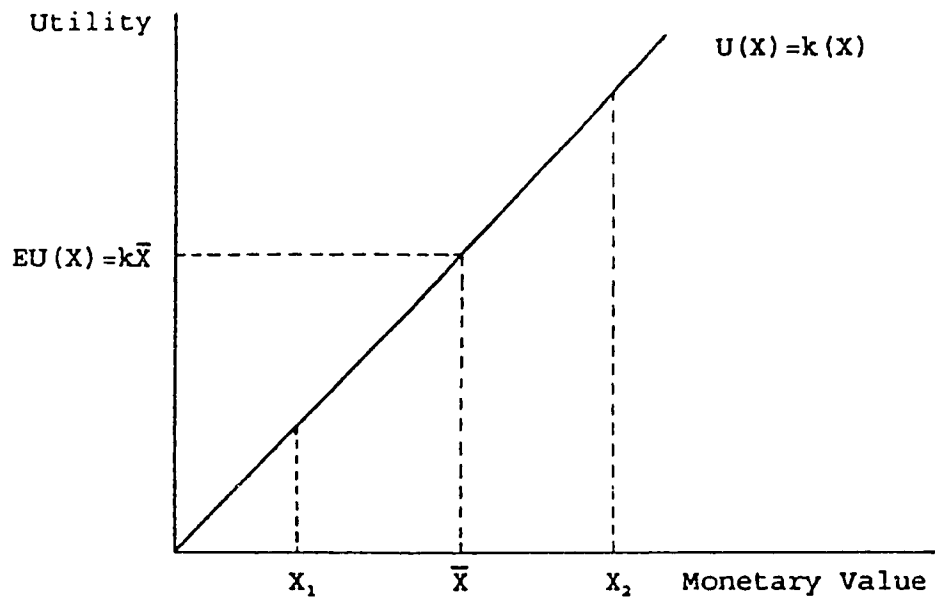


Figure 2.1a Constant Marginal Utility function

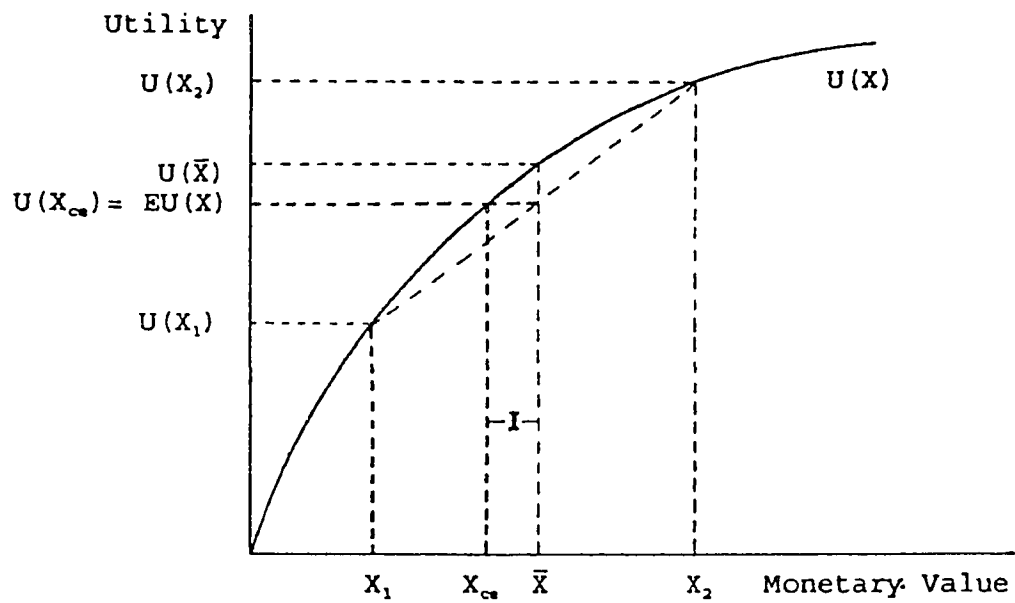


Figure 2.1b Diminishing Marginal Utility Function

for the risky action that would yield the same utility as the action's expected utility, where $U(X_{ce}) = EU(X)$. Therefore, the difference between the expected monetary \bar{X} and the certainty equivalent X_{ce} is a risk premium, the distance 'I' in Figure 2.1b. A similar approach can be used to explain the relationship between a convex utility function and risk-preferring attitudes.

The linear, concave and convex utility functions imply risk neutral, risk averse and risk prefer attitudes of the decisionmaker, respectively. The relationships between utility functions and risk attitudes can be explained by the signs of the second derivatives of utility functions. Risk-averse behavior results when the decisionmaker exhibits diminishing marginal utility of monetary value. Risk-neutral and risk-preferring behavior exhibit constant and increasing marginal utility, respectively.

2.3.2 Elicitation of Preferences

From previous empirical studies, risk attitudes of farmers are measured by three methods: 1) the direct elicitation of utility method (Lin, Dean and Moore 1974, Dillon and Scandizzo 1978, Anderson and Hamal 1983), 2) the experimental method (Binswanger 1980), and 3) the observed economic behavior method (Brink and McCarl 1978, Hazell 1982).

The direct elicitation method involves direct contact with decisionmakers to specify their risk attitudes. The method uses the certainty equivalent concept which has been

criticized as subject to biases arising from different interviewers, preferences for specific probabilities, negative preferences toward gambling, and compounding of errors in the elicitation process (Roumasset 1976, Binswanger 1980, Robinson 1982). Some of these drawbacks can be eliminated with a more complicated questioning method, such as the one used by Lin, Dean, and Moore in 1974 for eliciting decisionmakers' risk attitudes for six large California farms. The certainty equivalent method is generally being used in empirical studies because of its simplicity, its cost and time saving questioning procedure. This method was empirically used by many researchers, such as Francisco and Anderson (1972) for Australian pastoralists, Mohayidin (1981) for Malaysian fruit tree growers, and Anderson and Hamal (1983) for Nepalese rice farmers.

The experimental method was implemented by Binswanger in 1980 for farmers in India. This method is based on a gaming situation which is made as close to reality as possible by rewarding financial compensation. The experimental method was not used in this study because it is too expensive. Also, its accuracy is questionable.

The observed economic behavior method deal with decisionmakers' risk attitudes by recognizing the relationships between the actual behavior of decisionmakers and the behavior predicted from empirically specified models. This method is difficult to implement because numerous

assumptions must be made about the acquired data to eliminate influences other than risk attitudes.

The direct elicitation of utility method using the certainty equivalent concept was chosen for this study. It is also called a modified von Neumann-Morgenstern technique. The series of 50-50 gambles with the best and the worst possible outcomes as the two risky prospects were presented to decisionmakers who were asked to reveal their certainty equivalents that make them indifferent between the two risky prospects. In this process, the risky prospects were arranged in such a way that the decisionmaker's utility curve can be drawn directly from his answers. The hypothetical questions were made as realistic as possible to match the farmer's decision environment. The farmer's true preferences concerning farm decision making can be captured and closely represented by the estimated utility function. The sample question is as follows:

"Suppose that your rice crop will be ready for harvest by the next month. The village-headmen and government officials give a warning that rice fields in nearby villages had been completely destroyed by insects and the farmers in that village had no control over the situation. Therefore, insects might come to attack rice fields in this village at any time. Suppose there is only a 50 percent chance that your paddy field will not be damaged by insects. If you are able to harvest your rice crop without the attack from insects, you will receive 80,000 Baht (twice the family income) from selling your rice production. Conversely, if your rice crop is attacked by insects before harvest, you will get zero income. Given this situation, what price do you want to sell your green rice crop for now to a middleman for cash that makes you feel indifferent from taking a risk of waiting for the harvest of your matured rice crop?"

If farmers were uncertain, the interviewer would act as a middleman and start to bargain (for price). The certainty equivalent value, in which the farmer feels indifferent between selling or not selling his green rice crop. In order to have the farmer reveal his true preferences, he was asked to participate in the game seriously and was provided with sufficient time to answer the questions.

The diagram describing a series of seven questions is shown in Figure 2.2. Because each succeeding question is based on the answer to its prior question in the chain of questions, errors may be compounded. Therefore, consistent checks were implemented after question 3 and question 7. For instance, after question 3, the certainty equivalent values from question 2 and 3 are used in the question as unfavorable and favorable returns for the consistency check. To be consistent, the result should be approximately equal to the certainty equivalent value from question 1.

2.3.3 Formulation of Utility Function

After question 3 in the elicitation process, a utility curve can be drawn from the certainty equivalent values which consist of at least five data points. These data points were first decoded into utility values. The scale of utility values was assigned arbitrarily from 0 to 100. For instance, the utility value of \$0 income is 0 and \$80,000 income is 100 where \$0 and \$80,000 are the lowest and highest expected income values from the investment, respectively. The certainty

equivalent values of a 50-50 gamble were generated from these two extreme points (see question one in Figure 2.2). Each certainty-equivalent value was accordingly assigned an expected value based on the utility scale for the purpose of creating the decisionmaker's utility function. The formula used to acquire the utility value is as follows:

$$U(\$Z) = P(X)*U(\$X) + P(Y)*U(\$Y)$$

Since it is a 50-50 gamble, then $P(X) = 0.5$,
and $P(Y) = 0.5$.

From question 1:

$$U(\$CE1) = 0.5*U(\$0) + 0.5*U(\$80,000)$$

Since $U(\$0) = 0$ and $U(\$80,000) = 100$ by assignment,
therefore

$$\begin{aligned} U(\$CE1) &= 0.5*(0) + 0.5*(100) \\ &= 50 \end{aligned}$$

From question 2:

$$U(\$CE2) = 0.5*U(\$0) + 0.5*U(\$CE1)$$

Since $U(\$0) = 0$ and $U(\$CE1) = 50$, therefore

$$\begin{aligned} U(\$CE2) &= 0.5*(0) + 0.5*(50) \\ &= 25 \end{aligned}$$

A similar procedure was applied for assigning expected utility values for certainty-equivalents for subsequent questions.

The set of expected utility values and certainty-equivalents including two extreme values were estimated using regression analysis. For consistency, the functional form used to represent the decisionmaker's preference or utility was a quadratic function in all instances.

The concept of moments of a probability distribution is the general approach for utility analysis in decision making

problems. For utility with a single attribute such as monetary value or net income (X), the expected utility function can be approximated in terms of the moments of the probability distribution for the net income. The basis for the moment method is a Taylor series expansion. This Taylor series expansion about the mean can be written as follows:

$$U(X) = U[E(X)] + U_1[E(X)] [X - E(X)] + U_2[E(X)] [X - E(X)]^2/2! + U_3[E(X)] [X - E(X)]^3/3! + \dots$$

Taking the expectation of the above equation, gives

$$U(x) = U[E(X)] + U_2[E(X)]M_2(X)/2 + U_3[E(X)]M_3(X)/6 + \dots$$

Where $E[X - E(X)] = 0$, and the k^{th} moment about the mean $M_k(X) = E[X - E(X)]^k$.

This means that the expected utility of a risky prospect X is equal to the utility function evaluated at the mean of X plus a series of products of moments of X , corresponding derivatives of the utility function and inverse factorials. The terms beyond the third moment are usually not included in the above equation because they are relatively insignificant in magnitude (Anderson, Dillon and Hardaker 1977).

2.4 Measurement of Risk Perceptions

In decision analysis under uncertainty, the decisionmaker's belief about the occurrences of the states of nature can be expressed by the concept of subjective probability. This concept is consistent with the axioms, rules, and calculus of probabilities. It is well accepted in the theory of individual choice as an appropriate method for describing rational choice under uncertainty (Barry 1984).

Subjective probabilities must be elicited from the decisionmaker because he makes decisions corresponding to his own expectations about events. By contrast, objective probabilities, computed from historical observations, are not widely used in decision analysis (Anderson et al. 1977). Objective probabilities are used in some analyses, but they are relevant only for the period under review. However, the decisionmaker may use historical probabilities as an input in formulating his expectations.

The expected returns from a new technology, mungbean-rice crop rotation, depend on many factors, such as weather, pests, input and output prices, etc. A farmer assesses the likelihood of these factors under his decision environment and then translates them into degrees of belief or subjective probabilities concerning the potential returns (yields and prices) of all crops in the new cropping systems. Therefore, the procedure to elicit the farmer's degrees of belief is an important step in decision making analysis.

There are many suggested methods for eliciting subjective probabilities (Anderson et al. 1977). Some of these methods are in practice difficult and too complex for decisionmakers. Normally farmers do not contemplate risky events in terms of probability. Thus, these methods might be subject to inconsistencies in farmer responses. Some elicitation methods involve monetary rewards to farmers depending on the outcome of the uncertain event (Grisley and Kellog 1983). The purpose for monetary rewards is to motivate farmers to participate and

respond to questions more seriously. However, this method is expensive.

In this study, the method for assessing the farmer's risk perception was similar to the method used by Barry (1984) called "strength-of-conviction." It was designed to be practical and consistent. Estimates for the frequency distributions of income were drawn from yields and prices of various crops. The two random factors, weather and pests, that have major impact on farm production were first discussed. Then the categorization of seasons into 'Good,' 'Medium' and 'Poor' was characterized according to the degree of damage. The farmer was asked for the likelihood of occurrence of each season under his decision environment for a period of ten years. Furthermore, the expected yields and prices of production from crops were correspondingly asked of the farmer for each type of season.

2.5 Methodology

This comparative study utilized an expected utility model and an expected profit model in order to predict the farmer's behavior for a whole farm plan using the E-V portfolio analysis. In addition, safety-first considerations in farmer's decision making processes were also incorporated through the Target MOTAD programming method. The procedure is as follows:

- a) derive the Bernoullian utility function for each decisionmaker,

- b) derive the E-V efficient frontier of cropping systems for each farm,
- c) derive the optimal farm plan in E-V space that maximizes Bernoullian utility and expected profit,
- d) estimate farm plans which incorporate safety-first considerations by using the Target MOTAD model,
- e) compare the accuracy of the maximization hypotheses in predicting the actual cropping system for the decisionmaker or farmer in each village.

The farmers' utility functions were derived by the concept of certainty equivalent. The interview procedures were designed to determine points of indifference between certain outcomes and risk options involving hypothetical gains as explained above. This method was implemented by Francisco and Anderson (1972) for Australian pastoralists and Dillon and Scandizzo (1978) for Brazilian small farmers. Single attribute utility functions were derived because of their superior performance over the more complex multi-attribute utility functions and simplicity (Herath, Hardaker, and Anderson 1982). After a series of points in utility and income space have been identified in the interview, an explicit utility function was derived from these data points through regression analysis.

The E-V frontier for each farm was derived for alternative cropping combinations that provide minimum income variance for specified levels of expected income. The

following quadratic risk programming model was used to create the E-V frontier (Wolfe 1959).

$$\text{Minimize:} \quad V = \sum_i \sum_j \sigma_{ij} X_i X_j$$

Subject to:

$$\sum_j A_{kj} X_j \leq b_k, \text{ for all } k,$$

$$\sum_j C_j X_j = \alpha,$$

$$X_j \geq 0,$$

Where:

- V = the variance of the total expected net income;
- C_j = the expected net income per unit of crop j;
- X_j = the level of crop activity j;
- σ_{ij} = the variance of a crop when $i=j$ or covariance between crop i and j when $i \neq j$;
- A_{kj} = the requirement of resource k by one unit of crop j;
- b_k = the total availability of resource k; and
- α = a constant indicating total expected net income, varied parametrically from zero to a maximum possible value, providing the basis for tracing out the E-V frontier.

The objective is to minimize the variance (V) of expected net incomes of the farm plan. In this quadratic programming model, risk was considered only in relation to the activity expected net incomes C_j . In estimation of expected net incomes and the variance-covariance matrix of expected net incomes, subjective probability distributions of prices and yields were incorporated according to the decisionmaker's view of his own individual decision environment and to avoid the underestimation of risks in accordance with Debrah and Hall (1989). The constraints were regarded as deterministic. The activity expected net incomes were assumed to follow a multivariate normal distribution. The quadratic risk

programming problem can be solved by varying the constant α from zero to the maximum relevant value.

In finding the optimal point on the E-V efficient frontier, the corresponding E-V indifference curves were derived from the utility function using the Taylor series expansion concept. Then the optimal farm plan under the expected utility maximization and profit maximization hypotheses was determined along the E-V frontier. The tangency between the E-V indifference curve and the E-V efficient frontier was the optimal point or the farm plan under utility maximization hypothesis. Since the objective of the profit maximization model ignores risk, the utility function is linear as well as its indifference curve which is a parallel vertical line in E-V space. Therefore, the farm plan for the profit maximization hypothesis is the line farthest to the right of the E-V frontier line.

Research in farm managers' responses to risk provide evidence that supports safety-first considerations in the decision process (Roumasset 1976, Patrick et al. 1985). Therefore, the Target MOTAD programming model was used to capture safety-first considerations of the decisionmaker. The specification of the model is as follows (Tauer 1983).

$$\text{Maximize} \quad Z = \sum_j C_j X_j,$$

Subject to:

$$\sum_j A_{kj} X_j \leq b_k, \text{ for all } k,$$

$$T - \sum_j C_{tj} X_j - N_t \leq 0, \text{ for all } t,$$

$$\sum_t P_t N_t = \delta,$$

$$X_j, N_t \geq 0, \text{ for all } j \text{ and } t,$$

Where:

- Z = total expected net income;
- C_j = the expected net income per unit of crop j;
- X_j = the level of crop activity j;
- A_{kj} = the requirement of resource k by one unit of crop j;
- b_k = the total availability of resource k;
- T = the target income level;
- N_t = the deviation below target income level for state of nature t;
- P_t = the probability of state of nature t; and
- δ = a risk constant parameterized from zero to some large number.

The expected net incomes from crops and resource constraints were similar to those in quadratic risk programming (shown earlier). The target income levels were set at cash and variable costs of all crop enterprises within each farm. Total cash cost is the farm's obligation for operating expenses of the farms. The survival of the farm can be assured when the target level is higher than total variable costs. The solution for each target level was derived by parameterizing a risk constant (δ). The optimal farm plan was determined when it has the lowest possible risk measure (δ) or negative deviation from the corresponding target level. The results are interpreted within the safety-first conceptual framework when δ is specified at zero or no deviations below the target level are allowed.

To compare the optimal farm plans under the Target MOTAD model and the E-V model, regarding the prediction of the farmer's actual behavior within the E-V framework, the variance of expected net income for each farm plan under the

Target MOTAD programming model is estimated by (Elton and Gruber 1991):

$$V = \sum_i \sigma_i^2 X_i^2 + \sum_i \sum_j \sigma_{ij} X_i X_j,$$

Where:

$$\begin{aligned} \sigma_i^2 &= \text{the variance of crop } i; \text{ and} \\ \sigma_{ij} &= \text{the covariance between crop } i \text{ and } j \\ &\quad \text{when } i \neq j. \end{aligned}$$

The relative predictability of the expected utility model, the safety-first utility model and the expected profit model can be compared to the actual behavior of the decisionmaker. If the farmer incorporates risk and uncertainty in his decision, the expected utility models will better explain the farmer's behavior. This comparison was made within the E-V space because income distribution is probably the best single characterization of a farm plan (Lin, Dean, and Moore 1974). Statistically, the chi-square goodness-of-fit test was used to determine the predictive power of the model. The test determines whether the income distribution from each predicted plan differs significantly from the actual plan.

2.6 Summary

The basic assumptions of various decision making models are summarized in Table 2.1. The alternative decision making models have different ways to measure risk. For the utility maximization model, risk is based on variance or the sum of squared deviations about the mean of expected returns. Risk is incorporated into the profit maximization model by assuming

Table 2.1
The Comparison of Various Decisionmaking Models

	Decisionmaking Model		
	Utility Maximization	Profit Maximization	Target MOTAD
Risk Concept	Variance of expected income	Expected income	Negative deviation from a target-return level (T)
Utility Function	$a + bM - cM^2$	$a + bM$	$a + bM + c \min(M-T, 0)$
Solution Algorithm	Quadratic	Linear	Linear
Prefer More to Less	Not for $M > b/2c$	Yes, for $b > 0$	Yes, for b and $c > 0$
Diminishing Marginal Utility	Yes	No	Yes
Penalize Skewness to Left	No	No	Yes for $E(M) < T$

Note: M = Return; T = A target-return level (i.e., total cash or variable costs),
min = The minimum operator.

that decisionmakers maximize expected profit. Maximization of expected profit is a special linear case of the more general utility maximization model. Risk in the Target MOTAD model is specified as the negative deviation of a specified target level, such as cash or variable costs.

Alternative decision models can be compared by their relationship with expected utility theory. In general, more income should be preferred to less. This is true for utility functions of profit maximization and Target MOTAD models but not for quadratic utility function at a specified level ($M > b/2c$). The quadratic function of the utility maximization model and utility function of the Target MOTAD model possess diminishing marginal utility which implies risk-averse behavior of decisionmakers. This characteristic does not appear in profit maximization. In regards to skewness of the distribution, only Target MOTAD models penalize negative skewness (to the left).

The above decision models have differences in risk measures and concepts, utility functional forms and other basic assumptions. With differences in decision criteria and assumptions, these models are judged by their relative power in explaining and predicting of decisionmakers' behaviors or responses.

CHAPTER III

PHYSICAL AND SOCIO-ECONOMIC CHARACTERISTICS OF SAMPLE DISTRICTS

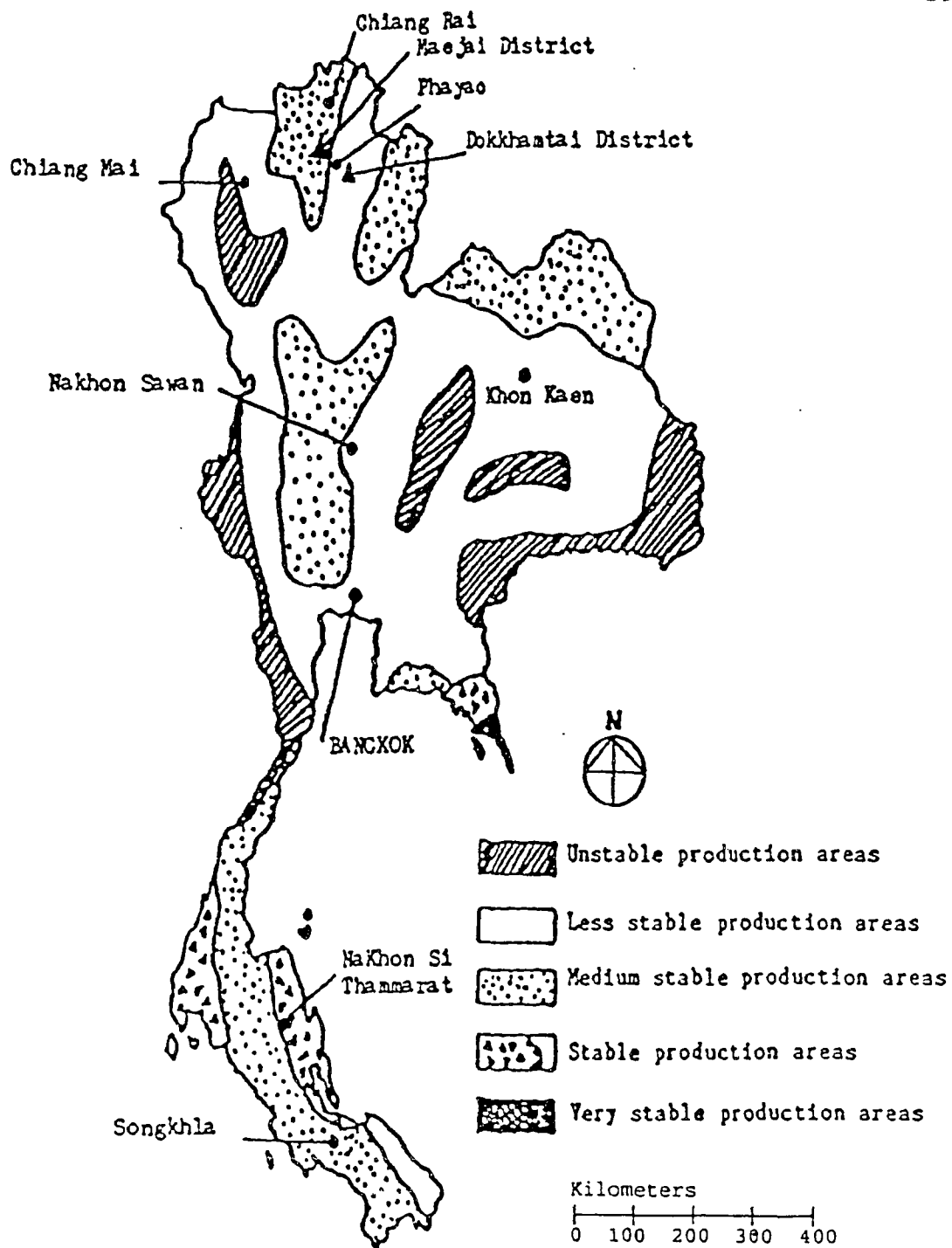
3.1 Site Description

The study sites were in Maejai and Dokkhamtai districts of Phayao province of the northern region of Thailand (Figure 3.1). The first consideration was that the government had introduced mungbean-rice technology to farmers in these two districts. Therefore, the study can be conducted on how farmers in these sites behave when they make decisions on the investment in mungbean-rice technology. The second reason was that these sites are supervised by the same researcher from the Farming Systems Research Institute in which he can help the enumerator to identify farmers for the interview. The last reason was that even though these two sites are under rainfed areas, they have differences in physiological as well as socio-economic aspects which will be elaborated in the next section.

3.1.1 Location and Land Topography

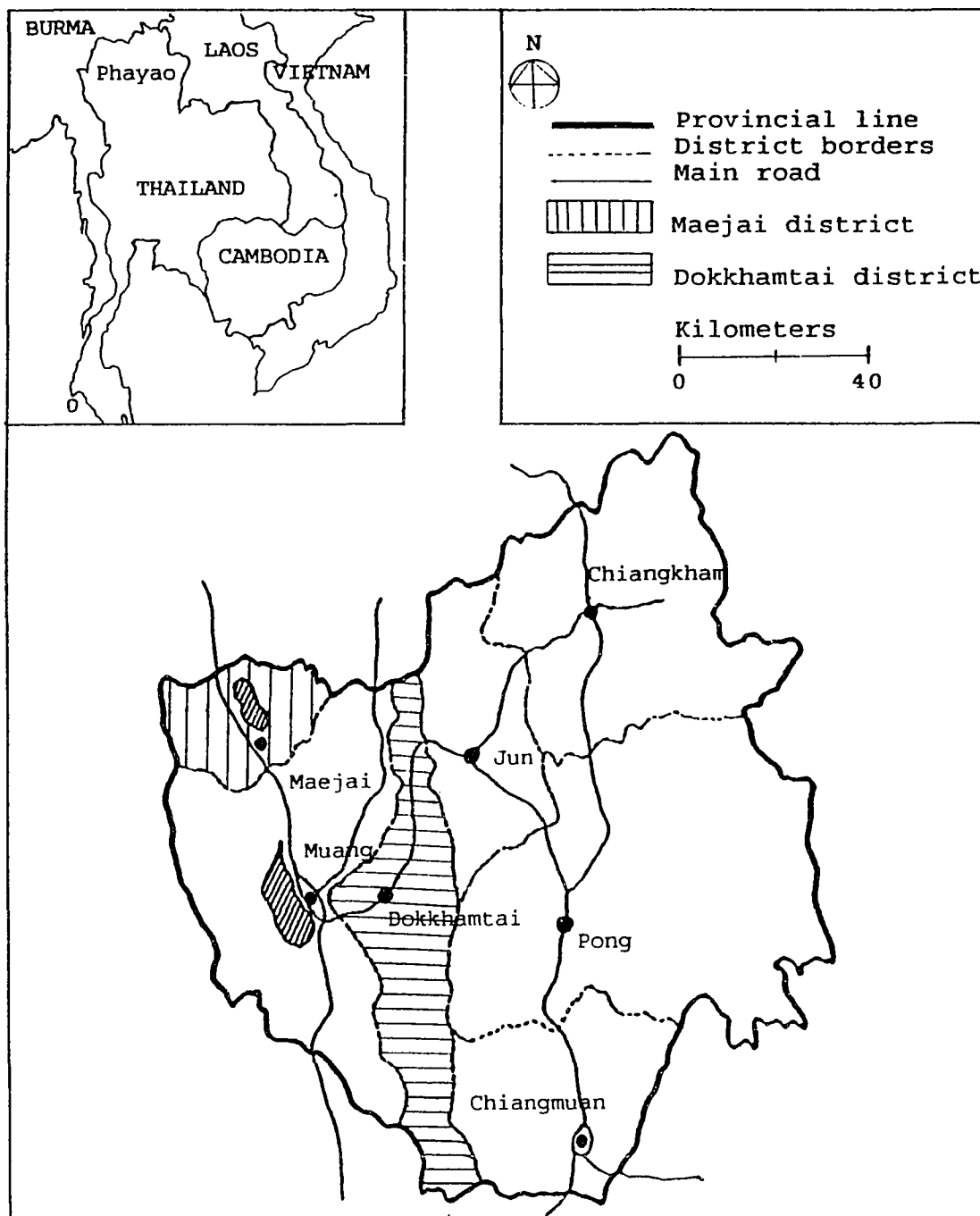
Phayao province is in the upper northern part of Thailand. It is about 735 kilometers from Bangkok. This province is situated on latitude 19 degrees north and longitude 100 degrees east. The elevation ranges from 620 to 3100 feet above sea level.

Maejai district is located at the northwest corner of Phayao province (Figure 3.2). It is situated on a flat



Source: Farming Systems Research Institute, 1983.

Figure 3.1 Map of Thailand by Production Stability of Annual Crops



Source: Phayao Agricultural Extension Office.

Figure 3.2 Map of Phayao Province

plain which is surrounded by mountains on both the east and the west. The study site is about 3 kilometers from the main road and it is accessible all year round. Its land topography is classified into five different types which are lowland paddy, upper paddy, upland, low hill and high hill (Figure 3.3).

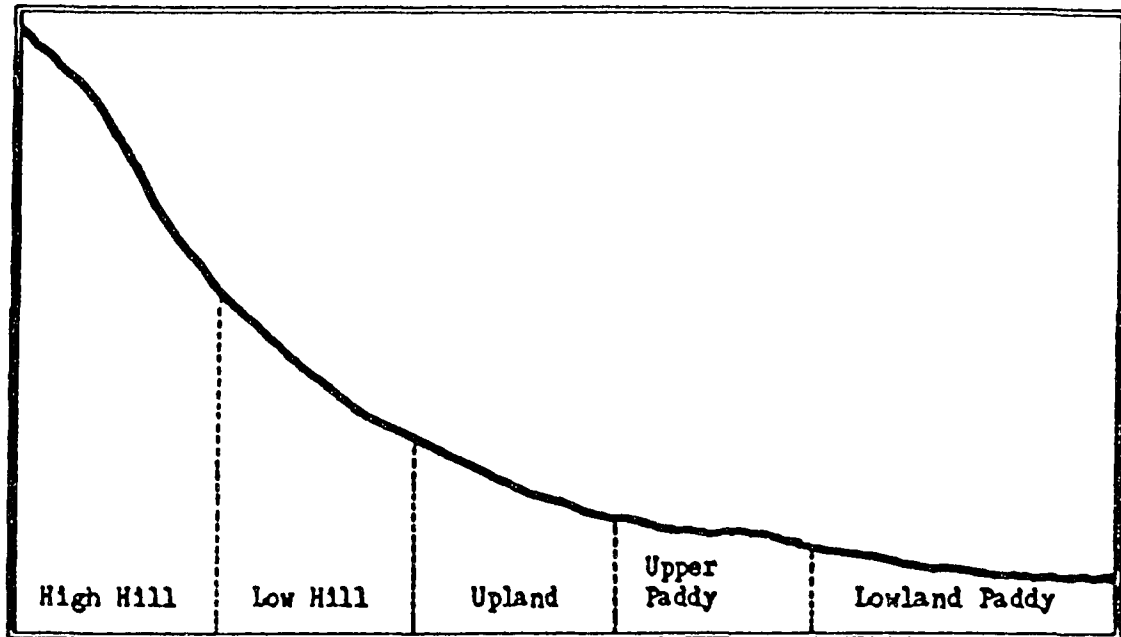
As shown in Figure 3.2, Dokkhamtai district is a long strip along the middle part of Phayao province. The east of the district is bounded by a mountain and it slopes down to the west. The study site is located in the middle-east part of the district and is accessed by an unpaved road at a distance of about 9 kilometers from the main road. The land topography of the district can be grouped into 5 types which are flooded lowland paddy, non-flooded lowland paddy, upper paddy, upland and hill (Figure 3.4).

3.1.2 Agro-Ecological Zone and Production Stability Grouping

According to the classification of the agro-ecological zone by the Food and Agriculture Organization which is based on the rainfall pattern, intensity and duration, as well as on soil conditions, Maejai district was classified under R3S5¹ while Dokkhamtai district was categorized as R3S6².

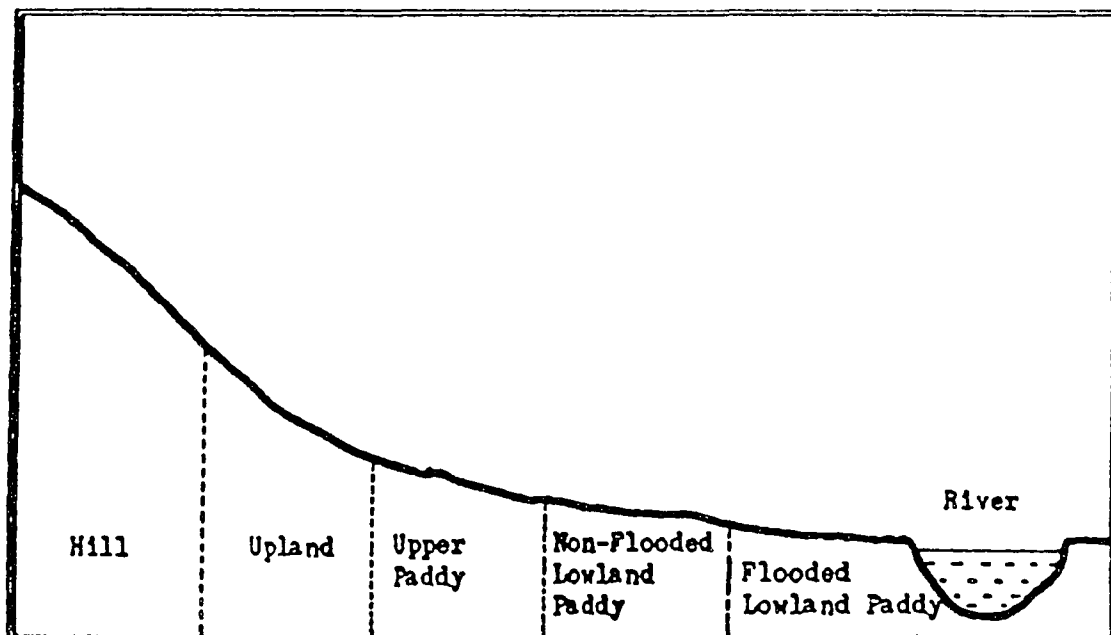
¹R3 means adequate rainfall and soil moisture during the main annual cropping season followed by a well-expressed dry season of at least two consecutive dry months. S5 implies soil with subsurface horizons of clay accumulation, medium to high base supply, usually moist for up to 90 consecutive days.

²S6 implies unproductive soil (very low fertility, high leaching, very old soil).



Source: Pathanothai, 1983.

Figure 3.3 Cross Sections of Land Topography, Maejai District



Source: Pathanothai, 1983.

Figure 3.4 Cross Sections of Land Topography,
Dokkhamtai District

In addition, the Crop Environment Branch of the Farming Systems Research Institute (FSRI) has produced a map that characterizes the production stability area of annual crops. Maejai and Dokkhamtai districts fall under "medium stable production area" and "less stable production area", respectively (Figure 3.1).

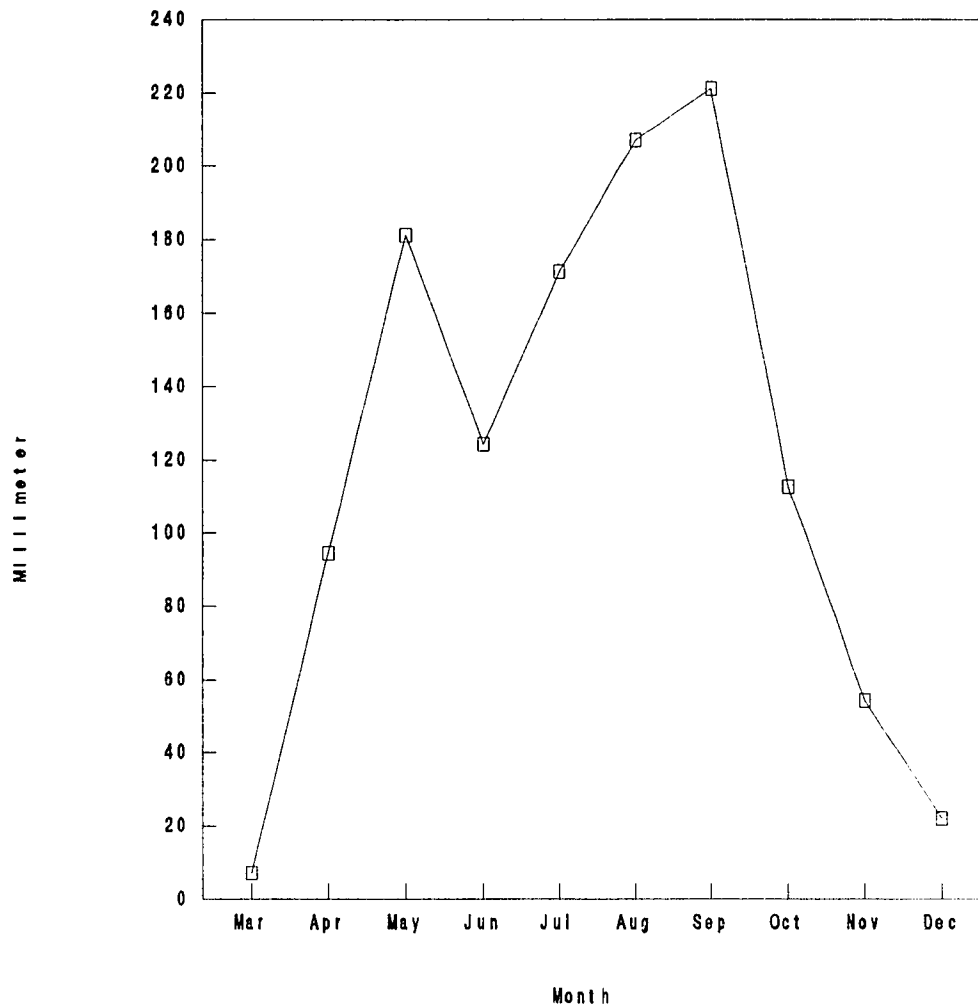
3.1.3 Rainfall Distribution

Figure 3.5 shows the average rainfall distribution of Maejai district between 1982 to 1991. It is a bi-modal distribution. The first mode begins in March and peaks in May. There is a wider and more intensive of rainfall distribution in the second mode. It starts in June and continues on to a high in September. The amount of rainfall drops sharply in October and November. The average amount of annual rainfall is about 1,203 millimeters.

The shape of rainfall distribution in Dokkhamtai district can be also defined into two separated modes (Figure 3.6). The first mode has the shorter span, April to June, with the highest point in May. The second distribution covers June to December, with the peak in August. The average annual rainfall of Dokkhamtai district between 1982-1991 is 1,062 millimeters.

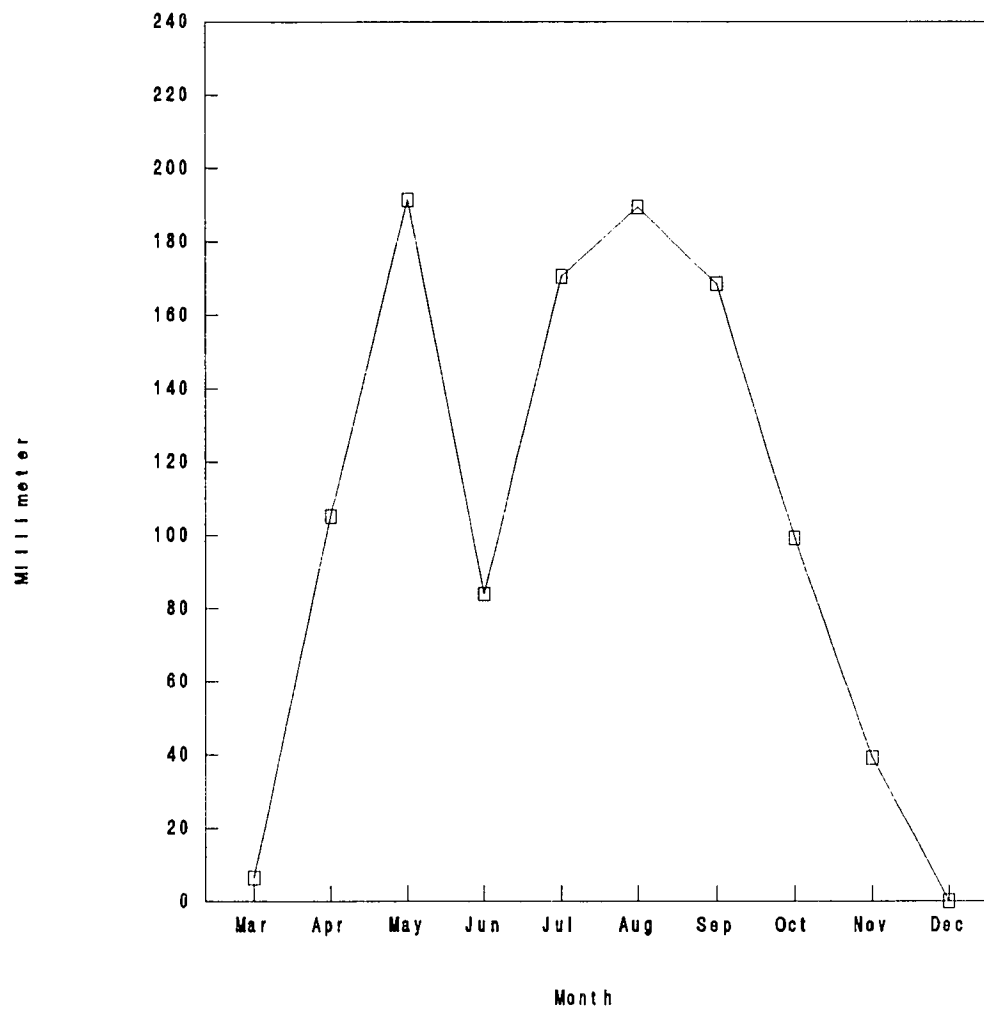
3.1.4 Cropping Pattern

The existing cropping pattern of farmers is important for the whole farm plan. This information is useful to both government officials and farmers. It helps government



Source: Maejai District Meteorological Station.

Figure 3.5 Average Rainfall Distribution of Maejai District Between 1982 and 1991



Source: Dokkhamtai District Meteorological Station.

Figure 3.6 Average Rainfall Distribution of Dokkhamtai District Between 1982 and 1991

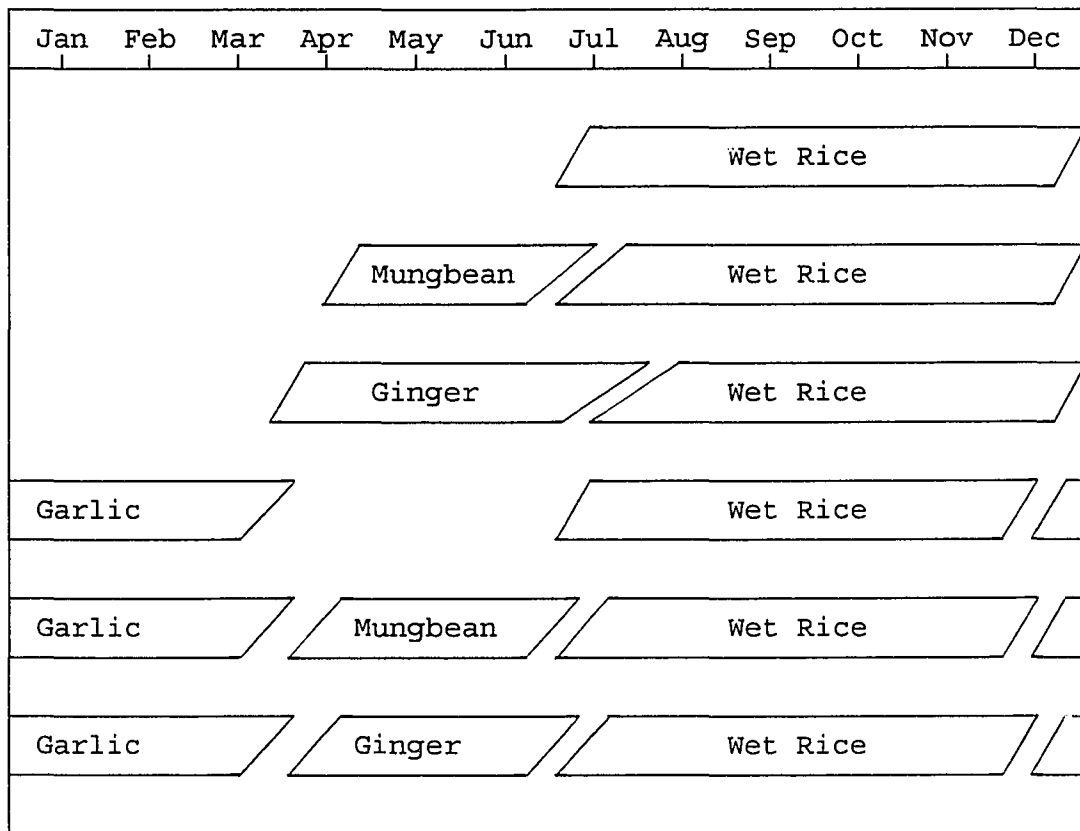
officials design new technology which conforms with farmers' existing system. Moreover, farmers use this information for management of their available resources.

Figures 3.7 and 3.8 show the existing cropping pattern for lowland and upland paddy in Maejai and Dokkhamtai districts, respectively. Most farmers in these two districts grow rice as the main crop during July to December. Some farmers in both districts grow mungbean before rice, according to the plan introduced by the Thai government. Ginger, which was introduced to farmers by a private company is grown by farmers in Maejai district only. During December to early April, farmers in both districts grow garlic for household consumption and surplus for sale after the harvest of their rice. In Dokkhamtai district, maize and mungbean are grown in upland areas. Direct seeded rice is grown in Dokkhamtai district because of erratic rainfall and high cost of labor during the planting period.

3.1.5 Marketing

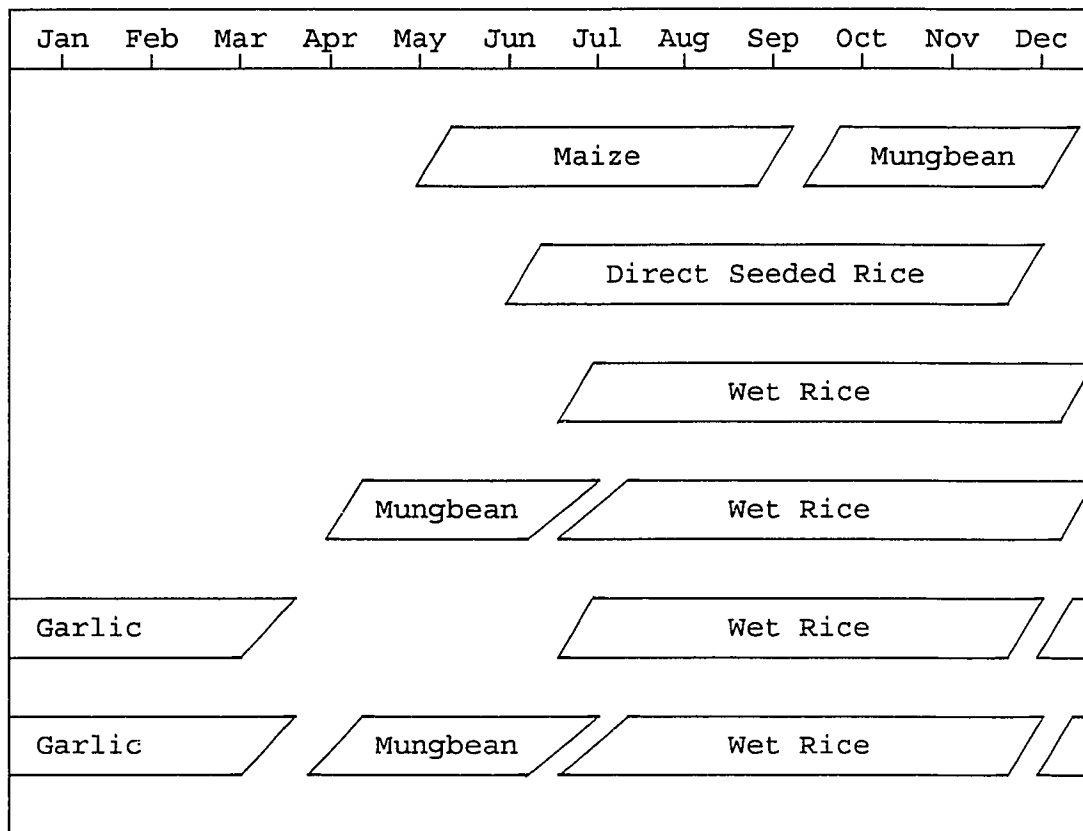
The marketing structure for Thai agricultural products can be categorized into two levels: 1) between farmer and local merchant and 2) between local merchant and terminal markets.

After harvest, most agricultural products are destined for local merchants that have shop or buying posts at the district or provincial level near the production areas. Local middleman also play a role between farmers and local



Source: From field survey, 1992.

Figure 3.7 Cropping Pattern of Maejai District



Source: From field survey, 1992.

Figure 3.8 Cropping Pattern of Dokkhamtai District

merchants. The typical local middleman has a pick-up truck. He buys all kinds of agricultural products from farmers at the farm gate and sells them to local merchants.

From local merchants, most agricultural products are transported and sold to Bangkok middlemen who play a significant role in domestic trading among local merchants and terminal markets (i.e., exporters, wholesalers, and processors). Bangkok middleman convey marketing information from terminal markets to local merchants. At the same time, they provide services for local merchants, such as measurement, grading and collecting money.

3.2 Decisionmaker Profile

3.2.1 Age

The sample consisted of 31 and 29 decisionmakers from Maejai and Dokkhamtai districts, respectively. The age of decisionmakers ranged from 27 to 64 years in Maejai district and 26 to 61 years in Dokkhamtai district. Table 3.1 shows the distribution of decisionmakers under five different age groups. In Maejai district, age group 40-49 had the highest number of decisionmakers, about 32 percent of the sample. A larger portion of decisionmakers in Dokkhamtai district, about 59 percent, were in the 40-49 age group. On average, the age of farm decisionmaker was about 45 years in both districts.

A minor proportion of decisionmakers were younger than forty years, 32 percent in Maejai and 21 percent in Dokkhamtai. About 68 percent of decisionmakers in Maejai

Table 3.1
Distribution of Decisionmakers by Age

Age Group	Maejai District		Dokkhamtai District	
	Number	Percent	Number	Percent
Less than 30	3	9.7	1	3.4
30 - 39	7	22.6	5	17.2
40 - 49	10	32.3	17	58.6
50 - 59	6	19.4	5	17.2
Older than 59	5	16.1	1	3.4
Total	31	100.0	29	100.0

district and 79 percent in Dokkhamtai district were forty years of age or older, but few were older than 59 years.

3.2.2 Education

All decisionmakers in the interview were able to read and understand numbers and the Thai language well. The distribution of education levels of decisionmakers is shown in Table 3.2. Only one decisionmaker in Maejai district did not have any formal education. More than three-fourths of decisionmakers in both districts had less than 5 years of schooling. Most of the decisionmakers were older than forty years and the compulsory education level was only to grad 4 at the time they were in school. Only about 13 percent in Maejai district and 7 percent in Dokkhamtai district had obtained higher than a seventh grade education.

3.2.3 Family Size

Table 3.3 shows the distribution of family size of the farm households. Family size ranged from 3 to 9 persons. The average number of members in each family was about 4.5 and 4.7 persons for Maejai and Dokkhamtai districts, respectively. In most cases, families consisted of parents with two or three children. Some families had three generations living in the same household.

In Maejai, the number of family members was about equally divided among size groups of 1-3, 4-5 and 6-9. Most households in Dokkhamtai, about 76 percent, consisted of 4 or 5 members.

Table 3.2
Education Level of Decisionmakers

Number of Years in School	Maejai District		Dokkhamtai District	
	Number	Percent	Number	Percent
Less than 5	24	77.4	24	82.8
5 to 7	3	9.7	3	10.3
More than 7	4	12.9	2	6.9
Total	31	100.0	29	100.0

Table 3.3
Distribution of Family Size

Number of Members	Maejai District		Dokkhamtai District	
	Number	Percent	Number	Percent
1 - 3	11	35.5	3	10.3
4 - 5	11	35.5	22	75.9
6 - 9	9	29.0	4	13.7
Total	31	100.0	29	100.0

Household sizes with 1-3 and 6-9 members composed 10 percent and 13 percent of the sample, respectively. One household in Dokkhamtai had 9 persons.

3.3 Farm Land

3.3.1 Farm Land Holdings

The range of farm sizes in the sample was very wide, from 5 rai for the smallest to 127 rai for the largest. The average farm size was 20.9 rai in Maejai and 33.6 rai in Dokkhamtai (Table 3.4).

A high percentage of farmers in Maejai, 58 percent, were grouped into the 11-25 rai farm size category. In Dokkhamtai, about 69 percent of farmers had farm sizes in the 11-25 and 26-40 rai categories.

3.3.2 Land Tenancy

In Maejai, all farm households surveyed had two or more plots of land for farming. Five farmers in Dokkhamtai grew crops only on a single plot of land. The number of farm plots per household varied from 1 to 7. However, the average number of plots per farm was 3.2 in Maejai and 3.0 in Dokkhamtai. All farmers in both districts owned at least one plot of land, except one farmer in Dokkhamtai who did not own any land and share-cropped on a plot of land owned by his relative. Seven farmers in Maejai and six farmers in Dokkhamtai had rented additional land for farming from relatives and/or neighbors. These normally consisted of crop-sharing arrangements. A few

Table 3.4
Farm Size Distribution by District

Farm Size (Rai ^a)	Maejai District		Dokkhamtai District	
	Number	Percent	Number	Percent
< 11	5	16.1	2	6.9
11 - 25	18	58.1	11	37.9
26 - 40	5	16.1	9	31.0
41 - 55	2	6.5	4	13.8
> 55	1	3.2	3	10.3
Total	31	100.0	29	100.0

^a 1 Rai = 0.4 Acre

farmers, two in Maejai and one in Dokkhamtai, rented out part of their lands to other farmers in the same village by sharing the harvest.

3.4 Farm Working Capital

3.4.1 Vehicle and Farm Equipment

Table 3.5 shows the percentage of vehicle and farm equipment ownership by farmers in Maejai and Dokkhamtai districts. The main vehicle for commuting within or between villages was the bicycle or motorcycle. When villagers have to travel to town, they can also use the truck service which makes one round trip per day, leaving the village in early morning and returning back in late afternoon.

Almost every household interviewed had at least one bicycle. A second or sometimes third bicycle was needed for use by their children to travel to school. Only two households in Dokkhamtai district did not have any bicycles, but both of these households had motorcycles. About 74 and 62 percent of farmers in Maejai and Dokkhamtai, respectively, owned motorcycles. For households with motorcycles, most owned only one motorcycle. Two households in Maejai and five in Dokkhamtai owned pick-up trucks. Pick-up trucks were used for many purposes, such as commuting, transporting farm products from the field or to the city, buying goods or supplies from the city, etc. In Maejai, both farmers with pick-up trucks were also middlemen. They used their trucks mainly to transport farm products for resale in the city.

Table 3.5
Percentage of Vehicle and Farm Equipment Ownership
by District

	Maejai District	Dokkhamtai District
	Percent	Percent
Vehicle:		
Bicycle	100.0	93.1
Motorcycle	74.2	62.1
Pick-up Truck	6.5	17.2
Farm Equipment:		
Two-wheel Tractor	74.2	89.7
Irrigation Pipe	32.3	37.9
E-tan Truck	9.7	-
Sprayer	54.8	69.0

Since most farmers in both areas owned relatively small amounts of farm land, the two-wheel tractor was the most important and efficient farm equipment. Most farmers, 74 percent in Maejai and 90 percent in Dokkhamtai, owned a two-wheel tractor. The tractor can serve many purposes, such as land tillage, water irrigation and transportation. With pipes, it can be used for irrigation. When it is mounted onto a truck called "E-tan", it can be used for transporting farm supplies and products between the fields and barns or houses.

Many farmers borrowed or rented irrigation pipes from their relatives or neighbors. Fewer farmers owned irrigation pipes than two-wheel tractors in both districts. Farmers without two-wheel tractors used custom services for land preparation or tillage which cost about 220 Baht per day. Only three farmers in Maejai used "E-tan" trucks for transportation. More than half of the farmers had chemical sprayers, 55 percent in Maejai and 69 percent in Dokkhamtai.

3.4.2 Savings and Loans

From the sample, 32.2 percent of the farmers in Maejai district and 48.3 percent in Dokkhamtai district had some bank savings. Many farmers had saving in other forms, such as gold jewelry, bracelets, necklaces or rings, which could easily be exchanged for cash at the district or provincial marketplace.

Most farmers borrowed money from the Bank for Agriculture and Agricultural Cooperatives (BAAC). Some farmers obtained loans from agricultural cooperatives in the district. The

interest rate ranged between 12.5 to 15 percent per annum and was essentially the same from both sources. Farmers occasionally borrowed money for emergency household expenditures from local money lenders in which they were charged high interest rates, e.g., 60 percent per annum.

Farmers mainly invested money in crop enterprises and purchasing farm inputs, such as gasoline, seeds, fertilizers, pesticides and others. One farmer in Maejai and three in Dokkhamtai bought two-wheel tractors through loan arrangements with the BAAC. Farmers started to use their credit at the beginning of cropping seasons and repaid after selling their produce. Some farmers supplied farm investment with their savings and/or bank loans. About 48.3 percent of the farmers surveyed in Maejai and 65.5 percent in Dokkhamtai had borrowed money for farming from banks and cooperatives.

3.5 Sources of Family Income

Family income of farmers was categorized into farm and off-farm sources (Table 3.6). Most farm income was derived from selling agricultural products, such as rice, corn, mungbean, garlic and ginger. In addition, there was at least one family member in almost every households who earned income from off-farm activities.

The average annual net income per household for the farm families in the survey was 33,040 Baht in Maejai and 31,023 Baht in Dokkhamtai. The majority of household income was from farming, 77 and 74 percent in Maejai and Dokkhamtai,

Table 3.6
Average Net Income of Farmers by Income Source

Unit: Baht/Household

Income Source	Maejai District		Dokkhamtai District	
	Income	Percent	Income	Percent
Farm	25,426	77.0	22,990	74.1
Off-farm	7,614	23.0	8,033	25.9
Total	33,040	100.0	31,023	100.0

respectively. The contribution of income from off-farm activities was about 23 percent in Maejai and 26 percent in Dokkhamtai. Statistical information from the Thai Office of Agricultural Economics indicates that the national average net income of farm households was 30,266 Baht per annum in 1990.

3.5.1 Farm Income

The distribution of annual net farm income of decisionmakers in each district is shown in Table 3.7. Net farm income of decisionmakers ranged from 1,971 to 63,514 Baht per annum. The percentage of farmers with farm incomes of less than 13,000 Baht per annum was 19 and 28 for Maejai and Dokkhamtai districts, respectively. More than sixty percent of farmers in both districts had income from farming between 13,000 and 39,000 Baht per annum. The percentage of farmers with farm incomes greater than 39,000 Baht per annum was higher in Maejai district (19 percent) than in Dokkhamtai district (10 percent).

The average net returns for various crops by district are shown in Table 3.8. All farmers, except one in Dokkhamtai, had grown rice, which is the most important crop in both districts. Rice provided more than 70 of net income from farming. In Maejai district, ginger gave the second highest of portion of net income to farmers after rice. This was followed by garlic and then mungbean-rice. In Dokkhamtai district, the portion of farmer's income was shared by corn, mungbean-rice, mungbean and garlic in descending order.

Table 3.7
Net Farm Income Distribution of Farmers by District

Income Level (Baht/Household)	Maejai District		Dokkhamtai District	
	Number	Percent	Number	Percent
< 13,000	6	19.4	8	27.6
13,000-26,000	15	48.4	9	31.0
26,000-39,000	4	12.9	9	31.0
39,000-52,000	3	9.7	2	6.9
> 52,000	3	9.7	1	3.4
Total	31	100.0	29	100.0

Table 3.8
Average Net Returns for Various Crops

Crop	Maejai District		Dokkhatai District	
	Net Income (B/Farm)	Percent	Net Income (B/Farm)	Percent
Rice	17,992	70.76	16,479	71.68
MBR ^a	298	1.17	1,462	6.36
Garlic	1,726	6.79	1,019	4.43
Ginger	5,410	21.28	-	-
Corn	-	-	2,693	11.71
Mungbean ^b	-	-	1,338	5.82
Total	25,426	100.00	22,990	100.00

^a Mungbean that is grown before rice in paddy field.

^b Mungbean that is grown in upland.

3.5.2 Off-farm Income

In addition to income from farming, farmers and their family members earned money from various sources of off-farm activities, such as collecting forest products, working as hired laborers or civil servants, trading and cottage industries. Table 3.9 shows the average income of decisionmakers from off-farm activities in each district. Farmers in Dokkhamtai district had slightly higher income from off-farm activities (8,034 Baht per household) than those in Maejai district (7,612 Baht per household).

Many farmers in both districts were hired to work in other farmers' rice fields for land preparation, planting, harvesting and threshing when they completed their activities in their own fields. The average income from hired labor in agriculture was higher in Dokkhamtai because of more work and higher wages.

Hired labor in non-agricultural jobs included employment in both private and public sectors. Many farmers and family members were hired to work in the private sector in nearby towns or cities as construction workers, housemaids, factory workers, clerks and in other types of employment. In Maejai district, some family members worked in the public sector as teachers, foresters, or temporary workers with irrigation departments. Many farmers in Dokkhamtai district received money or gifts from their family members who worked either permanently or temporarily during the off-farm season in the cities.

Table 3.9
Average Off-Farm Income of Farmers from Various Sources

Source	Maejai District	Dokkhamtai District
	Off-farm Income (Baht/Household)	Off-farm Income (Baht/Household)
Forest Products	194	19
Hired Labor in Agriculture	1,131	2,297
Hired Labor in Non-Agriculture	4,525	3,076
Trading	1,765	2,290
Cottage Industry	-	352
Total	7,614	8,034

Two decisionmakers in each district made profits from buying farm products from villagers and selling them to middlemen in the provincial markets. One decisionmaker in Dokkhamtai provided bicycle repair service at his home. Two decisionmakers in Maejai and two decisionmakers in Dokkhamtai owned small shops which sold household goods to other villagers. Income from these activities are categorized under trading.

A minor source of off-farm income was the collection of mushroom and bamboo shoots from nearby forests when they were free from farm work. These products were for household consumption and sale in local markets. The average income of farmers from forest products was higher in Maejai than Dokkhamtai because the forest in Maejai is closer to villages and more abundant.

The source of off-farm income for eight families in Dokkhamtai was the cottage industry, which included weaving, basket making, mattress making and rice container making. Farm families working in cottage industries mostly sold their products to merchants in provincial markets.

CHAPTER IV
RESULTS OF THE ANALYSIS

This chapter begins with the presentation of the two elements in the E-V model: the decisionmakers' risk attitudes and risk perceptions. The results of farmers' risk attitudes toward farm investment are presented first. This is followed by the results of farmers' risk perceptions for each crop within their cropping systems and decision environments. These two elements are used to find the solutions for utility and profit maximization models for each farm under the E-V framework. Target MOTAD models are also incorporated and comparisons made of their solutions to the solutions of the E-V models.

4.1 Farmers' Risk Attitudes

Table 4.1 shows the risk attitudes or preferences of decisionmakers based on the sign of the second coefficient of the quadratic utility function. A negative sign means risk averting and a positive sign means risk preferring. In Maejai district, 71 percent of the farmers were risk averting and only 29 percent risk preferring. The proportion of risk averting and risk preferring decisionmakers in Dokkhamtai district was about the same as in Maejai district, with 69 percent risk averting and 31 percent risk preferring.

Table 4.1
Decisionmakers' Risk Attitude

Risk Attitude	District	
	Maejai (n=31) ^a	Dokkhamtai (n=29)
Aversion	22 (70.9) ^b	20 (69.0)
Preference	9 (29.1)	9 (31.0)

^a Number of the sample.

^b Percentage of the sample.

4.2 Farmers' Risk Perceptions

Farmers' risk perceptions were determined by the strength-of-conviction method mentioned in chapter II. First, farmers discussed their production environment for the period of ten years according to weather conditions and pest damage. Then the environments were categorized into three unique seasons, 'good', 'medium', and 'poor.' Farmers were then asked to express their risk perceptions concerning each crop in terms of its expected yield and price under each categorized season. Table 4.2 shows the calculation of the average expected yield, price and gross income of paddy rice.

Expected gross income for each crop and season for a ten year period is shown in Table 4.3. Farmers in Maejai district had a more optimistic perception on environment for growing rice than those in Dokkhamtai district. This was seen by a higher average number of years for 'good' season and lower for 'poor' season. For mungbean-rice, the pattern of average subjective probability of each season was similar for Maejai and Dokkhamtai districts. Mungbean-rice farmers believed that the 'medium' season was most likely and followed by 'poor' and 'good' seasons, respectively.

Garlic was grown on small plots of land in both districts. Garlic farmers in both districts had similar perceptions of their production environment based on the average number of years in each season. The pattern of farmers' perceptions on the production environment was similar for corn and mungbean in Dokkhamtai district, since both crops

Table 4.2
Expected Yield, Price and Gross Income of Paddy Rice

Season	Number of Years Out of 10 Years	Yield (Kg/Rai)	Price (Baht/Kg)	Income (Baht/Rai)
Good	2	481	3.04	1,462
Medium	5	390	3.36	1,310
Poor	3	300	3.75	1,125
Average ^a		381	3.41	1,285

^a Average yield $E(Y) = \sum P_i Y_i$,
 Where P_i = Probability of the i^{th} season,
 Y_i = Yield of the i^{th} season.
 Average price and income are computed in similar manner.

Table 4.3
Average of Expected Number of Years
and Gross Incomes of Crops

Crop	Season	No. of Years Out of 10	Gross Income (Baht/Rai)
Maejai District:			
Rice	Good	2.44	2,480
	Medium	5.08	1,700
	Poor	2.48	1,251
Mungbean-Rice ^a	Good	2.47	1,526
	Medium	4.53	856
	Poor	3.00	454
Garlic	Good	2.68	7,637
	Medium	4.55	4,393
	Poor	2.77	2,500
Ginger	Good	2.23	12,192
	Medium	4.65	6,715
	Poor	3.12	2,353
Dokkhamtai District:			
Rice	Good	2.02	2,321
	Medium	4.77	1,578
	Poor	3.21	1,200
Mungbean-Rice	Good	2.04	1,379
	Medium	4.81	811
	Poor	3.15	480
Garlic	Good	2.75	7,468
	Medium	4.58	4,460
	Poor	2.67	3,163
Corn	Good	2.26	1,375
	Medium	4.61	1,077
	Poor	3.13	819
Mungbean ^b	Good	2.07	1,292
	Medium	4.50	765
	Poor	3.43	446

^a Mungbean that is grown before rice in paddy field.

^b Mungbean that is grown in upland.

were grown in the upland area. Ginger was only grown in Maejai district. On average, ginger farmers felt that there was higher subjective probability for a 'poor' season (.312) than a 'good' season (.223). The 'medium' season was the most likely with .465 subjective probability distribution.

4.2.1 Sources of Risks

Yields and prices are the expected sources of risks. To determine whether farmers exposed higher risk from yields or from prices, the coefficient of variation (CV) is used as a relative measure of risk between these two variables. The larger CV value implies that higher risk is associated with that variable. Table 4.4 shows the average coefficient of variation of yields and prices for various crops.

The average CV values of yields and prices of rice indicated that there was slightly more risk for rice prices than yields in both Maejai and Dokkhamtai districts. The CV values for rice prices and yields were negatively correlated, -0.024 in Maejai and -0.049 in Dokkhamtai. However, no statistical significance was found at the 0.05 probability level. This implies that farmers did not exposed higher yield risk with smaller price risk.

For corn growers in Dokkhamtai, twelve of twenty-three farmers felt that price risk was larger than yield risk. On the contrary, the aggregate CV values show that price risk (CV = 0.092) was slightly less than yield risk (CV = 0.103).

Table 4.4
The Average Coefficient of Variation (CV)
of Yields and Prices from Various Crops

Crop	Maejai		Dokkhamtai	
	CV ^a of Yield	CV of Price	CV of Yield	CV of Price
Rice	0.121	0.128	0.109	0.132
Corn	-	-	0.103	0.092
Mungbean-Rice ^b	0.232	0.211	0.170	0.208
Mungbean ^c	-	-	0.178	0.222
Garlic	0.144	0.285	0.083	0.254
Ginger	0.178	0.400	-	-

^a Coefficient of Variation = Standard Deviation / Mean

^b Mungbean that is grown before rice in paddy field.

^c Mungbean that is grown in upland.

No statistical significance was found for the correlation between yield and price risks for corn at the 0.05 probability level.

Yield risk (CV = 0.232) for mungbean-rice in Maejai was greater than price risk (CV = 0.211) on average, but a larger number of farmers in Maejai, eight of fifteen, believed that price risk was more important. In Dokkhamtai, the average of price risk coefficients was larger than yield risk coefficients. There were positive correlations between yield risks and price risks in both districts, but no statistical significance was found between the two variables at the 0.05 probability level. Similar findings were obtained among mungbean farmers in Dokkhamtai. Again, no significant correlation was found between the two coefficients of variation of price risk and yield risk among mungbean farmers. The relationship implies that farmers did not believe that a direct relationship between yield risk and price risk for mungbean existed.

From the average coefficients of variation of garlic yields and prices in both Maejai and Dokkhamtai districts, farmers believed that price risk were much more important than yield risk. A positive but statistically insignificant correlation between CV values of yields and prices was found in Maejai. The opposite was true in Dokkhamtai where there was negative, but statistically insignificant correlation between the two coefficients. The data provide some indications that

garlic farmers believed that yield risk was not related to price risk.

Risk due to price variations exceeded those for yield risk in Maejai among ginger growers. The average coefficients of variation of yields and prices were 0.178 and 0.400, respectively. The correlation between yield and price coefficients was 0.303, which was not statistically significant. This implies that farmers felt no direct relation between yield and price risk.

4.2.2 Comparison of Expected and Actual Incomes

The percentage difference between expected and actual gross incomes of farmers was used to measure the accuracy of farmers' expectations. The accuracy of expectations were measured by percentage differences from the actual. The distribution of the percentage differences from the actual and expected gross incomes of farmers in various crops is shown in Table 4.5.

For income from rice, 94 percent and 93 percent of farmers in Maejai and Dokkhamtai districts, respectively, reported that they received incomes within 30 percent of their expected values. There were two farmers in each district that stated their actual incomes differed more than 30 percent from the expected incomes. Eighty seven of the farmers in Maejai and 86 percent of those in Dokkhamtai expected lower returns from rice than the actual values, thus underestimating actual

Table 4.5
The Distribution of the Percentage Differences of
the Actual and Expected Gross Incomes of Farmers^a

Unit: Number of farmers

Crops	Underestimation			Overestimation		
	<-30%	-15 to -30%	0 to -15%	0 to 15%	15 to 30%	>30%
	Maejai District:					
Rice	2	13	12	2	2	-
MBR ^b	4	3	2	1	2	3
Garlic	-	5	6	5	3	3
Ginger	3	1	5	3	3	11
Dokkhamtai District:						
Rice	1	15	9	2	-	1
Corn	-	5	10	4	1	3
MBR	2	5	3	3	2	-
Mungbean ^c	2	3	5	3	1	-
Garlic	2	6	4	-	-	-

^a Based on crop yields and prices elicitation.

^b Mungbean that is grown before rice in paddy field.

^c Mungbean that is grown in upland.

incomes in both districts. In another words, most of farmers in both districts underestimated their incomes.

Corn and mungbean are grown only in Dokkhamtai district, where 87 percent of corn growers and 86 percent of mungbean growers had actual incomes within 30 percent of expected values. Thirteen percent of the farmers had expected income more than 30 percent above their actual incomes from corn. For mungbean, 14 percent of the farmers underestimated their actual income by more than 30 percent.

Farmers in Maejai poorly estimated their incomes from the mungbean-rice enterprise. Only 53 percent of the farmers in Maejai in contrast to 87 percent in Dokkhamtai received incomes from mungbean-rice that fell within 30 percent of their expected values. This could be due to farmers' short experience in growing and marketing of mungbean-rice. Also, mungbean-rice was grown in the early rainy season in which farmers felt greater uncertainty in their production. More than 60 percent of the farmers in Maejai and 67 percent in Dokkhamtai underestimated income from growing mungbean before rice.

There were mixed results on farmers' income expectations from growing garlic. About 90 percent of the farmers in Maejai and 83 percent in Dokkhamtai correctly predicted incomes from garlic within 30 percent of actual values. An equal number of farmers (11) in Maejai district underestimated or overestimated their incomes from garlic. All twelve garlic

growers in Dokkhamtai district underestimated their incomes from garlic.

Ginger was only grown by farmers in Maejai district. Farmers were not good in estimating incomes from ginger. Only 46 percent of the farmers received gross returns that fell within 30 percent of expectations. About 65 percent of ginger growers in Maejai district overestimated and 35 percent underestimated their potential incomes from ginger. This situation occurred primarily because of plant disease and low ginger price. Many farmers reported that their ginger plots were damaged by diseases for the first time. Estimation of ginger price was also difficult due to the extreme fluctuation from season to season.

4.2.3 Expected Incomes and Variances

Variance is a common measure of risk. A higher variance implies higher risk. The aggregate average of expected gross incomes and their variances for the crops grown in the two districts are shown in Table 4.6. The study indicated a positive relationships between expected gross income and variance. Crops which provided higher expected gross income had higher variances. Ginger and garlic provided high levels of income but also had the greatest variances. Ginger provided the highest average expected gross income as well as variance because its yield and price varied dramatically by season. The expected gross income and variance of rice was moderate in both districts. The two crops with relatively low gross income

Table 4.6
Average of Expected Gross Income and Variance from Crops

Crop	Maejai District			Dokkhamtai District		
	Number of Farm	Gross Income (Baht/Rai)	Variance	Number of Farm	Gross Income (Baht/Rai)	Variance
Rice	31	1,785	222,504	28	1,600	175,585
Corn	-	-	-	23	1,067	46,338
MBR ^a	15	899	182,253	15	834	113,569
Mungbean ^b	-	-	-	14	772	102,666
Garlic	22	4,786	4,346,169	12	4,906	2,966,479
Ginger	26	6,595	15,214,276	-	-	-

^a Mungbean that is grown before rice in paddy field.

^b Mungbean that is grown in upland.

and risk were corn and mungbean (both in upland and paddy fields).

The difference between expected gross incomes from crops of farmers in Maejai and Dokkhamtai districts was conducted by the use of an equality of the means test. For the expected gross income from rice, the t-value of the test was 2.32, which indicates a statistically significant difference between the means of expected gross incomes from rice for Maejai and Dokkhamtai farmers at the 0.05 probability level, with expected gross incomes from rice in Maejai being higher than for Dokkhamtai. The test for differences between the larger mean of expected gross income from mungbean-rice in Maejai than in Dokkhamtai had a t-value of 1.89, which was not significant at 0.05, but significant at the 0.10 probability level. For garlic, no statistically significant difference was found between the means of expected gross incomes of Maejai and Dokkhamtai districts.

4.2.4 Relationship of Expected Incomes and Their Variances

The relation between expected incomes and their respective variances for each crop can be discerned by their correlations. In addition, a hypothesis test was conducted to determine whether the decisionmaker believed that expected incomes and variances were positively correlated. Table 4.7 shows the correlations between expected incomes and variances for crops and their respective t-values. For Maejai district, the correlations between expected values and variances of

Table 4.7
Correlation between the Expected Gross Income
and Gross Income Variance from Crops

Crop	Correlation Coefficient (r)	Calculated t-value ^a
Maejai District:		
Rice	0.44	2.64*
Mungbean-Rice ^b	0.42	1.66
Garlic	0.48	2.42*
Ginger	0.70	4.80*
Maejai District:		
Rice	0.57	3.49*
Mungbean-Rice	0.30	1.14
Corn	0.19	0.89
Mungbean ^c	0.66	3.07*
Garlic	0.17	0.53

$$^a \text{ Calculated t-value} = \frac{r}{(1 - r^2)/(n - 2)}, \text{ df} = (n - 2)$$

* Indicates significance at 0.05 probability level.

^b Mungbean that is grown before rice in paddy field.

^c Mungbean that is grown in upland.

incomes for all crops were positive and significant at the 0.05 level, except for mungbean-rice. In Dokkhamtai, there were positive correlations between expected income and variance for all crops, but correlations were significant only for rice and mungbean.

From the results, it can be concluded that larger expected income is associated with larger expected income variance for rice, garlic and ginger in Maejai district. In Dokkhamtai district, expected income was directly related to income variance statistically only for rice and mungbean.

4.3 Construction of the E-V Frontier for a Sample Farm

An assumption of the E-V model is that the decisionmaker is risk averse. Different decisionmakers have different perceptions or subjective probabilities in crop production. Therefore, E-V frontiers were constructed for each risk-averse decisionmaker. There were 22 risk-averse decisionmakers out of 31 farmers in Maejai district and 20 out of 29 farmers in Dokkhamtai district (Table 4.1).

The crop activities included in the E-V model for each individual farmer were acquired from the interviews and varied from farm to farm. Data concerning farmer's subjective probability distribution of yields and prices for each season were incorporated to estimate the expected gross margins (gross income minus variable cost) and the variance-covariance matrix. This information, together with farmer's resource constraints (i.e., land, labor and capital), were then used to

construct a quadratic risk programming model. The E-V frontier can then be traced out by changing the parameter α of the quadratic risk programming model¹ as explained in chapter II.

Table 4.8 shows expected gross margins of four crops for each season, subjective probability distributions for the ten-year period and calculations for expected gross margins for a particular farm (farm number 110). Garlic provided the highest expected gross margin (5,616 Baht/Rai) followed by ginger (5,062 Baht/Rai), rice (854 Baht/Rai) and mungbean-rice (469 Baht/Rai).

A sample quadratic risk programming model for constructing an E-V frontier is presented in Table 4.9. The objective function was to minimize the variation of expected net incomes or gross margins from all activities within a farm plan subject to input-output coefficients and other constraints. Means and variances of expected net incomes for individual crops on each farm were estimated subjectively. However, it proved impossible to obtain subjective estimates of covariances directly from the farmers. The assumption of no correlation among expected net incomes from crops had to be made. The degree of risk from crop production can be ranked from lowest to highest as mungbean-rice, rice, garlic, and ginger when risk is measured by the variance of expected net incomes.

¹The model is coded by the use of GAMS (General Algebraic Modeling System) computer software package on microcomputer which has capability of handling non-linear programming.

Table 4.8
Gross Margins of Crop Activities within Farm

Unit: Baht/Rai

Season	Activities			
	Rice (X ₁)	Mungbean-Rice ^a (X ₂)	Garlic (X ₃)	Ginger (X ₄)
Good	1391 (n=3) ^b	896 (n=3)	8832 (n=4)	8362 (n=4)
Medium	713 (n=5)	414 (n=5)	4272 (n=3)	3862 (n=3)
Poor	401 (n=2)	-36 (n=2)	2672 (n=3)	1862 (n=3)
Weighted Average ^c	854	469	5616	5062

^a Mungbean that is grown before rice in paddy field.

^b n = number of years out of 10 years.

^c Average gross margin $E(G) = \sum P_i G_i$,
Where P_i = Probability of the i^{th} season,
 G_i = Gross margin of the i^{th} season.

Table 4.9
Sample of Quadratic Risk Programming Model

	Activities					
	Rice (X_1)	MBR ^a (X_2)	Garlic (X_3)	Ginger (X_4)		
Minimize: Income variance						
X_1	152882	0	0	0		
X_2	0	119129	0	0		
X_3	0	0	8087893	0		
X_4	0	0	0	8733333		
Subject to:						
Max. area for rice (Rai)	1	0	0	0	\leq	14
Max. area for MBR&ginger (Rai)	0	1	0	1	\leq	14
Min. area for rice (Rai)	1	0	0	0	\geq	10.59
Min. area for garlic (Rai)	0	0	1	0	\geq	0.23
July labor (Manday ^b)	3.50	4.50	0	5.50	\leq	75
December labor (Manday)	4.30	0	8.50	0	\leq	75
Capital (Baht)	0	666	0	2138	\leq	5000
Expected net income (Baht)	854	469	5616	5062	$=$	α

^a Mungbean that is grown before rice in paddy field.

^b Manday = 8 hours working labor.

The first constraint of the sample of quadratic risk programming model is the maximum land area for growing rice. It was limited to fourteen rai which was the total amount of land available for farming. Since there was an overlapping in growing ginger and mungbean-rice, the combination of these two activities was limited to fourteen rai. The minimum areas for rice and garlic were 10.59 and 0.23 rai, respectively. These were minimum land areas to produce such crops to meet household consumption. No minimum land area was required for mungbean since farmers grew mungbean only for cash. Throughout the year, there were two peaks of labor requirement for farming. The first peak was in July in which a large amount of labor was required for mungbean-rice and ginger harvesting and rice planting. Another peak was in December for harvesting of rice and growing of garlic. The total amounts of labor available in these months were derived by multiplying the number of days and family members expected to contribute to farming. The capital constraint was estimated by the amount of money that the farmer has and is willing to invest in mungbean-rice and ginger activities. The last equation, the total expected net income, was varied parametrically to create an E-V efficient frontier.

4.4 Target MOTAD Model Formulation

The specification of the Target MOTAD model was to maximize the total expected net income subject to technological coefficients and constraints. As mentioned

above, the purpose of constructing the Target MOTAD model was to compare its solutions to the E-V model solutions. Therefore, the expected net income, input-output coefficients and some resource constraints were the same as those from the E-V model. The difference was that the variance-covariance matrix was not incorporated into the Target MOTAD model. This model rather determines negative deviation from the target level as risk. The two target levels in this study were cash and variable costs of actual investment in all crop activities within the farmer's cropping system.

4.4.1 A Sample of the Target MOTAD Model

Table 4.10 shows an example of the Target MOTAD model for the same farm as the E-V model above. The objective for this model was to maximize the total expected net income rather than to minimize variance as in the E-V model. Technical coefficients and some resource constraints were carried over from equations 2 to 8 of the E-V model. In addition, the target MOTAD model included equations to capture negative deviations from target levels for the expected net income for each state of nature or season (equations 9 to 11). The target level in this example was 5,274 Baht which was total cash invested in crop activities. A similar procedure was applied for using variable costs as the target level. In equation 12, a risk constant (parameter δ) was the summation of the product between the probability of each season and its negative deviation from the target level. Parameter δ was varied

Table 4.10
Sample of Target MOTAD Model

	Activities					
	Rice (X_1)	MBR ^a (X_2)	Garlic (X_3)	Ginger (X_4)		
Maximize:						
1) Expected net income (Baht)	854	469	5616	5062		
Subject to:						
2) Max. area for rice (Rai)	1	0	0	0	\leq	14
3) Max. area for MBR&ginger (Rai)	0	1	0	1	\leq	14
4) Min. area for rice (Rai)	1	0	0	0	\geq	10.59
5) Min. area for garlic (Rai)	0	0	1	0	\geq	0.23
6) July labor (Manday ^b)	3.50	4.50	0	5.50	\leq	75
7) December labor (Manday)	4.30	0	8.50	0	\leq	75
8) Capital (Baht)	0	666	0	2138	\leq	5000
9) Good season (Baht)	5274	-1391	-896	-8832	\leq	N_g
10) Medium season (Baht)	5274	-713	-414	-4272	\leq	N_m
11) Poor season (Baht)	5274	-401	36	-2672	\leq	N_p
12) Negative Deviation (Baht)		$(.35)N_g$	$(.40)N_m$	$(.25)N_p$	$=$	δ

^a Mungbean that is grown before rice in paddy field.

^b Manday = 8 hours working labor.

parametrically to trace out a risk-return frontier for Target MOTAD model.

4.5 Results of Utility and Profit Maximization Models, and Target MOTAD Model

This section combines the results on farmers' attitudes (utility function) and farmers' perceptions (E-V frontier) to derive the optimal farm plans for utility maximization model under E-V analysis. The farm plans under utility and profit maximization models are then used to predict the actual behavior of individual farmers. In addition, the optimal plans under the Target MOTAD model are incorporated into E-V space for the purpose of comparing its predictability with the previous two models.

Comparisons of solutions from the predictive models to the actual behavior of the decisionmaker is possible when these solutions are in the same units or dimension. The actual behavior can be expressed in several dimensions, such as level of activities within a cropping system, level of specific crops within a farm plan, level of inputs and average expected income from crops.

Using acreage of activities within farm plan for comparison among predicted plans with actual farmer's plan was also tried. In many cases, the solutions showed that the acreage of farm activity was zero in predicted plans but not in the actual plan. Therefore, the chi-square goodness-of-fit test could not be performed for the solutions of predicted plans and actual plan being equal.

The expected income distribution of a farm plan (i.e., its mean and variance or E-V space), was used as a determinant to predict the actual decisionmaker's behavior (Lin, Dean and Moore 1974). Then the predictive power of the profit maximization model, the utility maximization model and the Target MOTAD model can be compared to the actual decisionmaker's behavior when solutions from the Target MOTAD model are translated into E-V space.

4.5.1 Prediction of Actual Income

Table 4.11 summarizes the number of farms for which expected incomes of the optimal farm plans under various predicted models compared to expected income of the actual farm plans. The actual values of expected income from the actual and predicted plans are shown in Appendix D. The results of these comparisons were categorized into higher than, equal to and lower than the expected income of the actual plan. For all predicted models, most of the farms had higher expected incomes than the actual plans. There were only 5 farms under the utility maximization model, 10 under cash-cost and 10 variable-cost Target MOTAD models for which expected incomes were lower than in the actual plan. This indicates that all predicted models had a tendency to predict more risky behavior than was in fact observed. The profit maximization model was the worst offender because all of its predicted plans were more risky than the actual behavior, except for five cases which had equal expected incomes.

Table 4.11
Comparison of Expected Income from
the Actual and Predicted Plans

Unit: Number of Farm

Category ^a	E-V Farm Plan		Target MOTAD Farm Plan	
	Utility Max.	Profit Max.	Cash-Cost	Variable-Cost
Maejai District:				
Higher	17	20	17	14
Equal	2	2	2	2
Lower	3	-	3	6
Dokkhamtai District:				
Higher	16	17	11	15
Equal	2	3	2	1
Lower	2	-	7	4
Combined Districts:				
Higher	33	37	28	29
Equal	4	5	4	3
Lower	5	-	10	10

^a The expected incomes of the predicted plan are categorized into higher, equal or lower if they are higher than, equal to or lower than the expected incomes of the actual plan.

4.5.2 Relative Performance of the Predicted Models

For a more rigorous comparison of each farm, the chi-square goodness-of-fit test² is used to determine whether the income distribution from each expected plan differed significantly from the actual farmer's plan. The lower the chi-square value the closer the predicted plan is to the actual plan. The results of chi-square values from various programming models and of farmers in different locations, Maejai and Dokkhamtai districts, are shown in Appendix E.

From chi-square values in Appendix E, the frequency of the best predicted model is summarized in Table 4.12. For Maejai district, the utility maximization model (UM) and the Target MOTAD model, using variable cost as the target level (VTM), predicted absolute best for 8 and 7 cases without any tie with other predicted models, respectively. The cash-cost Target MOTAD (CTM) had only one absolute best prediction. The profit maximization model (PM) was the least effective with no absolute dominating prediction.

For Dokkhamtai district, the utility maximization model also performed better than other models in terms of the number of absolute best predictions (6 cases). Cash-cost and variable-cost target levels under Target MOTAD models had three and two absolute best predictions, respectively. No profit maximization model outperformed other predicted models.

²The method of calculating the chi-square value is shown in Appendix G.

Table 4.12
Frequency of the Best Predicted Model

Predicted Model ^a	Maejai District (number)	Dokkhamtai District (number)	Combined Districts (number)
UM	8	6	14
PM	-	-	-
CTM	1	3	4
VTM	7	2	9
Total	16	11	27

^a UM = Utility maximization model,
PM = Profit maximization model,
CTM = Cash-cost Target MOTAD model, and
VTM = Variable-cost Target MOTAD model.

^b Based on chi-square values in Appendix E.

For the combined districts, the utility maximization model was the best predictor, with 14 leading predictions followed by the variable-cost Target MOTAD (9 cases) and cash-cost Target MOTAD models (4 cases), respectively. The least effective predictor was the profit maximization model, which had no absolutely best prediction.

There were many cases in which the four predicted models did not give identical predictions. These are summarized in Table 4.13 for Maejai, Dokkhamtai and combined districts with a pairwise comparison between models based on chi-square values with two decimal points. The smaller chi-square value indicates the more successful model, indicating the least difference.

As indicated in first column under Maejai district in Table 4.13, the UM model predicted better than the PM, CTM and VTM models in 10 out of 22 cases. The results in the first row show that the PM, CTM and VTM outperformed UM in 3, 5 and 9 cases, respectively. Using the same procedure, the pairwise comparison can be made for other models. UM and VTM were strongly superior than PM and CTM in term of prediction. UM and VTM were the best two competing models in which UM performed better than VTM in 10 cases while VTM outperformed UM in 9 cases.

In Dokkhamtai district, farm decision behavior of twenty farmers was predicted by the four models. For Dokkhamtai district the dominance of VTM was weaker than in Maejai and PM performed better in predicting farmers' behaviors in this

Table 4.13
Frequency of Pairwise Superior Prediction
of Models to the actual Behavior

Less Successful Model ^a	More Successful Model			
	UM	PM	CTM	VTM
Maejai District: (n=22) ^b				
UM	-	3 (14) ^c	5 (23)	9 (41)
PM	10 (45)	-	3 (14)	10 (45)
CTM	10 (45)	2 (09)	-	10 (45)
VTM	10 (45)	2 (09)	3 (14)	-
Dokkhamtai District: (n=20)				
UM	-	2 (10)	4 (20)	5 (25)
PM	8 (40)	-	5 (25)	3 (15)
CTM	10 (50)	7 (35)	-	7 (35)
VTM	12 (60)	5 (25)	7 (35)	-
Combined Districts: (n=42)				
UM	-	5 (12)	9 (21)	14 (33)
PM	18 (43)	-	8 (19)	13 (31)
CTM	20 (48)	9 (21)	-	17 (40)
VTM	22 (52)	7 (17)	10 (24)	-

^a UM = Utility maximization model,
 PM = Profit maximization model,
 CTM = Cash-cost Target MOTAD model, and
 VTM = Variable-cost Target MOTAD model.

^b Number of the sample.

^c Figures in parentheses are percentages of the sample.

^d Based on chi-square values in Appendix E.

district (Table 4.13). The performance of UM in Dokkhamtai district was still better than for the other three models.

For combined districts with forty-two farms, the best model in terms of the number of superior predictions was UM, which was closely followed by VTM (columns one and four of Table 4.13). For comparing the performance of PM and CTM, the result was mixed. CTM performed a little better than PM by considering the number of superior predictions for UM and VTM. But PM dominated CTM in 9 cases, while CTM outperformed PM in 8 cases.

4.5.3 Accuracy of Prediction

The Chi-square value can be used to calculate the probability of obtaining the two different distributions at random when in fact the two have the same mean and variance. The higher the probability value, the closer is the prediction. Results of the estimated probability values³ between the distributions of the actual behavior and the four predicted models (utility maximization, profit maximization, cash-cost Target MOTAD and variable-cost Target MOTAD) are shown in Appendix F. The averages of the estimated probability values for each model under Maejai, Dokkhamtai, and the combined districts are shown here in Table 4.14.

Using the average of the estimated probabilities, VTM was the best predictor for Maejai district since it provided the

³The calculation of probability values from chi-square values is done by using Shazam software package.

Table 4.14
Average of Probabilities of Equality of
Actual and Predicted Plans

Unit: Percentage

District	Predicted Models ^a			
	UM	PM	CTM	VTM
Maejai (n=22) ^b	29.33	27.38	28.94	37.12
Dokkhamtai (n=20)	50.90	48.55	42.16	45.75
Combined (n=42)	39.60	37.46	35.23	41.23

^a UM = Utility maximization model,
 PM = Profit maximization model,
 CTM = Cash-cost Target MOTAD model, and
 VTM = Variable-cost Target MOTAD model.

^b Number of farms in the sample.

^c Based on probability values in Appendix F.

highest probability value (37.12 percent). This was followed by UM, CTM and PM average probabilities of 29.33, 28.94 and 27.38 percent, respectively. For Dokkhamtai district, the best predictor was UM with an average probability of 50.94 percent. CTM was the worst predictor with an average probability of 42.16 percent.

For all four prediction models, the average probability values for Maejai district were lower than for Dokkhamtai district. This implies that there was a higher probability that the predicted distribution equaled the actual distribution in Dokkhamtai district.

For combined districts, the results show that UM and VTM predicted the actual behavior more closely than PM and CTM. However, the pairwise difference between probability values from various models was conducted using an equality of the mean test. The results indicated no statistically significant differences among the means of probability values from various models at the 0.05 probability level.

For relative prediction performance and accuracy, one can conclude that UM and VTM perform better than PM and CTM. This conforms with the results of Lin, Dean and Moore (1974), Mohayidin (1981) and Herath, Hardaker, and Anderson (1982) that the Bernoullian utility maximization model explains actual farmer's behavior more accurately than the profit maximization model. In addition, based on this study, the Target MOTAD model with a suitable selection of a target level

variable cost study can also be a good predictor of actual behavior of the farmer.

4.5.4 Prediction of Land Allocation to Mungbean-Rice

Comparisons of the predictive power of the four models can be made as to how they predict the actual amount of land allocated to a particular farm activity, mungbean-rice in this case. Table 4.15 shows the actual and predicted amount of land allocated to mungbean-rice by risk averse farmers. Under the actual farm plan, the average land allocation to mungbean-rice in Maejai district was much smaller than in Dokkhamtai district. The average parcel size was 3.3 and 15.4 rai for Maejai and Dokkhamtai districts, respectively. One reason for this difference is that in Maejai district mungbean-rice and ginger were planted at the same time and there was competitive for limited land, labor and capital resources. In Dokkhamtai district, there was no overlap between mungbean-rice and other crops.

There was only one case (farm number 110) in Maejai district where the actual land allocation to mungbean-rice was exactly predicted by the utility maximization model. For Dokkhamtai district, there were two cases (farm numbers 203 and 217) of exact prediction of mungbean-rice acreage by utility maximization, profit maximization and cash-cost Target MOTAD models.

In Maejai district, there were more cases of overestimation than underestimation of actual mungbean-rice

Table 4.15
Actual and Predicted Amount of Land Allocated
to Mungbean-Rice by Risk-Averse Farmers

Unit: Rai

Farm No.	Actual Plan	E-V Farm Plan		Target MOTAD Farm Plan ^a	
		Util. Max.	Profit Max.	Cash-Cost	Variable-Cost
Maejai District:					
102	1.00	<u>4.36</u>	<u>3.75</u>	<u>3.75</u>	0.00
104	2.00	0.49	0.49	0.49	0.00
106	3.00	0.52	1.31	0.00	0.00
107	12.00	<u>14.56</u>	<u>13.81</u>	<u>13.79</u>	<u>13.81</u>
110	3.00	3.04	1.09	1.09	0.00
111	2.00	<u>10.19</u>	<u>7.72</u>	<u>7.72</u>	<u>11.00</u>
113	2.00	<u>8.57</u>	<u>6.78</u>	<u>2.58</u>	0.00
115	6.00	<u>7.02</u>	<u>7.02</u>	<u>7.02</u>	0.00
119	0.25	<u>0.99</u>	<u>0.99</u>	<u>0.99</u>	0.00
121	2.00	<u>4.42</u>	0.39	0.39	0.00
Dokkhamtai District:					
201	27.00	25.56	25.56	0.00	0.00
203	10.00	10.00	10.00	10.00	0.00
207	6.00	<u>17.00</u>	<u>17.00</u>	0.00	<u>13.22</u>
210	19.00	9.82	18.39	14.66	18.39
212	15.00	14.35	11.11	0.00	11.11
213	19.00	<u>25.00</u>	<u>25.00</u>	0.00	<u>22.66</u>
214	9.00	<u>14.00</u>	<u>14.00</u>	<u>14.00</u>	0.00
217	10.00	10.00	10.00	10.00	8.17
218	9.00	<u>11.00</u>	<u>11.00</u>	6.73	<u>11.00</u>
222	10.00	1.91	0.00	0.00	0.00
223	40.00	0.00	0.00	0.00	0.00
226	10.00	<u>19.05</u>	<u>20.16</u>	0.00	2.43
227	16.00	13.36	13.39	0.00	13.39
228	15.00	8.77	8.77	0.00	0.00

^a Cash-cost and variable-cost are set as target levels in Target MOTAD model.

^b Underlined values are the land allocation of predicted plans when they are larger than the actual plan.

land allocations for three models; namely, utility maximization, profit maximization, and cash-cost Target MOTAD models. For the variable-cost Target MOTAD model, land allocations were underestimated in actual, eight out of ten cases. In Dokkhamtai district, all four predicted models tended to underestimate the actual land allocation to mungbean-rice.

Since all four models did not give the same predictions, pairwise comparison was made on how close they predicted the actual mungbean-rice land allocation. The results are summarized in Table 4.16. In Maejai district, the actual land allocation by ten farmers was predicted in all four models. UM performed better than PM in only one case while PM outperformed UM in five cases. For the comparison between UM and CTM, UM predicted better than CTM in two cases while CTM performed better than UM in four cases. For UM and VTM, UM predicted better than VTM in five cases while VTM outperformed UM in five cases. Similar procedures can be used to examine the performance of the other three models. The results indicated that CTM performed relatively better than the other three models in terms of having the largest number of successful predictions and the smallest number of less successful predictions. This was followed by PM, VTM and UM, respectively.

In Dokkhamtai, UM performed the best among the four models in term of having the largest number of superior predictions and the smallest number of inferior predictions

Table 4.16
 Frequency of Pairwise Superior Prediction for
 Land Allocation to Mungbean-Rice
 by Risk-Averse Farmers

Less Successful Model ^a	More Successful Model			
	UM	PM	CTM	VTM
Maejai District: (n=10) ^b				
UM	-	5 (50) ^c	4 (40)	5 (50)
PM	1 (10)	-	2 (20)	3 (30)
CTM	2 (20)	1 (10)	-	2 (20)
VTM	5 (50)	6 (60)	7 (70)	-
Dokkhamtai District: (n=14)				
UM	-	2 (14)	2 (14)	5 (36)
PM	3 (21)	-	2 (14)	3 (21)
CTM	8 (57)	7 (50)	-	6 (43)
VTM	7 (50)	5 (36)	4 (29)	-

^a UM = Utility maximization model,
 PM = Profit maximization model,
 CTM = Cash-cost Target MOTAD model, and
 VTM = Variable-cost Target MOTAD model.

^b Number of the sample.

^c Figures in parentheses are percentages of the sample.

for mungbean-rice land allocations. PM was the second best model, followed by VTM and CTM, respectively.

The predictive results of farmers' behavior in land allocation for mungbean-rice were different for Maejai and Dokkhamtai districts as indicated. UM, PM and CTM were more likely to overestimate the actual mungbean-rice land allocation for Maejai district and to underestimate it for Dokkhamtai district. This implies that the time overlap of mungbean-rice and ginger activities in Maejai district had some influence on farmers' decision making in land allocation to mungbean-rice, which affected performance of the four predictive models.

4.6 Summary of Decision Making Analyses

This chapter summarizes the results of the decision making analyses which include decisionmakers' risk attitudes, risk perceptions, and the predictability of actual behavior by various programming models. The first section presented the results of decisionmakers' risk attitudes. Most of decisionmakers in both Maejai and Dokkhamtai districts were risk averse.

Results on decisionmaker's risk perceptions were presented in section two. The subjective probability distributions of incomes from various crops were presented first. Based on coefficient of variation analysis, decisionmakers believed that variable prices were more risky than fluctuating yields. The research also indicated that

crops with higher expected income were also associated with higher variance.

Examples of the quadratic risk programming model and the Target MOTAD model were demonstrated in sections three and four, respectively. The next section showed the results of the prediction of actual decisionmakers' behaviors by utility maximization, profit maximization, cash-cost and variable-cost Target MOTAD models. All predicted models had a tendency to predict more risky behavior than was observed in the actual farm plans. The Chi-square goodness-of-fit test was used to determine the performance and accuracy of predicted models within E-V space. The results showed that utility maximization and variable-cost Target MOTAD models outperformed profit maximization and cash-cost Target MOTAD models. These coincided with the results from previous studies in both developed and developing countries.

The performance of the four models in predicting actual behavior of farmers in land allocation to mungbean-rice was shown in the last section 4.5.4. The results show that the cash-cost Target MOTAD model was the best predictor for Maejai district while the utility maximization model performed best for Dokkhamtai district. The difference in farmers' decision behavior on land allocation to mungbean-rice in Maejai and Dokkhamtai districts was influenced by the competition for limited farm resources between mungbean-rice and ginger activities, which occurred in Maejai district only.

CHAPTER V

SUMMARY AND SUGGESTIONS FOR FURTHER RESEARCH

5.1 Summary and Conclusions

In decision making analysis, the input-output relationships of individual farmer's production plans are unique and depend upon their decision making environment, both physically and economically. Additionally, a farmer's decision making process is also influenced by his/her attitudes toward risk and risk perceptions. The consideration of the farmer's attitude toward risk and risk perception could provide greater understanding of a farmer's decision making behavior.

Many risk programming models have been implemented in whole-farm decision making analyses based on different risk concepts. The main purpose of this study is to show whether alternative decision making models involving risk, utility maximization, and Target MOTAD models could better predict decisionmakers' behavior on farm investment than the profit maximization model. This research may help the government improve it's understanding of farmers' decision making behavior and assist in the formulation of policies which are more effective and suitable to farmer's needs.

A case study was conducted by sampling rice farmers in Maejai and Dokkhamtai districts of Phayao province in the northern part of Thailand where the mungbean before rice crop rotation was introduced. Most rice farmers in northern Thailand own small farms, averaging about 26 rai or 10 acres,

which are mostly in rainfed areas. The Thai government has made an effort to help small rice farmers achieve a higher and more stable income by the integration of an additional crop, mungbean before rice crop rotation, into their existing cropping systems.

The method used in the elicitation of decisionmakers' risk preferences was the modified von Neumann-Morgenstern or certainty equivalent technique. The formulation of decisionmakers' utility functions was done by regression analysis using a quadratic function. The sign of the second coefficient (squared term) was used to identify the types of decisionmakers' risk preferences. The results indicated that 71 percent of farmers in Maejai and 69 percent in Dokkhamtai district were risk-averse decisionmakers.

The strength-of-conviction method was used to elicit the decisionmakers' subjective probabilities for yield and price risks for various crops. Most farmers were reasonable in estimating gross incomes from all crops when the percentage difference of expected and actual gross incomes was used to measure the accuracy of their expectations. Most farmers underestimated their actual gross incomes from all crops, except for ginger. The coefficient of variation was used as a relative measure of risk stemming from yield and price variations. The results showed that price risk was more important than yield risk for most crops. These results are consistent with those of Grisley and Kellog (1983) in a study of farmers' subjective probabilities in northern Thailand. It

was also concluded from the current study that crops with higher expected gross incomes also had higher income variances.

Many conclusions can be drawn from the application of the E-V programming model and the Target MOTAD programming model. For the E-V approach, quadratic risk programming was used to create an efficient set of farm plans. This approach requires restrictive assumptions of a quadratic utility function and a multivariate normal distribution of expected net returns. Moreover, the elicitation process of individual decisionmakers' risk preferences and the construction of their utility functions are time consuming and expensive. For the Target MOTAD programming model, no assumptions need to be made for the nature of the distribution of expected returns. This programming model allows the obtainable data to indicate the nature of the multivariate distribution. The efficient set of farm plans for the Target MOTAD programming model can be approximated using a linear programming algorithm, while the E-V programming model requires nonlinear or quadratic programming algorithms.

The four models used in predicting decisionmakers' behavior were profit maximization, utility maximization, cash-cost Target MOTAD and variable-cost Target MOTAD models. The comparisons of predictions by the four models were made within the E-V space. The results indicated that all four models predicted farm plans with higher incomes than the actual farm plans. The profit maximization model was the least effective

in this regard. The relative performance and accuracy of the four models were tested using the chi-square goodness-of-fit test. The results showed that utility maximization and variable-cost Target MOTAD models predicted the actual decisionmakers' behavior equally well and both models outperformed the cash-cost Target MOTAD and profit maximization models. These results conform with those of previous studies (Lin, Dean and Moore 1974; Herath, Hardaker and Anderson 1982; and Anderson and Hamal 1983) that the utility maximization model explains actual farm decisionmakers' behavior more accurately than the profit maximization model. Moreover, the Target MOTAD model involving safety-first considerations performed quite well in explaining actual decisionmakers' behavior when the selected target level portrays their risk preferences and goals.

The decisionmakers' behaviors on land allocation to mungbean-rice were very different for Maejai and Dokkhamtai districts. The average amount of land allocated to mungbean-rice was 3.3 and 15.4 rai for Maejai and Dokkhamtai, respectively. These differences were due largely to different cropping systems in the two districts. In Maejai district, mungbean-rice was grown at the same time as ginger and competition between these two enterprises occurred for farmers' limited farming resources, such as land, labor and cash. This situation was not present in Dokkhamtai district. All four decision models performed poorly in predicting land allocation to mungbean-rice for both districts. However, the

relative performance of the four models was tested using pairwise comparison. The results indicated that the cash-cost Target MOTAD model performed best for Maejai district and the utility maximization model performed best in Dokkhamtai district.

The comparative results of the various decision making models indicate that farmers are rational in their farm investment and resource allocation decisions by including expected outputs, costs and risk into their considerations. The result of ignoring risk in decision making analysis, such as in the profit maximization model, is regarded as unrealistic and this may lead to overestimation of the output level of risky enterprises.

5.2 Suggestions for Further Research

Some suggestions can be drawn from the present study in relation to the elicitation methods for decisionmakers' risk preferences and perceptions. In elicitation of decisionmakers' risk attitudes using the certainty-equivalent method, the first crucial step is to make sure that the questions are clearly explained to and understood by decisionmakers before the beginning of the chain-like elicitation process. Otherwise, the respondents may incorrectly or inconsistently reveal their certainty-equivalent values for the first and succeeding questions. Mechanically, presenting each 50-50 gamble on a marker pen board also enhanced decisionmakers' conceptualization. Another important consideration is that

sufficient time should be allowed for decisionmakers to arrive with certainty-equivalent values without any assistance from the interviewer.

The strength-of-conviction method was used for elicitation of farmers' subjective probability distributions for crop yields and prices. This method is simple and practical, particularly for farmers in developing countries. It performed quite well for the elicitation of risk perceptions or subjective probability distributions of farmers. In the future, research studies involving subjective probability distributions may consider using and improving this method.

The E-V model is based on the assumption of a non-linear utility function. Therefore, the criteria for determining risk preference is considered by the concavity of this function. The solution for the E-V model cannot be known with certain for the risk preferrer (i.e., convex utility function), although it can be considered for risk averse and risk neutral farmers. Therefore, risk preferring individuals were eliminated from the analysis. This may have some significant effects on the conclusions and recommendations on policy implications of the study.

This issue could have been examined more thoroughly by considering methods of classification other than concavity of the utility function for distinguishing risk averters and risk preferrers. An alternative models, such as behavior decision

theory, could have be used. These issues are left for examination in the future research.

The Target MOTAD model as used in the study has several appealing considerations: 1) it can predict the actual decisionmaker's behavior well with a suitable selection of a target level, 2) it has theoretical appeal, 3) it is easier to implement since the formulation of the Target MOTAD programming model does not require variance-covariance matrix of all crops as in a quadratic risk programming model, and 4) it can be solved by using linear programming algorithm which requires less computational cost.

With a small sample, 60 farms, this study is a methodological case study. However, this comparative study on decision making models could help researchers in developing countries to be better equipped with analytical tools which provide them with more accurate predictions of farmers' behavior and planning. The findings of the current study can be served as guidelines for similar research work in the future and the application of the model may be improved further by including other factors that may have important influences on farmers' decision making.

In addition, an understanding of the farmers' decisionmaking processes is useful for designing effective policies to influence their behavior. From the results of this study, most farmers perceived that price risk was more important than yield risk for all crops, including the mungbean before rice crop rotation. Therefore, government

policy to mitigate price uncertainty rather than yield uncertainty may be more effective for promoting mungbean-rice technology adoption among small rice farmers. Reducing farmers' price uncertainty can be done by price stabilization schemes which can be achieved through various forms of government policy programs, such as commodity storage programs and price support programs (i.e., minimum price). Further research is warranted to determine the effectiveness and success of these programs with respect to their application to small rice farmers.

APPENDIX A

MUNGBEAN BEFORE RICE TECHNOLOGY PACKAGE^a

Variety:

U-Thong 1, VC 1178, Kampengsean 1, Kampengsean 2.

Suitable area to be grown:

Drainage should be good.

Land preparation:

Plowing should start at first rain.
Drainage ditch should be provided.

Time of planting:

Immediately after land preparation.

Planting space:

Hill planting, 50x20 cm. (row x hill).
Drop 4-5 seeds per hill, thin back to 2 plants/hill.

Weeding:

Hand weeding at 10 and 30 days after planting.

Insect and Disease control:

Captan or Terraclor 1-2.5 g./1 kg. seed is used
for neck rot disease.
Furadan 3 kg./rai prevent beanfly damage.

Fertilization:

Apply only in poor soil
(16-20-0 or 15-15-15 at 20-25 kg./rai).

Harvesting:

One or twice by hand, plow under the stubble
as green manure.

^a Recommended by the Farming Systems Research Institute,
Department of Agriculture, Bangkok, Thailand, 1986.

APPENDIX B

THE BENEFITS AND COSTS OF MUNGBEAN BEFORE RICE TECHNOLOGY

		Unit: Baht/rai ^a
<u>Variable cost</u>		679.54
1. Labor cost ^b		477.54
1.1 Planting labor		
Land preparation	121.73	
Sowing	9.95	
Hand weeding	25.68	
Spray pesticide	15.18	
Water irrigation	4.00	
Spray weedicide	8.00	
1.2 Harvesting labor		
Harvest	190.00	
Threshing	78.00	
Transport	17.00	
Drying	5.00	
Storing	3.00	
2. Material cost		170.00
Seed	65.00	
Pesticide	80.00	
Weedicide	10.00	
Equipment	15.00	
3. Miscellaneous		32.00
Equipment repair	2.00	
Investment cost	8.00	
Interest cost ^c	22.00	
<u>Fixed cost</u>		130.59
Land rent/land tax/land use	129.00	
Depreciation	1.59	
<u>Total cost</u>		810.13
<u>Total revenue/rai</u>		1280.00
(Yield at 160 kg./rai and price at 8 Baht/kg.)		
	Net revenue	469.87
	Gross margin	600.46
	Variable cost/kg.	4.24
	Total cost/kg.	5.06

Note: ^a U.S. \$ 1 = 25 Baht, 1 acre = 2.529 rai.

^b Labor cost at 35-40 Baht/manday (manday = 8 hours).

^c Interest rate at 12.5 per year.

Source: Integrated Rainfed Farming Systems Research and Development Project, Farming Systems Research Institute, Bangkok, Thailand, 1986.

APPENDIX C
THE FIELD SURVEY

1. Objective of the Survey

The objective of this study is to investigate how individual farmers behave or make decisions concerning their farm investments in relation to the introduction of mungbean-rice technology by the Thai government. A field survey was conducted in an attempt to explain why farmers act differently in terms of crop combination and amount of land allotment to various crops within their cropping systems. The sample of a questionnaire is shown in Appendix H.

The field survey identified for farmers' physical farm environment and resource endowments. The physical environment involves the amount of rainfall and rainfall distribution and soil structure of the two study areas. Generally, farmers possess different levels of resource endowment such as land, labor and capital. Other essential information in the survey included farmers' age, education attainment, source and level of income, etc. All these factors constitute a unique decision making environment for individual farmers. Furthermore, the survey also emphasized the influence of farmers' risk preferences and perceptions in their farm investment decisions.

2. Selection of Sample

A sophisticated sampling method could not be used because the population of mungbean-rice technology adopters were not distributed pervasively within the whole northern part of Thailand nor in the selected districts, Maejai and Dokkhamtai. Therefore, a purposive sampling procedure was used.

The list of mungbean-rice technology adopters was acquired with the assistance of the local FSRI researcher who is responsible for both districts. The sampling frame was determined after a tour of the areas and visits to local agricultural extension offices. Farmers were classified into adopters and non-adopters of mungbean-rice technology within each selected village. Then farmers from each category were drawn from the list. Before entering each village for the actual interview, information about the physical environment and socio-economic aspects of the village were provided by the responsible extension officer. Assistance with locating and making appointments with farmers for interviews was given by the local FSRI researcher, the responsible extension officer, and the village headmen.

The survey was made during the period from March to August 1992. The questionnaire was pre-tested and adjusted whenever necessary before the actual interview. A total of 60 farmers were interviewed. The study include 31 households from Maejai district and 29 households from Dokkhamtai districts.

3. Information from the Interview

The basic information gathered from each household during the interview was as follows:

1. Socio-economic information, such as number of members living in the household; family members' status, age, sex, and education; number of family members working on farm and off farm;
2. Farm household inventory of land holdings, such as number and size of plot holdings, type of land, topography, land tenure, main source of water, and cropping pattern on each plot, number of various types of livestock, number of farm and household equipments of various types and miscellaneous items;
3. Input use for each crop enterprise, including amounts and prices of gasoline, seed, fertilizer, chemicals, etc., labor inputs such as family labor or hired labor, and custom hired inputs such as land tillage and threshing;
4. Amount and price of outputs from each crop enterprise including output for sale, household consumption, seed, crop sharing, and others;
5. Risk perceptions of the decisionmaker, including information concerning subjective probabilities on yields and prices from crops;
6. Risk attitudes or preferences of decisionmaker on farm investment;
7. type and income flow from off-farm activities;

8. household expenditures;
9. credit information concerning how to access credit if necessary; the purpose, amount, interest charge and term of current borrowing; and
10. extension information such as opinions on mungbean-rice technology, how and where farmers obtain knowledge about technology, etc.

A formal questionnaire (see Appendix G) was used during the interview, but any additional information considered important and pertinent to farmer's decision making process was also recorded. Other informal information related to agriculture and socio-economic welfare of villagers was also obtained during the discussion with village headmen or members of village councils as well as farmers themselves.

Before the interview in each village, the purposes of the survey was explained to the village headman. The list of the selected farmers was also given for the interview arrangement with designated farmers. All village headmen and farmers were very cooperative for the interviews. In addition, most of farmers or decisionmakers were patient and helpful in providing answers during each interview, which ranged from two and a half to three hours for each household.

4. Difficulties on the Survey

Since growing mungbean before rice has not been widely practiced in the northern region, the selection of study sites was rather arbitrary. The main consideration for selection of

study sites was based on the areas in which mungbean-rice technology had been introduced to farmers. The two study sites were chosen after consultations with FSRI researchers at their Bangkok headquarters. After the study sites were chosen, it was not easy to distinguish between the adopters and non-adopters of mungbean-rice technology at the study site. This problem was solved by the help from the local FSRI researcher who has been in charge of the area for more than nine years. He was one of the government officers who introduced mungbean-rice technology into the areas and was well acquainted with farmers and their families. He thus knew the history of individual farmers' cropping systems in both study sites, particularly for those farmers who had adopted mungbean-rice technology.

The head of the family household was usually selected as the key farm decisionmaker for the interview. In some households, the decision making on the farm was dominated by the housewife, parent or a grown-up son. In many cases, farm decisions were made after discussions among family members. The analysis of the decision making process using group beliefs and preferences was not used because it would have been complex and encountered with conceptual problems. Only one key farm decisionmaker in each household was selected for the interview.

Interviews were long and intensive, which each respondent provided with enough time to understand questions clearly before answering. On many occasions the enumerator became

acquainted with the respondent by having a meal together and the interviews were conducted during and after the meal. This method allows both parties to feel relaxed during the interview. However, questions concerning farmers' risk attitudes were rather difficult to understand by some respondents. The pattern of this type of question also was chain-like. This problem was solved by using a marker pen board for writing numbers and explaining to respondents. Respondents were provided with a chance to look at numbers on the white board and think thoroughly before arriving with certainty-equivalent values.

APPENDIX D

EXPECTED INCOME OF THE ACTUAL AND PREDICTED FARM PLANS

Unit: Baht

Farm No.	Actual Plan	E-V Farm Plan		Target MOTAD Farm Plan ^a		
		Util. Max.	Profit Max.	Cash-Cost	Variable-Cost	
Maejai District:						
101	30,804	35,800	42,688	42,680	<u>23,878</u>	
102	47,273	<u>47,144</u>	57,664	57,664	<u>40,886</u>	
103	100,602	<u>64,680</u>	112,150	112,150	112,150	
104	22,192	26,800	26,800	26,175	24,772	
106	72,912	<u>55,890</u>	75,564	75,552	75,552	
107	44,099	44,250	47,190	<u>40,229</u>	47,190	
108	59,920	59,920	59,920	59,920	59,920	
110	24,042	31,220	33,385	33,385	32,875	
111	30,341	31,220	37,652	37,652	<u>26,362</u>	
113	55,979	60,100	64,118	<u>55,320</u>	<u>51,014</u>	
115	46,173	52,701	52,701	52,701	51,249	
116	17,404	28,600	32,538	32,538	32,538	
118	9,670	14,122	14,122	<u>5,580</u>	12,193	
119	18,351	27,831	27,831	27,831	27,803	
120	16,356	18,978	18,978	18,978	<u>14,294</u>	
121	17,554	22,480	25,495	25,495	<u>16,880</u>	
122	28,491	33,616	33,616	33,616	33,616	
123	14,400	17,590	20,130	20,130	20,130	
124	25,244	35,610	35,985	35,985	35,985	
127	18,316	24,490	28,470	28,470	28,470	
128	10,906	20,244	20,244	20,244	12,844	
131	22,903	22,903	22,903	22,903	22,903	
Dokkhamtai District:						
201	22,370	24,903	24,903	24,213	24,213	
203	11,114	16,822	16,822	16,822	16,312	
204	24,518	32,066	32,066	32,066	32,066	
205	33,819	35,310	40,020	40,020	40,020	
206	25,570	31,090	32,655	32,655	32,655	
207	10,886	13,155	13,155	<u>9,688</u>	12,743	
210	18,647	23,000	24,379	23,778	24,379	
211	8,609	8,610	8,610	8,610	8,610	
212	29,594	30,430	35,578	31,556	35,578	
213	61,730	63,427	63,427	<u>54,100</u>	63,211	
214	17,148	18,466	18,466	18,466	<u>13,894</u>	
216	49,766	<u>42,110</u>	49,766	<u>44,714</u>	<u>49,754</u>	
217	14,040	14,040	14,040	14,040	<u>13,470</u>	
218	8,867	9,590	9,590	<u>7,784</u>	9,590	

APPENDIX D. (CONTINUED)

EXPECTED INCOME OF THE ACTUAL AND PREDICTED FARM PLANS

Unit: Baht

Farm No.	Actual Plan	E-V Farm Plan		Target MOTAD Farm Plan ^a	
		Util. Max.	Profit Max.	Cash-Cost	Variable-Cost
222	57,844	58,180	69,225	69,225	69,225
223	39,389	43,250	48,885	44,658	48,885
226	29,696	31,390	31,652	<u>27,713</u>	<u>28,182</u>
227	40,597	45,910	58,040	49,802	58,040
228	29,175	29,501	29,501	<u>27,223</u>	29,308
229	18,371	<u>11,150</u>	20,325	<u>13,325</u>	20,325

^a Cash-cost and variable-cost are set as target levels in Target MOTAD model.

^b Underlined values are expected incomes of predicted plan when they are smaller than actual plan.

APPENDIX E

CHI-SQUARE TEST OF INCOME DISTRIBUTIONS OF
ACTUAL AND PREDICTED PLAN BEING EQUAL

Farm No.	E-V Model		Target MOTAD Model ^a	
	Utility Max.	Profit Max.	Cash-Cost	Variable-Cost
Maejai District:				
101	<u>1.030</u>	5.831	5.826	2.807
102	<u>0.855</u>	2.200	2.200	2.641
103	30.953	<u>1.394</u>	<u>1.394</u>	<u>1.394</u>
104	1.035	1.035	0.793	<u>0.414</u>
106	12.047	0.094	<u>0.093</u>	<u>0.093</u>
107	<u>0.130</u>	0.202	0.378	0.202
108	<u>0.000</u>	<u>0.000</u>	<u>0.000</u>	<u>0.000</u>
110	<u>2.069</u>	3.442	3.442	3.197
111	4.577	<u>1.430</u>	<u>1.430</u>	11.138
113	0.284	1.175	<u>0.037</u>	0.579
115	1.154	1.154	1.154	<u>0.810</u>
116	<u>4.713</u>	8.034	8.035	8.035
118	1.808	1.808	15.342	<u>0.529</u>
119	4.429	4.429	4.429	<u>4.410</u>
120	0.948	0.948	0.948	<u>0.470</u>
121	1.476	4.520	4.520	<u>0.027</u>
122	<u>1.346</u>	<u>1.346</u>	<u>1.346</u>	<u>1.346</u>
123	<u>0.646</u>	2.071	2.071	2.071
124	<u>3.997</u>	4.516	4.518	4.518
127	<u>1.823</u>	4.589	4.589	4.589
128	6.530	6.530	6.530	<u>0.314</u>
131	<u>0.000</u>	<u>0.000</u>	<u>0.000</u>	<u>0.000</u>
Dokkhamtai District:				
201	<u>0.268</u>	<u>0.268</u>	0.308	0.308
203	2.079	2.079	2.078	<u>1.657</u>
204	<u>2.605</u>	<u>2.605</u>	<u>2.605</u>	<u>2.605</u>
205	<u>0.430</u>	0.970	0.970	0.970
206	<u>1.056</u>	1.540	1.540	1.540
207	0.981	0.981	<u>0.174</u>	0.500
210	<u>1.078</u>	1.370	1.129	1.370
211	<u>0.000</u>	<u>0.000</u>	<u>0.000</u>	<u>0.000</u>
212	0.819	1.007	<u>0.210</u>	1.007
213	0.057	0.057	1.139	<u>0.044</u>
214	<u>0.185</u>	<u>0.185</u>	<u>0.185</u>	0.846
216	2.220	<u>0.000</u>	0.594	<u>0.000</u>
217	<u>0.000</u>	<u>0.000</u>	<u>0.000</u>	0.057
218	<u>0.108</u>	<u>0.108</u>	0.224	<u>0.108</u>

APPENDIX E. (CONTINUED)

CHI-SQUARE TEST OF INCOME DISTRIBUTIONS OF
ACTUAL AND PREDICTED PLAN BEING EQUAL

Farm No.	E-V Model		Target MOTAD Model ^a	
	Utility Max.	Profit Max.	Cash-Cost	Variable-Cost
222	<u>0.029</u>	3.713	3.713	3.713
223	1.055	1.981	<u>1.050</u>	1.982
226	<u>0.100</u>	0.332	0.911	0.823
227	<u>0.835</u>	8.179	3.858	8.179
228	<u>0.026</u>	<u>0.026</u>	0.386	0.058
229	7.358	<u>0.347</u>	2.246	<u>0.347</u>

^a Cash-cost and variable-cost are set as target levels in Target MOTAD model.

^b Underlined values are the best predictor in each farm.

APPENDIX F

THE PROBABILITY OF INCOME DISTRIBUTIONS OF
ACTUAL AND PREDICTED PLANS BEING EQUAL

Farm No.	E-V Model		Target MOTAD Model ^a	
	Utility Max.	Profit Max.	Cash-Cost	Variable-Cost
Maejai District:				
101	<u>0.310</u>	0.016	0.016	0.094
102	<u>0.355</u>	0.138	0.138	0.104
103	0.000	<u>0.238</u>	<u>0.238</u>	<u>0.238</u>
104	0.309	0.309	0.373	<u>0.520</u>
106	0.001	0.759	<u>0.761</u>	<u>0.761</u>
107	<u>0.719</u>	0.653	0.538	0.653
108	<u>1.000</u>	<u>1.000</u>	<u>1.000</u>	<u>1.000</u>
110	<u>0.150</u>	0.064	0.064	0.074
111	0.032	<u>0.232</u>	<u>0.232</u>	0.001
113	0.594	0.278	<u>0.848</u>	0.447
115	0.283	0.283	0.283	<u>0.368</u>
116	<u>0.030</u>	0.005	0.005	0.005
118	0.179	0.179	0.000	<u>0.467</u>
119	0.035	0.035	0.035	<u>0.036</u>
120	0.330	0.330	0.330	<u>0.493</u>
121	0.224	0.034	0.034	<u>0.870</u>
122	<u>0.246</u>	<u>0.246</u>	<u>0.246</u>	<u>0.246</u>
123	<u>0.422</u>	0.150	0.150	0.150
124	<u>0.046</u>	0.034	0.034	0.034
127	<u>0.177</u>	0.032	0.032	0.032
128	0.011	0.011	0.011	<u>0.575</u>
131	<u>1.000</u>	<u>1.000</u>	<u>1.000</u>	<u>1.000</u>
Dokkhamtai District:				
201	0.575	<u>0.605</u>	0.579	0.579
203	0.149	0.149	0.149	<u>0.198</u>
204	<u>0.107</u>	<u>0.107</u>	<u>0.107</u>	<u>0.107</u>
205	<u>0.512</u>	0.325	0.325	0.325
206	<u>0.304</u>	0.215	0.215	0.215
207	0.322	0.322	<u>0.677</u>	0.480
210	<u>0.299</u>	0.242	0.288	0.242
211	<u>1.000</u>	<u>1.000</u>	<u>1.000</u>	<u>1.000</u>
212	0.365	0.316	<u>0.647</u>	0.316
213	0.811	0.811	0.286	<u>0.833</u>
214	<u>0.667</u>	<u>0.667</u>	<u>0.667</u>	0.358
216	0.136	<u>1.000</u>	0.441	<u>1.000</u>
217	<u>1.000</u>	<u>1.000</u>	<u>1.000</u>	0.811
218	<u>0.742</u>	<u>0.742</u>	0.636	<u>0.742</u>

APPENDIX F. (CONTINUED)

THE PROBABILITY OF INCOME DISTRIBUTIONS OF
ACTUAL AND PREDICTED PLANS BEING EQUAL

Farm No.	E-V Model		Target MOTAD Model ^a	
	Utility Max.	Profit Max.	Cash-Cost	Variable-Cost
222	<u>0.864</u>	0.054	0.054	0.054
223	0.304	0.159	<u>0.305</u>	0.159
226	<u>0.751</u>	0.565	<u>0.340</u>	0.364
227	<u>0.361</u>	0.004	0.049	0.004
228	<u>0.872</u>	<u>0.872</u>	0.534	0.810
229	0.007	<u>0.556</u>	0.134	<u>0.556</u>

^a Cash-cost and variable-cost are set as target levels in Target MOTAD model.

^b Underlined values are the best predictor in each farm.

APPENDIX G

EXAMPLE OF CHI-SQUARE CALCULATION

Formula for chi-square calculation:

$$\chi^2 = \frac{(f_o - f_e)^2}{f_e}$$

Where: f_o = the observed income distribution,
 f_e = the income distribution predicted by
the model.

The example, for farm number 101, the calculation of χ^2 using the means and variances of the actual income distribution and of the income distribution predicted by the utility maximization model is as follows.

	<u>f_o</u>	<u>f_e</u>	<u>$(f_o - f_e)^2/f_e$</u>
Mean (1,000)	30.804000	35.800000	0.697
Std. Dev. (1,000)	9.239801	11.170246	0.334
			<u><u>$\chi^2 = 1.0306$</u></u>

The degree of freedom is 1. The corresponding estimated probability is 0.310, which is estimated using the Shazam computer software package.

APPENDIX H
QUESTIONNAIRE

1. Household Composition (RT-100)
2. Land Characteristics (RT-200)
3. Inventory (RT-210)
4. Animal Activities (RT-300)
5. Crop Activities (RT-310)
6. Off-farm Activities (RT-320)
7. Domestic Expenditure (RT-400)
8. Risk Attitude (RT-500)
9. Credit Information (RT-600)
10. Input-Output Information (RT-700)
11. Risk Perception (RT-710)
12. Extension Information (RT-800)

QUESTIONNAIRE

[2] Name () _____ [1] Farm No. _____

[3] Address () _____

1. Household Composition (RT-100)

[6] No. in family									
[8] Status									
[10] Sex									
[12] Education level									
[14] Work on-farm?									
[16] Work off-farm?									
[18] If yes, how many months									

[2] Adopter?

- 1 = Yes
- 2 = No

[3] Agro-ecological zone

- 1 = Medium stable
- 2 = Less stable

[8] Status

- 1 = Head
- 2 = Spouse
- 3 = Son/Daughter
- 4 = Relative
- 5 = Parent
- 6 = Other

[10] Sex

- 1 = Male
- 2 = Female

[12] Education level

- 4 = Grade 4
- 7 = Grade 7
- 10 = Grade 10
- 12 = Grade 12
- 16 = College

[14] Work on-farm?

- 1 = Full time
- 2 = Half time
- 3 = No

[16] Work off-farm?

- 1 = Yes
- 2 = No

2. Land Characteristics (RT-200)

[6] Plot number									
[8] Land type									
[10] Size									
[12] Ownership type									
[14] If rent-in, amount paid?									
[16] If rent-out, amount received?									
[18] Activity type									
[20] Source of water									
[22] Cropping pattern									
January									
February									
March									
April									
May									
June									
July									
August									
September									
October									
November									
December									

[8] Land type

- 1 = Low land
- 2 = Up land
- 3 = Hilly
- 4 = Mountainous

[12] Ownership type

- 1 = Own
- 2 = Rent in
- 3 = Rent out
- 4 = Government reserve

[18] Activity type

- 1 = Growing rice
- 2 = Growing field crop
- 3 = Orchard/tree
- 4 = Home/garden

3. Inventory (RT-210)

[6] Item	[8] Amount	[10] How long have you use it?	[12] Price	Remark
<u>Electric Appliance</u>				
1. Rice cooker				
2. Radio				
3. Television				
4. Refrigerator				
5. Fan				
6. Other, _____				
7. _____				
<u>Vehicle</u>				
11. Bicycle				
12. Motorcycle				
13. Pickup truck				
14. Other, _____				
15. _____				

[6] Item	[8] Amount	[10] How long have you use it?	[12] Price	Remark
<u>Farm equipment</u>				
21. Iron buffalo				
22. Water pump				
23. E-tan truck				
24. Sprayer				
25. Other, _____				
26. _____				
<u>Building & Miscellaneous</u>				
31. House				
32. Barn				
33. Generator				
34. Other, _____				

4. Animal Activities (RT-300)

[6] Type	Buffalo(1)	Cattle(2)	Pig(3)	Chicken(4)	Duck(5)	Other(6)
[8] Number of animal						
[10] If you sell now, how much will you get?						
[12] Since last wet season, how many you have bought?						
[14] How much you pay for?						
[16] Since last wet season, how many you have sold?						
[18] What is selling price?						
[20] How much money you spent for raising per week?						

5. Crop Activities (RT-310)

[6] Activity	[8] Area	[10] Total Output	[12] Price	[14] Amt. Consume	[16] Amt. Seeds	[18] Amt. Crop Share	[20] Income
1. Rice							
2. Corn							
3. Soybean							
4. Mungbean							
5. Mungbean-rice							
6. Garlic							
7. Ginger							
8. Other, _____							
9. _____							
10. _____							
11. _____							

6. Off-farm Activities (RT-320)

[6] Activity	[12] Amt. of input	[14] Amt. of output	[18] Revenue
<u>Forest</u>			
1. Mushroom, bamboo			
2. Wild animal			
3. Honey comb			
4. Fire wood			
5. Other, _____			
<u>Farm employment</u>			
11. Planting rice			
12. Harvesting rice			
13. Other, _____			
14. _____			
<u>Non-farm employment</u>			
21. Construction work			
22. Public servant			
23. House maid			
24. Factory worker			
25. Other, _____			

[6] Activity	[12] Amt. of input	[14] Amt. of output	[18] Revenue
<u>Trading</u>			
31. Ag. product			
32. Small shop			
33. Small restaurant			
34. Barber shop			
35. Other, _____			
<u>Cottage industry</u>			
41. Weaving			
42. Crafting			
43. Basket making			
44. Custom clothing			
<u>Other</u>			
51. Money lending			
52. \$ from fam. member			
53. Other, _____			

7. Domestic Expenditure (RT-400)

[6] Activity	[8] How often?	[10] Unit	[12] Expense	[14] Total	Remark
1. Home repair					
2. Food expenses					
3. Transportation					
4. Clothing					
5. Beverage					
6. Child education					
7. Health care					
8. Send money to parent					
9. Donation at temple					
10. Movie/play					
11. Buy lottery					
12. Betting/gambling					
13. Other, _____					
14.					
15.					

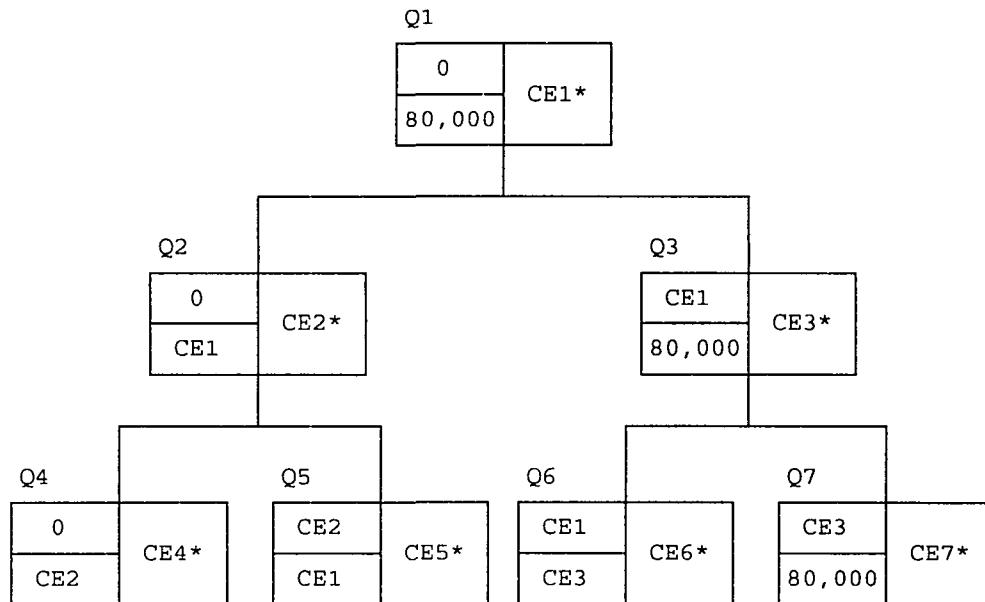
[10] Unit

1 = Day 3 = Month
 2 = Week 4 = Year

8. Risk Attitude (RT-500)

Hypothetical question:

"Suppose that your rice crop will be ready for harvest by the next month. The Village-headmen and government officials give a warning that rice fields in nearby villages had been completely destroyed by insects and the farmers in that village had no control over the situation. Therefore, insects might come to attack rice fields in this village at any time. Suppose there is only a 50 percent chance that your paddy field will not be damaged by insects. If you are able to harvest your rice crop without the attack from insects, you will receive 80,000 Baht (twice the family income) from selling your rice production. Conversely, if your rice crop is attacked by insects before harvest, you will get zero income. Given this situation, what price do you want to sell your green rice crop now to a middleman for cash that makes you feel indifferent from taking a risk of waiting for the harvest of your matured rice crop?"



9. Credit Information (RT-600)

- [8] If you need 8,000 Baht tomorrow, what will you do?
 (1) Don't know (2) Sell land (3) Sell jewelry
 (4) Borrow from bank (5) Borrow from relative (6) Borrow from local lender
 (7) Borrow form coop. (8) Borrow from land owner (9) Borrow from neighbor
 (10) Have own saving (11) Other, _____

- [10] Do you have any saving?
 (1) Yes, how much _____ (2) No

[11] Did you borrow any money?

[12] Purpose					
[14] Source					
[16] Principal					
When did you borrow? [18] Month					
[20] Year					
[22] Term of loan					
[24] Loan rate					

[12] Purpose

- | | |
|----------------------------|-------------------------|
| 1 = Cultivation investment | 8 = Buddhist lent |
| 2 = Buy land | 9 = Education fee |
| 3 = House repair | 10 = Household expenses |
| 4 = Buy iron buffalo | 11 = Wedding |
| 5 = Buy truck | 12 = Health care |
| 6 = Buy motorcycle | 13 = Other, _____ |
| 7 = Buy water pump | |

[14] Source

- 1 = From BAAC
- 2 = Cooperative
- 3 = Commercial Bank
- 4 = Land lord
- 5 = Middleman
- 6 = Neighbor/friend
- 7 = Relative
- 8 = Other, _____

10. Input-Output Information (RT-700)

[6] Type of crop _____ [8] Area grown _____ [10] Beginning month _____ [12] Ending month _____

[14] Activity	[16] Material			[18] Own labor	[20] Hired labor			[22] Custom Service			[24] Total	Remark
	Qt.	Price	Source		Qt.	Price	Source	Qt.	Price	Source		
<u>Land preparation</u>												
1. 1st tillage												
2. 2nd tillage												
3. Seed bed prep.												
4. Furrowing												
5. Other, _____												
<u>Planting</u>												
10. Seeding/Sowing												
11. Transplanting												
12. Apply fertilizer												
13. Other, _____												
<u>Maintenance</u>												
21. Replanting												
22. Thinning												
23. Weeding												
24. Apply insecticide												
25. Apply fertilizer												
26. Apply weedicide												
27. Apply fungicide												
29. Water irrigating												
30. Other, _____												
<u>Harvest</u>												
41. Cutting/Picking												
42. Threshing												
43. Transport												
44. Drying												

11. Risk Perception (RT-710)

[4] What crop do you plan to grow this year?							
[6] How many rai?							
[8] What is the expected price/unit for this year?							
[10] What is the expected yield/rai for this year?							
[18] In ten years, how many years are good,							
medium,							
poor.							
[20] What is the expected yield/rai for good season?							
[22] medium,							
[24] poor.							
[26] What is the expected price/unit for good season?							
[28] medium,							
[30] poor.							

12. Extension Information (RT-800)

[6] How long have you been growing mungbean-rice? _____

[8] Who introduce you about mungbean-rice? _____

- [10] What is the effect of mungbean-rice to ?
- 1. Rice productionbetter.....worst.....no
 - 2. Land preparation for rice.....better.....worst.....no
 - 3. Land fertility.....better.....worst.....no
 - 4. Weed in rice filed.....better.....worst.....no
 - 5. Cattle raising.....better.....worst.....no
 - 6. Upland mungbean.....better.....worst.....no

[16] If not growing mungbean-rice, why? _____

- [18] What kind of assistance do you wish to get the government?
- 1. Water source 2. Seed 3. Fertilizer 4. Insecticide
 - 5. Weedicide 6. Knowledge 7. Money for investment 8. Other _____

[20] Who would you ask for advice for these matters?

	Extension Worker	Village-head	Neighbor	Cousin	Researcher
(1) Growing new crop					
(2) Fertilization					
(3) Apply pesticide					

[22] How often do extension worker visit you?
 (1) Frequently (2) Occasionally (3) Never

[24] Since last year, have you ever visit or participate in workshop at extension offices?
 (1) Yes, how many times? _____ (2) No

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