

# **A Descriptive Model of Cropping Decision Making: Application to Crop Diversification in Irrigated Rice Farms**

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## **ABSTRACT**

*The research sought to model the cropping decision making of farmers vis-a-vis diversified crops. A three-stage descriptive model of cropping decision making under uncertainty was developed and tested in six case studies of successful crop diversification in irrigated rice farms. The six case studies consisted of tobacco farming in San Fabian, Pangasinan; cotton growing in Urdaneta and Manaoag, Pangasinan; tomato growing in Sta. Barbara and Mapandan, Pangasinan; onion growing in San Jose, Nueva Ecija; and garlic, corn, and peanut growing in Laoag, Ilocos Norte. A total of 266 farmers from the different sites were interviewed. Overall, the cropping decision tree model found empirical support in the various cases except for the case of mungbean which was not a free choice situation and for the case of corn and peanut which were not the major diversified crops but only subsidiary crops. Results indicate that the cropping decision tree model is applicable to the choice of a major diversified crop involving a free choice situation. The model appears promising as a diagnostic guide which can be used by change agents for determining whether or not farmers are ready to crop diversify.*

## INTRODUCTION

Traditionally, the existence of irrigation in the Philippines has meant two or more croppings per year of rice monoculture. Indeed, planting crops other than rice in irrigated farm is the exception rather than the rule in spite of the fact that the profitability of rice farming has not increased proportionately with the (secular) increase in rice yield. Crop diversification is important for achieving stable food supplies in the country and for earning and/or saving foreign exchange. More importantly, it could be the key means for increasing farmers' incomes. Hence, the impetus toward irrigated crop diversification.

In order to promote crop diversification, there is a need to understand how farmers make cropping decisions vis-à-vis diversified crops. Thus, this study presents a descriptive model of Filipino farmers cropping decision making on diversified crops.

### Models of Decision Making

There are two general approaches to the modeling of decision making under uncertainty. The first is the normative and the second is the positive or descriptive approach. The major difference between the two approaches lies in the purpose of the model. Normative models emphasize what should be done. These models seek to answer the following questions: What is an ideal approach to problem solving? How should decisions be made? In contrast, positive or descriptive models seek to describe how decision making is actually done in the real world. Thus, positive or descriptive models seek to answer the following questions: How do people make decisions in the real world? What is the actual behavior? What are the steps the decision maker should go through?

Early work on the analysis of human decision making under uncertainty had a normative emphasis. Investigators were concerned with how well decision makers follow the optimal models of decision making such as the Bayesian and expected utility models. Recent work on the cognitive psychology of decision making has, however, revealed that people are not good estimating probabilities (e.g., Kahneman and Tversky, 1972; Slovic, Fischhoff and Lichtenstein, 1977; Tversky and Slovic, Fischhoff and Lichtenstein, 1977; Tversky and Kahneman, 1973, 1974) and that people often violate the assumptions of the optimal models (e.g., Tversky, 1969). A number of studies have also shown that people use simplifying

procedures or heuristics in their decision-making processes because of limitations in human cognitive information processing capabilities.

In as much as normative models apparently do not reflect actual decision making by individuals, a number of positive, descriptive or "behavioral" models of human decision making have been proposed in the literature. In the field of agricultural decision making, Gladwin (1980) has developed a "decision tree" descriptive model of cropping decision making that "incorporates some of the simplifying procedures people use in making everyday real-life decisions". Gladwin (1983) tested her decision tree model using data gathered from 118 farmers in six sub-regions of the "Altiplano" in Guatemala and obtained a success rate of 90 percent prediction. That is, the model predicted the farmers' choices 90 percent of the time. Because of its comprehensiveness, cognitive simplicity, and predictive success, the present study has chosen the track of descriptive decision modeling along Gladwin.

### **A Three-Stage Crop Decision Model**

A three-stage descriptive model of cropping decision making under uncertainty for diversified crops was developed. The model is a modified version of Gladwin's (1980) decision tree model; it is presented in Fig. 1.

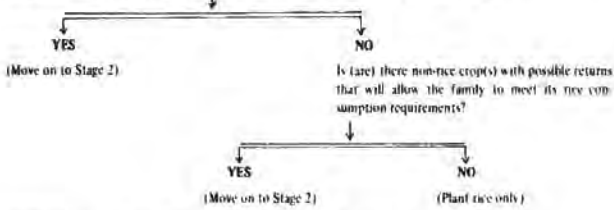
The model posits three stages in the cropping decisions making. The stages consist of a series of discrete decision criteria. Each criterion has to be passed for a farmer to reach the decision of planting a particular diversified crop. If the crop fails any one of the criteria, the model predicts that the farmer will not plant the crop.

Stage 1 consists of assuring the family's rice consumption requirements. Specifically, it is hypothesized that a risk-averse farmer will first make sure that food for his family, i.e., rice, will not be compromised by planting other crops. Stage 1 follows the findings of Ortiz (1979) that "peasants accept the risk of cash cropping [i.e., crop diversify] even when this is high, but do so only after subsistence is assured". If the rice consumption requirement is satisfied, the farmer then moves to Stage 2 of the decision making process which consists of testing for the technical and economic feasibility of planting the diversified crop.

Stage 2 is essentially an adaptation of Tversky's (1972) elimination by aspects theory which postulates that choice is an elimination process of alternatives involving the successive

Stage 1. Satisfaction of Basic Needs: Assuring rice consumption requirements

Q: Will the family's rice consumption requirements be met if the farmer plants other crop(s)?



Stage 2. Testing for Feasibility: Satisfaction of Technical constraints and economic feasibility<sup>1</sup>

*Technical Constraints:*

- soil, topography  
(Does crop X yield well at farmer's soil, topography? ) if no eliminate crop X
- water requirements  
(Does farmer have irrigation or is the water enough to meet the requirements of crop X? ) if no eliminate crop X
- timing of farm operations  
(Is the timing of farm operations for crop X acceptable to the farmer? ) if no eliminate crop X
- knowledge  
(Does farmer know how to plant crop X or will be able to obtain information? ) if no eliminate crop X

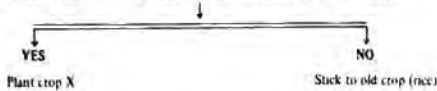
*Economic Feasibility:*

- Demand  
(Can the farmer sell crop X in a nearby market or to a merchant? ) if no eliminate crop X
- Time, labor  
(Does the farmer have the available time and accessible labor to help him plant crop X? ) if no eliminate crop X
- Capital, Credit  
(Does the farmer have the capital or accessible credit to buy inputs for crop X? ) if no eliminate crop X

Stage 3. Cost-Benefit Analysis

Examination of the expected returns of each alternative crop vis-a-vis costs.

Q: Is returns from X n times greater than returns from previous group (rice)?<sup>2</sup>



<sup>1</sup> There is no particular sequence in which the farmer processes each alternative crop vis-a-vis the technical constraints and economic feasibility. Suffice it to say that any alternative crop that fails to meet any one of the above-mentioned four technical constraints or three economic feasibility requirements is eliminated from consideration.

<sup>2</sup> n is a value which represents the minimum profitability of crop X over the previous crop for which the farmer will be willing to take risk of planting crop X. n is an empirical value that is greater than 1.

Fig. 1. A descriptive model of cropping decision making.

bean farming in Manaoag and Urdaneta, Pangasinan; onion growing in San Jose, Nueva Ecija; and garlic, corn, and peanut growing in Laoag, Ilocos Norte.

A structured interview schedule was constructed which contained questions in the various aspects of the cropping decision tree model. A total of 266 farmers, selected at random from the National Irrigation Administration (NIA) lists and from the various sites, were interviewed individually, namely: 40 tobacco farmers, 40 cotton farmers, 40 tomato farmers, 40 mung bean farmers, 40 onion farmers, and 66 garlic/corn/peanut farmers. The interviews were done in dry season 1986.

## RESULTS AND DISCUSSION

### Farmers' Profile

The tobacco farmers of San Fabian, Pangasinan plant burley tobacco. The Philippine Virginia Tobacco Administration (PVTA) office in Pangasinan oversees the burley production in San Fabian. Most of the farmers plant only rice in the wet season and only burley in the dry. The farmers have been growing burley tobacco for an average of 22.2 years. The major buyer/trader of burley tobacco leaves in San Fabian is a chinese middleman who lives in the area. The chinese trader also acts as an informal money and input lender to the farmers.

The cotton farmers of Urdaneta and Manaoag, Pangasinan are contract growers for the Philippine Cotton Corporation (PCC) which provides the farmers with technical advice and inputs -- seeds for free and fertilizer, chemicals, and cash loans at no interest, the payment of which are deducted from the gross sales. PCC sets the purchase price of cotton before the cropping season. Rice is the predominant wet season crop and cotton is the predominant dry season crop of the farmers who are relatively new at planting cotton, having planted it an average of only 2.5 years.

The tomato farmers of Sta. Barbara and Mapandan, Pangasinan are also contract growers; the contractor in this case is the Philippine Fruit and Vegetable Industries, Inc. (PFVII) which introduced the contract growing scheme in the area in the 1983-84 dry season for the production of "California" variety tomatoes for processing into tomato paste. Under the contract growing scheme, PFVII provides the farmers with technical assistance and credit in the form of seeds, fertilizer, chemicals and cash at the interest rate of 1.5 percent per

month. PFVII buys the produce at a price that it sets before the cropping season. Although the farmers are relatively "new" planters of California variety tomatoes, they had been growing tomatoes (mostly the native variety) for an average of 11.9 years.

Mung bean has been the traditional dry season crop of rice farmers around the border of Manaoag and Urdaneta, Pangasinan. The lack of adequate irrigation water for rice or other diversified crops in the dry season is the primary reason for the widespread cultivation of mung bean in the area during the dry season. Given this, the National Irrigation Administration (NIA) office in Urdaneta, Pangasinan had been programming the area for mung bean production during the dry season, i.e., it provides farmers in the area with water sufficient for mung bean production. The farmers have been planting mung bean for an average of 18.1 years. The farmers themselves market their mung bean harvest. The produce is brought to the Urdaneta public market by tricycle and sold to the traders/grain dealers or stall owners there.

The onion farmers come from San Jose, a city in the northern section of the province of Nueva Ecija, which is one of the biggest producers of onions in the dry season. The farmers regularly grow onions after their wet season rice crop; they have been doing it for an average of 20.8 years. The major buyers of the onions are the owners of cold storage facilities in Bongabon and Palayan City, Nueva Ecija. They get the onions in large quantities from a number of trading centers in San Jose City, which in turn buy the onions from individual traders who buy from the farmers.

Laoag, Ilocos Norte is an area where farmers regularly grow a variety of diversified crops in the dry season. Among the farmers interviewed, garlic is the major diversified crop during the dry season but the farmers also grow subsidiary or secondary diversified crops such as corn and peanut. In dry season 1986, for example, the farmers interviewed planted an average of 0.345 ha to garlic, 0.16 ha to corn, and 0.17 ha to peanut. Of the 66 farmers interviewed, 60 have been planting garlic in the dry season for an average of 15.6 years; and 46 have been planting peanut for an average of 16.1 years. The farmers sell their garlic, corn and peanut harvests to traders and stall owners at the Laoag City public market.

### **Cropping Decision Making**

An in-depth examination of the cropping decision making of the individual farmers vis-a-vis diversified crops was con-

ducted. Information on the various aspects of the cropping decision tree model was obtained from each of the farmers interviewed with respect to the diversified crop they had actually planted in dry season 1986. For purposes of comparison, each farmer was also asked information on the various aspects of the decision tree model with respect to an alternative diversified crop that is grown in the area but which the farmer is not planting. If the decision tree model captures well the farmers' cropping decision making, then the diversified crops which the farmers planted should pass the requirements of all three stages of the decision tree model (since the farmers had actually planted them) whereas the alternative diversified crops which the farmers did not plant should not pass the requirements of all three stages of the decision tree model (since the farmers had actually planted them) whereas the alternative diversified crops which the farmers did not plant should not pass the requirements of one or more stages of the decision tree model. The results of the tests of the model are presented in Tables 1 and 2.

Table 1 presents the results on the farmers' cropping decision making vis-a-vis the diversified crops planted. Overall, the cropping decision tree model found empirical support in the various cases except for the mung bean case which is really not a free choice situation for the farmers (due to lack of water for rice and other diversified crops and, the area's water supply having been programmed by NIA for mung bean production) and for the corn and peanut cases which were not the major diversified crops of the farmers but only subsidiary or secondary diversified crops. Except for these cases, the cropping decision making of majority of the farmers were consistent with the decision tree model. Specifically, the diversified crop planted passed the requirements of all three stages of the decision tree model for 82.1 percent of the tobacco farmers, 65 percent of the cotton farmers, 72.5 percent of the tomato farmers, 72.5 percent of the onion farmers, and 63.3 percent of the garlic farmers. These results indicate that the cropping decision tree model is applicable to the choice of a major diversified crop involving a free choice situation.

Examination of the responses of the farmers whose behavior is inconsistent with the decision tree model (i.e., farmers for whom the diversified crop planted did not pass one or more stages of the model) reveals that about 60 percent of the inconsistencies involved the diversified crop's not passing the farmer's minimum profitability requirement in Stage 3 of the model. There appear to be two possible reasons for this. One is

Table 1. Cropping decision making vis-a-vis diversified crops planted.

STAGES OF DECISION TREE N	PERCENTAGE OF FARMERS WHO PASSED EACH STAGE							
	Tobacco 40	Cotton 40	Tomato 40	Mung Bean 40	Onion 40	Garlic 60	Corn 40	Peanut 46
<i>Stage 1</i>								
Assuring rice Consumption	97.4%	92.5%	97.5	72.5%	100.0%	98.3%	92.5%	89.1%
<i>Stage 2</i>								
Testing for feasibility								
Soil, topography	100.0	100.0	97.5	100.0	97.5	100.0	100.0	100.0
Water	100.0	100.0	100.0	100.0	92.5	83.3	92.5	82.6
Timing	100.0	100.0	100.0	100.0	97.5	98.3	100.0	100.0
Knowledge	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Demand	100.0	100.0	100.0	100.0	100.0	100.0	97.5	100.0
Time, labor	100.0	100.0	100.0	100.0	100.0	98.3	97.5	100.0
Capital, credit	97.5	97.4	97.5	100.0	100.0	100.0	100.0	100.0
<i>Stage 3</i>								
Cost-benefit analysis	85.0	72.5	74.4	52.5	82.5	80.0	52.5	50.0
Farmers whose behavior is consistent with decision tree*								
	82.1	65.0	72.5	47.5	72.5	63.3	47.5	36.9

\*i.e., the crop planted passed all three stages of the decision tree.



that the farmers may have misinterpreted the question on the minimum profitability requirement as some kind of "ideal" profitability for the diversified crop. The other is that over the years of planting the diversified crop, the farmers have consistently realized positive net returns above cash costs from their harvests (see Table 3); given that for majority of the farmers the irrigation water during the dry season is not enough for planting rice, planting the diversified crop might have been the best alternative under the circumstances, a kind of "satisfying" solution (Simon, 1966).

Table 2 presents the results on the farmers' cropping decision making vis-a-vis the alternative diversified crops not planted. The alternative diversified crops not planted for which the decision tree model was tested are cotton for the tobacco farmers, tomato for the cotton farmers, cotton for the tomato farmers, tomato for the mung bean farmers, tomato for the onion farmers, corn for the garlic farmers not planting it, and corn for the peanut farmers not planting it. The results in Table 2 indicate substantial support for the decision tree model. Overall, averaging across all crops, about 80 percent of the cropping decision making of the farmers were consistent with the decision tree model. That is, the alternative diversified crop not planted failed to pass the requirements of one or more stages of the decision tree model in about 80 percent of the cases.

Table 3 presents a profitability profile of the diversified crops planted. Excluding mung bean, corn and peanut, the farmers tended to perceive the diversified crop planted as about twice as profitable as rice. In contrast, excluding mung bean, garlic and corn, the farmers tended to have a minimum profitability requirement for the diversified crop of about 1-1/2 times that of rice. The garlic farmers tended to have high expectations of their diversified crop (average perceived profitability over rice of 2.36 and average minimum profitability requirement of 2.24) while the mung bean farmers (who really did not have much of a choice in planting mung bean) tended to have low expectations (average perceived profitability over rice of 1.03 and average minimum profitability requirement of 1.11).

In terms of actual returns, tobacco, cotton, onion and garlic yielded net returns above cash costs that were substantially higher than those realized for rice. In contrast, the tomato and mung bean farmers experienced losses. The major reason for the losses were the low yields in the face of high input costs. When the non-cash costs (i.e., unpaid family labor) are considered, the picture is reversed with rice coming out as

Table 3. Profitability profile of diversified crops planted.

	TOBACCO	COTTON	TOMATO	MUNG BEAN	ONION	GARLIC	CORN	PEANUT
Perceived profitability over rice	2.06	1.84	1.79	1.03	2.31	2.36	1.09	1.32
Minimum profitability requirement over rice	1.59	1.54	1.49	1.11	1.52	2.24	1.29	1.54
Net returns above cash costs (ratio to returns for rice) <sup>a</sup>	3.48	2.58	b	b	4.77	2.69	0.93	1.62
Net returns above non-cash costs <sup>c</sup> (ratio to returns for rice) <sup>a</sup>	d	2.59	d	d	3.75	d	d	0.44
Average number of years farmer planted crop	22.2	2.5	11.9	18.1	20.8	15.6	14.8	16.1
Ratio of no. of years of positive net returns above cash costs to no. of years of planting crop	0.92	0.90	0.84	0.91	0.87	0.90	0.96	0.97

Note: Values are averages.

<sup>a</sup>Values are based on the costs and returns for rice production in wet season, crop year 1985-86 and for the diversified crop in dry season, crop year 1985-86.

<sup>b</sup>Net returns above cash costs of diversified crop is negative while that of rice is positive.

<sup>c</sup>Noncash costs refer to unpaid family labor.

<sup>d</sup>Net returns above cash and non-cash costs of diversified crop is negative while that of rice is positive.

as more profitable vis-a-vis most of the diversified crops (except cotton and onion). This is because the diversified crops in general tend to be much more labor-intensive than rice thereby having a very high unpaid family labor component. Table 3 also indicates the major reason for persistence of crop diversification among the farmers: over the years the farmers have consistently realized positive net returns over cash costs from their diversified crop. Specifically, the ratios of the number of years in which the farmers realized positive net returns above cash costs from the diversified crop planted to the number of years the farmers had been planting the crop are all very high - the diversified crop planted yielded positive net returns above cash costs an average of 92 percent of the time for the tobacco farmers, 90 percent of the time for the cotton farmers, 84 percent of the time for the tomato farmers, 91 percent of the time for the mung bean farmers, 87 percent of the time for the onion farmers, 90 percent, 96 percent, and 97 percent of the time for the garlic, corn, and peanut farmers, respectively.

### **Implications of Results to Promoting Crop Diversification**

From these results of testing the cropping decision tree model there are important points to consider regarding crop diversification which can be used by change agents as diagnostic guide for determining whether or not farmers are ready to crop diversify. These are:

1. Farmers will be more willing to crop diversify in the dry season if their family's rice consumption requirements for the year are met by their wet season rice crop and other sources of income as this gives the farmer greater leeway to take bigger risks in the dry season. This points out the need to also pay attention to the wet season rice production in efforts at encouraging crop diversification during the dry season.

2. The crop must be perceived as technically feasible by the farmer. In particular, the farmer must perceive it as suitable to the soil and topography of his farm and he must perceive the timing of the cropping season as "right," i.e., it suits his wet season schedule and at the same time has a good chance of hitting the high market price at harvest time. The irrigation water must also be perceived as sufficient to support the crop.

3. The crop must be perceived as economically feasible by the farmer. In particular, that it will be bought and that there will be sources of credit if needed. In this regard, the contract

growing scheme appears to be a good vehicle for assuring the farmer of the crop's economic feasibility. The tomato and cotton case studies indicate, however, that certain points must be taken into consideration in order for the contract growing scheme to succeed. First, a fair market price must be paid for the produce (as in the case of cotton) because if the price is too low (as in the case of the contract grown tomatoes), the only way for the farmers to realize a profit is to have very high yields which is not realistic given the conditions under which most farmers operate. Thus, the tomato farmers incurred huge losses because PFVII had set the purchase price at P0.80/kg. when the market price for native tomatoes hovered between P10-12/kg. and even reached a high of P14/kg. Second, the yield estimates given to the farmers must be realistic. In the case of the tomato farmers, the 40 ton/ha potential yield for the California variety given to the farmers by the PFVII technicians created false expectations and, as shown by their large input expenditures, the farmers' behavior was guided by such expectations. Had the farmers been given more realistic estimates, they would probably have been more prudent in their input expenditures. Third, the farmers must be given sound advice by the technicians regarding the use of inputs (especially pesticides which was consistently one of the highest input expenditures across diversified crops) and must be helped to be more aware of their input expenditures during the course of the cropping season.

4. Examination of the individual responses of the farmers indicates that the availability of hired labor does not appear to be a crucial economic feasibility variable because family labor is used overwhelmingly by the farmers for their diversified crops. The heavy use of family rather than hired labor is critical, however, to the overall economic viability of the planting of diversified crops as in general, results indicate that diversified crops tend to be more labor-intensive than growing rice. The implications of this is that crop diversification is probably more viable for small farm areas which the family can work on because there is a need to get more hired labor with larger areas and this could adversely impact the net cash returns that the farmer eventually gets from the diversified crop. There is also a positive aspect to the high utilization of unpaid family labor in the growing of diversified crops which is that it absorbs the excess family labor that would otherwise be unemployed or underemployed during the dry season.

5. Data on the cost-benefit analyses indicate that the farmers tend to have high minimum profitability requirements for the

diversified crop vis-a-vis rice. This is mainly due to the higher risks involved in planting diversified crops. This implies that for a farmer to agree to plant a diversified crop in the dry season, he must be sufficiently convinced that it will yield high returns and not just marginally higher returns than rice. Indeed, we note from the cases that farmers are willing to plant crops that are much more time, input, and labor intensive than rice provided they perceive it as having high profitability compared to rice. The data, nonetheless, also indicate that some farmers may be willing to plant diversified crops that fall below their minimum desired profitability if there is no better alternative under the circumstances (e.g., not enough water for planting rice and the other alternative crops are less attractive or feasible) provided that they expect to realize profits from the venture.

#### ACKNOWLEDGMENT

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#### NOTES

1. See Nisbett and Ross (1980) for an excellent summary of research findings on the strategies and shortcomings of human inference and decision making.
2. This implies that what matters to farmers is cash profitability and that the opportunity cost of family labor is near zero during the dry season.

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