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Construction of Decision Support Systems for Agriculture Marketing Boards and Other Public Agencies in Less Developed Countries: Parts 1 and 2

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# CONSTRUCTION OF DECISION SUPPORT SYSTEMS
## FOR AGRICULTURE MARKETING BOARDS AND
### OTHER PUBLIC AGENCIES IN LESS DEVELOPED COUNTRIES:
### PARTS 1 AND 2

Gordon C. Rausser and Joseph Yassour

The framework and methods outlined in Construction of Decision Support Systems for Agricultural Marketing Boards and Other Public Agencies in Less Developed Countries: Part I provide the basis for designing a Decision Support System for price policy for rice in the Philippines. Decision Support Systems differ from traditional computer-based approaches to problem solving in that they are used to help solve the instructured problems typical of the decision-maker's real world. Unlike the traditional techniques of operations research and optimization methods, Decision Support Systems rely on the decision-maker's insights and judgment at all stages of problem solving—from problem formulation, to choosing the relevant data to work with, to selecting the approach to be used in generating solutions, and on to evaluating solutions presented to the decision-maker. The constructed Decision Support System for Philippines rice price policy serves as in illustrative application of the general approach.

Part II of the manual begins with a description of the environment in which the National Grains Authority operates. Section II presents a general model for grains in the Philippines. It presents a framework for an operational and implementable model of price policy for rice in the Philippines which is described in section III. Section IV outlines some preliminary results obtained from the constructed decision support system. The formal preference analysis is presented in Appendix A and, finally, the computer program for the decision support system is provided in Appendix B.

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Working Paper No.

# CONSTRUCTION OF DECISION SUPPORT SYSTEMS FOR AGRICULTURE MARKETING BOARDS AND OTHER PUBLIC AGENCIES IN LESS DEVELOPED COUNTRIES: PARTS 1 AND 2

Gordon C. Rausser and Joseph Yassour

The framework and methods outlined in <u>Construction of Decision</u> <u>Support Systems for Agricultural Marketing Boards and Other Public</u> <u>Agencies in Less Developed Countries: Part I</u> provide the basis for designing a Decision Support System for price policy for rice in the Philippines. Decision Support Systems differ from traditional computer-based approaches to problem solving in that they are used to help solve the instructured problems typical of the decision-maker's real world. Unlike the traditional techniques of operations research and optimization methods, Decision Support Systems rely on the decision-maker's insights and judgment at all stages of problem solving—from problem formulation, to choosing the relevant data to work with, to selecting the approach to be used in generating solutions, and on to evaluating solutions presented to the decision-maker. The constructed Decision Support System for Philippines rice price policy serves as in illustrative application of the general approach.

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CONSTRUCTION OF DECISION SUPPORT SYSTEMS FOR AGRICULTURAL
MARKETING BOARDS AND OTHER PUBLIC AGENCIES IN
LESS DEVELOPED COUNTRIES:   PART I

1. The Problem

Agricultural Marketing Boards (AMB) and other public agencies in less-developed countries generally and in most cases correctly reject the analysis provided by economists. The traditional "box of tools" often employed by development economists is not sufficient to address the important issues facing these agencies. The typical approach can be described as "solution rich" where the focus is on perceived problems amenable to neoclassical economic analysis--which often do not relate to the right questions or identify the real problems. In other words, the typical approach is not sufficiently "problem rich."

To correct many of the limitations of the traditional box of tools, two major issues facing AMBs must be explicitly recognized. These issues are:

   a.  Uncertainty.

   b.  Multiple and conflicting objectives.

To be sure, these issues make the planning process difficult and some would argue more difficult in agriculture than in other industries.

1.1 Uncertainty

Uncertainty is a principal feature of agricultural commodity systems. Weather conditions, pests, and diseases cause high fluctuations quantities produced. As a result of low price elasticities of farm products, the price variability is also very high. Thus, it is necessary to construct a stochastic model which accurately represents the problem in the environment within which AMBs must operate.

1.2 Multiple and Conflicting Objectives

AMBs and government agencies are generally charged with the responsibility of responding to the needs and desires of the different groups and participants within the commodity system. These groups are the producers,

consumers, the government, suppliers of inputs, intermediaries (assemblers and distributors), and landowners. As a result, these agencies have more than a single objective or performance measure by which to evaluate their effectiveness. The most common objectives are to increase and stabilize farm income, to reach self-sufficiency in food production, increase consumer welfare, decrease price variability, and improve the balance of payments. Many of these objectives naturally conflict with one another and, thus, explicit trade-offs must be recognized.

## 1.3 Separation of Uncertainty and Aversion to Risk

In dealing with the above issues, decision-makers often confuse their perceived uncertainty with their degree of risk aversion. In an intuitive decision-making context, this phenomenon has been demonstrated in numerous settings. This confusion often results in clouded and what would appear to be the implementation of "irrational" decision actions. Quantitative decision-support systems offer the advantage of being able to clearly delineate perceived uncertainty from aversion to risk.

This manual is thus concerned with the construction of quantitative decision-making systems which will aid managers of public agricultural agencies to (1) identify and structure objectives, (2) make value trade-offs, and (3) balance various risks.

## 2. Methodology

The paradigm for operationally dealing with decision making under uncertainty and multiple objectives has been referred to as Multiattribute Decision Analysis. This approach consists of two major components:

a. The decision tree.

b. The objective function.

## 2.1 Decision Trees

A decision tree is a flow diagram which structures the problem as a chronological arrangement of those choices that are controlled by the decision-maker and those choices that are determined by chance. Decision choices are described by decision forks and the uncertain events by chance forks. Associated with each chance fork is a probability distribution which provides the probability of occurrence of the uncertain event conditional on the action taken. The probability distributions assigned to each chance fork can be based on historical data; regression analysis; econometric modeling; or, as it happens in most real cases, on subjective perceptions of the decision-maker.

At the end points of the decision tree appear the different "payoffs." These are the levels of the different attributes for a given set of actions and chance events.

The results of the above analysis isolate an initial optimal action and a contingency plan for any given sequence of events along the path. The set of optimal decisions is determined by maximization (minimization) of an objective function which reflects the probabilities and the payoffs.

## 2.2 The Objective Functions

The most difficult part of multiattribute decision analysis is to determine the appropriate objective function. The least restrictive objective function is the expectation of the Multiattribute Utility Function. The construction of such a function involves the following steps (a more detailed description is given in Section 3):

a.  List of objectives.

b.  Performance measure or attribute for each objective.

c.  Univariate utility functions for each attribute.

d.  Independence relationship among the attributes.

e.  Functional form of the multiattribute utility function.

f.  Scaling constants (weights) of the different attributes.

g.  Expected value of the multiattribute utility for each alternative.

3.  **Steps in Construction of a Decision Support System for AMB**

The following steps are suggested for the construction of a comprehensive and consistent decision support system.

3.1  The Environment

A qualitative description of the environment in which the AMB operates must be completed in order to understand the reasoning behind the establishment of the agency in question and its operations.  The description should include:

3.1.1  The Country

Social structure, culture, education, economy, institutional setting, ethnic groups, etc.

3.1.2  The Agricultural Sector

Role in the economy, level of technology, producer characteristics, marketing channels, financial institutions, etc.

3.1.3  The Commodity

Importance in diet, import-export, technology of production, biological growth characteristics, processing facilities, characteristics of the product, perishability, varieties, spatial and size distribution of farms and production, substitutable and complementary products, seasonality, etc.

### 3.1.4  The Agency (AMB)

Organization, facilities, budget, power, effective interest group coalitions, political constraints, activities, etc.

### 3.2  The Model

#### 3.2.1  Objectives

It is crucial to clearly identify the major objectives of the AMB. Most often, objectives are only vaguely identified.  The most common objectives of AMBs are:

    a.  Increased income of farmers.

    b.  Increased consumers' welfare.

    c.  Self-sufficiency.

    d.  Price stability.

    e.  Improvement of balance of payments.

    f.  Decrease operational expenditures.

    g.  Stable flow of supply.

Other "objectives" like increased productivity, integration of the commodity system, improved quality, research and development, and the like are means to achieve some of the objectives mentioned above and thus are only intermediate goals.

#### 3.2.2  Performance Measures

The performance measure or attribute associated with each relevant objective should be quantified.  The measures should be simple and meaningful to the users of the Decision Support System (DSS).  This is particularly important since the users must provide the utility functions for each of the attributes and the independence relationships and weights for the multiattribute utility function.  This task by itself is sufficiently complicated with

simple performance measures and thus overly sophisticated or theoretical

measures should be avoided.

### 3.2.3 Alternatives

After the objectives are known, the question to be asked is: What

are the means to accomplish these objectives? The most common means

for achieving the objectives mentioned above are:

a. Production and/or marketing quotas.

b. Floor price to the producers.

c. Ceiling price to the consumers.

d. Input subsidies to farmers.

e. Quality control.

f. Research.

g. Extension programs.

h. Reserve or buffer stocks.

i. Import or export taxes and premiums.

j. Infrastructure facilities—transportation, irrigation, etc.

### 3.2.4 The Commodity System

A qualitative as well as a quantitative analysis of the commodity

system is the core of the model. In the qualitative analysis the relevant

participants of the system must be identified. These are the producers, con-

sumers, intermediaries, input suppliers, financial institutions, the govern-

ment, etc. In each category significant subgroups must be distinguished.

Thus, for example, subsistent farmers might be distinguished from semisub-

sistent and commercial farmers. The distinction could be based on different

technologies used, on spatial grounds, on distance from the urban markets,

etc. The qualitative analysis should also investigate commodity charac-

teristics and links, e.g., among the grains in general, with rice and corn

separately, or different types of rice with regard to quality, variety, season of marketing, etc. One should also list all the variables to be incorporated in the model. These are the decision variables, state variables, endogenous and exogenous variables, random variables, and parameters.

In the quantitative analysis, the process begins with specification of the functional form relating the variables isolated by the qualitative analyses. These relations are the demand and supply functions, state equations, probabilistic relationships, and the performance measures.

For the reasons noted above, it is especially important that the random variables or uncertain quantities be properly characterized. The most common uncertainties involved in the agricultural systems relate to:

    a.   Weather condition--drought, floods, typhoons, frost, etc.

    b.   Pests and diseases.

    c.   Supply and demand functions.

    d.   World market prices.

The probability distributions assigned to these uncertain quantities and the factors (explanatory variables) on which these uncertainties are conditioned should be based on "hard" data; previous research; and, if necessary, on consistently assessed and quantified perceptions.

### 3.2.5 The Objective Function

The construction of the objective function relies heavily on the preference structure of the decision-maker and, therefore, requires a thorough interviewing process. After the objectives are identified and the appropriate performance measures quantified, the following stages must be completed.

### 3.2.5.1 Univariate Utility Functions

In this stage the researcher evalutes the risk perception of the decision-maker with regard to each of the attributes. A five-point utility function is constructed by using 50-50 lotteries and the general form of the function (risk neutral, constant risk averse, decreasing risk averse, etc.) is also determined. Using the general form of the utility function and the five-point utilities, a continuous utility function is approximated.

### 3.2.5.2 Independence Relationships

Three types of independence relationships are examined:

a. Preferential Independence (PI).

b. Utility Independence (UI).

c. Additive Independence (AI).

### Definitions and Examples

#### Preferential Independence:

The set of attributes A is PI of the set B if preferences over the set A do not depend on the amounts in B. PI is not reflexive, namely, A is PI of B does not imply that B is PI of A.

For a simple example, consider a manager who always prefers a secretary who types fast but with spelling mistakes to one who types slowly but with no mistakes, regardless of attractiveness. In this event we would say that the set "speed and spelling" is PI of attractiveness. If, however, the manager prefers the one who types fast with mistakes to the slow and accurate one when both are unattractive but the slow accurate to the fast inaccurate when both are attractive, it follows that these attributes are not PI. Note that the "attractiveness" attribute was the same for the two secretaries.

For an AMB example, if an AMB always prefers an outcome in which the level of the producers' welfare is high and the level of the consumers' welfare

is low to an outcome in which the consumers' welfare is high and the producers' welfare is low, regardless of the level of food sufficiency, the set of attributes--"producers' welfare and consumers' welfare"--is PI of food sufficiency. If, however, the AMB prefers high producers' welfare and low consumers' welfare when the level of food sufficiency is high and high consumers' welfare and low producers' welfare when the level of food sufficiency is low, then the set of attributes is not PI.

Hence, in summary, when the level of a third attribute does not influence the preference between combinations of two other attributes, these two attributes are PI of the third; or more formally, the property of PI follows if

$$a_1 b_1 c_1 > a_2 b_2 c_1 \quad \text{for all all } c_1$$

where $a_1$ and $a_2$ are different levels of one attribute, and $b_1$ and $b_2$ are different levels of a second attribute, and $c_1$ is a fixed level of a third attribute. The symbol, >, stands for "preferred to." Similarly, PI does not follow if

$$a_1 b_1 c_1 > a_2 b_2 c_1,$$

but

$$a_1 b_1 c_2 < a_2 b_2 c_2$$

where $c_2$ is another fixed level of the third attribute.

Utility Independence:

The set A is Utility Independent (UI) of the set B if preferences over lotteries on $(\tilde{a}, b')$ do not depend on the fixed amount of b'.

For a simple example, suppose two secretaries apply for a job. The first, when in a good mood (50 percent of the time), types 100 words per minute but when in a bad mood types only 50 words per minute. The second is a very stable person who types 70 words per minute. If the manager has the same preference between them regardless of their attractiveness, which is equal, then typing speed is UI of attractiveness. Thus, if she (the manager) prefers the stable secretary when both are unattractive and when both are attractive, we have UI. If, however, she prefers the stable one only when both are attractive, but the unstable when both are unattractive, these two attributes are not UI.

Hence, UI follows if

$$70 \text{ WPM, } b' > \begin{array}{l} .5 \quad 100 \text{ WPM, } b' \\ \\ .5 \quad 50 \text{ WPM, } b' \end{array} \quad \text{for all } b'$$

where b' stands for some fixed level of attractiveness.

Similarly, UI does not follow if

$$70 \text{ WPM, attractive} > \begin{array}{l} .5 \quad 100 \text{ WPM, attractive} \\ \\ .5 \quad 50 \text{ WPM, attractive} \end{array}$$

but

$$70 \text{ WPM, unattractive} < \begin{array}{l} .5 \quad 100 \text{ WPM, unattractive} \\ \\ .5 \quad 50 \text{ WPM, unattractive} \end{array}$$

For an AMB example, consider the manager of an AMB who is faced with two possible outcomes, each with a 50 percent chance of occurring: (1) If natural conditions are favorable, the level of food sufficiency for a certain commodity would be 100 percent; (2) If the natural conditions are unfavorable, the level of food sufficiency would be only 70 percent. Suppose, in addition, a large insurance company offers to purchase all available quantities of the commodity in question and to provide in return 80 percent of the level required for food sufficiency. If the management prefers the offer of the insurance company, regardless of the level of the producers' welfare, we would say that food sufficiency and producers' welfare are UI. However, if management prefers the offer only when the level of producers' welfare is low and the uncertain situation when the level of producers' welfare is high, then we would say that these two attributes are not UI.

Hence, to formally summarize, the property of UI follows if

$$80\%,\ w' \ > \ \begin{array}{c} \overset{.5}{\diagup}\ 100\%,\ w' \\[4pt] \underset{.5}{\diagdown}\ 70\%,\ w' \end{array}$$

where $w'$ stands for any fixed level of the producers' welfare, and $>$ reads "preferred to." Similarly, UI does not follow if

$$80\%,\ w_1 \ > \ \begin{array}{c} \overset{.5}{\diagup}\ 100\%,\ w_1 \\[4pt] \underset{.5}{\diagdown}\ 70\%,\ w_1 \end{array}\ ,$$

but

$$80\%,\ w_2 \ < \ \begin{array}{c} \overset{.5}{\diagup}\ 100\%,\ w_2 \\[4pt] \underset{.5}{\diagdown}\ 80\%,\ w_2 \end{array}\ .$$

where $w_1$ and $w_2$ are two different levels of producers' welfare.

In summary, when the risk we are willing to take with regard to uncertainties in one attribute does not depend on the level of another attribute, then the first attribute is UI of the second.

Additive Independence:

The set of attributes A and the set B are Additive Independent (AI) if preferences over lotteries ($\tilde{a}$, $\tilde{b}$) depend only on the marginal probability distributions of a and b and not on their joint distributions.

For a simple example, suppose a manager must select an office; she has two choices—room 101 or room 102. There are two secretaries in room 101, one of whom (50 percent chance) will be assigned to her. The first is a perfect secretary who types fast and with no mistakes, while the other types slowly with frequent mistakes. The same situation exists in room 102, but the first secretary there types fast with mistakes, while the other types slowly with no mistakes.

If the manager is indifferent between the two rooms, the two attributes are AI and the manager is risk neutral. If, however, she prefers one room to the other, the two attributes are not AI. If she prefers room 101, she is said to be double-attribute risk prone. If she prefers room 102, she is said to be double-attribute risk averse.

Formally, the AI property follows if

.5 / fast, accurate          .5 / fast, inaccurate
  < .5                    $\sim$     < .5
     \ slow, inaccurate          \ slow, accurate
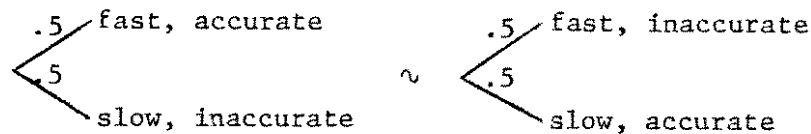
where $\sim$ reads "indifferent to."

To illustrate this property with an AMB example, suppose the management of an AMB can choose between two policies. If they choose the first, there is a 50 percent chance that the producers' welfare and the consumers' welfare will be high, and there is a 50 percent chance that both will be low. If the second policy is selected, there is a 50 percent chance that the producers' welfare would be high but the consumers' welfare low and a 50 percent chance that the consumers' welfare would be high and the producers' welfare low (see figure below).

$$\text{Policy 1} \begin{array}{c} \overset{.5}{\diagup} \quad \text{P*, C*} \\ \overset{.5}{\diagdown} \\ \text{P}_*, \text{ C}_* \end{array} \qquad \text{Policy 2} \begin{array}{c} \overset{.5}{\diagup} \quad \text{P* C}_* \\ \overset{.5}{\diagdown} \\ \text{P}_* \text{ C*} \end{array}$$
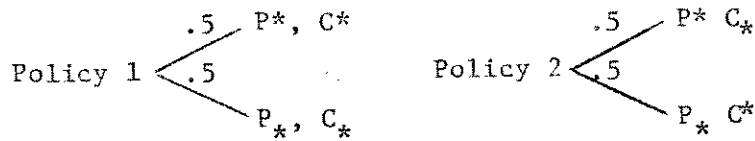
where P* and C* are the high levels of producers' and consumers' welfare, re-
spectively, and $P_*$ and $C_*$ are the low levels. If the management is indif-
ferent between the two policies, we would say that the two attributes are AI,
If, however, the management is risk averse and wants to avoid the two bad out-
comes, it would prefer policy 2, and the two attributes are not AI.

### 3.2.5.3 The Scaling Constants

The researcher has also to determine the weights of the different
attributes in the objective function. These constants can be determined
only when some independent relationships hold and, thus, the objective func-
tion has a relatively simple form. The two most simple forms of the multi-
attribute utility function are the additive and the multiplicative utility
functions.

The additive form is

$$u\ (x_1, \ldots, x_n) = \sum_i k_i\ u_i(x_i),$$

where

$u\ (x_1, \ldots, x_n)$ = The multiattribute utility function,

$x_i$ = The value of the $i$th attribute,

$n$ = The number of attributes,

$k_i$ = The scaling constant of the $i$th attribute,

and

$u_i$ = The univariate utility function of the $i$th attribute.

The additive form is the appropriate form if Additive Independence holds among all attributes. The multiplicative form,

$$1 + k \cdot u \ (x_1, \ \ldots, \ x_n) = \prod_i \ [1 + kk_i \ u_i(x_i)],$$

where $1 + k = \prod_i (1 + kk_i)$, is the appropriate form if the properties of Preferential Independence and Utility Independence hold among all attributes, but not Additive Independence. A complete description of applying these concepts to construct a utility function for the National Grains Authority in the Philippines is given in Part II of this manual.

4. Implementation

Throughout the model construction process, the researcher must be continuously concerned with the implementation of the decision support system. He has to be willing to sacrifice the use of some sophisticated theories and techniques in order to achieve an operational model which can be implemented. Since the methodology described above depends very heavily on judgments and interviews, it is very important that the decision-maker not be confused with unnecessary terminology. Where sophisticated tools are unavoidable, the researcher should construct simple examples to enhance an intuitive appreciation of the approach.

The model and the computer program designed to solve the model should allow for flexibility in the implementation of the decision support system. Not only must sensitivity analysis be admitted in addition to the optimization, but the model should enable the users to efficiently change the values of the variables, the probability distributions, and the utility function in response to interactive feedbacks. This quality of the decision support system is extremely important since much of the input is based on judgments of some officials which may undergo revision.

One of the advantages of the multiattribute decision analysis approach is the requirement that decision-makers be faced with questions on the trade-off between attributes and the probabilities of uncertain events. This process "forces" the decision-maker to consistently evaluate the policy problem, an act which he/she does not typically perform. As the former Administrator of the Rice and Corn Administration in the Philippines said: "If only these questions, even without the analysis that follows them, were asked ten years ago, the current situation would have been much better."

In conclusion, multiattribute utility analysis begins a qualitative analysis of the environment in which the agency must operate, followed by a specification of a quantitative model and a heavy dose of interaction with the actual decision-makers and users of the decision support system. The entire process is represented by information flows in Figure 1. An illustrative application of this process is presented in Part II of this manual.

Figure 1

Decision Support System Construction Process

Environment → Objectives → Performance Measures → Alternatives → Specification

Quantitative ← Qualitative ← Specification

Quantitative:
- Demand & Supply
- State Equations
- Probability Distributions

Qualitative:
- System Participants
- Variables
- Aggregation
- Uncertainty

→ Objective Function

- Univariate Utility Function
- Independence Relationships
- Functional Form
- Scaling Constants
- Multi-attribute Utility Function

→ Maximization of Expected Utility
→ Optimal Solution
→ Sensitivity Analysis
→ Implementation

## GLOSSARY OF SYMBOLS

$AI$ = Additive Independence

$AMB$ = Agricultural Marketing Board

$BAECON$ = Bureau of Agricultural Economics, Philippines

$E$ = Expectation operator

$F_s$ = Food sufficiency measure (see $x_2$)

$G_e$ = Government expenditures measure (see $x_5$)

$HYV$ = High-yielding varieties

$k, k_1, \ldots, k_5$ = Scaling constants (weights) of the multiattribute utility function

$NGA$ = National Grains Authority, Philippines

$P_e$ = The market clearing (equilibrium) price of rice (₱/Kg)

$PI$ = Preferential Independence

$P_i$ = The margin of the intermediaries (₱/Kg)

$P_m$ = The actual price of rice to the consumers (₱/Kg)

$P_p$ = The actual price of rice to the producers (₱/Kg)

$P_p^*$ = The floor price of rice (₱/Kg)

$P_x$ = World market price for rice, c.i.f. Manila ($/Kg)

$q_m$ = The actual quantity purchased by the consumers per year (Kg/capita)

$q_m^*$ = The quantity marketed, necessary to achieve the ceiling price (Kg/capita)

$q_p^*$ = The quantity marketed, necessary to achieve the floor price (Kg/capita)

$q_s$ = Quantity supplied (Kg/capita)

$q_x$ = Quantity exported (Kg/capita)

$r$ = rate of currency exchange (₱/$)

RCA = Rice and Corn Administration

$R_p$ = Producers' revenue measure (see $x_1$)

UI = Utility Independence

$u_i(x_i)$ = Univariate utility function of the $i$th attribute

$u(x_1, \ldots, x_5)$ = The multiattribute utility function

$V_p$ = Price variability measure (see $x_4$)

$W_c$ = Consumers' welfare measure (see $x_3$)

$x_1 = R_p$ = Average net income to farmers (₱/semester)

$x_2 = F_s$ = Percent self-sufficiency in rice production

$x_3 = W_c$ = Consumer price of rice (₱/Kg)

$x_4 = V_p$ = Change in the consumer price of rice from previous period (₱/Kg)

$x_5 = G_e$ = Government expenditures per capita (₱)

CONSTRUCTION OF DECISION SUPPORT SYSTEM
FOR THE NATIONAL GRAINS AUTHORITY
OF THE PHILIPPINES:  PART II

# 1. THE RICE INDUSTRY OF THE PHILIPPINES

## 1.1 Introduction: The Philippines

The Philippines is an archipelago of about 7,000 islands. Its
total land area is 300,000 square kilometers (116,000 square miles) and its
population is about 44 million. Most of the population (about 95%) is con-
centrated in three groups of islands: 1) The Northern group: Luzon –
105,000 $Km^2$, Mindoro – 10,000 $Km^2$; 2) The Central group: Samar – 13,000 $Km^2$,
Negros – 13,000 $Km^2$, Palawan – 12,000 $Km^2$, Panay – 11,000 $Km^2$; and 3) Mindanao
in the South – 95,000 $Km^2$.

The growth rate of the population is 3% per year. This is among
the highest in the world (compared to India – 2.3%, China 1.7% and USA 1%).
This high rate is attributed to the fact that most of the population belong
to the Roman Catholic Church and also live in the rural areas. The mortality
rate, on the other hand, has decreased dramatically in the last few decades.
Life expectancy has increased from about 37 years in 1900 to about 52 in
1960, 59 in 1970 and 61 in 1978.

As mentioned above, most of the population, more than 80% are
affiliated with the Roman Catholic Church. Other religious groups are Muslims,
Aglipayans and Protestants with about 6% each. Religion is not the only
aspect in which the Spanish influence can be found. The social structure of
the Philippines, its economy and its culture were also heavily influenced by
the Spaniards who ruled the Philippines from the middle of the 16th century
to the end of the 19th century. The English language is widely spoken in
the Philippines. It is one of the two official languages (together with the
Tagalog). It is taught in the elementary schools and is the only language
used in the high school and universities. The official publications of the

government are in English as are most of the newspapers and radio and
television broadcasts. American influence can be found also in other aspects of Philippine culture and in the political system (before Martial Law).

Ranking among the poorest countries in the world, the Philippines'
Gross National Product per capita in 1975 was only $370 (compared with
India - $140, Brazil - $920, Mexico - $1,090, and USA $6,670). Per capita
daily calorie consumption in 1965 was 1900 calories (compared with India -
1950 and Brazil - 2500). Inequality in income is indeed substantial. The
richer 10% of the population earn 40% of the total national income while
the poorer 20% earn only 4%. The average growth rate in real Gross National
Product per capita is about 1% per year. This is attributed to the low level
of industrialization, primitive agriculture, low level of infrastructure
(road networks, electricity, telephone, irrigation systems, etc.), and also
to the "easy-going" nature of the Filipinos who are not highly motivated by
"profit-maximization" but rather assign high value to free time.

Agriculture is the most important sector in the national economy.
It accounts for about 50% of total employment, about 35% of the gross domestic
production and over 65% of export earnings. Together with its role to meet
the food requirements of the country the agricultural sector also provides
a market for industrial goods since 70% of the population is in the rural
areas.

The principal farm products are rice, coconut, sugar, abaca,
tobacco, corn and pineapple. While rice and corn are grown for domestic
consumption, coconut and its products, sugar and abaca account for most of
the Philippines export income. Mining is the second source of national

income. The Philippines is rich in mineral resources like gold, silver, copper, iron and other metals. The exploitation of these resources is not very efficient due, again, to low level of technology and infrastructure.

The economy of the Philippines is based on free enterprise. The government limits its involvement only into areas where the public sector does not operate in line with the government view of public welfare. Thus, for example, the government gets involved in the trade of rice, but only up to a certain percentage of the total trade.

The prospects of the future of the Philippines are controversial. On one hand there has been progress in the economic and social structure. The education system is considered to be the best in the Far East. The middle income class is growing and poverty has decreased in most areas. On the other hand, the cost of labor is still very low. This results in a slow adoption of capital investment in equipment and modern technologies and impedes the industrialization of the country. The low cost of human labor may also perpetuate the current social structure in which extreme richness and poverty coexist and several maids and private drivers are customary in almost any family in the middle and high income classes. The future political structure of the Philippines is also unclear.

In September 1972, President Marcos declared Martial Law and, thereby, assumed vast powers. The Congress has been dissolved, the mass media have been controlled and strikes and demonstrations disallowed. When declaring Martial Law, President Marcos said it would be temporary and would exist until the New Society of the Philippines was established. With the growing opposition to Martial Law on one hand and the willingness of the government to move towards higher level of democracy, on the other hand, it is hard to predict what the day may bring forth.

1.2  The Rice Industry

1.2.1  Introduction

Rice is with no doubt the most important food crop of the Philippines.
It is the staple food for about 80% of the population.  More than one-third
of the areable land is devoted to rice, and about one-half of the labor force
is located in the rice areas.

Although rice is such an important crop for the Philippines the
level of technology and the yields per hectar are relatively very low.  See
Table 1 for comparison of yields.

Table 1

Yields of Paddy (rough rice) in Different
Asian Countries - 1975

| Country | Yield (Kg./ha.) |
|---|---|
| Afghanistan | 2,148 |
| Bangladesh | 1,959 |
| Burma | 1,779 |
| China | 3,536 |
| India | 1,771 |
| Indonesia | 2,779 |
| Japan | 5,954 |
| Cambodia | 1,286 |
| Korea | 5,300 |
| Lao | 1,340 |
| Malaysia | 2,666 |
| Nepal | 2,082 |
| Pakistan | 2,264 |
| PHILIPPINES | 1,721 |
| Sri Lanka | 2,095 |
| Taiwan | 4,323 |
| Thailand | 1,771 |
| Vietnam | 2,150 |

Source:  A. C. Palacpac, World Rice Statistics, IRRI, April 1977.

As a result of its poor production relative to the fast-growing
population the government has imported rice almost every year.  (See Table 2.)

Table 2

Annual Total Supply, Imports and Exports of Rice,
Philippines 1960-1977

| Year | Total Available Supply (M tons) | Imports (M tons) | Exports (M tons) |
|---|---|---|---|
| 1960 | 2.292 | .010 | — |
| 1961 | 2.369 | .109 | — |
| 1962 | 2.455 | .070 | — |
| 1963 | 2.548 | .128 | — |
| 1964 | 2.691 | .347 | — |
| 1965 | 2.959 | .524 | — |
| 1966 | 2.812 | .327 | — |
| 1967 | 2.715 | .218 | — |
| 1968 | 2.902 | .174 | .054 |
| 1969 | 2.670 | — | .041 |
| 1970 | 3.191 | — | .001 |
| 1971 | 3.277 | .018 | — |
| 1972 | 3.744 | .633 | — |
| 1973 | 2.931 | .238 | — |
| 1974 | 3.723 | .311 | — |
| 1975 | 3.691 | .238 | — |
| 1976 | 3.838 | .071 | — |
| 1977 | 3.962 | .024 | — |

Source: Alix, Kunkel and Gonzales, Analyzing Statistics on Palay Production Area, Yield, Stock Inventory and the Masagana '99 Program, Baecon, Quezon City, 1978.

Importation of rice is not the only activity taken by the government with regard to the rice industry. In a fact, the government gets involved in the production, processing and marketing of rice.

1.2.2 Production

The rice farms in the Philippines are divided into two major groups: irrigated and non-irrigated. In the irrigated farms the farmers usually grow more than one crop per year. Sometimes, even three or four. The physical irrigated rice land accounts for about 40% of the rice area, however, the harvested irrigated area accounts for about 55% of the total harvested area. In the recent years there has been an increase in the irrigated area, although this trend was more significant in the provinces which are closer to Manila;

Central Luzon, Southern Tagalog and Bicol. The yield per irrigated hectar is higher than that of a non-irrigated hectar by almost 60%. Not only the irrigated farms are independent on natural moisture but also there is a high correlation between irrigation and the use of high-yielding-varieties (HYV), fertilizers and modern technologies.

The non-irrigated farms consist of lowland and upland areas. The upland areas are the least productive and there is a constant declining trend in their total area. (See Table 3.) It has been shown that the impact of HYV was to increase production levels by 15%-16% while the occurrence of severe typhoons and drought would pose a negative impact on production by 8% and 14%, respectively. The impact was shown to be only half of the above on irrigated areas and 50% more on non-irrigated areas. This indicates that increased irrigation not only contributes to increased production but provides for a less variable supply [Alix, Kunkel, and Gonzales, 1978].

There is a significant trend of increasing the use of HYV of rice. HYV are currently planted on 81% of the irrigated areas but only on 64% of the non-irrigated. (See Tables 4, 5, and 6.) Increase in the yields over the past two decades were responsible for almost all of the increases in the production. Furthermore, this production came mostly from increased irrigated areas and the High-Yielding-Varieties associated with these areas. The increase in irrigated area was offset by a decline in the upland area.

Although rice can be grown all year long there is a clear distinction between the wet and the dry seasons. The wet season (July-December) produces about 62% of the total annual rice production. At this season both irrigated and non-irrigated areas are utilized. The yields per hectare in this season, however, are lower by more than 10% than those of the dry season due to lower radiation, lower temperatures and higher occurrency of typhoons and floods. (See Table 7.)

Table 3

Palay:   Production, Harvest Area and Yield per Hectare, by Crop Type
Crop Year 1960-1977

| Crop Year | IRRIGATED LOWLAND | | | NON-IRRIGATED LOWLAND | | | UPLAND | | |
|---|---|---|---|---|---|---|---|---|---|
| | Production M Ton | Harvest Area '000 has. | Yield Ton/ Hectare | Production M Ton | Harvest Area '000 has. | Yield Ton/ Hectare | Production M Ton | Harvest Area '000 has. | Yield Ton/ Hectare |
| 1960 | 1468 | 1016 | 1.44 | 1645 | 1500 | 1.10 | 627 | 790 | .79 |
| 1961 | 1450 | 960 | 1.51 | 1840 | 1660 | 1.11 | 415 | 578 | .72 |
| 1962 | 1529 | 987 | 1.52 | 1877 | 1510 | 1.24 | 524 | 682 | .77 |
| 1963 | 1589 | 1014 | 1.56 | 1812 | 1451 | 1.25 | 566 | 697 | .82 |
| 1964 | 1526 | 930 | 1.64 | 1824 | 1530 | 1.19 | 494 | 627 | .79 |
| 1965 | 1578 | 958 | 1.64 | 1915 | 1607 | 1.19 | 500 | 634 | .79 |
| 1966 | 1734 | 960 | 1.80 | 1901 | 1543 | 1.23 | 437 | 606 | .72 |
| 1967 | 1864 | 1171 | 1.60 | 1858 | 1480 | 1.26 | 372 | 445 | .84 |
| 1968 | 2271 | 1309 | 1.74 | 1894 | 1514 | 1.25 | 397 | 481 | .83 |
| 1969 | 2545 | 1483 | 1.72 | 1549 | 1407 | 1.10 | 351 | 443 | .79 |
| 1970 | 2761 | 1346 | 2.05 | 2049 | 1356 | 1.52 | 423 | 412 | 1.03 |
| 1971 | 2931 | 1471 | 2.00 | 2038 | 1277 | 1.60 | 374 | 365 | 1.02 |
| 1972 | 2617 | 1332 | 1.96 | 2170 | 1548 | 1.40 | 313 | 366 | .86 |
| 1973 | 2344 | 1241 | 1.89 | 1729 | 1436 | 1.20 | 342 | 434 | .79 |
| 1974 | 2015 | 1494 | 2.02 | 2195 | 1534 | 1.43 | 384 | 409 | .94 |
| 1975 | 3034 | 1412 | 2.14 | 2241 | 1674 | 1.34 | 385 | 453 | .85 |
| 1976 | 3370 | 1495 | 2.26 | 2450 | 1695 | 1.44 | 340 | 390 | .87 |
| 1977 | 3494 | 1490 | 2.35 | 2536 | 1657 | 1.53 | 427 | 401 | 1.06 |

SOURCE:   Bureau of Agricultural Economics, Quezon City.

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Table 4

Palay (Rough Rice):  Area Harvested of Irrigated and Rainfed Crops,
by Variety Group, Philippines, Crop Year 1970-1977, ('000 Hectares)

| Crop Year | IRRIGATED | | | NON-IRRIGATED LOWLAND | | | UPLAND | TOTAL |
|---|---|---|---|---|---|---|---|---|
| | High Yielding Varieties | Other Varieties | All Varieties | High Yielding Varieties | Other Varieties | All Varieties | | |
| 1970-1971 | 985.0 | 435.5 | 1470.5 | 580.4 | 697.0 | 1277.4 | 364.7 | 3112.6 |
| 1971-1972 | 977.1 | 354.9 | 1332.0 | 849.7 | 698.5 | 1548.2 | 366.2 | 3246.4 |
| 1972-1973 | 872.8 | 368.1 | 1241.0 | 807.0 | 629.4 | 1436.4 | 434.4 | 3111.8 |
| 1973-1974 | 1194.5 | 299.2 | 1493.7 | 982.1 | 551.8 | 1553.9 | 409.2 | 3436.8 |
| 1974-1975 | 1108.9 | 302.8 | 1411.7 | 1066.1 | 608.2 | 1674.3 | 452.8 | 3538.8 |
| 1975-1976 | 1207.3 | 287.3 | 1494.6 | 1092.4 | 602.3 | 1694.7 | 390.0 | 3599.3 |
| 1976-1977 | 1285.5 | 204.0 | 1489.5 | 1131.2 | 536.2 | 1657.4 | 400.6 | 3547.5 |

SOURCE:   Bureau of Agricultural Economics, Quezon City.

Table 5

Palay (Rough Rice): Production of Irrigated and Rainfed Crops
by Variety Group, Philippines, Crop Year, 1970-1977 ('000 ton)

| | IRRIGATED | | | NON-IRRIGATED LOWLAND | | | UPLAND | TOTAL |
|---|---|---|---|---|---|---|---|---|
| Crop Year | High Yielding Varieties | Other Varieties | All Varieties | High Yielding Varieties | Other Varieties | All Varie- ties | | |
| 1970-1971 | 1993.4 | 937.4 | 2930.8 | 937.0 | 1101.3 | 2038.3 | 373.8 | 5342.9 |
| 1971-1972 | 2005.8 | 611.5 | 2617.3 | 1226.3 | 943.3 | 2169.6 | 313.2 | 5100.1 |
| 1972-1973 | 1702.4 | 641.2 | 2343.6 | 1030.5 | 698.9 | 1729.4 | 341.6 | 4414.6 |
| 1973-1974 | 2450.0 | 365.0 | 3015.1 | 1503.5 | 690.9 | 2194.4 | 384.6 | 5594.1 |
| 1974-1975 | 2465.5 | 568.4 | 3033.9 | 1523.6 | 717.0 | 2240.6 | 385.5 | 5660.0 |
| 1975-1976 | 2796.9 | 572.9 | 3269.8 | 1648.8 | 800.7 | 2449.5 | 340.2 | 6159.5 |
| 1976-1977 | 3085.0 | 408.6 | 3493.5 | 1870.8 | 664.7 | 2535.5 | 427.1 | 6456.1 |

SOURCE: Bureau of Agricultural Economics, Quezon City.

Table 6

Palay (Rough Rice):  Yield per Hectare of Irrigated and Rainfed Crops,
by Variety Group, Philippines, Crop Year 1970-1977, (Ton/Hectare)

| Crop Year | IRRIGATED | | | NON-IRRIGATED LOWLAND | | | UPLAND | TOTAL |
|---|---|---|---|---|---|---|---|---|
| | High Yielding Varieties | Other Varieties | All Varieties | High Yielding Varieties | Other Varieties | All Varieties | | |
| 1970-1971 | 2.024 | 1.932 | 1.993 | 1.615 | 1.580 | 1.596 | 1.025 | 1.716 |
| 1971-1972 | 2.055 | 1.725 | 1.967 | 1.443 | 1.351 | 1.401 | .854 | 1.571 |
| 1972-1973 | 1.949 | 1.742 | 1.888 | 1.276 | 1.109 | 1.204 | .788 | 1.417 |
| 1973-1974 | 2.050 | 1.888 | 2.020 | 1.531 | 1.254 | 1.412 | .942 | 1.628 |
| 1974-1975 | 2.222 | 1.879 | 2.147 | 1.430 | 1.179 | 1.338 | .854 | 1.602 |
| 1975-1976 | 2.315 | 1.993 | 2.253 | 1.509 | 1.329 | 1.445 | .871 | 1.720 |
| 1976-1977 | 2.400 | 2.005 | 2.345 | 1.655 | 1.265 | 1.530 | 1.065 | 1.820 |

SOURCE:  Bureau of Agricultural Economics, Quezon City.

## Table 7

### Palay: Production, Area and Yield by Crop Type, by Semester, Philippines, Crop Year 1970-1977

| Crop Year | Semester | IRRIGATED LOWLAND | | | NON-IRRIGATED LOWLAND | | | UPLAND | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Production M Ton | Harvest Area '000 has. | Yield Ton/ Hectare | Production M Ton | Harvest Area '000 has. | Yield Ton/ Hectare | Production M Ton | Harvest Area '000 has. | Yield Ton/ Hectare |
| 1970 | I | 1667 | 791 | 2.11 | 1589 | 979 | 1.62 | 396 | 380 | 1.04 |
| | II | 1094 | 555 | 1.97 | 460 | 377 | 1.22 | 27 | 32 | .84 |
| 1971 | I | 1716 | 840 | 2.04 | 1446 | 876 | 1.65 | 355 | 346 | 1.02 |
| | II | 1215 | 630 | 1.92 | 592 | 402 | 1.48 | 19 | 19 | 1.03 |
| 1972 | I | 1449 | 745 | 1.94 | 1482 | 1038 | 1.42 | 277 | 329 | .84 |
| | II | 1169 | 587 | 1.99 | 688 | 510 | 1.35 | 36 | 37 | .97 |
| 1973 | I | 1333 | 734 | 1.82 | 1371 | 1057 | 1.30 | 302 | 377 | .80 |
| | II | 1011 | 507 | 1.99 | 359 | 379 | .94 | 40 | 57 | .70 |
| 1974 | I | 1758 | 904 | 1.94 | 1639 | 1073 | 1.52 | 353 | 369 | .96 |
| | II | 1257 | 590 | 2.13 | 556 | 460 | 1.20 | 31 | 40 | .78 |
| 1975 | I | 1597 | 812 | 1.96 | 1535 | 1139 | 1.34 | 338 | 393 | .86 |
| | II | 1437 | 600 | 2.40 | 705 | 535 | 1.32 | 47 | 60 | .79 |
| 1976 | I | 1864 | 854 | 2.18 | 1764 | 1152 | 1.53 | 295 | 336 | .88 |
| | II | 1506 | 640 | 2.35 | 686 | 543 | 1.26 | 45 | 54 | .84 |
| 1977 | I | 1886 | 873 | 2.16 | 1778 | 1114 | 1.60 | 365 | 333 | 1.10 |
| | II | 1607 | 616 | 2.61 | 758 | 544 | 1.40 | 62 | 68 | .91 |

SOURCE: Bureau of Agricultural Economics, Quezon City.

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1.2.3  Storage and Processing

Because of the seasonal pattern of rice production most of the produce
is stored for about 3-4 months.  Farmers store the rough rice (paddy) for self-
consumption and when they expect higher prices in the future.  The storage
facilities of farmers and also those of most traders are of low quality and
the spoilage rate is quite high.  The quality of the stored rice depends also
on the practices used in harvesting, threshing and drying.  Since most farmers
still use primitive techniques in these activities the quality of the rice and
the net quantity of stored rice are relatively low.  It has been estimated
[Asian Productivity Organization, 1970] that losses resulting from pre-storage
practices are about 8% of the crop.  Losses in storage are about 5% and in
transportation around 1%.  The main cause for losses in storage are rodents
and also moisture and insects.

Out of the total stock of rice in the Philippines, farm-household
storage accounts for about 60%, private, commercial and government stocks
account for about 25% and non-farm household for the rest [Mears, et al.].

Most of the rice milling facilities in the Philippines are also quite
primitive.  About one-third of the mills are of the kiskisan type.  These mills
are inefficient and have a recovery rate of only 45% by volume [Drilon and Gold-
berg, 1969]. Their cash operating cost is relatively low, and they are quite
simple to operate.  A more advanced mill is the cono-type which has a higher
rate of recovery and lower percentage of broken grains.  The most advanced

type used in the Philippines is the rubber-roller mill. It is the highest
capital intensive but the best rate of recovery and lowest percentage of
brokens. The average rate of recovery from palay in the farm to rice in the
market place is estimated at 61% [Alix, Kunkel and Gonzales, 1978].

Rice is harvested as paddy with the husk and bran layers. In the
milling process the husk is separated from the grain and the outer layers
of the bran are polished. Unlike other cereals the rice grains are not ground
to a fine flour but rather kept as whole grains. The efficiency of milling
is determined by the rate of recovery from paddy to rice and by the percentage
of broken grains.

### 1.2.4 Marketing

The importance of rice marketing in the Philippines is increasing
continuously as the yields per hectare are increased and more farmers get out
of substantive farming. Because of the growing urbanization and the higher
yield associated with the intensified cultivation of the new varieties the
percentage of production that has been market-directed has increased from
around 20% in 1920 to over 60% in 1969-70 [Mears, et al., 1974].

The rice in the Philippines moves in the private and government
channels. In the private channel the farmer sells: 1) in the local market;
stores, mills, consumers, landlords and suppliers of inputs, and 2) to middlemen;
mills or wholsalers. The millers in the consumers' area and the sholesalers
sell the rice to retailers. In the government channel the NCA buys paddy from
the farmers (if market price goes below the minimum price) and either processes
it in its own mills or sells it to the mills. From this stage the rice follows
more or less the same route as in the private channel. If the price to the

consumers goes above the ceiling price the NGA releases rice from its own storage and/or imports rice to drive the price to the ceiling price. (For detailed charts of the marketing channels see [Mears, et al., 1974, pp. 86-87].) Most rice consumers buy the low-quality rice with up to 50% brokens. In Manila which is the biggest single market of rice, however, the rice market is segmented, with the upper and middle income groups demand the better quality of rice.

It is believed that price and income elasticities of demand for rice in the Philippines are low. Exact figures are not available because of low levels of significance in the researches done in this matter. Nevertheless, the estimates of price elasticity of demand for rice range between $-.1$ and $-.4$, and the income elasticity of demand between $+.1$ and $+.4$. One explanation to the low elasticities is that consumers substitute high quality rice by low quality rice when the price increases and the opposite when the price goes down or the income increases. (For probabilistic approach to the uncertainty concerning the price elasticity see Section II.)

1.3 Government Intervention in the Rice Industry

Because of its major role in the economy rice, has always been a political commodity in the Philippines. Government intervention in the rice industry began as early as in 1857 with the elimination of the import duties. In 1936 the government itself entered more actively into the trade of rice. At that year the government established the National Rice and Corn Corporation (NARIC) with the objectives of assuring the farmers a fair income and the consumers a steady supply of rice in a reasonable price [Buencamino, 1937]. NARIC established a minimum price at which it bought rice from the farmers

and also imported rice in years where low production drove the consumers' price above some certain levels. In 1962, after years of corruption and losses, NARIC was dissolved and the Rice and Corn Administration (RCA) was established. RCA's responsibilities and objectives were similar to those of NARIC. Despite their efforts, neither NARIC nor RCA were very successful in achieving their objectives. The income of farmers remained low, there was a black market of rice in the big cities and no price stability.

In 1971 President Marcos, in Presidential Decree #4 ordered the establishment of the National Grains Authority (NGA), which took the responsibilities held by RCA.

Government involvement in the rice industry is not restricted only to NGA activities which include price policy, procurement, distribution, post-harvest facility development, industry regulation and some research. Other agencies, authorities, councils, commissions, bureaus and banks also participate in the policy making, subsidizing, promoting and developing the rice industry. The actitivies of all these bodies are not always well coordinated. Each body has its own budget and even if all were operating optimally it was not necessary that the system as a whole would operate optimally.

The government promotes the rice industry by subsidizing the inputs (fertilizers, working capital, etc.). It develops irrigation systems and promotes research and extencion services. Land reform, credit diffusion, imports and crop insurance are among some other activities by which the government expects to achieve its social and economic goals for the benefit of the farmers and the consumers.

## 1.4  The National Grains Authority[1]

The National Grains Authority (NGA) was established by Presidential Decree No. 4 immediately after Martial Law was declared in September 1972. NGA replaced the Rice and Corn Administration (RCA) and inherited its tasks and responsibilities. This Act was part of the new government's desire to get rid of "undesirables" and to expand the degree of involvement of local government officials in the rice program [Mangahas, 1975].

The NGA adopts the policy of the state to promote the integrated growth and development of the grains industry so that to fulfill its social responsibilities and be capable of providing adequate and continuous food supply and contributing its share to the national economy. The basic objectives of NGA are:

1) Increased and efficient productivity to meet growing demand.

2) Higher income and living standards of farmers.

3) Stabilized grain prices within the reach of low-income families.

4) More foreign exchange earnings for whatever grain product which may be available for export.

5) Efficient processing and distribution system of grains.

6) Maximum development and utilization of by-products.

Actions taken by NGA to achieve its objectives are:

1) Providing farmers with ready market for their produce at government support price which is based on their cost of production and a "fair" income.

2) Holding buffer stock for adequate supply and stability of grain prices "within the reach of low-income families."

---

[1]Parts of this section were derived from various NGA publications.

3) Information campaign, extension service and credit incentives for the adoption, in the production, processing and distribution, of new technologies and systems.

4) Import grains in periods when local production is not sufficient to cover the demand at the desirable price.

5) Export grains when the supply exceeds the demand.

Procurement and distribution of grains and especially rice are the most important activities of NCA. Most of the budget and manpower is spent in this area.

Presidential Decree No. 4 specifically provides that:

NGA shall devise a system by which it can insure the adequacy of supply and stability of consumer prices at levels within the reach of the low-income families while maintaining the announced floor price to assure farmers or producers with a fair return on their investment. The rationale behind this is the fact that grain is a major item in the food basket of Filipino families. Thus, it has a pervasive effect on Philippine society such that the slightest imbalance in its supply and price is felt nationwide.

Nevertheless, NGA limits its market intervention to the extent of procuring and distributing only 10% of the market-directed grain produce. In addition, NGA builds up a "security buffer stock" which at the onset of the traditional lean months must be such a volume equivalent to at least 30 days consumption requirement of the urban populace.

In policy making the most important decision is to determine the floor price to the producers and the ceiling price to the consumer. These two decisions are not independent. Since NGA wants to keep the margin of the middlemen fixed more or less, a decision regarding the price to the producers implies also the price to the consumers.

The current method by which NGA determines the minimum price to the producers is by estimating the average cost per kilogram of rice produced, plus some "fair" profit. In order to do that NGA needs information on the

average cost of production per hectare and the average yield per hectare.
It should be noted that the decision on the minimum price is not necessarily
consistent with the constraint of market intervention to the extent of maxi-
mum 10%. In a good year, when the yields are high, NGA might procure much
of the produce in order to assure the floor price. This may result in
procurement of more than 10%. On the other hand, since NGA is limited by
its storage capacity it might not be able to procure all the produce necessary
to assure the floor price. In these cases NGA usually exports the excess
produce but the total amount procured, for domestic consumption and for
export may well exceed 10% of the quantity sold by the farmers.

In conversations with farmers it was found that the floor price
does not always hold. Because of administrative delays, palay with high
percentage of moisture, and inability to reach NGA buying stations farmers
were forced to sell their palay for 100 and even ₱.95 per kilogram when
the official floor price was ₱1.10 per kilogram palay. One would expect that
when farmers get the floor price (₱1.10/kg.) the consumers would pay less
than the ceiling price (₱2.10/kg.). But, as a matter of fact, which NGA
officials do not deny, the farmers get the floor price and the consumers
do pay the ceiling price. (More on these issues can be found in the next
section.)

Another shortcoming in determining the floor price with respect
to the farmers' profit only is the inability to incorporate the implications
on other objectives of the government like self-sufficiency, price stability,

etc. In addition, the uncertainty effects,which are very common in any agricultural system and especially in the Philippines, are not taken into consideration when the price policy is made.

NGA deals with all grains produced in and imported into the country. The most important, however, are rice, corn and wheat.

Besides procurement and distribution, NGA also aids in programs involving:

1) Corporate farming
2) Postharvest facilities
3) Industry regulation
4) Research
5) Extension services

(See Chart 1.)

Since its establishment in 1972 NGA has contributed significantly to the grain industry of the Philippines. During that period the country has reached a stage in which self-sufficiency in food supply is not anymore an unattainable goal. Due to research, introduction of new technologies and extension services the yields per hectare have continuously increased.

In a span of six years NGA has diversified from mere marketing to the vast areas of grains infrastructure, corporate farming, industry regulations, research, extension services and even conservation. Wheat and feedgrain, never before handled by its predecessors, are now within the operational scope of NGA.

Nevertheless, the role of NGA is not yet over. Farmers' income is still far below the average. With the fast growing population there is a need for more and faster introduction of modern technologies in production, storing and milling, to keep in pace with the growing demand.

Chart 1

**GRAINS INDUSTRY DEVELOPMENT**

| 1. PROCUREMENT DISTRIBUTION | 2. CORPORATE FARMING | 3. POST-HARVEST FACILITY | 4. INDUSTRY REGULATION | 5. RESEARCH | 6. EXTENSION SERVICES |
|---|---|---|---|---|---|
| 1.1. Local Procurement | 2.1. Private Corporation | 3.1. Warehouse Construction | 4.1. Registration and Licensing | 5.1. Economic | 6.1. Training Program |
| 1.2. Distribution | 2.2. NGA-DEC | 3.2. Grain Centers | 4.2. Enforcement | 5.2. Technical | 6.2. Facility Assistance |
| 1.3. Import/ Export | 2.3. NGA-Farms | 3.3. Grain Terminal Silo | 4.3. Quedan | 5.3. Wheat Research | |
| | | 3.4. Transport Facility | | 5.4. NGA Post-Harvest Institute | |

Source:  Corporate Planning Group, NGA.

## 2. MODEL FOR GOVERNMENT INTERVENTION IN THE GRAINS INDUSTRY

### 2.1 Introduction

In the following two sections, we develop two models. The first is for the government involvement in the grains industry. This is a comprehensive but general model. The objectives and the options of the government as well as the uncertainties and the dynamic aspects of the system are outlined. There is not, however, a detailed description of the system at that stage. The second model is a representation of NGA's objectives and alternatives. This model is a significantly simplified version of the first model. It is much more detailed, however, and the full specification is given.

The approach taken in this chapter, and in this work as a whole, is similar to that mentioned by Little. "The best approach is to lead the potential user through a sequence of models of increasing scope and complexity.... Often a user, having a simple model, will start to ask for just the additional considerations found in the advanced models." A similar approach is suggested by Hammond. "It is far better to get a simple version of a model up and running as soon as possible, use it for a while, and then expand it on the base of enhanced understanding. A certain self-restraint is advisable in such expansions, since the tendency is to err in the direction of too much machinery and detail." Timmer in a Methodological Introduction to the Political Economy of Rice in Asia [Timmer, 1975 a] claims that, "while economists were busy measuring demand

and supply elasticities in a ceteris paribus world, the astonishing

variation in national "rules of the game" and the frequency with which

these rules changed were ignored or went unnoticed.  The result was a

myopic blend of technical sophistication with an air of unreality that

politicians often (rightly) rejected."

Following this approach we were willing to sacrifice a full

representation of all factors taking part in the grains industry and to

compromise on the accuracy of the data used for making the model more

implementable and understandable to its users.


## 2.2  Model for Decision Making in the Government Level

### 2.2.1  Introduction

In this chapter we do not distinguish between different govern-

ment agencies involved in the grains industry of the Philippines.  We

rather view the government as the sole body which has some control over

the industry.

### 2.2.2  Objectives

By its grains policy the government wishes to achieve the

following objectives:[1]

1. Sustained food production programs to meet the demand
   of the fast-growing population.

2. Uplifting the productivity and per capita income of
   grain farmers.

3. Stabilization of the consumers' price of grains for
   the benefit of the low-income group.

---

[1]Based on government publications and interviews with government
officials.

4. Product and by-product development both for local consumption and for the export market, thereby generate employment and earn more foreign exchange.

5. Decrease government expenditures with regard to supporting the grains industry.

Similar objectives, although named differently, are proposed by Mangahas [1975]. These objectives are: political stability, consumers' welfare, farm income, anti-inflation and self-sufficiency. Timmer outlines eight broad areas of objectives that Asian countries have pursued with their rice policies [Timmer, 1975]. These are:

1. welfare protection for consumers,
2. income generation for farmers,
3. generation of government revenue,
4. generation of foreign exchange,
5. reduced reliance on uncertain foreign markets for the basic foodstuff (self-sufficiency),
6. price stability (both inter- and intra-seasonally),
7. regional development (and equity), and
8. provision of adequate nutrition.

Most of these objectives are found also in [Apiraksirikul and Barker, 1977] and [Herdt and Lacsina, 1976].

Since some of these objectives conflict with others it is impossible to suggest a policy which would optimize each of the objectives and by that the system as a whole. It is necessary, therefore, to construct an objective function which will incorporate the performance in each of the objectives and the proper weights to be associated with them.

The following six objectives were chosen to reflect the most important issues confronted by the government with regard to grains policy:

1. Increasing farmers' income
2. Increasing consumers' welfare
3. Self-sufficiency in food production
4. Price stability
5. Increase generation of foreign exchange
6. Decrease government expenditures

### 2.2.3 Alternatives and Options of the Government

A variety of options is open for the government for promoting its objectives. Among these are those which improve the infrastructure for the agricultural system as a whole like development of the transportation and communication networks, national development of irrigation systems, land reform and more.

More specifically, for the grain industry the government has the following alternatives:

1. Price policy – floor price and ceiling price
2. Subsidizing fertilizers
3. Irrigation systems in grain areas
4. Extension services
5. Crop insurance
6. Subsidizing farm equipment
7. Farm credit
8. Research promotion
9. Rationing
10. Storage
11. Imports and exports

Mangahas [1975] lists some rice policies and their effects on the government objectives. See Table 1.

| Policy | Objectives | | | | |
|---|---|---|---|---|---|
| | Political Stability | Consumer Welfare | Farm Income | Anti-inflation | Self-sufficiency |
| Floor price | + | – | + | – | + |
| Farm credit | + | + | + | – | + |
| Fertilizer subsidy | + | + | + | + | + |
| Farm equipment subsidy | + | + | + | + | + |
| Extension | + | + | + | + | + |
| Imports | + | + | – | + | – |
| Ceiling price | – | – | + | – | + |
| Rationing | + | + | – | + | – |
| Land transfer | + | + | + | + | + |

Table 1 – Effects of Rice Policies on Government
Objectives in the Philippines

The policy tools open for the government are not just these eleven mentioned above. In each policy the government has to decide on the level at which to operate. For most alternatives there is a continuous range in which to choose the optimal level. In addition, the optimal policy to be taken by the government is not just the collection of all "optimal" levels in each alternative but rather the optimal combination of all levels of operation in the different options.

### 2.2.4  Uncertainties

Uncertainty is one of the main·features of agricultural commodity systems. Weather conditions, pests and diseases cause high fluctuations in the quantity produced. Uncertainty in the grain industry of the Philippines is even greater than most other crops and most other countries.

### 2.2.4.1  Nature Conditions

Weather conditions, pests and diseases are the basic source of uncertainty in the production of grains in the Philippines. Typhoons, floods and droughts are common phenomena in the Philippines. It was shown [Alix, Kunkel and Gonzales, 1978] that the occurrence of a severe typhoon and drought causes production to decline by 8% and 14%, respectively. If both typhoons and droughts occur in the same year a 22% decline in production can be expected.

2.2.4.2  Farmers Response to Government Policy

Another random variable on the production side is the amount of

response by farmers to government policies.  Although some research was

done in the area of price elasticity of the supply of rice and corn

[Mangahas, Recto and Ruttan, 1966] and [Sison and Hayami, 1977], most

of the results were not statistically significant and examined only a

few areas of farmers response to government policies.

2.2.4.3  Demand

The demand for grains in the Philippines is also a random

variable.  Some government officials and economists claim that the

quantity consumed per capita is fixed.  Their explanation is that when

there are changes in the prices of grains the consumers change the quality

of food grains they buy rather than the quantity.  This is true, they

claim, not only for the aggregate grains but also for each commodity

separately.  The evidences from the economic research, however, do not

support this argument.  Different researchers show that the price

elasticity of the demand for food grains in the Philippines is rather

negative.  [Nasol, 1971],  [Apiraksirikul, 1972], [Mears, 1973], [Te, 1978].

Since different results were obtained by different researchers it has

been necessary to assign a subjective probability distribution over

different demand functions.

2.2.4.4  The World Market Price

Decisions on export, import and storage should depend, among

other variables, on the price of grains in the world market, in the

following season. These prices are not known with certainty. A probability distribution, has, therefore, to be assigned over this variable. This distribution will depend on time series analysis as well as on updated information about weather conditions, pests and diseases in the grains producing countries.

### 2.2.4.5 Prices

The prices of grains to the producers and consumers are also uncertain. We do not have, however, to evaluate a probability distribution over the prices since it is determined by the intersection of the supply and the demand curves. Thus, if, for example, there is a probability $(P_1)$ that the supply curve is $S_A$ and a probability $(P_2)$ that the demand is $D_B$, then there is a probability of $P_1 * P_2$ (joint probability) that the price would be $P_{ab}$ (see Figure 1).
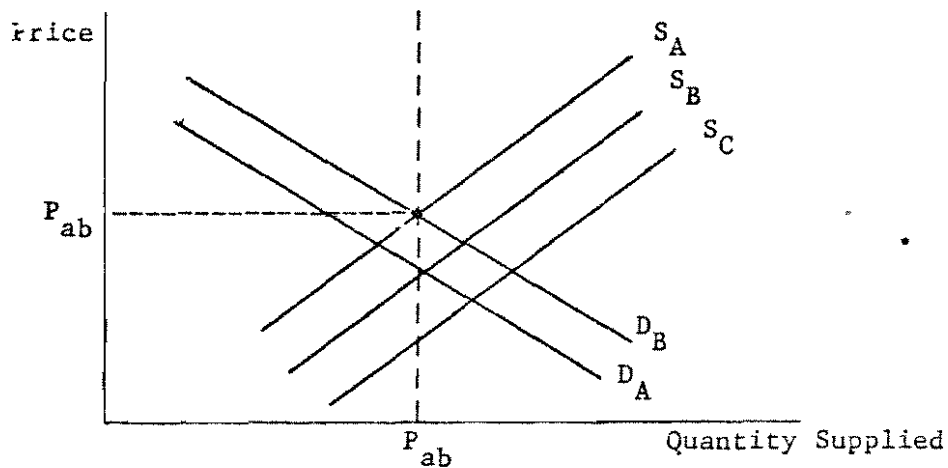


Figure 1 - Demand, Supply and Price Relationship

### 2.2.5 Horizon Plan and the Dynamics of the System

We distinguish between two cycles of production per year.
These are the wet semester and the dry semester. (This is true mainly
for rice, but can be assumed for grains in general.) Some of the
government decisions can be changed each semester. These are the minimum
and maximum price, imports, exports, and storage decisions, and
subsidies to inputs. Other alternatives, however, require a longer
period for planning and executing. These are construction of irrigation
systems, research and extension service programs, and crop insurance and
farm credit policies.

Some of the objectives, on the other hand, have short-run
implications (price stability) while others have long-run implications
(food sufficiency).

The horizon-plan of the model should, therefore, be long
enough to account for those implications which occur some years after
a certain alternative is chosen. In addition the model has to represent
the dynamic properties of the system. We shall distinguish between
three types of dynamic influences: stock variables, constraints and
learning.

Stock variables are those variables, the level of which at
the end of period $t$ has an impact on the decision made at period $t+1$.
For example, the quantity of grains in storage at the end of a certain
year would influence the decisions to be made with regard to promoting
the production in the following year.

Some decisions in a certain year may impose some constraints on the decisions in the following years. These decisions may result in some stock variables like storage capacity or stock of irrigation systems. They may result also in some political constraints. If, for example, because of political pressure, the government "feels" that it cannot increase the price to the consumers by more than 10% per year, it might decide to increase the price in a certain year by 8% and in the following by another 8%, even if it finds that the best policy could have been not to increase the price at that certain year and if necessary to increase the price by 17% in the following year.

The third dynamic property is the effect of learning along the horizon plan. Since the parameters of most variables are uncertain, the government can learn from the results at the end of each cycle. The future implication of this learning can be taken into account at the time when the decisions are made. (See [Pratt, Raiffa and Schlaifer, 1965] and [Rausser, 1978] for an explanation on the Preposterior Analysis and Active Learning, respectively.)

### 2.2.6  Summary of the Government Model

When viewing the Philippines government involvement in the grains industry we identify the following characteristics:

a. Main objectives

   1. increased farm income
   2. increased consumer welfare
   3. self-sufficiency in food production
   4. price stability
   5. improvement of balance of payments
   6. decrease in government expenditures

b.  Available policies

1.  price policy
2.  subsidies to inputs:  fertilizers, pesticides, credit
3.  development of irrigation systems
4.  extension services
5.  research
6.  crop insurance
7.  import and export
8.  buffer stock storage

c.  Uncertainties

1.  nature conditions
2.  farmers' response to government policies
3.  demand for grains
4.  world market price for grains

The decision tree in Figure 2 summarizes the above characteristics.
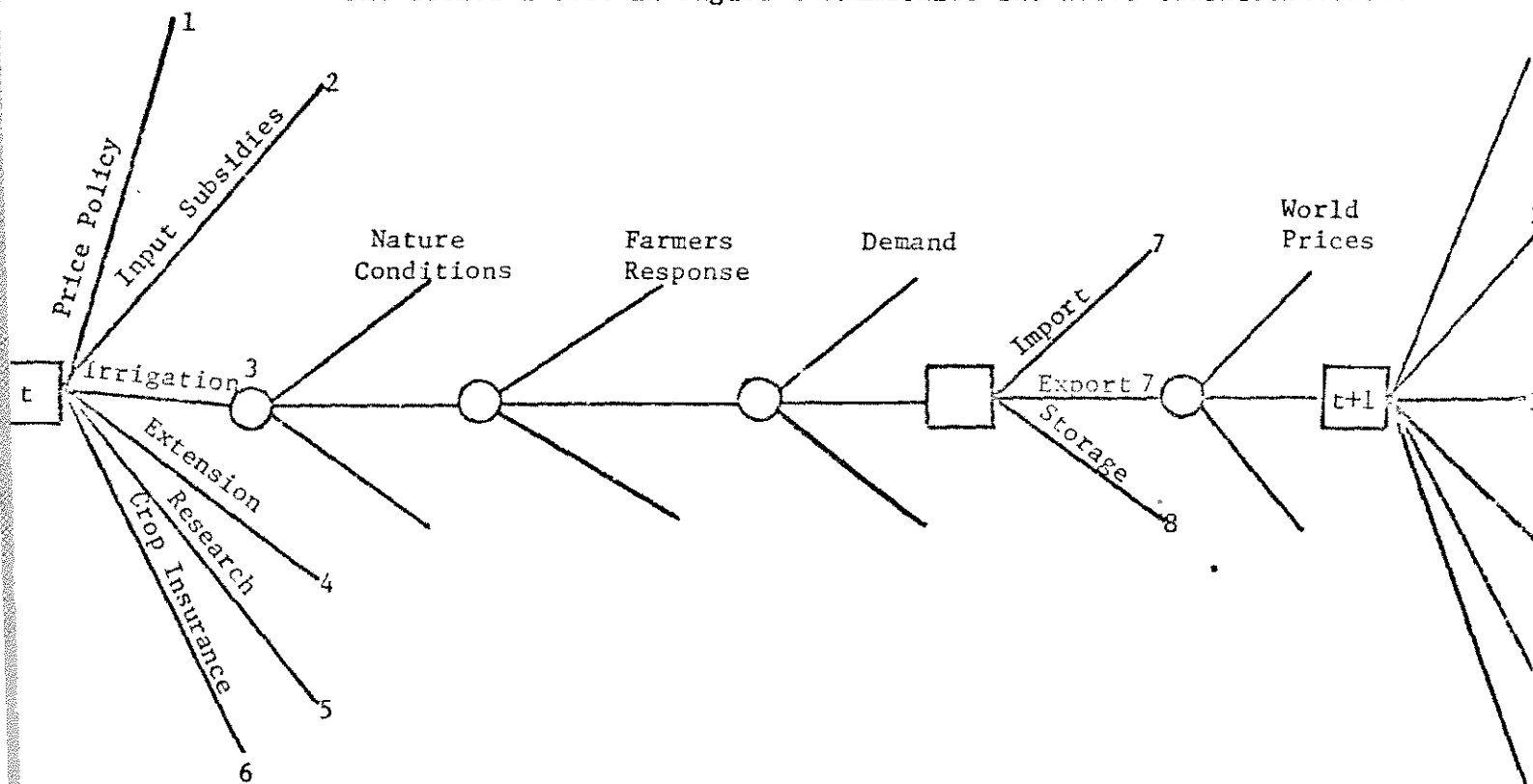


Figure 2 - Decision Tree for Government Activities in
the Grains Industry of the Philippines

Remarks:

1. The performance measures of the government's objectives
   are measured and evaluated at the end of each cycle.

2. Since the production of grains is, more or less, continuous
   along the cycle, the order of the Demand - Decision -
   World Prices is not very accurate. Import, export and
   storage decisions are made partially after the world price
   for grains is known and before some demand is known.
   Certainly the decision regarding imports, exports, and
   storage in cycle t are made before the world price and
   the demand of cycle t+1 are known.

3. In addition to the six alternatives described at the
   beginning of the tree we have to consider all the possible
   combinations of these policies under some budget or
   managerial constraints.

4. All the probability distributions shown in the tree have
   only three-point discrete probability functions. These,
   may, of course, be extended to more points and even a
   continuous density function given the functional relation-
   ships between the random variable and other variables, the
   performance measures, for example, are known.

5. Since the performance measures are evaluated at the end
   of each cycle it is not at all a simple task to construct
   an appropriate objective function that would account for
   the different weights of the different objectives and at
   different periods.

6. Note that there are no explicit requirement constraints
   in the model. One possible requirement could be that at
   least 80% (for example) of the total consumption of grains
   would come from the domestic production. The problem with
   such constraints is that we do not allow for any trade-offs
   between this requirement and other requirements at the
   level of the constraint. Thus, for the example given above,
   79% of self production would never be acceptable even if
   this would drive all other objectives to some extremely
   desirable levels. By using the multi-attribute utility
   function as an objective function we can overcome this
   problem by assigning a very low preference to the 80%
   self production but a high preference to the combination
   with the desired levels of the other objectives.

Mangahas [1975] outlines the following constraints on any policy taken by the government: peace and order, production parameters, demand parameters, the supply of foreign assistance, the marketing system, foreign supply of fertilizers, government administrative capacity, the government budget, the welfare of organized political and economic groups, and the welfare of the civil service. All these constraints can be taken care of by the probability distributions assigned to the random variables like production and demand (a zero probability would be assigned to production and demand which are out of the capacity or reasonability bounds), and by the functional form and weights of the utility function.

### 2.2.7 Problems and Difficulties in the Government Model

Practically and theoretically the government model is too complicated. The following problems and difficulties arise in its specification and implementation.

#### 2.2.7.1 The Commodity

In the government model we treated all grains as one commodity. Not only that the characteristics of the production, processing, marketing and consumption are different for rice, corn and wheat, they also differ for different varieties and grades of a certain grain crop. In addition there are inter-relationships between the different crops. These are the cross-elasticities of the demand and supply and the competition on the consumer's purchasing power and on the production means. The government

should not necessarily take the same policy in dealing with different

crops. Thus, it may choose to promote the research on rice production

but not of corn. This increases significantly the number of the

alternatives to be examined to a level which is far beyond a reasonable

analysis.

### 2.2.7.2  Number of Alternatives

Even if we consider only one crop the number of possible

alternatives is enormous. The alternatives outlined in the government

model are not Yes-No alternatives. For each alternative there is a

continuous range of possible levels to be chosen. Thus the range of all

possible combinations of the different alternatives is infinite.

### 2.2.7.3  Objective Function

Because of the significant role uncertainty and risk play in

the agricultural industry these factors have to be incorporated in the

objective function. With the different objectives of the government,

the appropriate objective function is the expected value of a multi-

attribute utility function. Since, in the government model, we evaluate

the performance measure at the end of each cycle along the horizon plan

it is necessary to take into account the time factor. Two problems arise

in this respect. First, the number of objectives is multiplied by the

number of cycles. Thus, if, for example, the horizon plan is three

years (six cycles) and there are six objectives, the total number of

the attributes would be 36. The second problem, which is related to the

first, is that within the framework of multi-attribute utility analysis
it is not a simple task to consider the time factor.  Discounting of
future values, a common technique in dealing with a stream of cash flows
can be used only under certain independence relationships (see [Meyer,
1976]).

### 2.2.7.4  Applicability for NGA

NGA is only one of several agencies who are involved in the
grains industry of the Philippines.  Most of the alternatives mentioned
in the government model are not under NGA's authority.  Only price policy,
import and export, and storage policy are under its control.  Since this
work is aimed to assist NGA in making decisions we shall assume that
all other decisions made by the other government agencies are known to
NGA and are used as inputs in the decision making process.

### 2.2.7.5  Horizon Plan and Dynamics of the Model

The issue of short-run vs. long-run policies is well summarized
in Timmer's article - The Political Economy of Rice in Asia:  Lessons
and Implications [Timmer, 1975b].  "Policy makers live forever in any
short run.  Even if they perceive the long-run possibilities, they must
react to short-run realities.  But some short-run policies have more
favorable long-run implications, and the secret of success is to search
these out."

## 3.  MODEL FOR PRICE POLICY FOR RICE IN THE PHILIPPINES

### 3.1  Introduction

In this section we develop a model for decision making on price
policy for rice to be implemented and used by the NGA.  Because of the diffi-
culties in the government model, described in Section 3.2.7, the model has
been simplified so it would fit NGA's needs, objectives and responsibilities,
and be manageable by NGA's officials.  This model deals only with rice rather
than all grains and  only  with part of NGA's activities rather than all possible
interventions by the government.  The model developed here is not only directly
useful but can also be regarded as an initial version  of a more comprehensive
representation.

We have chosen to work with rice only.  It represents 80% of the
grains consumed in the Philippines.  The relationships between the produc-
tion and consumption of rice and other grains, namely, the cross elasticities
of supply and demand were only partially investigated, and most of the find-
ings were statistically insignificant.  (See [Mangahas, Recto and Ruttan,
1965], [Sison and Hayami, 1977]).  Incorporation of these vague relation-
ships would not improve the model significantly and also would unnecessarily
complicate  the  analysis.  For the same reasons, the horizon plan of the model
is one cycle of rice production, namely, one semester.  The application and

analysis of the model were done for the wet cycle in which almost two-thirds

of the rice is produced in both irrigated and nonirrigated farms. Some minor

changes in the model will be necessary to adjust it for the dry season.

The problem this model is designed for is: What should be the price

policy for rice which would maximize the "total rice welfare" in the

Philippines.

## 3.2 Objectives

The "total rice welfare" is quite a fuzzy objective. It consists

of the welfare of all the participants in the rice system, namely, consumers,

producers, the government, intermediaries, input suppliers and others. Fol-

lowing are the objectives, a combination of which was chosen to represent

the "total rice welfare" of the Philippines.

1) Increased income of farmers

2) Self-sufficiency of rice production

3) Increased consumers' welfare

4) Decrease price variability

5) Decrease government expenditures

These five objectives are only a subset of the list appearing in

2.2.2. They were selected by NGA's officials as their most important objectives.

The objective of improving the balance of payments via price policy

for rice was regarded by NGA officials as less important and, therefore, was

excluded from the model. To measure performance and to determine the

optimal policy with regard to how much rice should be stored or exported,

released from storage or imported, it was necessary to construct a com-

plicated model for reserve stock policy.

Figure 1

Price Policy Alternatives of NGA

Ceiling Price

Floor price

$P_m^* = 1.70$

1.90

2.10

2.30

2.50

2.70

2.90

$P_m^* = 3.10$

$P_p^* = 1.00$

$P_m^* = 1.70$

1.90

2.10

2.30

2.50

2.70

2.90

$P_m^* = 3.10$

$P_p^* = 1.10$

$P_p^* = 1.20$

$P_m^* = 1.70$

1.90

2.10

2.30

2.50

2.70

2.90

$P_m^* = 3.10$

Free Market
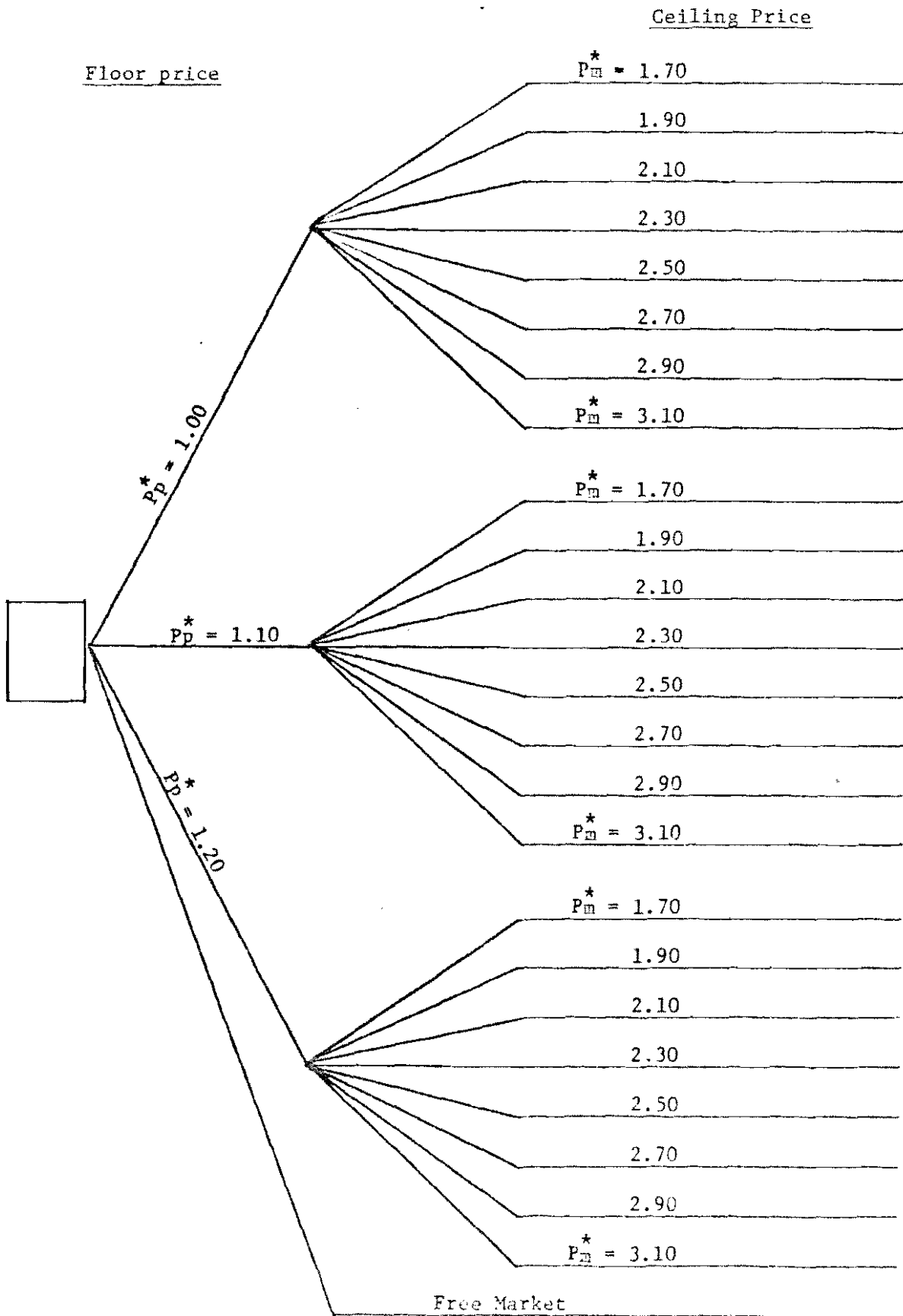
Krishna [1967] argues: "It is true that input price subsidiza-
tion avoids an immediate increase in food and raw material prices, but
this will not prevent a long-run steep increase in their prices if input
subsidization does not succeed in stepping up agricultural output at
the same rate as price guarantees would. Input subsidization may seem
cheaper than product price support in the short run, but product price
support may prove cheaper in the long run."

The horizon plan of a model does usually reflect the period at
which the performance is evaluated. If the horizon plan is longer than
one cycle the model should specify the relationships between the different
cycles. These relationships are the dynamic characteristics of the system.

In the government model, these dynamic characteristics are
quite difficult to be measured. The impact of some stock variables like
the quantity of grains in storage or the total irrigated land can be
quantified and incorporated in the model. The impact of the dynamic
political constraints and the learning effects, however, is not easily
quantified.

This area is currently under research conducted in the International Rice Research Institute (IRRI) in the Philippines, [Te, 1978]. The results of this research, when completed, could be introduced into our framework with the additional objectives. Another reason for excluding this objective which was regarded by NGA officials as less important was to improve our assessment of the multiattribute utility function. Since the concepts of utility analysis are not very familiar to the NGA's officials we felt it was necessary to limit the number of attributes and by this to decrease the difficulties faced when determining the independence relationships between the different attributes, and when presenting the analysis to the users.

## 3.3 The Alternatives of NGA

The price policy for rice consists of determining the floor price to the producers, $P_p^*$ ($\text{P}$/Kg palay); ceiling price to the consumers, $P_m^*$ ($\text{P}$/Kg rice); and reserve stock policy. We shall evaluate only the different alternatives of floor and ceiling price. It will be assumed that if the market clearing price, Pe, is above the ceiling price, the government would import the quantity necessary to drive the price down to the ceiling price. If the market clearing price is below the floor price, the government would export rice to drive the price up to the floor price. The current floor price to the producer $(P_p^*)$ is 1.10 $\text{P}$/Kg of palay, and the ceiling price to the consumers $(P_m^*)$ is 2.10 $\text{P}$/Kg of rice.

Three different levels of floor price to the farmers (1.00, 1.10 and 1.20 $\text{P}$/Kg palay) and eight different levels of ceiling price to the consumers (1.70, 1.90, 2.10, 2.30, 2.50, 2.70, 2.90 and 3.10 $\text{P}$/Kg rice) will be evaluated. In addition, we shall evaluate the "free market" policy, namely, no floor or ceiling price. The total number of alternatives to be evaluated is, therefore, $3 \cdot 8 + 1 = 25$. (See Figure 1.)

## 3.4 Uncertainties

### 3.4.1 Supply

The total quantity supplied by the farmers is the total quantity
produced less household consumption of farmers

$$\widetilde{Q}_s = \widetilde{Q}_p - Q_f. \tag{3.1}$$

It is assumed that the quantity consumed by the farmers is fixed
irrespective of the price for rice. This is based on [Toquero, et al,
1975] and [Barker and Hayami, 1976].

The quantity produced is a function of the nature conditions, the
amount of hectares devoted to rice and the amount of inputs (fertilizers,
labor, etc.) per hectare.

$$\widetilde{Q}_p = f\ (\widetilde{N},\ \widetilde{L}_r,\ \widetilde{I}_r) \tag{3.2}$$

where $\widetilde{Q}_p$ is the quantity produced

$\widetilde{N}$ is the nature conditions

$\widetilde{L}_r$ is the total land devoted to rice

$\widetilde{I}_r$ is the level of inputs devoted to rice

The amount of land and inputs devoted to rice depends, among other
variables, on the floor price of palay to the farmers. Before the intro-
duction of the High Yielding Varieties (HYV) the farmer's response to changes
in price were mostly attributed to changes in the land devoted to rice [Mangahas,
Recto and Ruttan]. In the recent years, however, it was found [Sison and
Hayami] that: (a) "The response of rice area to price declined as cultivation
frontiers were pushed into marginal area... and (b) the response of rice yield
per hectare to price increased owing to the introduction of new rice technology
and the development of irrigation systems which heavily influenced the applica-
tion of fertilizer and related inputs in response to changes in the price of
rice relative to the price of those inputs."

Table 1

Subjective Probability Distributions of Nature Conditions

| Person | Good | Moderate | Bad |
|--------|------|----------|-----|
| 1 | .25 | .5 | .25 |
| 2 | .3 | .4 | .3 |
| 3 | .16 | .5 | .34 |
| 4 | .2 | .5 | .3 |
| 5 | .25 | .5 | .25 |
| 6 | .25 | .5 | .25 |
| 7 | .2 | .5 | .3 |

The probabilities do not differ very much from interviewee to another. The average probabilities are $P(G) = .23$, $P(M) = .49$, $P(B) = .28$. Therefore, for the simplicity of the analysis and the presentation of the model we have chosen the following probability distribution:

| | |
|---|---|
| Good nature conditions | $P = .2$ |
| Moderate nature conditions | $P = .5$ |
| Bad nature conditions | $P = .3$ |

The 10% below and above the normal production for Bad and Good years, respectively, are based on interviews with the staffs of the Departments of Agricultural Economics in IRRI and UPLB. The figures in Table 2, which are based on hard data rather than subjective, also confirm the suggested range of $\pm 10\%$.

Alix, Kunkel and Gonzales [1978] have found that the impact of adverse weather conditions on nonirrigated palay was 50% higher than the average and on irrigated farms about 50% less that the average. Thus, we shall assume that in a good year irrigated and nonirrigated yields would be 105% and 115% of the average, respectively, and in a bad year 95% and 85% of the average, respectively.

Another measure for the distribution of nature conditions can be supplied by the historic variation of the average yield per hectare. Since the changes in the average yield are due not just to nature conditions but also to technological change, the average yields will be adjusted by the trend over the period examined.

Two trend analyses were done over the period 1956-1975. In the first, the average growth rate of yield was calculated for five 15-year periods. The average of these five rates was taken as the average growth rate of yields over the 20-year period.

$$I = 1 + \frac{1}{5} \sum_{i=0}^{4} \sqrt[15]{\frac{Y_{1971+i}}{Y_{1956+i}}} = 1.0228$$

where $Y_t$ is the average yield in year t. The actual yields ($Y_t$) were then inflated by the appropriate power of I. Thus,

$$Y_t^1 = Y_t \cdot I^{1975-t}$$

where $Y_t^1$ are the adjusted yields.

The adjusted yields were divided by their mean to give the measure of nature conditions ($N_t^1$)

$$N_t^1 = Y_t^1 / \bar{Y}_t^1$$

The second trend analysis was done by fitting a regression line. Then the computed values ($\hat{Y}_t$) were calculated. The measure for nature conditions ($\hat{N}_t$) was the ratio between the actual yield ($Y_t$) and the computed yield.

$$\hat{N}_t = Y_t / \hat{Y}_t.$$

The regression line was found to be

$$Y_t = 1054 + 30 \cdot (t-1956)$$

See Table 2 for the results of the analyses.

Table 2

Average Palay Yields in the Philippines:
Trend and Variation, 1956-1975

| Year | $Y_t$ (Kg/hec.) | $Y_t^1$ | $N_t^1$ | $\hat{Y}_t$ | $\hat{N}_t$ |
|---|---|---|---|---|---|
| 1956 | 1,194 | 1,832 | 112 | 1,054 | 113 |
| 1957 | 1,209 | 1,814 | 110 | 1,084 | 111 |
| 1958 | 1,016 | 1,490 | 91 | 1,114 | 91 |
| 1959 | 1,107 | 1,588 | 97 | 1,144 | 97 |
| 1960 | 1,131 | 1,586 | 97 | 1,174 | 96 |
| 1961 | 1,158 | 1,588 | 97 | 1,204 | 96 |
| 1962 | 1,230 | 1,649 | 100 | 1,234 | 100 |
| 1963 | 1,255 | 1,645 | 100 | 1,264 | 99 |
| 1964 | 1,245 | 1,594 | 97 | 1,294 | 96 |
| 1965 | 1,248 | 1,564 | 95 | 1,324 | 94 |
| 1966 | 1,310 | 1,605 | 98 | 1,354 | 97 |
| 1967 | 1,322 | 1,583 | 96 | 1,384 | 95 |
| 1968 | 1,380 | 1,616 | 98 | 1,414 | 98 |
| 1969 | 1,334 | 1,527 | 93 | 1,444 | 92 |
| 1970 | 1,681 | 1,882 | 115 | 1,474 | 114 |
| 1971 | 1,716 | 1,878 | 114 | 1,504 | 114 |
| 1972 | 1,571 | 1,681 | 102 | 1,534 | 102 |
| 1973 | 1,419 | 1,484 | 90 | 1,564 | 91 |
| 1974 | 1,627 | 1,664 | 101 | 1,594 | 102 |
| 1975 | 1,599 | 1,599 | 97 | 1,624 | 98 |
| Average | | 1,643 | 100 | 1,339 | 99.8 |

Source (to $Y_t$):  Philippine Statistical Yearbook, 1977.

We see that the two measures of nature conditions are very similar
to each other. If we divide the indices ($N_t^1$ and $\hat{N}_t$) into three groups:
1)($N_t \geqslant 104$; 2) $103 \geqslant N_t \geqslant 97$; and 3) $N_t \leqslant 96$, we get the following frequencies:

$$F(N_t \geqslant 104) = 4 \qquad \text{or } P_r(N_t \geqslant 104) = .2$$

$$F(103 \geqslant N_t \geqslant 97) = 11 \qquad \text{or } P_r(103 \geqslant N_t \geqslant 97) = .55$$

$$F(N_t \leqslant 96) = 5 \qquad \text{or } P_r(N_t \leqslant 96) = .25$$

These probabilities are very similar to those calculated based on the
subjective assessments. It should be noted, however, that the frequencies
above are based on an arbitrary choice of the ranges. In addition, the yields
are not influenced/by the nature conditions and a constant technological change.
only
The policy of the government, the expectations of the farmers, availability of
inputs and other factors also contribute to the variations in the yields.
Nevertheless, it seems that the subjective probability of distribution of nature
conditions can and should be replaced by a more accurate and objective one.

### 3.4.1.2  Farmers' Response

We have distinguished between two types of farms: Irrigated and
Nonirrigated. In the irrigated farms the farmers usually grow more than one
crop per year.  They are less vulnerable to nature conditions and are more
profitable. The nonirrigated farms, however, are less intensively cultivated.
Most of them are in the areas far from the big marketing centers and are
less flexible in their marketing options. Tables 3, 4, 5, 6, and 7
in  Section 1   show the differences between irrigated and nonirrigated farms
With respect to production, yields and the adoption of High Yielding Varieties.

NCA officials and Filipino agricultural economists have been asked to
assess the response of farmers who grow rice in irrigated and nonirrigated farms
to different levels of floor  price for palay. Their assessments are summarized
in Table 3.

## Table 3a

### Distributions of Farmers Response
### to Floor Price of Palay = 1.00 ₱/Kg

| | Irrigated | | | | | | Nonirrigated | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % of production* | 80 | 90 | 95 | 100 | 105 | Ave. | 80 | 90 | 95 | 100 | 105 | Ave. |
| Proportions given by: | | | | | | | | | | | | |
| Person #1 | | | .2 | .7 | .1 | .995 | | | .05 | .95 | | .9975 |
| Person #2 | .6 | .2 | | .2 | | .86 | .3 | .3 | | .4 | | .91 |
| Person #3 | | | ⌐1. | | | 1. | | | | 1. | | 1. |
| Person #4 | | | .35 | .5 | .15 | .99 | | .2 | | .7 | .1 | .995 |
| Person #5 | .2 | | | .8 | | .96 | | .4 | | .6 | | .96 |
| Person #6 | | | 1. | | | 1. | | | | 1. | | 1. |
| Average | | | | | | .97 | | | | | | .997 |
| Standard Deviation | | | | | | .05 | | | | | | .03 |

*% of production is relative to 100% which is the planned production of farmers with the current level of minimum price which is 1.10 ₱/kg palay.

## Table 3b

### Distributions of Farmers Response
### to Floor Price of Palay = 1.20 ₱/Kg

| | Irrigated | | | | | | Nonirrigated | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % of Prodcution | 80 | 100 | 105 | 110 | Ave. | 95 | 100 | 105 | 110 | Ave. |
| Proportions given by: | | | | | | | | | | |
| Person #1 | | .55 | | .45 | 1.045 | | .25 | .75 | | 1.0375 |
| Person #2 | | .5 | .3 | .2 | 1.035 | | .6 | .3 | .1 | 1.025 |
| Person #3 | | .05 | .55 | .4 | 1.0675 | | .8 | .15 | .05 | 1.0125 |
| Person #4 | .2 | .3 | .5 | | 1.015 | .1 | .55 | .35 | | 1.0125 |
| Person #5 | | .4 | | .6 | 1.06 | | .9 | .1 | | 1.005 |
| Person #6 | | 1. | | | 1. | 1. | | | | 1. |
| Average | | | | | 1.037 | | | | | 1.015 |
| Standard Deviation | | | | | .02 | | | | | .012 |

Table 3c

Distribution of Farmers Response to
Free Market (Neither Floor Nor Ceiling Price)

| % of production | Irrigated | | | | Nonirrigated | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 95 | 100 | 105 | Ave. | 90 | 95 | 100 | 105 | 110 | Ave. |
| Proportions given by: | | | | | | | | | | |
| Person #1 | .05 | .75 | .2 | 1.0075 | | | 1. | | | 1. |
| Person #2 | .5 | .3 | .2 | .985 | .6 | | .3 | | .1 | .95 |
| Person #3 | .1 | .5 | .4 | 1.015 | | | 1. | | | 1. |
| Person #4 | .1 | .7 | .2 | 1.005 | | .1 | .6 | .3 | | 1.01 |
| Person #5 | | | | | | | 1. | | | 1. |
| Average | | | | 1.003 | | | | | | .992 |
| Standard Deviation | | | | .01 | | | | | | .02 |

Unlike the probability distributions of the nature conditions, the distributions of the farmers' response differ significantly from one assessor to another. Some assessors (#3, #6) believe that most farmers do not respond to changes in the floor price of palay. This view is also found in Castillo [1975]. Based on research by Dimaano and de Guzman, she proposes that response to price may not necessarily mean response to price support and, therefore, the use of the latter in order to induce productivity increases may not bring expected results. Other assessors believe that price support does induce increases in production and one assessor (#4) even believes that some farmers may decrease their production when the floor price is higher. This is based on the feeling that there is a group of farmers which are not profit maximizers but rather assign quite high values to leisure time. These farmers are believed to have some fixed level of demand for money to cover their basic needs. If they knew that the price they would receive would be higher, they might not devote as much resources (mainly labor) to their farm as if the floor price was lower. There are evidences

that the motivation to increase productivity depends on the farmers' needs.
Castillo [1976] found that the size of the family is a factor influencing the
motivation for increased productivity. As it is often heard: "What is the use
of working so hard when you have only two children?"

It should be emphasized that the figures in Tables 3a, 3b, and
3c are not probability distributions but rather the proportions by which
different groups of farmers would respond to different levels of the floor
price. For each policy we have calculated the Expected Farmers' response (E)
and its standard deviation (SD). The probability distribution for each case
was assumed to be:

| % Production | Probability |
|---|---|
| E-SD | .25 |
| E | .5 |
| E+SD | .25 |

This is, of course, a very arbitrary assumption, but, nevertheless,
it attempts to reflect the uncertainty around the assessments made by the NGA
officials and the other assessors with respect to the farmers' response to
different levels of the floor price.

The summary of the probability distributions of farmers' response
to be used in the analysis are shown in Table 4.

Table 4

Probability Distributions of Farmers Response
to Different Levels of Floor Price

| Probability | Irrigated | | | Non-Irrigated | | |
|---|---|---|---|---|---|---|
| | .25 | .5 | .25 | .25 | .5 | .25 |
| | % Production[*] | | | % Production | | |
| Floor Price = 1.00 ₱/Kg | 92 | 97 | 102 | 95 | 98 | 101 |
| Floor Price = 1.10 ₱/Kg | 100 | 100 | 100 | 100 | 100 | 100 |
| Floor Price = 1.20 ₱/Kg | 102 | 104 | 106 | 100 | 101.5 | 103 |
| Free Market | 99 | 100 | 101 | 97 | 99 | 101 |

[*]100% production is what the farmers intend to grow under the current
floor price (1.10 ₱/Kg). This basic figure differs for irrigated and
non-irrigated farms.

### 3.4.2 Demand

Findings of Mears [1973], Nasol [1971], Apiraksirikul [1972], and
Te [1978] determine that the price elasticity of demand for rice ranges between
-.2 and -.5. These elasticities were found under the assumption of a demand
function of the form

$$q_m = a \cdot (P_m)^b$$

where    $q_m$ = quantity purchased per capita per year

$P_m$ = price to the consumer

b = price elasticity of demand, and

a = constant

By substituting the current quantity consumed per capita per year (100 Kg) and
the current consumer price (2.10 ₱/Kg) we obtained the respective demand func-
tions. A subjective probability distribution was assigned over the elasticities.
This was done with the advice of the researchers of the Department of Agricul-
tural Economics of the University of the Philippines, Los Baños, and of the

International Rice Research Institute (IRRI). Higher probabilities were assigned to recent findings and to medial values. The elasticities to be analyzed in the model, their respective demand functions and probabilities are shown in Table VI-5.

Table 5

Price Elasticities of Demand for Rice,
Demand Functions and Probabilities

| Price Elasticity | Demand Function | | Probability |
| | Exponential | Linear* | |
| --- | --- | --- | --- |
| -.2 | $P=(116/q)^5$ | $P=12.60-.105q$ | .3 |
| -.3 | $P=(125/q)^{3.33}$ | $P= 9.10-.07q$ | .3 |
| -.4 | $P=(135/q)^{2.5}$ | $P= 7.10-.05q$ | .3 |
| -.5 | $P=(145/q)^2$ | $P= 6.10-.04q$ | .1 |

*The linear demand functions are the linear approximations of the exponential functions at the region of the current price and quantity consumed per capita.

Similar elasticities to those appear above, although not in probabilistic context were recently used by Hayami and Herdt [1977].

In order to avoid skyrocket prices for very small quantities, as a result of an exponential demand function, and negative prices for very large quantities, as a result of a linear demand function, it has been assumed that the demand function is linear to the left of the current quantity consumed (100 Kg/Capita/year), and exponential to its right.

3.4.3 The World Market Price of Rice

The prices NGA would pay for imported rice and would receive for exported rice are also random variables. Since in our model the decisions with regard to price policy are made each semester we assume that NGA has some prior information on the world market price. Thus, historical time series of the world price are not relevant for assessing the probability distribution for the short run.

Based on their knowledge about the situation of rice and grains in the international market, NGA officials provided the following probability distribution for the year 1978. (See Table 6.)

Table 6

Subjective Probability Distribution of World
Market Price for Rice

| Price of imported rice, CIF, $/ton | Probability |
|---|---|
| 250 | .1 |
| 270 | .2 |
| 300 | .4 |
| 330 | .2 |
| 350 | .2 |

Source: Department of Corporate Planning, NGA.

The prices in Table 6 include the cost of the rice itself, sea transportation and insurance, and transportation from the port to the warehouse. The price that NGA would get for one ton of exported rice (FOB) is, of course, lower. NGA officials estimated that for the same quality of rice the export price per ton would be lower than the import price by about 20%.

### 3.4.4 The Domestic Price for Rice

The price of palay to the producers and the price of rice to the consumers are also random variables. We do not have, however, to assign a probability distribution over these variables, since they are determined by the intersection of the demand curve and the quantity supplied, and by the margin of the intermediaries.

### 3.4.4.1 The Margin of the Intermediaries

There are many evidences that the margin between the retail price and the farm price is, more or less, constant. Castillo [1975, p. 21] says that "the analysis of marketing margins indicates that price changes at one level of

the marketing system are typically reflected rather rapidly, and with little
changes in the marketing margin at other levels." Mangahas, Recto and Ruttan
[1965, p. 67] conclude that "the most important finding is that, in most cases,
the farm-retail margin does not rise when farm price does." A similar result
is found in Mears, et al., [1974, p. 254].

A regression analysis on the relationship between the deflated retail
price and the deflated farm price gave the following result:

$$P_m = .16 + .99 \ P_m$$

Where $P_m$ and $P_p$ are the deflated retail and farm prices, respectively. The
calculated slope was significant in .001% and the intercept in only 11%. The
correlation between the deflated margin and the deflated farm price was found
to be $r = -.01$.

The regression analysis was based on the data in Table 7.

Table 7

Retail and Farm Price of Rice, Philippines 1961-1977

| Year | CPI | Retail Price ₱/kg | Deflated Retail Price ₱/kg | Farm Price ₱/kg* | Deflated Farm Price* ₱/kg |
|------|-----|-------------------|----------------------------|------------------|---------------------------|
| 1961-62 | .806 | .43 | .53 | .38 | .47 |
| 1962-63 | .853 | .50 | .59 | .44 | .52 |
| 1963-64 | .901 | .63 | .70 | .52 | .58 |
| 1964-65 | .975 | .67 | .69 | .51 | .52 |
| 1965-66 | 1.000 | .69 | .69 | .54 | .54 |
| 1966-67 | 1.054 | .89 | .84 | .56 | .53 |
| 1967-68 | 1.120 | .85 | .76 | .54 | .48 |
| 1968-69 | 1.146 | .75 | .65 | .57 | .50 |
| 1969-70 | 1.169 | .83 | .71 | .56 | .48 |
| 1970-71 | 1.337 | .95 | .71 | .82 | .61 |
| 1971-72 | 1.532 | 1.24 | .81 | 1.02 | .67 |
| 1972-73 | 1.689 | 1.20 | .71 | 1.02 | .60 |
| 1973-74 | 1.875 | 1.90 | 1.01 | 1.49 | .79 |
| 1974-75 | 2.519 | 1.91 | .76 | 1.51 | .60 |
| 1975-76 | 2.720 | 1.87 | .69 | 1.54 | .57 |
| 1976-77 | 2.871 | 2.05 | .71 | 1.62 | .56 |

*Farm prices are converted to rice at 61% rate of recovery.

Source:  Alix, Kunkel and Gonzales [1978].

Based on the above findings, namely, the retail-farm margin does not depend on the farm price, we shall assume a fixed margin at the level of .45 ₱/Kg. This figure is the 1976-77 margin inflated for 1977-78 by 9% (the average yearly increase in the CPI). This figure is also consistent with the findings of Mangahas, Recto and Ruttan [1965, p. 65] which reported an average margin of 20%-30% of the retail price.

It should be noted that under the current floor price to the producers (1.10 ₱/Kg palay = 1.80 ₱/Kg rice) and the ceiling price to the consumers (2.10 ₱/Kg rice) the theoretical maximum margin can be only .30 ₱/kg. There are evidences, however, that the actual floor price to the farmer is under the official floor price. If we use the reported actual price to the producers (1.00 ₱/Kg palay = 1.64 ₱/kg rice) the actual margin will indeed be 2.10-1.64 = .46 ₱/kg rice. Therefore, we shall hold the assumption of a fixed retail-farm margin of .45 ₱/Kg.

### 3.4.4.2 NGA Post-Harvest Activities

#### 3.4.4.2.1 Notation

In order to facilitate the analysis of the post-harvest activities, a summary of the notation used is presented in Table 7a (see, also, Figure 2).

Table 7a

Summary of Notation

| Notation | Variable | Measure |
|----------|----------|---------|
| Ge | Government (NGA) expenditures | $\mathbb{P}$/cap. |
| Pe | Market clearing price | $\mathbb{P}$/Kg |
| Pi | Intermediaries margin | $\mathbb{P}$/Kg |
| Pm | Actual price of rice to the consumer | $\mathbb{P}$/Kg |
| $Pm^*$ | Ceiling price of rice to the consumer | $\mathbb{P}$/Kg |
| Pp | Actual price of <u>rice</u> to the producer | $\mathbb{P}$/Kg |
| $Pp^*$ | Floor price of <u>rice</u> to the producer | $\mathbb{P}$/Kg |
| Px | World market price for rice, CIF Manila | \$/Kg |
| $q_m$ | Actual quantity purchased by the consumers | Kg/cap. |
| $q_m^*$ | Quantity marketed, necessary to meet the ceiling price to the consumers | Kg/cap. |
| $q_p^*$ | Quantity marketed, necessary to meet the floor price to the producers | Kg/cap. |
| $q_s$ | Quantity supplied | Kg/cap. |
| $q_x$ | Quantity exported (imported) | Kg/cap. |
| r | Rate of currency exchange | $\mathbb{P}$/\$ |

Figure 2

Price-Quantity Relationship   (illustration)
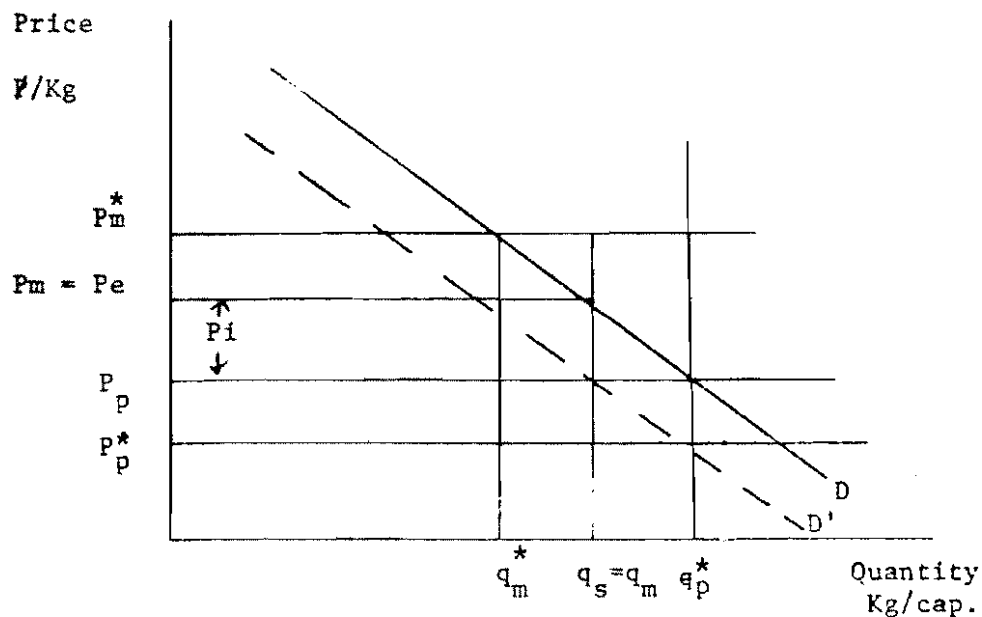


3.4.4.2.2.  General NGA Policies

We shall distinguish between two possible policies of NGA:

a)  The floor price to the producers ($P_p^*$) plus the intermediaries' margin (Pi) is greater or equal to the ceiling price to the consumers ($P_m^*$)

$$P_p^* + Pi \geq P_m^*$$

b)  The floor price plus the intermediaries' margin is lower than the ceiling price

$$P_p^* + Pi < P_m^*.$$

In case (a) NGA has to intervene regardless of the market behavior. We shall assume that for those policies which imply $P_p^* + Pi > P_m^*$, NGA will subsidize the rice by the amount $P_p^* + P_i - P_m^*$ for a kilogram consumed domestically.

If the quantity supplied is greater (smaller) than needed to meet the ceiling price, NGA will export (import) the surplus (deficiency). In this case we shall have (see also Figure 3):

$$Pm = P_m^*$$

$$Pp = P_p^*$$
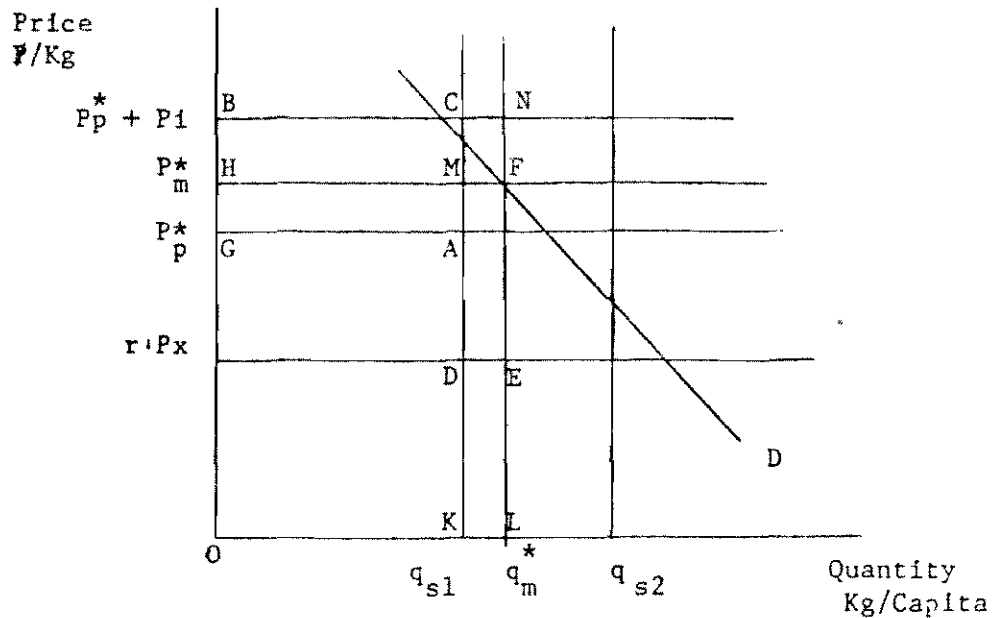
$$Ge = q_m^* (P_p^* + P_i - P_m^*) - (q_s - q_m^*)(\delta \cdot r \cdot P_x - P_p^* - P_i)$$

Where     Ge = government (NGA) expenditures per capita

$$\text{and } \delta = \begin{cases} 1 & \text{if } q_s \leq q_m^* & \text{(CIF)} \\[2em] .8 & \text{if } q_s > q_m^* & \text{(FOB)} \end{cases}$$

Figure 3

Price-Quantity Relationships for fixed rice prices and subsidies

As we can see in Figure 3, if the quantity supplied is $q_{s1}$, NGA would pay a subsidy of BCMH for domestic rice and KDEL for the imported rice. The consumers will pay for the imported rice the amount KMFC. If the quantity supplied is $q_{s2}$, NGA would export $q_{s2} - q_m^*$ and other costs and revenues would be similar to those for $q_{s1}$.

Remarks:

1) A policy in which the ceiling price to the consumers ($P_m^*$) is lower than the floor price to the producers ($P_p^*$) plus the margin of the intermediaries (Pi) actually means fixed prices at both the consumer and farm levels along with a government subsidy.

2) All the quantities in the above presentation are per nonrice-farming capita. In order to find the total quantities we have to multiply the results by the total nonrice-farming population.

3) We have assumed that, if NGA exports some of the rice, it would incur the same processing, transportation, and handling costs at the same level as those of the private sector. Therefore, NGA would pay for one kilogram of exported rice the price $P_p^* + P_i$.

In case (b) where $P_p^* + P_i < P_m^*$ we distinguish between three possible market scenarios:

1) $P_e < P_m^*$ and $P_e - P_i < P_p^*$. (See Figure 4.)

In that case the consumers' side is satisfied but not the producers'. We assume that, in order to meet the floor price to the producers ($P_p^*$), NGA would export the quantity $q_s - q_p^*$. The prices and expenditures would be:

$$Pp = Pp^*$$

$$Pm = Pp^* + \bar{P}_i \quad (< Pm^*)$$

$$Ge = (q_s - q_p^*) \cdot (Pp^* + P_i - .8 \cdot r \cdot P_x)$$

Figure 4

Price-Quantity Relationships for Excess Supply
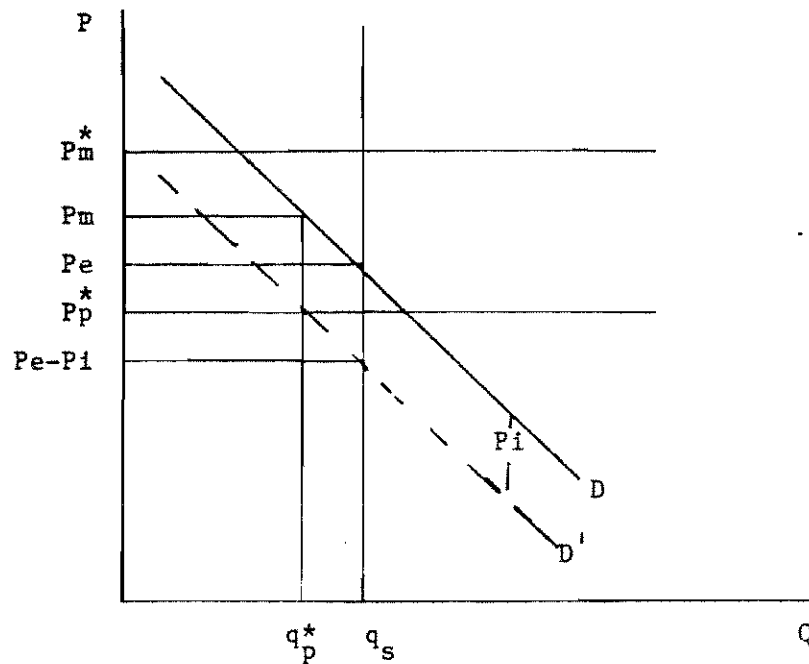


2) $Pe < Pm^*$ and $Pe - Pi > Pp^*$. (See Figure 5.)

In this case, since both sides are satisfied NGA would not intervene in the market. The prices and expenditures would be:

$$Pm = Pe$$

$$Pp = Pe - Pi$$

$$Ge = 0$$

Figure 5

Price-Quantity Relationships with No Post-Harvest NGA Intervention
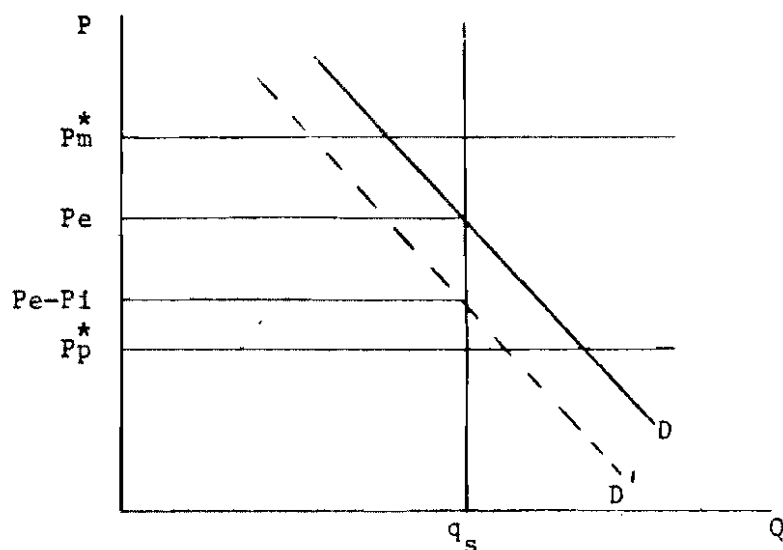


3)  $Pe > P_m^*$ and $Pe - Pi > P_p^*$.  (See Figure 6.)

In this case the producers' side is satisfied but not the consumers'. We assume that, in order to meet the ceiling price to the consumers $(P_m^*)$, NGA would import the quantity $q_m^* - q_s$.  The actual prices and expenditures would be:

$$Pm = P_m^*$$

$$Pp = P_m^* - Pi \quad \diamondsuit P_p^*)$$

$$Ge = (q_m^* - q_s) \cdot ( r \cdot Px - P_m^*)$$

Figure 6

Price-Quantity Relationships for Shortage in Supply
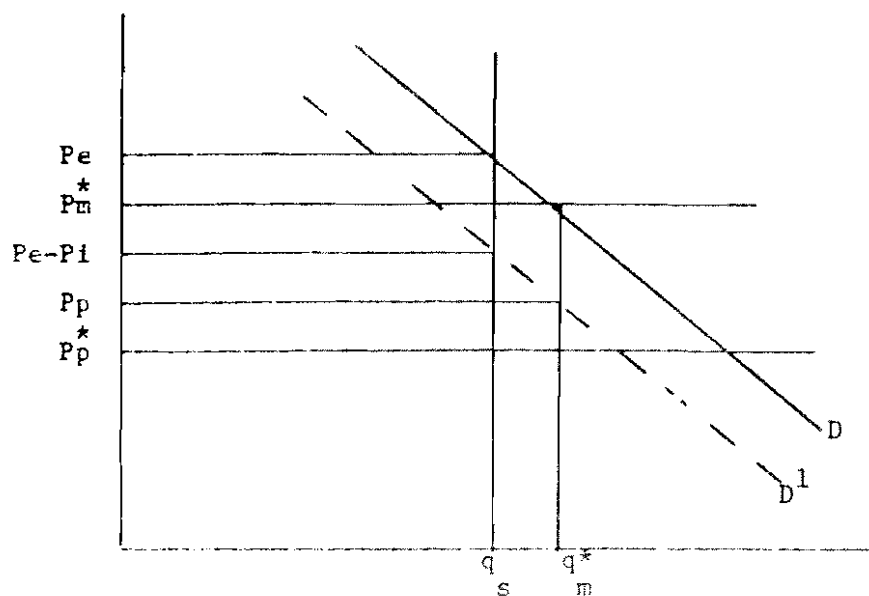
3.4.5  Summary of Uncertainties

Probability distributions were assesed to the following random
variables:

1)  Nature conditions - (3 possible conditions)

2)  Irrigated farms response to price policy - (3 possible outcomes)

3)  Non-irrigated farms response to price policy - (3 possible outcomes)

4)  Demand function for rice - (4 possible functions)

5)  World market price of rice - (5 possible prices)

All other random variables like the total quantity produced,
supplied, marketed or exported, the price to the producers and consumers,
and all the performance measures (to be discussed below) are assumed to be
deterministic functions of the five uncertain quantities mentioned above and
the policy variables.

At the end of the season, when the level of all uncertain quantities
is known, NGA is assumed to import or export rice, if necessary, to meet the
floor and/or ceiling price as determined by the policy it took before the
season.  The uncertainty part of the decision tree is shown in Figure 7.  In
spite of the many simplifications, e.g., limiting the alternatives of NGA and
restricting the probability distributions to only 3-5 points, the resulting
decision tree consists of almost 10,000 different end points.  The breakdown
of the total number of end-points is shown below.

Figure 7. Summary of Uncertainties
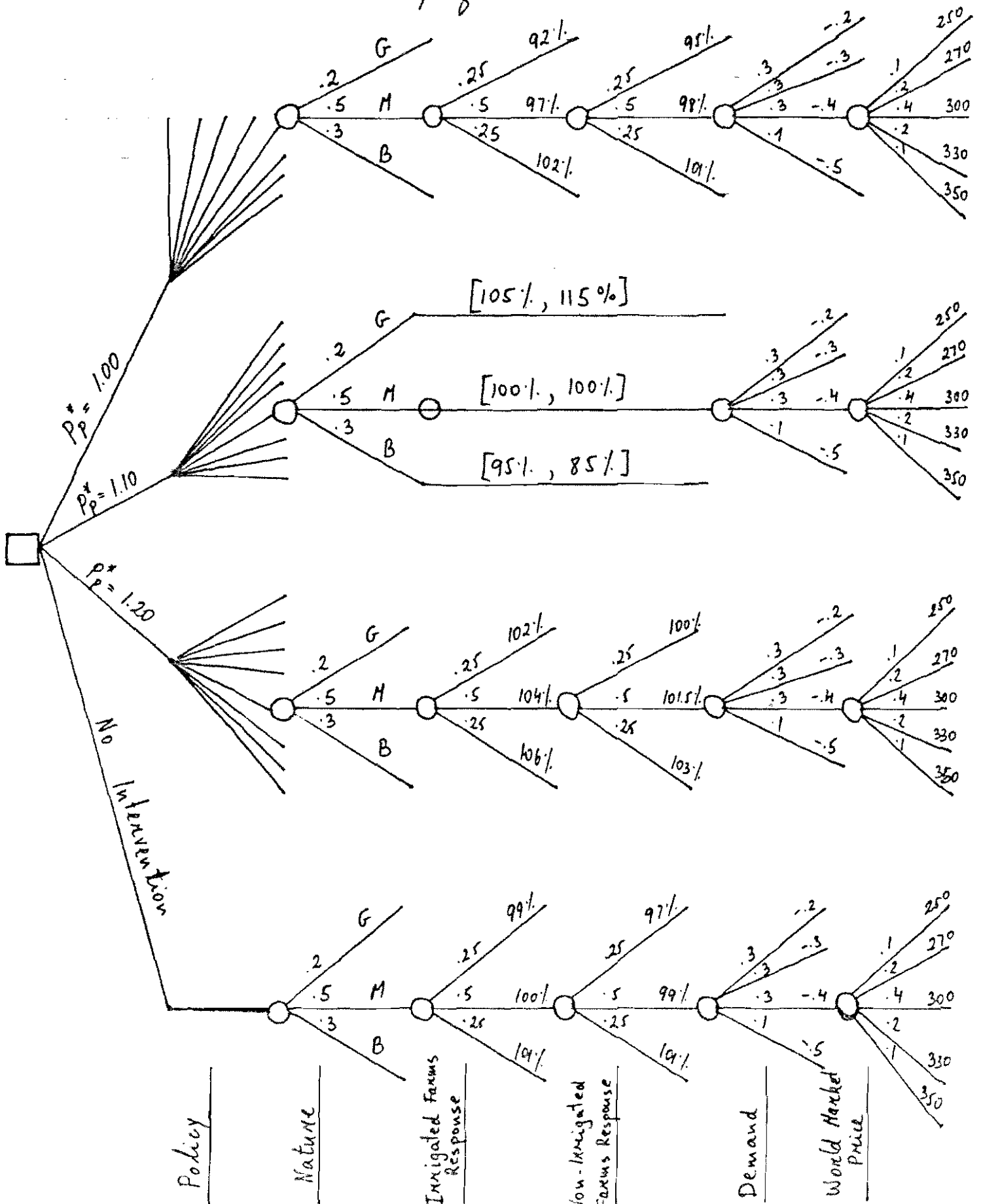
| Floor Price Policy | Ceiling Price Alternatives | Nature Conditions | Irrigated Farms Response | Non-Irrigated Farms Response | Demand | World Market Price | Total |
|---|---|---|---|---|---|---|---|
| 100₣/Kg | 8 | 3 | 3 | 3 | 4 | 5 | 4320 |
| 1.10₣/Kg | 8 | 3 | 1 | 1 | 4 | 5 | 480 |
| 1.20₣/Kg | 8 | 3 | 3 | 3 | 4 | 5 | 4320 |
| Free Market | 1 | 3 | 3 | 3 | 4 | 5 | 540 |
| Total | 25 | 75 | 177 | 483 | 1932 | 9660 | 9660 |

Notice that for the 1.10₣/Kg we have only one possible response of irrigated and non-irrigated farms. This is because the current floor price was the base case upon which the probability distributions of farmers' response to different policies were evaluated.

## 3.5 Performance Measures

The performance measure or attribute associated with each relevant objective should be quantified and measured. Thus, for example, if one of the objectives was full employment, a possible performance measure would be the percentage of people employed. If another objective was to avoid inflation, the performance measure might be the change in price index.

For some objectives there are many alternative performance measures that might be employed. For example, the performance measure for a price sta- bility objective could be the standard deviation of the prices, the absolute deviation of the prices from their mean, the deviation of the current price from that of the previous period and the like. Since some objectives may be quanti- fied by different performance measures, it is important that the analyst clearly define the appropriate measure for each attribute. The measures should be reasona- bly simple and clear to the users of the model since they must provide their risk perceptions toward each of the attributes (utility functions), the trade- offs between the different attributes (independence relationships), and the

importance of each attribute in the overall objective function (weights). The assessment task on each of these perceptions is sufficiently complicated with simple performance measures and thus "sophisticated" performance measures should be avoided wherever possible.

### 3.5.1 Farmers Net Income

The performance measure of this attribute is the average net income of a rice farm in one cycle (wet). The net income was defined as the gross income (sales) minus the variable cost (hired labor and inputs).

$$R_p = \frac{\sum_{j=1}^{2} M_j \left[(\tilde{Y}_j h - H_c - H_s) \tilde{P}_p - h (\tilde{CL}_j + \tilde{CI}_j)\right]}{\sum_{j=1}^{2} M_j}$$

$R_p$ = average net income to farmer per cycle (₱)

$M_j$ = number of farms in category j

$j = \begin{cases} 1 \text{ for irrigated farms} \\ 2 \text{ for non-irrigated farms} \end{cases}$

$\tilde{Y}_j$ = yield per hectar in farm of type j (Kg/hectare)

$h$ = average farm size = 2.5 hectars

$H_c$ = farm household consumption per cycle = 535Kg palay

$H_s$ = farm household storage in wet cycle = 135Kg palay

$\tilde{P}_p$ = the price of palay to the farmer (₱/Kg)

$\tilde{CL}_j$ = cost of hired labor in farm type j (₱/hectare)

$\tilde{CI}_j$ = cost of inputs in farm type j (₱/hectare)

Remarks:

1) Average farm size is assumed to be equal for irrigated and non-irrigated farms.

2) Household consumption is based on average family size of 6.5 and yearly consumption of 100Kg rice per capita which is equal to 164 Kg palay.

3) Since the wet season supplies about 5/8 of the total annual production it is assumed that the farmers store 1/8 of their yearly consumption to be consumed in the dry season.

4) Hired labor is used mainly in the planting and harvesting seasons. We shall assume that the hired labor used for planting rice will not change as the floor price policy changes. The hired labor used for harvesting, however, will be assumed to be proportional to the yield per hectare. Thus, if in a normal year (weather wise) and under the current floor price the cost of hired labor per irrigated hectar is $X_1$, approximately half for planting, and half for harvesting, the cost of hired labor for floor price equals 1.20 ₱/Kg and farmer's response of 116%, and bad nature conditions would be:

$$CL_1 = .5 (X_1 + X_1 \cdot 1.06 \cdot .95) = 1.0035X_1$$

For non-irrigated farms with 1.03% response to $P^*_p = 1.20$ ₱/Kg and good nature conditions the cost of hired labor would be:

$$CL_2 = .5 (X_2 + X_2 \cdot 1.03 \cdot 1.15) = 1.092X_2$$

The figures in the above calculation were derived from the respective uncertainty sections. The .5 is based on the fact that in a normal year about 50% of the hired labor is devoted for planting and the other 50% for the harvesting.

(5) The cost of inputs is assumed to be proportional to the farmer's response to the floor price.


## 3.5.2 Self-Sufficiency in Rice Production

The performance measure for this objective will be the percentage of the quantity supplied out of the quantity needed to meet the average consumption of the non-rice-farming population (100 Kg/cap/year.)

$$F_s = \frac{q_s}{50} \cdot 100$$

Where:

$F_s$ = measure for self-sufficiency

$q_s$ = the quantity of rice supplied per capita (Kg)

50 = quantity consumed per semester per capita (Kg)

Remark:

$$q_s = \frac{\{\sum_{j=1}^{2} M_j (Y_j \cdot h - H_c - H_s)\} \cdot .5}{T_n \cdot .625}$$

Since about 5/8 of the total yearly production is produced in the

wet season, 100% self-sufficiency is defined as the quantity necessary

to meet the consumption at the wet season plus 1/8 of the yearly

consumption to be consumed in the dry season but produced in the

wet season.

The total non-rice farming population (Tn) is based on total population

of 44 million and .96 million rice farms with average family size of 6.5.

### 3.5.3  Consumers' Welfare

The common measure for consumers' welfare is the area bound by the

demand curve, price line, and price axis (see Figure 8) commonly referred to

as consumers' surplus,

$$W_c' = \int_{P_m}^{P'} D(P) \, dp$$

where

$W_c'$ = measure of consumer welfare

$P'$ = reference price to the consumer

$P_m$ = the price to the consumer

$D(P)$ = demand function

Figure 8

The Consumers' Surplus
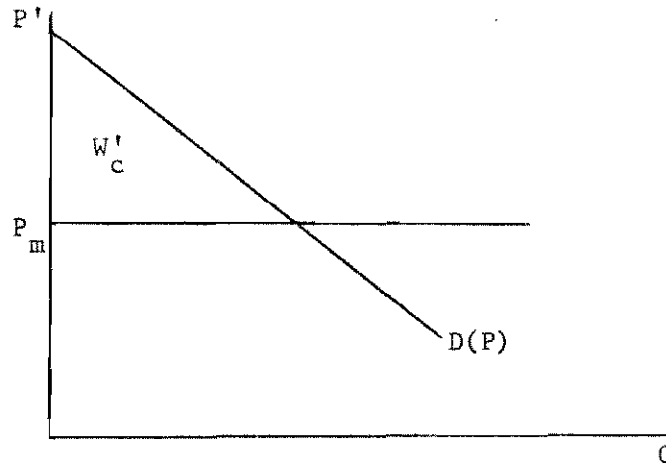


This measure has some difficulties, namely, the inability of government officials and economists to assign a utility function over such a theoretical measure. For this reason, it is important from a preference assessment standpoint to select a measure which is meaningful to the decisionmakers. Fortunately, in the case of rice in the Philippines, such a measure is readily available. In particular, for a perfectly inelastic demand, the change in consumer welfare, as implied by the theoretical measure $W_c'$, is equivalent to the change in price. Hence, since the demand for rice in the Philippines is highly inelastic, a good performance measure is

$$W_c = P_m$$

Where

$W_c$ = measure of consumer welfare

$P_m$ = price of rice to the consumer

The assessment over this performance measure will clearly be much easier than the consumer surplus measure $W_c'$.

### 3.5.4  Price Variability

The performance measure for price variability will be the absolute deviation of the consumers' price from the price in the previous cycle.

$$V_p = |P_{m_t} - P_{m_{t-1}}|$$

Where

$V_p$ = price variability measure

$P_{m_t}$ = the price to the consumer in period t

The common measure for price variability is the standard deviation of the prices. But, once again, we have chosen a more simple measure which is more clear to the users of the model when assigning the utility function. In addition, the proposed performance measure does not penalize for large deviations from the expected price. The performance measure should be used only for measuring the performance and not as a penalty function. The penalty for large deviation, if necessary, would be reflected in the utility function.

### 3.5.5 Government Expenditures

The performance measure for this attribute is the total expenditure (see Section 3.4.2.2) per capita of NGA in executing its policies. These expenditures consist of:

a) Cost of purchasing palay from the farmers (+)

b) Cost of importing rice (+)

c) Revenues from selling rice to consumers (-)

d) Revenues from exporting rice (-).

### 3.6 The Objective Function

Because of the uncertainties and risks involved in the rice industry of the Philippines, and the multiple objectives of NGA, the appropriate objective function is the expected value of a multi-attribute utility function. The following steps were taken in identifying the utility function:[1]

Assessing the univariate utility functions: After an appropriate performance measure is chosen for each objective, it is necessary to evaluate NGA's risk perception toward different levels of the attributes. Risk perception is assessed by determining a certainty equivalent for each risky prospect. A certainty equivalent is the amount exchanged with certainty that makes the decisionmaker indifferent between this exchange and some particular risky prospect. In order to determine the decisionmaker preference, we first find the certainty equivalent (CE) for a hypothetical 50-50 lottery for two risky consequences representing the best and worst possible outcomes. The worst outcome will be denoted by $x_i^0$, the best by $x_i^1$, and the first CE by $x_i^{.5}$. The i stands for the ith attribute and the .5 for the midvalue between 0 and 1, to reflect the 50-50 lottery for two extreme consequences. The point $x_i^{.5}$ is found by

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[1] For theoretical background and applications of the use of mutli-attribute utility functions, see Keeney and Raiffa (1976).

posing the question: what would x have to be such that the decisionmaker would be indifferent between x with certainty and the uncertain situation in which there is a 50 percent chance of the best outcome and a 50 percent chance of the worst outcome? After one finds $x_i^{.5}$, one can in turn find the CE for each of the two 50-50 lotteries involving $x_i^{.5}$; this yields $x_i^{.25}$ and $x_i^{.75}$, which are the CEs between $X_i^0$ and $x_i^{.5}$ and $x_i^{.5}$ and $x_i^1$, respectively. At this stage we have five utility points, $x_i^0$, $x_i^{.25}$, $x_i^{.5}$, $x_i^{.75}$, and $x_i^1$, which are the basis for approximating a continuous utility function.[1]

Determining the independence relationships among the different attributes and the functional form of the multi-attribute utility function: Here the preference structure of the decisionmaker is examined. Of particular concern is whether the level of a certain attribute, say $x_1$, influences his preferences among other attributes, say $x_2$ and $x_3$ (preferential independence) and a determination of whether a level of one attribute, say $x_1$, influences the risk the decisionmaker is willing to take toward uncertainties in the levels of other attributes, say $x_2$, $x_3$, and $x_4$ (utility independence). Finally, multi-attribute risk neutrality, or additive independence, must be investigated. Definitions and examples for these independence relationships are given in part I of the manual.

Assessing the scaling factors (weights) of each of the attributes in the overall utility function: In this final stage, after the general functional form of the objective function is known (from the previous two steps), the relative importance or weight of each attribute in the overall objective function must be isolated.

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[1] For further elaboration on this assessment procedure, see J. R. Anderson, J. L. Dillon, and B. Hardaker, "Agricultural Decision Analysis," Chapter 4, and H. Raiffa, "Decision Analysis," Chapter 4.

The utility function to be developed below is based on an interview with Dr. J. D. Drilon, former Undersecretary of Agriculture and Administrator of the Rice and Corn Administration and currently the Director of the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) in Los Baños.

### 3.6.1 Five-Point Univariate Utility Functions

The univariate utility functions were assessed by using the Certainty Equivalent to 50-50 lotteries. The summary of the five-point utility functions is reported in Table 8.

Table 8

Five-Point Univariate Utility Functions

| Attribute | Utility | | | | |
|---|---|---|---|---|---|
| | $x_i^0$ | $x_i^{.25}$ | $x_i^{.5}$ | $x_i^{.75}$ | $x_i^1$ |
| $x_1$ (₱) | 1,500 | 1,700 | 2,000 | 2,500 | 3,600 |
| $x_2$ (%) | 80 | 85 | 93 | 100 | 120 |
| $x_3$ (₱/Kg) | 4.00 | 3.60 | 3.00 | 2.50 | 1.00 |
| $x_4$ (₱/Kg) | 3.00 | 2.60 | 2.00 | 1.30 | 0.00 |

Remarks:

1) $x_1 = R_p$ = average net income to the farmer

   $x_2 = F_s$ = percentage of self-sufficiency in rice production

   $x_3 = W_c$ = consumers' price of rice

   $x_4 = V_p$ = change in the consumers' price.

2) When the interview with Dr. Drilon took place, decreased government expenditures ($G_e = x_5$) were not considered by NGA officials as a very important objective. The utility function of this attribute does not appear, therefore, in Table 8.

3) The values of $x_i^0$ and $x_i^1$ in Table 8 are not necessarily the worst and the best possible values of $x_i$; they only represent estimates of the extreme outcomes. Since the decision tree had not been analyzed prior to the interview, these figures represent the decisionmaker's estimates of the minimum and maximum values of $x_i$. The appropriate adjustments to these values and the univariate utility functions derived from them are described in the following section.

### 3.6.2 Continuous Univariate Utility Functions

The minimum and the maximum levels of the five attributes, those estimated in the interview and those calculated in the decision tree, are shown in Table 9.

Table 9

Estimated and Actual Minimum and Maximum Levels
of the Five Attributes of the Objective Function

| Attribute | Minimum | | Maximum | |
|---|---|---|---|---|
| | Estimated | Actual | Estimated | Actual |
| $x_1$--Farmers' Income (₱) | 1,500 | 1,160 | 3,600 | 5,760 |
| $x_2$--Self-Sufficiency (%) | 80 | 76 | 120 | 111 |
| $x_3$--Consumers' Welfare (₱/Kg) | 1.00 | 1.53 | 4.00 | 4.13 |
| $x_4$--Price Variability (₱/Kg) | 0 | 0 | 3.00 | 2.03 |
| $x_5$--Government Expenditures (₱/cap) | -- | -9 | -- | 42 |

Since the feasibility ranges of $x_1$, $x_2$, and $x_3$ did not coincide with the estimated ones, it was necessary to adjust the original utility functions. This adjustment was done in the following steps:

1) Make an assumption on the form of the utility function (constant risk averse, decreasing risk averse, etc.).

2) Solve for the parameters of the implied utility function.

3) Compute the utility of the new extreme points.

4) Make a positive linear transformation such that the utility of the best and the worst outcomes would be 1 and 0, respectively.

5) The transformed utility functions are the ones to be used in the multi-attribute utility function.

Based on the values from Table 8 and the assumptions made with regard to the Government Expenditures attribute, the five univariate utility functions were found to be (see Appendix A):

$$u_1(x_1) = 1.01 - 4.29e^{-.00125x_1}$$

$$u_2(x_2) = -1.12 + .54 \ln (x_2 - 68)$$

$$u_3(x_3) = .09 + .66 \ln (5 - x_3)$$

$$u_4(x_4) = .72 \ln (4 - x_4)$$

$$u_5(x_5) = -4.81 + 1.28 \ln (85 - x_5)$$

where

$u_i(x_i)$ = utility function for the $i$th attribute, $i = 1, 2, 3, 4, 5$

$x_i$ = level of the $i$th attribute, $i = 1, 2, 3, 4, 5$

ln = natural logarithm.

### 3.6.3 The Multiattribute Utility Function

Based on the interview mentioned above, it was found that a multiplicative utility function is the appropriate form to represent the preference structure of NGA. The procedure used (see Appendix A ) was to check first for preferential independence between $x_1 x_i$ and $\bar{x}_{1i}$, where $i = 2, 3, 4$ and $\bar{x}_{1i}$ are all the couples not containing $x_1$ or $x_i$. In other words, we checked for and found preferential independence between $x_1 x_2$ and $x_3 x_4$; $x_1 x_3$ and $x_2 x_4$; and $x_1 x_4$ and $x_2 x_3$. thus, for example, when making preference assessment over pairs of $x_1$ and $x_2$, these assessments are not influenced by the joint level of $x_3$ and $x_4$.

After preferential independence had been found we checked for and found utility independence between $x_1$ and $x_2 x_3 x_4$. This means that the four attributes $x_1$, $x_2$, $x_3$, and $x_4$ are mutually utility independent.

The last check with regard to the functional form of the utility function was for additive independence. It was found that additive independence does not hold for NGA, or, in other words, NGA is multiattribute risk averse. The explanation for this attitude was that administrators of government and other public agencies would prefer to be successful in one objective and to fail in another rather than either succeed or fail in both. As the saying goes, "A bird in the hand is worth two in the bush."

Based on these finding the utility function was determined to be of the form

$$1 + ku(x_1, x_2, x_3, x_4) = [1 - kk_1 u_1(x_1)] \cdot [1 - kk_2 u_2(x_2)]$$
$$\cdot [1 - kk_3 u_3(x_3)] \cdot [1 - kk_4 u_4(x_4)] \tag{3.18}$$

where $k$ and $k_i$, $i = 1, 2, 3, 4$, are the scaling constants.

After the functional form had been determined, the scaling constants ($k_i$) were found (see Appendix A ) and $k$ was calculated by solving

$$1 + k = (1 + kk_1)(1 + kk_2)(1 + kk_3)(1 + kk_4). \tag{3.19}$$

Based on these findings the form of the utility function was determined
to be

$$u(x_1, x_2, x_3, x_4) = 1 - [1 - .7u_1(x_1)] \cdot [1 - .5u_2(x_2)]$$
$$\cdot [1 - .6u_3(x_3)] \cdot [1 - .5u_4(x_4)]. \qquad (3.20)$$

As mentioned above, $x_5$ (government expenditures per capita) was not considered
as an important attribute at the time the interview took place. In order to complete
the utility function to include $x_5$ it was assumed that the independence relation-
ship found for the four other attributes also holds for $x_5$. Thus, the final form
of the utility function is

$$1 + k'u(x_1, x_2, x_3, x_4, x_5) = [1 - k'k_1'u_1(x_1)] \cdot [1 - k'k_2'u_2(x_2)]$$
$$\cdot [1 - k'k_3'u_3(x_3)] \cdot [1 - k'k_4'u_4(x_4)]$$
$$\cdot [1 - k'k_5'u_5(x_5)] \qquad (3.21)$$

where $k'$ and $k_i'$, i = 1, 2, 3, 4, 5, are the adjusted scaling constants and $u_1$,
$u_2$, $u_3$, $u_4$, and $u_5$ are (3.11), (3.14), (3.15), (3.16), and (3.17), respectively.

Based on the findings on the four-attribute utility function and on an assump-
tion about the value of $k_5'$ (see Appendix A ) the variables $k_i'$ and $k'$ were calcu-
lated and the final utility function to be used in the analysis of the decision
tree is

$$u(x_1, x_2, x_3, x_4, x_5) = 1 - [1 - .8u_1(x_1)] \cdot [1 - .58u_2(x_2)]$$
$$\cdot [1 - .65u_3(x_3)] \cdot [1 - .52u_4(x_4)]$$
$$\cdot [1 - .33u_5(x_5)]. \qquad (3.22)$$

## 4.  PRELIMINARY RESULTS

### 4.1  Introduction and Data

A computer program was written for solving the model (Appendix B).  The program incorporates all the specifications and assumptions of the model and the following data:

1.  Average family size of a rice-growing farm is 6.5.[a]

2.  Current yearly consumption of rice is 100 Kg/capita.[b]

3.  Rate of recovery from palay to rice is .61.[c]

4.  Wet season production is 62.5% of the total year production.[c]

5.  Intermediaries margin is ₱.45/Kg.[d]

6.  Yield of irrigated and nonirrigated farms are 2.25 and 1.5 tons/hectare, respectively (45 and 30 cavans/hectare).[c]

7.  Average farm size, irrigated and nonirrigated is 2.5 hectares.[c]

8.  Numbers of irrigated and nonirrigated farms are 360,000 and 600,000, respectively (900,000 and 1,500,000 hectares).[c]

9.  Costs of labor per irrigated and nonirrigated hectares are 400 ₱/h and 300 ₱/h, respectively.[e]

10.  Cost of inputs per irrigated and nonirrigated hectares are 400 ₱/h and 250 ₱/h, respectively.[e]

11.  Current price of rice to consumers is 2.10 ₱/Kg.[c]

12.  Exchange rate = ₱7.3 per $1.00.

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Sources:

[a]Y. Hayami et al., "Anatomy of Peasant Economy:  The Economic Accounts of Rural Households in the Philippines," IRRI, Paper No. 76-25 (revised), July, 1977.

[b]Aviguetero et al., "Summary of 19 Economic Surveys of Food Consumption," Special Studies Division, Department of Agriculture, March, 1977.

[c]J. E. Alix, D. E. Kunkel, and L. A. Gonzales, "Analyzing Statistics on Palay Production Area, Yield, Stock Inventory and the Masagana 99 Program." Quezon City:  Bureau of Agricultural Economics.

[d]Section 3.4.4.1 of the model.

[e]NGA files.

## 4.2 The Optimal Policy

The expected utilities of the different policies, as computed by the computer program, are given in Table 1.

### Table 1

The Expected Utilities of the Various Policies

| Ceiling price | Floor price | | |
|---|---|---|---|
| | 1.00 | 1.10 | 1.20 |
| 1.70 | .93569 | .95244 | .96190 |
| 1.90 | .93977 | .95566 | .96470 |
| 2.10 | .94362 | .95809 | .96678 |
| 2.30 | .95274 | .95851 | .96581 |
| 2.50 | .95752 | .96222 | .96577 |
| 2.70 | .95946 | .96351 | .96666 |
| 2.90 | .95983 | .96375 | .96675 |
| 3.10 | .95940 | .96345 | .96646 |

No government intervention:  .95569.

These expected utilities can be used not only for ranking the policies but also to compare their performance in terms of the five attributes. Such comparisons between the alternative (floor price of ₱1.20/Kg palay and ceiling price of ₱2.10/Kg rice) selected on the basis of the preliminary analysis and the current policy (₱1.10 and ₱2.10, respectively) shown in Table 2. The difference in the expected utility of the two alternatives may be translated to values of the individual performance measures. Thus, for example, the levels of $x_1$, $x_2$, $x_3$, and $x_4$ are held fixed, and the

TABLE 2

Comparison Between the Preliminary Selected and the Current Policies

| | Selected policy 1.20, 2.10 | Current policy 1.10, 2.10 | Difference percent |
|---|---|---|---|
| Expected utility | .96678 | .95809 | |
| Value of:[a] | | | |
| $X_1$ ($\not\!P$)[b] | 2,460 | 2,095 | 17.4 |
| $X_2$ (percent)[c] | 101.7 | 89.3 | 13.9 |
| $X_3$ ($\not\!P$ per kilogram)[d] | 2.10 | 2.84 | 26.1 |
| $X_4$ ($\not\!P$ per kilogram)[e] | 1.10 | 2.10 | 47.6 |
| $X_5$ ($\not\!P$ per capita)[f] | 11.5 | 39.5 | 70.9 |

[a]Computed for all other attributes satisfy $u_j (X_j) = .84$, $j \neq 1$.

[b]Farmers' income.

[c]Self-sufficiency.

[d]Consumer price.

[e]Change in consumer price.

[f]Government expenditures.

values of $x_5$--which yield the respective expected utility--are computed.
Note that the expected utility of the selected and current policies were
found to be .96678 and .95809, respectively.

Note that a small difference in the expected multiattribute utility may
imply a very large difference in the performance measures of the individual
attributes.  The reasons are:  (1) at the higher levels of the utility (as
those reported in the analysis above), the utility curve is very flat and
(2) if we hold four of the five attributes constant, all the differences in
the multiattribute utility are concentrated on the remaining attribute.
Since the univariate utility function at the higher levels of the utility
is also flat, it results in a large difference in the performance measure.

As Table 2 suggests, the differences between the two policies are striking
when measured with individual attributes.  This is due to the slopes of the
univariate utility functions over the specified range and the different
values of the scaling constants ($k_i$s) in the multiattribute utility function.

## Appendix A--Preference Analysis

### A.1  Introduction

In this appendix we first describe the interview with Dr. J. D. Drilon which led to the construction of the utility function of the first four attributes. In the second part of the appendix, we describe the adjustments of the parameters of the utility function to include the fifth variable and to account for the difference in the range between the estimated and actual minimum and maximum values of the five attributes.

The five attributes in the utility function are:

$X_1$ = Net income of farmers ($\text{\P}$ per farmer)

$X_2$ = Rice sufficiency (percent)

$X_3$ = Consumers' welfare ($\text{\P}$ per Kg of rice)

$X_4$ = Price variability ($\text{\P}$ per Kg change from previous cycle)

$X_5$ = Government expenditures ($\text{\P}$ per capita)

### A.2  The Continuous Univariate Utility Functions of $x_1$, $x_2$, $x_3$, and $x_4$

#### A.2.1  Utility Function for Farmers' Income $(x_1)$

The utility function with regard to the farmers' income was assumed to be constant risk averse, i.e., of the form

$$u_1(x_1) = a_1 - b_1 e^{-c_1 x_1}.$$

The reason for that assumption was mainly practical. The difference between the estimated and the calculated values of the minimum income per farmer was very significant (1,500 versus 1,160 ₽ per farmer). Risk aversion was demonstrated as reported in Table 8. If we assumed decreasing risk aversion, the extrapolation of the utility function would have resulted in a very inaccurate value due to the sharp slope of the logarithmic utility function (the appropriate one for decreasing risk aversion) at the lower values of the attribute. A constant risk averse function fitted quite well the five points and prevented the bias for the new minimum level of the farmers' income.

Using the two extreme points ($x^0$ and $x^1$) and the .5 utile we get:

$$-e^{-2,000\ c_1} = 1/2\left(-e^{-1,500\ c_1} -e^{-3,600\ c_1}\right)$$

and solving for $c_1$ we get $c_1 = .00125$.

In order to find the values of $a_1$ and $b_1$ in (3.5) we solve

$$a_1 - b_1 e^{-.00125 \cdot 1,500} = 0,$$

and

$$a_1 - b_1 e^{-.00125 \cdot 3,600} = 1$$

which results in $b_1 = 7.03$ and $a_1 = 1.08$.

The utility function (before transformation) is, therefore,

$$u_1(x_1) = 1.08 - 7.03e^{-.00125x_1} \qquad (A.1)$$

Substituting for $x_1$, we get:

$$u_1(1,160) = -.57$$

$$u_1(1,700) = .24$$

$$u_1(2,500) = .77$$

$$u_1(5,760) = 1.07$$

From $u_1(1,700)$ and $u_1(2.500)$ we see that (A.1) fits well the five original points (note that 1,700 and 2,500 were the .25 and .75 utiles, respectively). By solving

$$A + B \cdot 1.07 = 1$$

and

$$A + B \cdot (-.57) = 0,$$

we get A = .35 and B = .61. The transformed utility function $A + B \cdot u_1(x_1)$ is, therefore,

$$u_1(x_1) = 1.01 - 4.29e^{-.00125x_1} \tag{A.2}$$

A.2.2    <u>Utility Functions for Self-Sufficiency, Consumers' Welfare, and</u>
<u>Price Variability $(x_2, x_3, x_4)$</u>

The utility functions of these attributes were assumed to be decreasingly risk averse. This reflects the general assumption that the better the situation the less risk averse is the decision-maker.

The general form of this utility function is

$$u(x) = a + c \cdot \ln(x - b)$$

for increasing utility functions and

$$u(x) = a + c \cdot \ln(b - x)$$

for decreasing utility functions.

Following a similar procedure described in A.2.1 we get the following utility functions:

$$u_2(x_2) = -1.12 + .54 \cdot \ln(x_2 - 68) \tag{A.3}$$

for self-sufficiency,

$$u_3(x_3) = .09 + .66 \cdot \ln(5 - x_3) \tag{A.4}$$

for consumers' welfare, and

$$u_4(x_4) = .72 \cdot \ln(4 - x_4) \tag{A.5}$$

for price variability.

## A.3 Independence Relationships

### A.3.1 Preferential Independence (PI)

a) $X_1 X_2$ PI of $X_3 X_4$

Q. What would you prefer, $S_1$ or $S_2$?

$$S_1 \equiv \begin{cases} x_1 = ₱1,800 \\ x_2 = 100\% \\ x_3 = ₱3/Kg \\ x_4 = ₱1/Kg \end{cases} \qquad S_2 \equiv \begin{cases} x_1 = ₱3,600 \\ x_2 = 90\% \\ x_3 = ₱3/Kg \\ x_4 = ₱1/Kg \end{cases}$$

A.  $S_2 > S_1$.

Q.  What would you prefer, $S_3$ or $S_4$?

$$S_3 \equiv \begin{cases} x_1 = \text{₱}1,800 \\ x_2 = 100\% \\ x_3 = \text{₱}2/Kg \\ x_4 = \text{₱}0/Kg \end{cases} \qquad S_4 \equiv \begin{cases} x_1 = \text{₱}3,600 \\ x_2 = 90\% \\ x_3 = \text{₱}2/Kg \\ x_4 = \text{₱}0/Kg \end{cases}$$

A.  $S_4 > S_3$.

Q.  How did the levels of $x_3$ and $x_4$ affect your preference?

A.  As long as $x_3$ and $x_4$ are the same in the two situations compared I would prefer (₱3,600, 90%) to (₱1,800, 100%).

Conclusion:   $x_1 x_2$ PI of $x_3 x_4$

b)  $x_1 x_3$ PI of $x_2 x_4$

Q.  What would you prefer, $S_5$ or $S_6$?

$$S_5 \equiv \begin{cases} x_1 = \text{₱}1,800 \\ x_3 = \text{₱}2/Kg \\ x_2 = 90\% \\ x_4 = \text{₱}1/Kg \end{cases} \qquad S_6 \equiv \begin{cases} x_1 = \text{₱}3,600 \\ x_3 = \text{₱}3/Kg \\ x_2 = 90\% \\ x_4 = \text{₱}1/Kg \end{cases}$$

A.  $S_6 > S_5$.

Q.  What would you prefer, $S_7$ or $S_8$?

$$S_7 \equiv \begin{cases} x_1 = \text{₱}1,800 \\ x_3 = \text{₱}2/Kg \\ x_2 = 110\% \\ x_4 = \text{₱}0/Kg \end{cases} \qquad S_8 \equiv \begin{cases} x_1 = \text{₱}3,600 \\ x_3 = \text{₱}3/Kg \\ x_2 = 110\% \\ x_4 = \text{₱}0/Kg \end{cases}$$

A.  $S_8 > S_7$.

Q.  How did the levels of $x_2$ and $x_4$ affect your preference?

A.  As long as $x_2$ and $x_4$ are the same in the two situations compared I would prefer (₱3,600, ₱3/Kg) to (₱1,800, ₱2/Kg).

Conclusion:  $x_1 x_3$ PI of $x_2 x_4$

c)  $x_1 x_4$ PI of $x_2 x_3$

Q.  What would you prefer, $S_9$ or $S_{10}$?

$$S_9 \equiv \begin{cases} x_1 = ₱3,600 \\ x_4 = ₱1/Kg \\ x_2 = 90\% \\ x_3 = ₱3/Kg \end{cases} \qquad S_{10} \equiv \begin{cases} x_1 = ₱1,800 \\ x_4 = ₱0/Kg \\ x_2 = 90\% \\ x_3 = ₱3/kg \end{cases}$$

A.  $S_9 > S_{10}$.

Q.  What would you prefer, $S_{11}$ or $S_{12}$?

$$S_{11} \equiv \begin{cases} x_1 = ₱3,600 \\ x_4 = ₱1/Kg \\ x_2 = 110\% \\ x_3 = ₱2/Kg \end{cases} \qquad S_{12} \equiv \begin{cases} x_1 = ₱1,800 \\ x_4 = ₱0/Kg \\ x_2 = 110\% \\ x_3 = ₱2/Kg \end{cases}$$

A.  $S_{11} > S_{12}$.

Q.  How did the levels of $x_2$ abd $x_3$ affect your preference?

A.  As long as $x_2$ and $x_3$ are the same in the two situations compared I would prefer (₱3,600, ₱1/Kg) to (₱1,800, ₱0/Kg).

Conclusion:  $x_1 x_4$ PI of $x_2 x_3$.

### A.3.2 Utility Independence (UI)

a) $x_1$ UI of $\bar{x}_1$

  Q. What should $x_1'$ be so that you would be indifferent between $L_1$ and $S_{13}$?

$$L_1 \equiv \begin{cases} .5 \nearrow \text{\textP}1,800, \ 90\%, \ \text{\textP}3/Kg, \ \text{\textP}1/Kg \\ \\ .5 \searrow \text{\textP}3,600, \ 90\%, \ \text{\textP}3/Kg, \ \text{\textP}1/Kg. \end{cases}$$

$$S_{13} \equiv x_1', \ 90\%, \ \text{\textP}3/Kg, \ \text{\textP}1/Kg$$
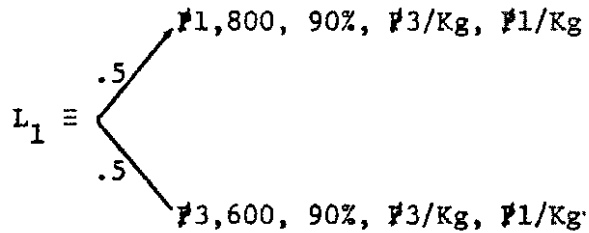
  A. $x_1' = \text{\textP}2,400.$

  Q. What should $x_1''$ be so that you would be indifferent between $L_2$ and $S_{14}$?

$$L_2 \equiv \begin{cases} .5 \nearrow \text{\textP}1,800, \ 110\%, \ \text{\textP}2/Kg, \ \text{\textP}0/Kg \\ \\ .5 \searrow \text{\textP}3,600, \ 110\%, \ \text{\textP}2/Kg, \ \text{\textP}0/Kg \end{cases}$$

$$S_{14} \equiv x_1'', \ 110\%, \ \text{\textP}2/Kg, \ \text{\textP}0/Kg$$
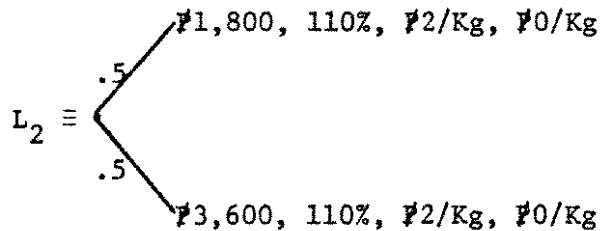
  A. $x_1'' = \text{\textP}2,400.$

  Q. How would different levels of $(x_2, x_3, x_4)$ affect the level of $x_1$ you decide on?

  A. As long as the levels of $(x_2, x_3, x_4)$ are the same in the two branches of the lottery and the situation it is compared to, the level of $x_1$ will be the same and determined by the levels of $x_1$ on the branches of the lottery only.

Conclusions:

  1) $x_1$ UI of $x_2 x_3 x_4$;

  2) $x_1$, $x_2$, $x_3$, and $x_4$ are mutually utility independent (MUI).

### A.3.3 Additive Independence (AI)

a)  $x_1$  AI of  $x_2$

Q. What would you prefer,  $L_3$  or  $L_4$ ?



$$L_3 \equiv \begin{cases} .5 \quad \text{₱1,800, 100\%, ₱2.5/Kg, ₱1/Kg} \\ .5 \quad \text{₱3,600, 90\%, ₱2.5/Kg, ₱1/Kg} \end{cases} \qquad L_4 \equiv \begin{cases} .5 \quad \text{₱1,800, 90\%, ₱2.5/Kg, ₱1/Kg} \\ .5 \quad \text{₱3,600, 100\%, ₱2.5/Kg, ₱1/Kg} \end{cases}$$
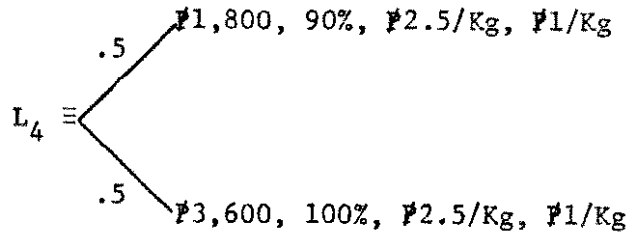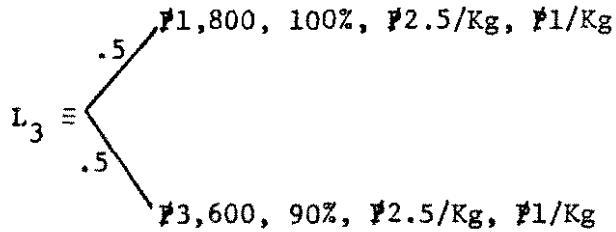
A.  $L_3 \succ L_4$ .

Conclusions:

1)  $x_1$  is not additive independent of  $x_2$ .

2) The utility function is of the form

$$1 + ku(x_1 x_2, \; x_3, \; x_4) = \prod_{i=1}^{4} [1 + kk_i u_i(x_i)] \qquad (A.6)$$

### A.3.4 Scaling Constants

Q. What should  $x_1'$  be such that

$(x_1', \; 80\%, \; ₱4/Kg, \; ₱3/Kg) \sim (₱1,500, \; 120\%, \; ₱4/Kg, \; ₱3/Kg)$ ?

(The symbol  $\sim$  means "is indifferent to.")

A.  $x_1' = ₱2,500$ .

Conclusion:  $k_1 u_1(2,500) = k_2$

Q. What should  $x_1''$  be such that

$(x_1'', \; 80\%, \; ₱4/Kg, \; ₱3/Kg) \sim (₱1,500, \; 80\%, \; ₱1/Kg, \; ₱3/kg)$ ?

A.  $x_1'' = 3,000$ .

Conclusion:  $k_1 u_1(3,000) = k_3$ .

Q. What should $x_1'''$ be such that

$(x_1''',\ 80\%,\ \#4/Kg,\ \#3/Kg) \sim (\#1,500,\ 80\%,\ \#4/Kg,\ \#0/Kg)$?

A. $x_1''' = 2,500$.

Conclusion: $k_1 u_1(2,500) = k_3$.

Q. What should be $P_1$ such that



$\#3,600,\ 120\%,\ \#1/Kg,\ \#0/Kg$

$\sim \#3,600,\ 80\%,\ \#4,Kg,\ \#3/Kg$

$\#1,500,\ 80\%,\ \#4/Kg,\ \#3/Kg$
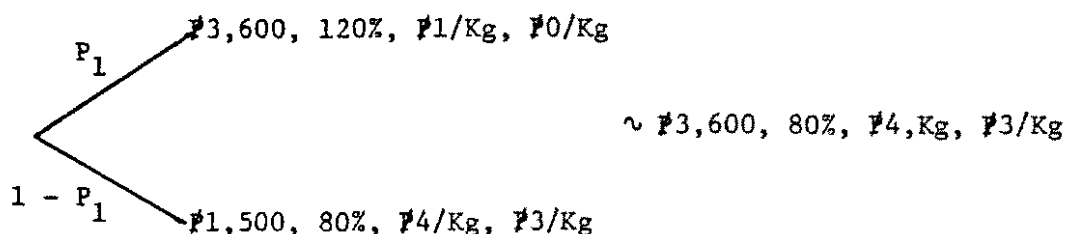
A. $P_1 = .7$.

Conclusion: $k_1 = .7$. (A.7)

From the five-point utility function of $x_1$ (Table 8), we know that $u_1(2,500) = .75$. By substituting $x_1 = 3,000$ into the continuous utility function of $x_1$ (A.2) we get $u_1(3,000) = .91$. Thus, we get $k_1 = .7$, $k_2 = .5$, $k_3 = .6$, and $k_4 = .5$; and by solving

$$1 + k = (1 + kk_1)(1 + kk_2)(1 + kk_3)(1 + kk_4) \tag{A.8}$$

we get $k = -1$. Thus the utility function for the first four attributes is

$$u(x_1,\ x_2,\ x_3,\ x_4) = 1 - [(1 - .7u_1(x_1)] \cdot [1 - .5u_2(x_2)] \cdot [(1 - .6u_3(x_3)]$$
$$\cdot [(1 - .5u_4(x_4)] \tag{A.9}$$

## A.4 The Complete Utility Function

Since a new variable $(x_5)$ was introduced and also the minimum and maximum possible values of some variables were different from the estimated ones, it was necessary to adjust the parameters of the utility function and its form to incorporate $x_5$.

### A.4.1 Assumptions

a) The independence relationships found for the first four attributes hold also for $x_5$.

b) Since $x_5$ was not considered initially as an important attribute it was assumed that the answer to the (unasked) questions, what should $x_1''''$ be such that

$$\left(x_1'''', \ 80\%, \ ₱4/Kg, \ ₱3/Kg, \ x_5^0\right) \sim \left(₱1,500, \ 80\%, \ ₱4/Kg, \ ₱3/Kg, \ x_5^*\right),$$

is $x_1'''' = ₱2,000$. This figure is lower than those given for similar questions with regard to $x_2$, $x_3$, and $x_4$ (2,500, 3,000, and 2,500, respectively), and thus reflects the relative importance of the fifth attribute. A smaller value would imply that the value of ₱1 spent by the government (paid by the taxpayer) is much lower than ₱1 earned by farmers or saved by the consumers; and, as a result, the optimal policy would imply an unrealistic trade-off between the government expenditures and the other attributes.

A.4.2  The Continuous Utility Function for
       Government Expenditures $(x_5)$

As mentioned above, the utility function for government expenditures was

not evaluated in the interveiw with Dr. Drilon.  On the basis of discussion with

other NGA officials, the utility function of this attribute was specified as

decreasing risk averse.  The degree of risk aversion was found, however, to be

lower than that for the other attributes.  This is simply because government ex-

penditures were not considered to be a crucial measure of performance by NGA

officials.  It was assumed, therefore, the NGA is less risk averse with regard

to this attribute and also that the ceiling constant of this attribute in the

multi-attribute utility function $(k_5)$ is lower than those for other attributes.

The five-point utility function was estimated by using the midpoints between

the average of the .25, .5, and .75 utiles of $x_1$, $x_2$, $x_3$, and $x_4$, and a linear

utility function.  This was done by the following steps:

1) The five-point utility functions of $x_1$, $x_2$, $x_3$, and $x_4$ were transformed

   such that the utiles are on a percentage scale.

2) The average value of each column was computed.

3) The values of the linear utility function were recorded.

4) The midpoint between the average of $x_1$, $x_2$, $x_3$, and $x_4$, and the linear function was determined.

5) The midpoint percentages were transformed to the original values of $x_5$. Table A.1 summarizes steps (1)-(5).

Table A.1

Evaluation of the Five-Point Utility Function for Government Expenditures

| Step | $x_i^0$ | | $x_i^{.25}$ | | $x_i^{.5}$ | | $x_i^{.75}$ | | $x_i^1$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Value | % | Value | % | Value | % | Value | % | Value | % |
| (1) $x_1$ | 1,500 | 0 | 1,700 | 9.5 | 2,000 | 23.8 | 2,500 | 47.6 | 3,600 | 100 |
| $x_2$ | 80 | 0 | 85 | 12.5 | 93 | 32.5 | 100 | 50.0 | 120 | 100 |
| $x_3$ | 4.0 | 0 | 3.6 | 13.3 | 3.0 | 33.3 | 2.5 | 50.0 | 1.0 | 100 |
| $x_4$ | 3.0 | 0 | 2.6 | 13.3 | 2.0 | 33.3 | 1.3 | 56.7 | 0.0 | 100 |
| (2) E(%) | | 0 | | 12.5 | | 30.7 | | 51.1 | | 100 |
| (3) Linear U. F. | | 0 | | 25.0 | | 50.0 | | 75.0 | | 100 |
| (4) Midpoint | | 0 | | 18.6 | | 40.4 | | 63.0 | | 100 |
| (5) $x_5$ | 42.0[a] | | 32.5 | | 21.4 | | 9.8 | | -9.0[a] | |

[a]The minimum and maximum values of $x_5$ from the decision tree.

Thus, using 21.4 as the $x_5^{.5}$ and the logarithmic utility function, the resulting utility function for government expenditures was found to be

$$u_5 (x_5) = -4.81 + 1.28 \ln (85 - x_5) \tag{A.10}$$

A.4.3 Computing the Scaling Constants

Based on the answers to the questions in A.3 and the continuous utility functions (A.2), (A.3), (A.4), (A.5), and (A.10), we derived the following set of equations:

$$(1 + k'k_1' \cdot .82)(1 + k'k_2' \cdot .22) = (1 + k'k_1' \cdot .35)(1 + k'k_2') \qquad \text{(A.11)}$$

$$(1 + k'k_1' \cdot .92)(1 + k'k_3' \cdot .09) = (1 + k'k_1' \cdot .35)(1 + k'k_3') \qquad \text{(A.12)}$$

$$(1 + k'k_1' \cdot .82) = (1 + k'k_1' \cdot .35)(1 + k'k_4') \qquad \text{(A.13)}$$

$$(1 + k'k_1' \cdot .65) = (1 + k'k_1' \cdot .35)(1 + k'k_5') \qquad \text{(A.14)}$$

$$.7(1 + k'k_1' \cdot .96)(1 + k'k_2')(1 + k'k_3')(1 + k'k_4')(1 + k'k_5')$$
$$+ .3(1 + k'k_1' \cdot .35)(1 + k'k_2' \cdot .22)(1 + k'k_3' \cdot .09) =$$
$$(1 + k'k_1' \cdot .96)(1 + k'k_2' \cdot .22)(1 + k'k_3' \cdot .09) \qquad \text{(A.15)}$$

$$1 + k' = (1 + k'k_1')(1 + k'k_2')(1 + k'k_3')(1 + k'k_4')(1 + k'k_5') \qquad \text{(A.16)}$$

Equation (A.11), for example, results from the fact that

$$(₱2,500, 80\%, ₱4/Kg, ₱3/Kg) \sim (₱1,500, 120\%, ₱4/Kg, ₱3/Kg)$$

as found in section (A.3.4). This implies that the utility of these two combinations is equal. By using the multiplicative utility function (A.9) and the univariate utility functions of $x_1$ (A.2) and $x_2$ (A.3), we got (A.11) where $u_1(2,500) = .82$, $u_2(80) = .22$, $u_1(1,500) = .35$, and $u_2(120) = 1$.

In equation (A.14) the .65 stands for $u_1(2,000)$ according to the assumption, mentioned above, about the government expenditures. By solving the set of equations (A.11-A.16) which is a nonlinear set of six equations and six unknowns, we

derived the adjusted scaling constants: $k_1' = .8$, $k_2' = .58$, $k_3' = .65$, $k_4' = .52$, $k_5' = .33$, and $k' = -.1$.

Thus, the final multiattribute utility function used in the analysis of the decision tree is

$$u(x_1, x_2, x_3, x_4, x_5) = 1 - [1 - .8u_1(x_1)] \cdot [1 - .58u_2(x_2)]$$
$$\cdot [1 - .65u_3(x_3)] \cdot [1 - .52u_4(x_4)] \quad \text{(A.17)}$$
$$\cdot [1 - .33u_5(x_5)]$$

where

$$u_1(x_1) = 1.01 - 4.29 \exp(-.00125x_1), \quad \text{(A.2)}$$

$$u_2(x_2) = -1.12 + .54 \ln(x_2 - 68), \quad \text{(A.3)}$$

$$u_3(x_3) = .09 + .66 \ln(5 - x_3), \quad \text{(A.4)}$$

$$u_4(x_4) = .72 \ln(4 - x_4), \quad \text{(A.5)}$$

and

$$u_5(x_5) = -4.81 + 1.28 \ln(85 - x_5). \quad \text{(A.10)}$$

```
// FOR
*XREF
*IOCS(CARD,1132 PRINTER)
*ONE WORD INTEGERS
C          PRICE POLICY FOR RICE IN THE PHILIPPINES - NGA
C          ***************************************
       REAL TIF,NTIF
       DIMENSION NA(22)
C       DATA
C       ****
       AFS=6.5
       YCC=100.
       ROR=.61
       WSP=.625
       HHC=AFS*(YCC/1000.)*.5*(1./ROR)
       HHS=2.*HHC*(WSP-.5)
       CMI=.45
       YHI=2.25
       YHII=1.5
       AHIF=2.5
       AHIIF=2.5
       NTIF=360000.
       NNTIF=600000.
       TP=44000000.
       TRF=AFS*(TIF+NNTIF)
       TNRF=TP-TRP
       CIIH=400.
       CIOIH=250.
       CLIH=400.
       CLNIH=300.
       CPC=2.1
       EP=7.3
C       SCALING CONSTANTS
C       ******************
       WK1=.8
       WK2=.58
       WK3=.65
       WK4=.52
       WK5=.33
C       COMPUTING K
C       ***********
       WV=1000.
       DO 20 L=1,21
       WL=.05*L-1.1
       NA(L)=ABS((1+WL*WK1)*(1+WL*WK2)*(1+WL*WK3)*(1+WL*WK4)*(1+WL*WK5)-1
      =-WL)
       IF (NA(L)-WV) 19,20,20
   19  WK=WL
       WV=NA(L)
   20  CONTINUE
   30  FORMAT ( 76H    MIN. PRICE          MAX. PRICE          EXPECTE
      =D UTILITY)
       WRITE (3,30)
C       MINIMUM PRICE
C       *************
       DO 4100 M1=1,7
       IF (M1-7) 40,50,50
   40  CMPH=.3+.1*M1
C       MAXIMUM PRICE
C       *************
```

```
      DO 4000 M2=1,8
      EU=0.
      GTPC=1.5+.2*M2
      GO TO 50
   50 EU=0.
C         NATURE CONDITIONS
C         *****************
   60 DO 3900 M3=1,3
      GO TO (80,100,120),M3
   80 P1=.2
      RPI=1.05
      RMPI=1.15
      GO TO 140
  100 P1=.5
      RPI=1.
      RMPI=1.
      GO TO 140
  120 P1=.3
      RPI=.95
      RMPI=.85
  140 GO TO (160,180,160,160,160,160,160),M1
  160 MT=3
      GO TO 200
  180 MT=1
C         IRRIGATED FARMS RESPONSE TO MINIMUM PRICE
C         *****************************************
  200 DO 3800 M4=1,MT
      GO TO (220,320,420,420,420,420,520),M1
  220 GO TO (240,260,280),M4
  240 P2=.25
      RPI=.92
      GO TO 600
  260 P2=.5
      RPI=.97
      GO TO 600
  280 P2=.25
      RPI=1.02
      GO TO 600
  320 P2=1.
      RPI=1.
      GO TO 600
  420 GO TO (440,460,480),M4
  440 P2=.25
      RPI=1.02
      GO TO 600
  460 P2=.5
      RPI=1.04
      GO TO 600
  480 P2=.25
      RPI=1.06
      GO TO 600
  520 GO TO (540,560,580),M4
  540 P2=.25
      RPI=.99
      GO TO 600
  560 P2=.5
      RPI=1.
      GO TO 600
  580 P2=.25
      RPI=1.01
```

```
C          FOR IRRIGATED FARMS RESPONSE TO MINIMUM PRICE
C          *************************************************
  600 DO 3700 M=1,MT
      GO TO (620,720,820,820,820,820,920),M1
  620 GO TO (640,660,680),M5
  640 P3=.25
      RPMI=.95
      GO TO 1000
  660 P3=.5
      RPMI=.98
      GO TO 1000
  680 P3=.25
      RPMI=1.01
      GO TO 1000
  720 P3=1.
      RPMI=1.
      GO TO 1000
  820 GO TO (840,860,880),M5
  840 P3=.25
      RPMI=1.
      GO TO 1000
  860 P3=.5
      RPMI=1.015
      GO TO 1000
  880 P3=.25
      RPMI=1.03
      GO TO 1000
  920 GO TO (940,960,980),M5
  940 P3=.25
      RPMI=.97
      GO TO 1000
  960 P3=.5
      RPMI=.99
      GO TO 1000
  980 P3=.25
      RPMI=1.01
C          QUANTITIES PRODUCED AND SUPPLIED
C          ****************************************
 1000 QSI=(YHI*AHIF*RMI*RPI-HHC-HHS)*NIF*ROR
      QSMI=(YHMI*AHMIF*RPMI*RPMI-HHC-HHS)*NMIF*ROR
      QST=QSI+QSMI
      QSC=(QST/TLRP)*1000.
      QSPS=QSC/TSP*.5
      X2=(QSPS/(YCC*.5))*100.
C          DEMAND PARAMETERS
C          *******************
      DO 3600 M6=1,4
      GO TO (1020,1040,1060,1080),M6
 1020 DEF=-.2
      P4=.3
      GO TO 1100
 1040 DEF=-.3
      P4=.3
      GO TO 1100
 1060 DEF=-.4
      P4=.3
      GO TO 1100
 1080 DEF=-.5
      P4=.1
 1100 QSL=QPC/(DEF*YCC)
```

```
       CIL=CPC-DSL*YCC
       CPE=YCC/(CPC**DER)
C          INTERNATIONAL PRICE OF RICE (CIF)
C          ************************************
       DO 3500 M7=1,5
       GO TO (1120,1140,1160,1180,1190),M7
 1120 PRI=.25
       P5=.1
       GO TO 1200
 1140 PRI=.27
       P5=.2
       GO TO 1200
 1160 PRI=.3
       P5=.4
       GO TO 1200
 1180 PRI=.33
       P5=.2
       GO TO 1200
 1190 PRI=.35
       P5=.1
C          POLICIES AND OUTCOMES
C          **********************
 1200 IF (P1-7) 1220,2000,2000
 1220 IF ((GMPP/POR)+CMI-GMPC) 1600,1240,1240
 1240 X3=GMPC
       PP=GMPP/POR
       IF (GMPC-CPC) 1260,1260,1270
 1260 GMPC=CPE*(GMPC**DER)
       GO TO 1275
 1270 GMPC=(GMPC-DIL)/DSL
 1275 GMPCS=GMPC*.5
       IF (GMPCS-QSPS) 1280,1300,1300
 1280 D=.8
       GO TO 1320
 1300 D=1.
 1320 X5=QSPS*(PP+CMI)-GMPCS*X3-(QSPS-GMPCS)*D*ER*PRI
       GO TO 2100
 1600 IF (QSPS*2.-YCC) 1640,1620,1620
 1620 PE=(QSPS*2./CPET**(1./DER)
       GO TO 1660
 1640 PE=DIL+DSL*QSPS*2.
 1660 IF (PE-GMPC) 1680,1900,1900
 1680 IF (PE-CMI-GMPP/POR) 1700,1700,1800
 1700 PP=GMPP/POR
       X3=(GMPP/POR)+CMI
       IF (GMPP/POR+CMI-CPC) 1720,1720,1740
 1720 GMPP=(CPE*(GMPP/POR+CMI)**DER)*.5
       GO TO 1760
 1740 GMPP=(GMPP/POR+CMI-DIL)/DSL*.5
 1760 D=.8
       X5=(GMPP/POR+CMI-D*ER*PRI)*(QSPS-GMPP)
       GO TO 2100
 1800 X3=PE
       PP=PE-CMI
       X5=0.
       GO TO 2100
 1900 X3=GMPC
       PP=GMPC-CMI
       IF (GMPC-CPC) 1920,1920,1940
 1920 GMPC=CPE*(GMPC**DER)
```

```
                  GO TO 1980
     1940  GMPC=(GMPC-DSL)/DSL
     1980  QSPCS=QSPS*.5
           X5=(QSPCS-QSPS)*(ER*PRI-GMPC)
                  GO TO 2100
     2000  IF (QSPS*2.-YCU) 2040,2040,2020
     2020  PE=(QSPS*2./DPE)**(1./DER)
                  GO TO 2060
     2040  PE=DTL+DSL*QSPS*2.
     2060  X3=PE
           PP=X3-GMI
           X5=0.
     2100  X4=ABS(X3-CPC)
           CLIHA=.5*CLIH*(1.+RMI*RPI)
           CIIHA=CIIH*RPI
           CLNHA=.5*CLNIH*(1.+RMNI*RPNI)
           CINHA=CINIH*RPNI
           TIFP=((YHI*AHIF*RNI*RPI-HHC-HHS)*ROR*1000.*PP-AHIF*(CLIHA+CIIHA))*
          =NIF
           TNIFP=((YMNI*AHNIF*RMNI*RPNI-HHC-HHS)*ROR*1000.*PP-AHNIF*(CLNHA+CI
          =NHA))*NNIF
           X1=(TIFP+TNIFP)/(NIF+NNIF)
     C        UTILITY FUNCTION
     C        ****************
           U1=1.01-4.29*2.7183**(-.00125*X1)
           U2=-1.12+.54*ALOG(X2-68.)
           U3=.09+.65*ALOG(5.-X3)
           U4=.72*ALOG(4.-X4)
           U5=-4.81+1.23*ALOG(35.-X5)
           U6=((1.+WK*WK1*U1)*(1.+WK*WK2*U2)*(1.+WK*WK3*U3)*(1.+WK*WK4*U4)*(1
          =.+WK*WK5*U5)-1)/WK
           EU6=U6*P1*P2*P3*P4*P5
           EU=EU+EU6
     3500  CONTINUE
     3600  CONTINUE
     3700  CONTINUE
     3800  CONTINUE
     3900  CONTINUE
     C        OUTPUT
     C        ******
     3920  FORMAT (8X,F4.2,15X,F4.2,17X,F9.7)
     3930  FORMAT (34H          NO GOVERNMENT INTERVENTION,15X,F9.7)
           IF (M1-7) 3950,4100,3960
     3960  WRITE (3,3920) GMPP,GMPC,EU
     4060  CONTINUE
     4100  CONTINUE
           WRITE (3,3930) EU
     4200  CONTINUE
           CALL EXIT
           END
```

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