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Uncertainty and Allocative Behaviour in Peasant Agriculture: A Study of Small-Holding Farmers in Bangladesh

Quazi Shahabuddin

UNCERTAINTY AND ALLOCATIVE BEHAVIOUR IN PEASANT AGRICULTURE: A STUDY OF SMALL-HOLDING FARMERS IN BANGLADESH

By

© QUAZI SHAHABUDDIN, B.A. (Honours), M.A., M.Sc.

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AUTHOR: Quazi Shahabuddin, B.A. (Honours, University of Dacca)
M.A. (University of Dacca)
M.Sc. (University of London)

SUPERVISOR: Professor D.W. Butterfield

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ABSTRACT

Knowledge of farmers' decision making behaviour constitutes an essential element in the formulation of appropriate policies for agricultural development in low-income countries. Since agricultural production is inherently a risky process in which farmers are exposed to numerous sources of uncertainty, any study of farmers' decision making behaviour should explicitly consider the role of risk. This study analyses farmer behaviour in Bangladesh, focussing on the effects that risk has on resource allocation decisions. The key issues explored in this context are: (a) analysis of peasant behaviour towards risk in terms of subsistence requirements and income earning potential of the farm family; and (b) investigation of allocative efficiency in the presence of risk for the small-holding farmers in Bangladesh.

In peasant agriculture where the farms are extremely small and cultivation is dependent upon highly variable rainfall, the farm family may be preoccupied not with maximising income but with maximising their chances of survival. Safety-first models of decision making are based upon this notion of disaster-avoidance and this study specifically employs Roy's Safety Principle under which the decision maker attempts to minimise the probability that income falls below a certain level. Based on the allocative efficiency conditions derived from our safety-first model, alternative testable hypotheses are developed to ascertain whether the small-holding farmers in Bangladesh efficiently allocate their resources to various crops in the presence of risk. A comparison of resource allocation behaviour under two rival criterion for analysing decision making under uncertainty shows that it is possible to analyse

the risk preferences of the farm household in a safety-first model much in the same way as in an expected utility model. The interpretation of the risk coefficient, however, will be somewhat different for the safety-first model. Emphasizing the farmer's behaviour towards risk, the safety-first approach attempts to explain, in terms of subsistence needs and income generating capacity of the farm households, whether the household is 'forced to gamble' or 'allowed to accept less risk' in their choice of crop portfolio.

The model was estimated using field survey data collected in four different regions in Bangladesh. In particular, data on minimum consumption needs were directly elicited from each farm household in the sample. Our estimates of the risk coefficients in each region show that while most of the farm households in Sylhet should display 'gambling type' behaviour, which occurs when the subsistence needs of the farm family exceeds their income earning potential from farming activities, the situation for the farm households in the other three regions is not so desperate. For most of these households, the minimum consumption needs were less than their income earning capacity, thereby allowing them to undertake less risky activities. Attempts were then made to establish a systematic relationship between our coefficients capturing peasant behaviour towards risk and a number of socio-economic variables characterising the peasant households and their access to income-earning opportunities. Our regression results show that although the explanatory power of the risk-predictive equations are not very high, major explanatory variables such as family size, farm size and off-farm income have the expected signs in most cases and are statistically significant. We are thus able in our study to identify some specific determinants of peasant behaviour towards risk and also to quantify their impact on decision making.

Our empirical results indicate that in general the safety-first model outperforms the expected profit maximisation model in our sample. This tends to validate the hypothesis that in subsistence agriculture like that in Bangladesh, peasant households are preoccupied with their security and survival, and therefore, are very likely to follow some sort of safety-first behaviour in their resource allocation decisions. There were, however, considerable regional variations in resource allocation behaviour. Such observed differences in the behaviour pattern across the four regions examined in Bangladesh are explained in terms of a disaster-avoidance motive which is ultimately traced to the capacity of the farm households to generate sufficient income to meet their subsistence needs.

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CHAPTER I

INTRODUCTION

I.1 The Problem: Its Nature and Importance

It is now widely believed that knowledge of decision-making behaviour of low-income farmers and the use of it in formulating suitable agricultural policies occupies a position of central importance in shaping appropriate strategies for agricultural development in underdeveloped countries. Since a number of recent studies have evidenced the importance of risk in decision-making by farmers in traditional agriculture, we shall explicitly consider the role of risk in our study of resource allocation behaviour of the small farm households in a subsistence agriculture like Bangladesh. The importance of risk aversion in farmer's decision-making process can never be over-emphasized. Not only are future prices uncertain but more importantly, expected outputs are highly variable as well. This is especially true in the case of Bangladesh. Buchanan (1976) has said:

> "The description, originally applied to Ireland, as 'a distressful country' might equally appropriately be applied to Bangladesh. Here is a country essentially of far-stretching flood plains created, and still being created, by mighty rivers subject to the vagaries of the monsoon rains. Life is adjusted to the annual flooding of enormous areas of productive farm land, but not to the recurrent variations of the rains and the floods from excess to deficiency or to the cyclonic storms that spread devastation over vast areas every few years. On this land of such high risks lives such an exceedingly dense agricultural population that farms are prevailingly tiny and incomes so low that there is little margin available to cushion bad times or to build up some capital - all the more serious in that few countries are so heavily dependent on agriculture."

Therefore, in analysing farmer behaviour in Bangladesh, considerable attention will be given in this study to examine the role of risk in their resource allocation behaviour. More specifically, in analysing farmer behaviour in Bangladesh, we shall try to answer the following questions:

(i) What effects does risk have upon farmers' resource allocation decisions?

(ii) Do farmers efficiently allocate their resources in the presence of risk?

(iii) How do subsistence farmers react in general to the prevasive uncertainty of their environment?

More than a decade ago, Schultz (1964) suggested that peasant agriculture although primitive may still be efficient within the context of traditional technology and factor availability. He defended the hypothesis of the 'optimising peasant' - the shrewd fellow who has learned enough through long experience to allocate resources efficiently and who is responsive to economic incentives within his perceived opportunity set. Since then, a substantial amount of research has been undertaken to test this hypothesis. This is not surprising, in view of the fact that testing for economic efficiency also provides for an indirect test of certain assumptions of economic rationality. Peasants who do not respond to economic incentives are not likely to embark on a programme of dynamic agricultural growth and change, the pay-off of which lies primarily within the economic sphere. Most such studies which have been conducted within the framework of neo-classical profit-maximising behaviour have found peasants to be reasonably efficient [See Chennareaddy (1967, Hopper (1965), Sahota (1968), Massel (1967) and Yotopoulos (1968)].

However, it may be recognised that agricultural production is inherently a risky process in which farmers are exposed to numerous natural and economic sources of uncertainty. Many empirical studies do suggest that these risks can have important consequences for farmers decisions, especially among small-holding farms in developing countries [See Dillon and Anderson (1971), Herath, Hardaker and Anderson (1982), Wiens (1976) and Wolgin (1975)]. Therefore, to the extent risk plays an important role in farmer decision-making behaviour, it becomes necessary to develop tests of allocative efficiency in a model of economic behaviour under uncertainty.[1] In fact, using an expected-utility model of resource allocation, Wolgin (1975) has already demonstrated that the traditional tests of economic efficiency are, in general, misspecified.

We, however, feel that in a peasant agriculture characterised by a predominance of small-holding farms, the farm family's behaviour is better conceptualised in terms of a decision-making rule known as safety-first. These rules, as emphasized by Moscardi (1975), shape a particular economic behaviour where the possibility that income from agricultural activity may fall below some subsistence level plays an important role in production decisions. Also, Griffin (1974) argues convincingly how the stark reality of disaster makes the safety-first rule a very appealing criterion for analysing farmer behaviour in a traditional agriculture:

> "Specially, in regions where farms are extremely small and cultivation is dependent upon highly variable rainfall, average incomes will be extraordinarily low and in poor years, the peasant and his family will be exposed to the dangers of starvation. In such circumstances, the peasant may be preoccupied not with maximising his income but with maximising his chances of survival"

Therefore, in our study of resource allocation behaviour of small farm households in Bangladesh, risk will be introduced in a model of resource allocation as a safety-first rule.[2]

Models of decision making under risk requires knowledge of decision makers risk preferences. This is true for both positive and normative applications of risk theory. In fact, it is widely suggested that attitudes towards risk are major determinant of the rate of diffusion of modern crop technology among the small-holding farms in a peasant agriculture. To make the rural development programs incorporating this modern bio-chemical technology effective, they need to be optimally tailored to the peasant's economic behaviour.[3] Thus, it becomes very important to identify the specific determinants of behaviour towards risk and also to quantify their impact on decision making [Moscardi and De Jahvry (1977)]. In this study, therefore, attempts will be made to derive an expression capturing peasant behaviour towards risk in a model of safety-first behaviour, and also to obtain quantitative estimates of this measure for different farm households utilising field survey data. The differential behaviour towards risk as captured in these estimates are then explained by a set of socio-economic and structural variables that characterise small farm holds in Bangladesh.

I.2 Organisation of the Study

Our study is organised as follows. Chapter II provides a brief overview of Bangladesh agriculture. In particular, it examines the structure and organisation of agricultural production, and also to provide a description of the physical environment and climatic conditions that creates much of the uncertainty facing the typical farm households in Bangladesh. Chapter III contains the theoretical underpinnings of our study, in which we present a microeconomic model of resource allocation under risk based on a decision rule that incorporates the probability of disaster. Such a formulation, we shall see, leads to somewhat different conclusions concerning the type of behaviour that implies efficiency than what is envisaged under expected profit maximisation. In particular, it is shown that if the farmer follows risk minimising behaviour in resource allocation, then he no longer equates the marginal value products of an allocable input among its various uses (i.e. alternative crop production activities). His resource allocation pattern will now be dictated by an inequality according to which the expected value of the marginal productivity of any input in a particular crop will differ from its alternative uses in the same order as the risk factors associated with the use of that input in various crops differ.

Suitable testable hypotheses are then developed based on these efficiency conditions to ascertain whether the small-holding farms efficiently allocate resources to various crop activities in the presence of risk. Also, our basic resource allocation model was modified to explore the conditions under which risk induces a shift of acreage in favour of the food crop vis-a-vis the cash crop in subsistence farming. Finally, given alternative criterion for analysing decision-making under uncertainty, a comparison of resource allocation behaviour has been made which brings out some of the important implications of peasant behaviour towards risk under a safety-first approach. In particular, it provides an explanation of 'gambling type' behaviour sometimes observed among the small-holding farms in peasant agriculture.

Chapter IV gives a description of the basic data set used in our empirical study. To meet the data requirement of the model, a field survey was conducted among the small farm households in four different regions in Bangladesh. This chapter discusses the survey procedures and analyses in depth the various data characteristics in the sample. These characteristics include (a) the distribution of land ownership and tenurial conditions (b) the size-composition of the farm family and the average land/man ratio (c) the amount of fixed capital and labour use of different categories (d) the cropping pattern, cropping intensity and average yield of various crops (e) the gross value of output, farm income and structure of variable cost (f) the sources of farm and non-farm incomes (g) the credit situation, property valuation and disaster income levels of each household and finally, (i) the overall income-expenditure pattern of the farm households.

In Chapter V, we discuss the estimation of various parameters of our resource allocation model presented in Chapter III. This includes the estimation of cross section production functions and the variance-covariance matrices of random disturbances associated with output and prices of various crops grown in Bangladesh. In the estimation of cross section production functions of different crops using the farm-level data collected earlier, both the regional nature of production and the specification of alternative functional forms are explored. In the absence of farm-level time series on output and prices, the variance-covariance matrices of output and price disturbances have been estimated utilising the district-level aggregate time series data. The general procedure adopted was to extract the systematic portion of aggregate time series so that the residuals represented the estimates of random disturbances from which relevent variance-covariance matrices were computed.

In Chapter VI, we present the estimates of the risk factors associated with various crops, as well as the coefficients capturing peasant behaviour towards risk under the safety-first approach. These estimates were derived for the farm households in each sampling region utilising the estimates of disaster incomes as well as the mean and the variance of crop portfolio of each farm household, which in turn were based on the expected prices and outputs of various crops and the variance-covariance matrices of the disturbances affecting farmer's income. The risk factors (ϕ_{Q_i}) it may be recalled, are derived from the first-order conditions of our resource allocation model under risk and capture the effects of risk in resource allocation in peasant agriculture like Bangladesh. These estimates are required for testing the hypotheses involving resource-use efficiency in the presence of risk.

Our estimated risk coefficients (ψ_k), on the other hand, describe peasant behaviour towards risk (i.e. how they react to the pervasive uncertainty in their environment) in terms of the subsistence needs of the farm family relative to its income earning capacity from farming activities. Attempts are also made to explain differential behaviour towards risk both across regions and more importantly, across different farm households in each sampling regions. In particular, socio-economic and other structural characteristics are introduced in order to explain differential peasant behaviour towards risk in subsistence farming like that in Bangladesh.

In Chapter VII, we attempt to answer some of the questions raised in the beginning of this chapter. This is primarily done by testing the validity of the set of efficiency conditions in our sample. The results of our tests, generally support risk minimising behaviour (as opposed to profit maximising behaviour) among the small farm households in Bangladesh. However, considerable regional variations in resource allocation behaviour exist in our study. Such observed differences in the behaviour pattern in resource allocation across the four surveyed regions could be explained in terms of a disaster avoidance motive in the sample which could ultimately be traced to the capacity of the farm households to generate sufficient incomes to meet their subsistence needs.

Chapter VIII, summarises the results of this study, draws implications for agricultural policy in Bangladesh, in particular, and developing countries, in general, and finally, suggests some promising directions for further research.

FOOTNOTES

1. Dillon and Anderson (1971), in particular, have emphasized the need for alternative behavioural hypotheses that explicitly allows for subjective risk consideration in the appraisal of resource allocational efficiency in traditional agriculture. In fact, their appraisal of some of the evidence previously adduced gives only mixed support to the hypothesis of profit maximising behaviour, which led them to conclude: "The way is thus left open for investigation of alternative hypotheses - in particular, the hypothesis of allocative efficiency based on (expected) utility maximisation in the face of subjective risk."

   Also, the econometric analysis conducted by Srivastava and Nagadevra (1972) indicates that judgements on allocative efficiency that are based on neo-classical profit maximising assumption may be misleading, particularly when the production coefficients are probabilisitc.

   A number of studies undertaken by Junanker (1980a, 1980b) in the context of Indian agriculture also indicate that their results do not support the profit function model in any of the regions studied, which led him to conclude: "Despite some evidence that inputs and outputs respond normally to price changes, a simple neo-classical model of profit maximising behaviour does not work. It is clear that more research needs to be done to explain the behaviour of farmers in poor countries."

2. Scandizzo and Dillon (1979) in an econometric study analysing the risk preferences of small farmers in Northeast Brazil observed: "The overall picture provided by our data appears to validate the qualitative hypotheses advanced for risk preferences of subsistence farmers and in particular, the hypothesis that they are likely to follow some type of safety-first approach whenever the satisfaction of basic needs may be at risk."

   Also, Asaduzzaman (1981) while studying some of the implications of safety-first behaviour in the context of adoption of HYV rice technology in Bangladesh agriculture concluded: "Subsistence needs in a risky situation shape fairly strongly the behaviour of the peasantry in a environment like that in Bangladesh."

3. In particular, knowledge of attitudes towards risk may be used for the purpose of tailoring technological recommmendations to particular categories of peasants, as done by Moscardi and De Janvry (1977) for the small farm households in Mexico.

CHAPTER II

AGRICULTURE IN BANGLADESH - AN OVERVIEW

II.1 Introduction

This chapter presents a brief overview of Bangladesh agriculture. In particular, it examines (a) some selected features of the Bangladesh economy with special emphasis on the importance of the agricultural sector and (b) some physical and organisational aspects of agricultural production in Bangladesh. Section 2 provides some basic information on the economy of Bangladesh, particularly its agriculture. Section 3 examines the agrarian structure and the organisation of agricultural production in Bangladesh. Section 4 describes the physical environment and the natural constraints that characterise agricultural production in Bangladesh. The last section summarises the chapter and presents some concluding remarks.

II.2 Some Selected Aspects of the Economy of Bangladesh

II.2.1 The Economy and the Importance of the Agricultural Sector

Bangladesh, with about 55000 square miles of land and about 85 million (as of 1978) people, is one of the poorest countries in the world. The gross domestic product (GDP) of Bangladesh in 1977/8 was estimated, at constant 1972/3 factor cost, to be about 60.9 thousand million taka. Per capita GDP in 1975 was about 90 US dollars as compared to 144, 196 and 162 US dollars for India, Indonesia and Pakistan respectively (at the prevailing exchange rates).[1] This dismally low level of income is the result of the sluggish performance of the economy in the past three decades - the growth of GDP hardly kept pace with the rate of growth of population. This is quite evident from the information on the composition of GDP and its changes over the last 29 years as reported in Table 2.1. One can observe that the economy made hardly any progress during the fifties; GDP grew at a rate of 2.3% which was lower than the rate of population growth of 2.5% during the period. Progress was much better in the sixties; GDP managed to grow at a rate of 4.3% compared to a population growth rate of 2.9%, thereby permitting a per capta GDP growth of 1.4% during the period. The early seventies were a period of relapse mainly due to the War of Liberation in 1971, and it took several years even to restore GDP to the 1969-70 level. In fact, it was only in 1975-76 that per capita GDP reached the 1969-70 level thanks to the bumper harvest which increased rice production by 18% over the previous year. However, growth picked up momentum somewhat in the late seventies, which enabled the economy to achieve, between 1972-73 and 1977-78 (during the First Plan Period), an annual compound GDP growth rate of 3.2%. Still, this was hardly sufficient to raise the level of income from its dismally low level as the per capita GDP in 1977-78 stood at Taka 1310 or 87 US dollars.

A look at the composition of GDP, shown in Table 2.1 makes it readily evident that the economy is characterised by its heavy dependence on agriculture. Even as late as in 1977-78, more than half of GDP (at constant 1972-73 factor cost) originated in this sector; the manufacturing sector which is as yet very small contributed only 8.4% of GDP. What, however, is more significant and emphasizes the predominantly rural nature of the economy is the fact that roughly 90% of the total population live in rural areas and over 80% of them are dependant on agriculture.

Table 2.1

Growth and Composition of Gross Domestic Product of Bangladesh: 1949-50 to 1977-78

		at 1959-60 factor cost			at 1972-73 factor cost	
		1949-50	1959-60	1969-70	1972-73	1977-78
I.	GDP (million taka)	11298	14161	21504	45300	60890
II.	Composition of GDP (as % of GDP)					
	1. Agriculture	65.4	60.4	53.3	60.1	56.7
	2. Manufacturing	3.0	6.0	7.8	7.3	8.4
	a. Large Scale	.6	2.9	3.6	4.6	5.6
	b. Small Scale	2.4	3.1	4.2	2.7	2.8
	3. Other	31.6	33.6	38.9	32.6	34.9
III.	Annual Compound Rates of Growth					
	1. GDP		2.28	4.26		6.09
	2. Agriculture		1.46	2.98		4.88
	3. Manufacturing		9.65	7.04		9.23
	4. Population		2.47	2.98		2.92

Sources: No single source provides GDP estimates either in current or constant factor cost for the whole period. Figures for 1949-50 to 1969-70 are from Alamgir & Barlage (1974). The other figures are from the World Bank (1978) and the Statistical Year Book of Bangladesh (1979).

The fact that the major share of GDP originates in agriculture means that for a long time to come the overall growth of the economy will be influenced by the growth of this sector. In fact, the past stagnation of the economy may be attributed to the sluggish performance of this sector. During the fifties, the growth of the agricultural sector was much below that of population (Table 2.1). During the sixties, the growth rate of this sector doubled but still this was barely sufficient to keep pace with the rate of growth of population. It was only during the seventies particularly during the First Plan Period that the growth of this sector surpassed the rate of population growth but this was hardly sufficient, as mentioned earlier, to raise the level of income or increase per capita availability of agricultural products in recent years.

II.2.2 Population and Labour Force

Table 2.2 presents some relevant demographic features of Bangladesh for the period 1951 to 1974. According to the 1974 Census, the population of Bangladesh was estimated at 76.2 million. For an area of about 55000 square miles of land in Bangladesh, this gives a population density of 1385 people per square mile which is undoubtedly one of the highest in the world. In fact, no other country with a population of more than 10 million has a higher population density. And among countries with a population of more than one million, only Singapore and Hongkong are more densely populated. The rate of population growth in Bangladesh between 1961 and 1974 was 2.8% which compares with the growth rate of 2.1% for India and over 3.0% for Pakistan, Thailand and Philippines.[3]

Table 2.2 indicates that the labour force participation rate in Bangladesh is quite low. In 1961, only 1/3 of total population in Bangladesh was economically active. The situation only marginally improved in 1974. This must be attributed largely to a very low female participation rate in Bangladesh. The female participation rates, however, showed considerable improvement over the years, from 5% in 1951 to about 19% in 1974. A tapering age distribution of population associated with a high rate of natural increase is also responsible for this low percentage of the economically active population in Bangladesh.

Table 2.2

Some Demographic Features of Bangladesh: 1951-1974

Characteristics	1951		1961		1974
Population (million)	41.9		53.4		76.2
Rate of population growth		2.44		2.77	
Density of population (per square mile)	762		971		1385
Labour Force					
(as a % of population)	30.7		33.2		35.2
Male (as a % of total male population)	54.2		45.2		50.6
Female (as a % of total female population)	5.0		10.8		18.6
Agricultural Labour Force					
(as a % of total labour force)	83.2		85.1		77.2
Male (as a % of total male labour force)	83.3		84.1		77.5
Female (as a % of total female labour force)	82.4		91.7		69.8

Sources: Census of Pakistan, vol. 2, 1961, East Pakistan and Bangladesh Population Census, 1974

Table 2.2 shows that in 1961 roughly 85% of the total labour force in Bangladesh was employed in agriculture. In view of the very limited non-agricultural employment opportunities in Bangladesh and the fact that most of the people live in rural areas, it is only natural that the bulk of the labour force of the country is absorbed in this sector. Even in 1974, agriculture still employed more than three-fourths of the total labour force in Bangladesh.

II.3 Structure and Organisation of Agricultural Production

II.3.1 Land Utilisation and Cropping Pattern

Rice dominates the agricultural scene in Bangladesh, and in 1976-77 occupied roughly 80% of the total cropped area in the country. In fact, Bangladesh is one of the world's major areas of rice production. With an average total acreage of 24.26 million, it exceeds the combined acreage of Thailand, Formosa and Java. It is grown in three varieties - aus, aman and boro and through two general techniques, broad-casting and transplanting. Of the three varieties, aman is the most extensive crop and generally, its acreage is two and a half times that of aus, while boro occupies only a fourth of the area under aus. Of course, the varieties of rice grown vary by season and techniques and the choice depends on the characteristics of the land, the resources available to the farmer, the state of technology and alternative cropping possibilities.

Next to rice, jute is the most important crop in Bangladesh. In fact, Bangladesh is the largest producer of jute in the world and the quality of its fibre is the finest. It is the main cash crop in Bangladesh, and accounts for about half the money income of the agricultural community. Also, jute is the

Table 2.3

The Cropping Pattern in Bangladesh

Crops	Average of 1955-56 to 1959-60		Average of 1965-66 to 1969-70		Average of 1970-71 to 1974-75		1976-77	
	Area in million acres	%	Area in million acres	%	Area in million acres	%	Area in million acres	%
1. Rice	20.1	77.6	23.9	77.6	24.0	80.5	24.4	80.2
Aus	5.8	22.4	7.9	25.0			7.9	26.0
Aman	13.5	52.1	14.5	47.1			14.4	47.3
Boro	.8	3.1	1.7	5.5			2.1	6.9
2. Jute	1.5	5.8	2.3	7.5	1.9	6.4	1.6	5.3
3. Wheat	.1	.4	.2	.7	.3	1.0	.4	1.3
4. Sugarcane	.3	1.2	.4	1.4	.4	1.3	.4	1.3
5. Tea	.1	.3	.1	.3	.1	.3	.1	.3
6. Tobacco	.1	.4	.1	.3	.1	.3	.1	.3
7. Pulses	n.a.	n.a.	.9	2.9	.8	2.7	.8	2.6
8. Oilseeds	.8	3.1	.8	2.6	.5	1.7	.8	2.6
9. Others	3.0	11.6	2.4	6.9	.8	2.7	1.0	3.4
Total	25.9	100.00	30.8	100.00	29.8	100.00	30.4	100.00

Sources: Statistical Digest of Bangladesh (1972), Bangladesh Agriculture in Statistics (1973) and Statistical Yearbook of Bangladesh (1979).

leading export, in raw and manufactured form, and accounts for nearly 90% of the foreign exchange earning for Bangladesh. Other prominent cash crops are tea, sugarcane and tobacco which together accounted for 1.8% of the total cropped area in the country in 1976-77.

Other important crops include pulses, wheat and oilseeds whose total acreage in 1976-77 amouted to 2.0 million acres, or about 6.5% of the total cropped area in Bangladesh.

The overall cropping pattern in Bangladesh and its variation over time is brought out clearly in Table 2.3. It is observed that the relative importance of different crops remained almost the same over the years, except that there was a slight increase in the shares of rice and wheat while the shares of other crops declined. Also, jute's share rose in the late 1970's as compared to the late 1960's but the share fell again, almost to the same level in 1976-77.

Data on land utilisation are shown in Table 2.4.

Table 2.4

Pattern of Land Utilization in Bangladesh

(million acres)

Particulars	5-year average ending 1959-60	5-year average ending 1964-65	5-year average ending 1974-75	5-year average ending 1976-77
1. Forest	5.46	5.46	5.50	5.45
2. Not available for cultivation	5.59	5.97	6.57	6.63
3. Cultivable waste	1.95	1.82	.70	.67
Total	13.00	13.25	12.77	12.75
4. Current Fallow	1.32	.98	1.69	2.10
5. Net Cropped Area	20.33	20.93	20.82	20.04
Total Cultivated Area	21.65	21.91	22.51	22.14
6. Total Cropped Area	25.91	27.88	30.29	30.44
7. Cropping Intensity	120%	127%	135%	138%

Source: Statistical Pocket Book of Bangladesh (1978) published by the Bangladesh Bureau of Statistics, Govt. of Bangladesh.

It is quite evident from the land utilisation figures in Table 2.4 that there has not been any appreciable change in the net cropped area over the years in Bangladesh, though gross cropped area has increased from 25.91 million acres in 1955-56/1959-60 to 30.44 million acres in 1976-77. This was made possible by an increase in multiple cropping raising cropping intensity from 120% in the period ending 1959-60 to 138% in the period ending 1974-75.

II.3.2 Size-Tenure Structure of Bangladesh Agriculture

Data on the size-distribution of landholdings (operational) in Bangladesh are available from the Agricultural Census (1960), the Master Survey of Agriculture (1968), the Summary Report of Land Occupancy Survey of Bangladesh (1977) and a number of surveys carried out by the Ministry of Agriculture and by the Bangladesh Institute of Development Studies. The percentage distribution of farms and farm-areas in different size-groups are shown in Table 2.5.

Table 2.5

Size-Distribution of Farms and Farm-Areas in Bangladesh

Size	Farms (%)			Farm-Areas (%)		
(in acres)	1960	1968	1974	1960	1968	1974
Less than .5	13	12	32	1	1	2
.5 to 1.0	11	13	9	2	3	3
1.0 to 2.5	27	32	25	13	17	18
2.5 to 5.0	26	26	22	26	30	34
5.0 to 7.5	12	9	7	19	18	19
7.5 to 12.5	7	5	3	19	15	13
12.5 and above	4	3	2	20	16	11

It is quite clear from the figures presented in Table 2.5 that Bangladesh agriculture is not only characterised by a predominance of small-sized farms - the majority of farms (ranging from 51% in 1960 to 66% in 1974) belong to less than 2.5 acre-group - but there exists a pronounced inequality in the distribution of land-holdings as well. While more than a quarter of farms (ranging from 24% in 1960 to 41% in 1974) are less than a size of one acre with a share of total land-holdings of 5% or less, only about one-tenth of the farms (with 7.5 acres or more) account for 24% to 39% of the total farm-area.

The tenurial arrangements in Bangladesh agriculture may broadly be classified into three groups: owner-operated, owner-cum-tenant and tenant farms. Tenant farming is mainly on a sharecropping basis, the share of the tenant farms in most cases being 50% of the total output produced. The distribution of farms and farm-areas by types of tenure is shown in Table 2.6.

Table 2.6

Tenurial Arrangements in Bangladesh Agriculture

Type of Tenure	Number of Farms(million)			Percentage of Farms		
	1960	1968	1977	1960	1968	1977
Owner-Operated Farms	3.73	n.a.	5.00	61	66	61
Owner-cum-Tenant Farms	2.31	n.a.	2.62	37	30	32
Tenant Farms	.10	n.a.	.56	2	4	7
	Farm Area (%)					
	1960	1968	1977			
Owner-Operated	82	83	77			
Tenant-Operated	18	17	23			

Table 2.6 indicates that while the proportion of owner-operated farms has remained roughly the same over the years at 61%, the percentage of owner-cum-tenant farms has declined from 37% in 1960 to 32% in 1977. During the same period, the share of tenant farms increased steadily from 2% to 7%. In terms of area operated, the share of tenant-operated farms in total cultivated area which was slightly less than one-fifth of the total farm-area in 1960 increased somewhat to 23% in 1977. This, however, shows that owner-operated farming still constitutes the overwhelmingly dominant form of tenancy in Bangladesh, accounting for 77% of the total farm-area in 1977.[4]

An important question which may be raised here is whether the existing pattern of landholding distribution and the prevailing tenurial arrangements act as a retarding force in the process of agricultural growth and productivity in Bangladesh. Although a definitive answer to this question cannot be given in the absence of a comprehensive study of the dynamics of rural development in Bangladesh, one can nevertheless make some pertinent observations in the light of some of the empirical studies already undertaken to examine some of the specific issues involved.

Empirical studies undertaken by Hussain (1974, 1977) using both direct functional analysis and later an indirect but more realistic approach (in the context of a peasant economy) demonstrate conclusively that smaller farms are relatively more productive than larger ones. Thus the inverse relationship between farm size and productivity, which is one of the stylised fact of traditional agriculture, is clearly established in Bangladesh. However, there does not seem to be any conclusive evidence regarding the impact of tenurial arrangements on relative productive efficiency in Bangladesh. Hussain's empirical study (1977) concludes: "If one controls for the effects of size, tenant's productivity is still found to be higher than owner's in all cases, but the hypothesis of equality of productivity cannot be rejected statistically." Empirical evidence presented by Jabbar (1977), on the other hand, reveals that in rural Bangladesh, different tenure classes achieve different levels of productive efficiency; among them owner-operator farms have been identified to be the most efficient group.

II.3.3 Nature of Agriculture and Method of Cultivation

Although a detailed description of the factors governing the physical conditions of production in Bangladesh is provided in the next section, we consider it worthwhile to discuss briefly here the nature of agriculture and the methods of cultivation followed in traditional agriculture like Bangladesh.

Bangladesh agriculture is characterised by its heavy reliance on nature. In fact, the agricultural activity in Bangladesh centers around the monsoon which patterns and dictates the choice of crops. Agriculture is overwhelmingly dominated by rice which is grown in three main varieties, aus, aman and boro. Medium quality of land is suitable for aman cultivation by transplantation which is usually done between July and mid September. The plant grows on the inundated land and is harvested from November to January when the land is dry. Broadcast aman is a deep water floating rice which elongates with rising water levels in the flood season. This crop is sown from mid March to the end of April and harvested in November and December, when the water level recedes. The aus season starts with the first Nor'western rainfall in March or April and is usually harvested before the onset of flood from monsoon in July and August. Jute has the same seasonal cycle as aus and competes with it for land. Aus is usually followed by winter crops such as pulses and oilseeds on dry land and by transplanted aman on low land if the Nor'wester starts early. Boro rice is usually grown in dry winter season in very low lying land, without irrigation, or in medium/high elevation land which has access to controlled irrigation facilities. Table 2.7 presents the crop calender for major crops in Bangladesh.

Table 2.7

Crop-Calendar of Some Major Crops in Bangladesh

Crops	Period of Sowing or Transplanting	Period of Harvesting
Rice:		
Aus	March - May	July - August
Aman (Broadcast)	March - April	November - December
Aman (Transplant)	July - September	November - January
Boro (Local)	November - December	April - May
Boro (HYV)	January - February	May - June
Jute	April - May	July - September
Pulses	October	February - April
Rape & Mustard	October - November	January - February

Source: Statistical Pocket Book of Bangladesh, 1978.

Although the Bangladesh deltaic plain is fairly fertile, the soils do lack adequate amounts of important nutrients. Moreover, heavy dependence on monsoon and other natural factors makes crop cultivation an extremely risky activity. In fact, extreme variation in water flows throughout the year combined with flat terrain in Bangladesh produces a very risky environment for growing crops and depresses yields below their potential. For example, untimely and insufficient rainfall in the dry regions frequently reduces cultivated acreage and lowers crop yields while many areas in the wet zones are very susceptible to damaging floods.

Farming methods used in Bangladesh are still very primitive. The major agricultural implements consist of a wooden plough, a comb harrow made of wood, a bamboo ladder for crushing and levelling of land and a pair of bullocks. Practically, all farm power is provided by bullocks which are used for land preparation, transportation and threshing of harvested plants. As late as in 1970, Bangladesh had only 2072 tractors of an average 45 h.p. each. Also, until 1970 only about 2571 power tillers had been distributed by the government in Bangladesh. Obviously, this has not reduced the dependence on bullock power to any significant extent. However, since modern mechanical-engineering technology is usually associated with labour replacement, one should not worry too much about its virtual absence in a labour-abundant country like Bangladesh.

It is the lack of advance in the diffusion of modern bio-chemical technology and irrigation facilities that is believed to have been a matter of greater concern in an economy characterised by extreme scarcity of land.

Mechanised irrigation is mostly provided by the government in Bangladesh. However, in 1975-76 modern mechanical methods of irrigation covered only 5.2% of total cropped acreage in the country.[5] The issue is important because although the monsoon land of Bangladesh is generally pictured as a water-submerged region, it, nevertheless, has a long dry season when cultivation is possible only with irrigation except in some low lying areas.

The modern bio-chemical technology has also not spread much in Bangladesh. In the mid-fifties, the use of such technology was virtually absent. Since then, some progress has been made in the use of fertilizers, HYV seeds and pesticides as shown in Table 2.8.However, as the figures in Table 2.9 indicate, Bangladesh still lags far behind in this respect as compared to most of her neighbouring countries in Asia.

Table 2.8

Use of Selected Modern Inputs in Bangladesh Agriculture

Selected Inputs	1959-60	1964-65	1969-70	1972-73	1976-77
Use of chemical fertilizers (nut. lb./acre)	1.0	3.5	8.9	13.3	16.9
Percentage of cropped acreage irrigated by mechanical means	.2	.5	2.5	4.9	6.0
Percentage of cropped area covered by plant protection measures	1.6	16.8	30.3	37.0	n.a.
Percentage of rice acreage under HYV	nil	nil	2.6	11.1	13.0

Sources: Bangladesh Agriculture in Statistics (1973) and Statistical Pocket Book of Bangladesh (1978).

Table 2.9

Use of Modern Inputs in Selected Asian Countries, 1972

Countries	Fertilizer Use (lb./acre)	Percentage of Arable Land Under Irrigation	Percentage of Rice and Wheat Area under HYV
India	14.66	19.70	20.60
Indonesia	22.25	38.10	4.61
Pakistan	20.39	72.40	47.30
Phillipines	20.23	17.00	50.30
Thailand	11.67	23.10	2.10
Bangladesh	18.55	13.60	6.70

Sources: FAO Production Year Book, 1973 and 1976 and UN, ESCAP, 1973.

II.4 Physical Conditions and Natural Constraints

II.4.1 Ecological Setting

Bangladesh, situated between latitude 20° 30" and latitude 26° 45" north and longitude 86° and longitude 92° 56", is one of the biggest deltaic countries of the world. The dominating characteristics of the topography is the extreme flatness of the country in general, with only a few hills in the Southeast and Northeast. The highest areas in the country lie in the Chittagong Hill Tract in the Southeast where elevation range up to approximately 3000 feet. Most of the land area of the country lies between 20' and 50' contours. The land to the west of Brahmaputra river is generally higher than that in the eastern part of the country as several large depressions have been formed during the process of deltaic building, particularly in Mymensingh and Sylhet districts.

Bangladesh is a land of numerous rivers meandering over a vast alluvial plain. A vast network of rivers, of which the Ganges, the Padma and the Brahmaputra-Meghna are important, canals and streams, with a total length of about 1500 miles, covers the country flowing down into the Bay of Bengal. The alluvial soils are thus continuously enriched by heavy silts deposited by the rivers during the rainy season. Most of the rivers, however, are characterised by limited depths, sandy bottoms, flat slopes and shifting channels.

Although the prime importance of physical considerations lends a certain uniformity to the agricultural scene in Bangladesh, still there are considerable variations in the regional patterns of cultivation. In fact, there is an interesting relationship between geographic and economic factors in land use and cropping pattern which is reflected in the following divisions of the country into four major regions based primarily on physiographic and hydrological considerations.[6]

I. <u>Northwest Region</u>

The Northwest Region of Bangladesh is north of the Ganges and west of the river Brahmaputra and its northern tip is within a few miles of the Himalayan foothills. The physiography of the region which covers 24.5% of the total 55000 square miles of Bangladesh, is characterised by the land sloping downward in a southeasterly direction. Much of the land in this region is higher than the rest of the country except for the hilly areas along the eastern boundary of the Eastern Region, and as a result, flooding is less deep and less extensive than elsewhere.

The Northwest Region has a warmer summer and a cooler winter than the other three regions, and Rajshahi district in the west of the region is on average the driest area in the country. Compared to other regions, there is less rainfall in this region which varies from 50" in the southwest and 80" in the south to 90" in the north. This must be compared with extremely high rainfall in the northeast of Sylhet in Central Region of 220" and 120" in the south of Patuakhali district in Southwest Region.

Rice is grown throughout the region. Transplanted aman is the major crop throughout the north and the west, grown on land that is shallowly flooded in the monsoon season. On the Barind Tract and the north of Dinajpur, it is mainly grown as a single crop. Elsewhere, it is usually preceded by broadcast aus or jute and the land remains fallow in the dry season. Aus is the only rice crop grown on well-drained highland soils. On land flooded too deeply for transplant aman, broadcast deepwater aman is the major crop. Boro presently occupies only a small proportion of the area mainly on deep basin sites. Just is important on poorly drained Tista flood plain soils and tobacco is grown on well drained soils specially in Rangpur. Sugarcane is important in Rajshahi and in Dinajpur districts.

II. Central Region

The Central Region lies between the river Meghna and Brahmaputra Jamuna rivers. The landscapes in the Central Region which occupies about 16% of the total area of the country are lower and relatively flat. The physiography of the region is generally characterised by a downward slope in the southeasterly direction.

In the Central Region, both the summers and winters are relatively mild. Rainfall is very heavy in the north-eastern part of this region where mean annual rainfall is nearly 200" per annum. The quantity of rainfall gets progressively smaller moving southwest across the region and is less than 70" in the west of Tangail district. 95% of the rainfall occurs between April and October. The region is not seriously affected by the cyclones that originates over the Bay of Bengal, although torrential downpour cause local flooding.

Land use is more diversified in the Central Region than in any other regions. Transplanted aman is the major crop on the extensive areas of shallowly flooded land in the Old Brahmaputra Floodplain, the Northern Piedmont and the shallow valley on the Modhupur Tract. It is usually preceded by aus and partly by jute in the floodplain land. Most of the land remains fallow in the dry season. Broadcast deepwater aman is grown extensively on deeply flooded basins on the Old Brahmaputra floodplain, almost the whole landscape on the Jamuna and middle Meghna floodplain and parts of broad valleys in the Modhupur Tract. In the basin centers, aman is usually the only crop grown. On basin margins, it is commonly followed by khesari (a variety of pulses), and on floodplain sites is generally sown mixed with aus (locally with jute) and followed by a wide range of rabi crops specially mustard/rapeseed, khesari and mushkalai. The most deeply flooded land - "Arial Bill" and lower parts of broad valleys in the Madhupur Tract - is mainly used for the cultivation of boro rice using either traditional or low-lift pump irrigation. Broadcast aus is the main crop on well developed soils in the Modhupur Tract and the highest ridge on the old Brahmaputra floodplains. Shallow Madhupur Tract soils and northern hills are under forest. Jute is the main cash crop on floodplain land, especially on the old Brahmaputra and Jamuna floodplains.

III. Southwest Region

The Southwest Region with an area of 15504 miles comprises roughly 28% of the total area of the country. It has a very flat terrain and is interlaced with rivers and tidal channels. The land relief in this region is characterised by gentle downward slope in the southeasterly direction. Elevation varies from 55 feet in the northwest of Kushtia district to sea level along the southern boundary.

The Southwest Region has a hot summer and a mild winter and the region can be severely affected by the cyclones that originate over the Bay of Bengal. Rainfall is heaviest in the southeast of the region where the mean annual rainfall recorded is 120 inches. The northwest of the region is much drier with an average annual rainfall of 60 inches; this highlights the considerable difference in annual rainfall across the region.

Most of the different crops grown in Bangladesh are to be found in this region. A small surplus in foodgrains is produced here, but considerably less land is devoted to jute than in the Central and Northwestern Regions. As elsewhere in Bangladesh, present land use in the Southwest Region is mainly determined by land levels in relation to flooding, but the greater dryness of the western border areas and extensive salinity in the south provide additional limitations. The more permeable droughty, ridge soils in the west are mainly used for broadcast aus followed by a rabi crop. Seasonally flooded land in the west is mainly used for transplanted aman, partly preceded by aus or jute, and displaced by deepwater aman in low-lying areas. Wheat and pulses are widely grown on such land in the rabi season. The eastern half of the Ganges river floodplain is deeply flooded. In the less deeply flooded north, mixed aus and aman are widely grown, usually followed by a rabi crop. Jute is also important in this area. Deeply flooded basins, specially in the south, are mainly used for deepwater aman. Tidally flooded land in the south is almost entirely used for a single crop of transplanted aman, but this is preceded by aus (locally jute) in the northeast and in Bhola island, and more locally by transplanted aus in perennially wet basin centers. Yields in Khulna are reduced by salinity in years of low or late monsoon rainfall, but this is much less of a problem further east, except immediately adjacent to the Patuakhali coast. Cyclones and associated storms periodically cause serious crop damage and loss.

IV. The Eastern Region

The Eastern Region with an area of 17032 square miles (roughly 31% of total area of Bangladesh) covers the whole eastern third of the country from the foothills of the Meghalaya in Sylhet to the border of Arakan in southern Chittagong. The land relief in the Eastern Region is irregular but characterised by downward slope in a westerly direction. Hills rise to 200 feet above sea level in the southern part of Sylhet and up to 3000 feet in the Chittagong Hill Tracts. The long eastern boundary of the region is bordered by hills and in the south, the Chittagong Hill Tract occupies much of the area.

The climate in the Eastern Region varies considerably across the region due to the varying physiography and large physical extent of the region. For example, the northeast of Sylhet experiences very heavy rainfall, averaging about three times that recorded in the north of Comilla. The south is a cyclone-prone area but the north is relatively unaffected by cyclonic storms. Very heavy rainfall occurs across the region. The annual average rainfall figures are 220" in northeast of Sylhet, 150" in the southern part of Chittagong, 120" in the south of Noakhali and about 80" in the north of Comilla district. April and October rainfall are noticeably higher in this region than in others. The southern part of the region is more prone to cyclone storms than any other part of the country. In fact, the low-lying land in the coastal area is in continuous danger of flooding by the storm surges associated with the cyclonic storms.

Most of the different varieties of agricultural commodities are produced in the region. Apart from rice, vegetables are of considerable importance. This is the least important region for jute, and little is grown here, except in Comilla district where nearly 11% of the national production is grown, part of a total regional contribution of 14%. Most of the tea produced in the country comes from Sylhet district in the north of the region. In keeping with its varying physiography, the region is characterised by wide contrasts in land use, ranging from dry season grazing only in extensive areas of the Sylhet basin and jhum (shifting) cultivation in the Chittagong Hill Tracts, to multiple cropping of rice and rabi crops throughout much of the densely populated Comilla and Noakhali districts. The most intensive land use is found on the old Meghna floodplain. Young floodplain land in the Meghna estuary is mainly used for transplanted aman. Piedmont land and the highest part of the Surma-Kushiyara flood plain are mainly used for aus and transplanted aman with little production of jute or rabi crops; flash floods frequently cause crop damage. More deeply flooded parts of the Surma-Kushiyara floodplain produce deepwater aman, which also frequently suffer flood damage. Basin centers here, as well as the adjoining Sylhet basin, are extensively used for boro where irrigation can be provided but large areas remain under grassland for dry season cattle grazing. Tea is widely grown in low hill part of Sylhet, and to a much lesser extent in Chittagong. Shifting cultivation is widely practiced in the Chittagong Hill Tracts.[7]

II.4.2 Climatic Conditions: Variability of Rainfall

The climate of Bangladesh, generally described as tropical monsoon, is characterised by high temperatures for most of the year, by high humidity, heavy summer rainfall and by a small range of temperatures. The weather variation within the general uniformity, however, are of direct and great significance to crop production which is, as we observed in the last section, the dominant aspect of Bangladesh agriculture. Among the weather elements, it is particularly the distribution of rainfall that conditions the performance of crops. To quote Ahmad (1976), an eminent geographer in Bangladesh:

"It is otherwise with the rainfall whose general character condition the nature of agriculture and the timetable of the farming year and whose variations, both from region to region and from year to year, can spell success or failure for crops, property or suffering for cultivator."

In other words, though there are various environmental uncertainties, variations in rainfall may be thought to be the most important of all. Bangladesh, with a normal annual rainfall of about 84" and a tropical temperature level, should be considered to be ideal for cultivation of various crops. There is, however, a significant annual variation around the normal level of rainfall. As shown in Table 2.10, rainfall varied within a range of more than 15% in eight out of twenty-one years in Bangladesh between 1953-54 and 1973-74. Also, in the twenty-one year period, Bangladesh experienced annual rainfall which was below normal in fifteen years.

The picture looks almost similar when the variations in annual rainfall are shown district-wise, as in Table 2.11. Calculating coefficients of variation as the relevant indices of variability of rainfall, it is observed that for fifteen out of nineteen districts in Bangladesh, the values of the coefficients lie within the range between .20 to .25, with one falling below .20 and only three above .25, the highest value recorded being .27 in Rajshahi district. For Bangladesh as a whole, this coefficient has been computed to be .13.

Table 2.10

Variations in Annual Rainfall in Bangladesh
(1953-54 to 1973-74)

Variations around Normal up to	Number of Years in which below Normal	Number of Years in which above Normal	Total
5%	2	3	5
10%	6	3	9
15%	10	3	13
20%	12	5	17
25%	15	6	21

Source: BIDS Research Report (New Series) No. 23 (1974)

Note: Annual normal rainfall in Bangladesh is 83.95 inches. The lowest and the highest rainfalls recorded in twenty-one year period were 64.29 and 104.36 inches respectively.

Even after making an allowance for a 25% variability around the mean level in the annual rainfall, there may still be rainfall adequate for most of the crops grown in Bangladesh. One should, therefore, focus on the seasonal distribution of rainfall within a year and what is more important, the deviation from that seasonal norm from year to year. The erratic behaviour of weather during the critical periods of sowing and flowering has quite important implications. This is particularly true in Bangladesh where rainfall is seasonal in character and the success of cultivation very much depends on the arrival of enough rain at the right time. To quote Ahmad (1976):

"The small winter rains of North Bengal supports the cultivation of rabi crops and vegetables. The Northwesters are the bringers of the hot season rains, essential for ploughing and sowing of aus paddy and jute while a normal monsoon is essential for the growth and maturing of the aus paddy and jute and the sowing of aman paddy."

Thus, although the variability of annual rainfall in Bangladesh in percentage terms is quite moderate or to put it differently, there exists a high degree of reliability in mean annual rainfall, it is precisely the variations in seasonal rainfall that become critical features for distinguishing between good and bad years. To quote Ahmad (1976) again:

"Insufficient rain for the year is hardly a problem, providing that it is distributed so that it is received at the appropriate times for crop germination and growth. Timing, then, is critical. Late arrival of the northwesters or the monsoon or their cessation, even if the total amount of rain they bring in is at or even above the normal amount, may prove fatal to the aus paddy and jute crops, by far the most important crops in the country. In variations of annual rainfall, it is upward variations that are critical. Excessive rainfall normally brings unmanageable floods, which damage crops and may destroy them altogether."

Table 2.12 presented below attempts to capture this timeliness in the availability of rainfall as reflected in the computed coefficients of variability of seasonal rainfall in Bangladesh.

It is observed that in April-June, when the main rice crop is sown and/or transplanted, the coefficient of variation is around .25 and during October-December period when flowering critically depends on adequate rains, the variability of rainfall is recorded to be .52.

Table 2.11

Variability of Annual Rainfall in Different Districts in Bangladesh

Regions/ Districts		Mean Rainfall (mm)	Index of Variability: Standard Deviation (mm)	Index of Variability: Coefficient of Variation (S.D./Mean)
I.	Northwest Region			
1.	Rangpur	2073.64	443.32	.21
2.	Pabna	1721.56	438.84	.25
3.	Borgra	1653.82	400.31	.24
4.	Rajshahi	1495.70	400.55	.27
5.	Dinajpur	2056.01	541.56	.26
II.	Central Region			
6.	Dacca	2041.94	400.79	.20
7.	Mymensingh	2441.29	517.06	.21
8.	Tangail	1750.43	374.60	.21
III.	Southwest Region			
9.	Kushtia	1525.03	389.07	.26
10.	Faridpur	1802.31	338.58	.19
11.	Kuhlna	1716.80	389.65	.23
12.	Barisal	2306.97	543.97	.24
13.	Patuakhali	2821.58	679.24	.24
14.	Jessore	1601.77	355.66	.22
IV.	Eastern Region			
15.	Chittagong	3037.29	732.66	.24
16.	Sylhet	3623.29	778.32	.21
17.	Comilla	2177.89	526.21	.24
18.	Ctg. Hill Tract	2590.18	559.47	.22
19.	Noakhali	2790.47	695.00	.25

Source: Compiled from the Agroclimate Survey in Bangladesh [1974].

Table 2.12

Variations in Seasonal Rainfall in Bangladesh

Season	Average Rainfall (inches)	Standard Deviation (inches)	Coefficient of Variation (S.D./Mean)
April-June	28.75	7.14	.25
July-September	41.00	5.75	.14
October-December	7.24	3.92	.52
January-March	2.41	1.54	.64

Source: BIDS Research Report (New Series) No. 23 (1974)

Such variability of seasonal rainfall becomes more pronounced when one considers the district-wise figures as recorded in Table 2.13. In the April-June period, the coefficient is observed to be as high as .76 in Rajshahi district. In the October-December period, the index of variability rises as high as 2.08 in Bogra district, with all other districts (excepting the Chittagong Hill Tracts) recording a value of greater than one. This clearly demonstrates that the seasonal character of rainfall and its variability over time and space contribute much towards making agriculture a very risky operation in Bangladesh.

Table 2.13

Variability of Seasonal Rainfall in Different Districts in Bangladesh

Regions/ Districts	January-March	April-June	July-September	Oct.-Dec.
I. Northwest Region				
1. Rangpur	1.473	.601	.493	2.082
2. Pabna	1.331	.587	.483	1.651
3. Bogra	1.474	.724	.452	2.000
4. Rajshahi	1.294	.764	.484	1.533
5. Dinajpur	1.583	.703	.502	1.990
II. Central Region				
6. Dacca	1.197	.518	.459	1.166
7. Mymensingh	1.087	.525	.433	1.036
8. Tangail	1.208	.536	.499	1.387
III. Southwest Region				
9. Kushtia	1.281	.581	.443	1.629
10. Faridpur	1.171	.572	.442	1.216
11. Khulna	1.532	.688	.457	1.811
12. Barisal	1.309	.633	.430	1.353
13. Patuakhali	1.421	.706	.422	1.474
14. Jessore	1.245	.608	.456	1.528
IV. Eastern Region				
15. Chittagong	1.236	.552	.435	1.147
16. Sylhet	.964	.440	.397	1.024
17. Comilla	1.237	.607	.489	1.365
18. Ctg. Hill Tract	1.204	.630	.450	.971
19. Noakhali	1.059	.542	.392	1.096

Source: Compiled from the Agroclimatic Survey in Bangladesh (1974)

Note: The reported numbers represent the coefficient of variation of seasonal rainfall in the respective regions.

II.4.3 Incidence of Floods and Cyclones

Although we explained earlier that the variability of annual rainfall is not of much importance in Bangladesh, the upward variability in annual rainfall sometimes becomes very critical in that excessive rainfall normally brings unmeanageable floods which damage crops and may destroy them completely. Of course, there are other more cogent reasons for the occurance of floods in Bangladesh. Bangladesh, part of the biggest delta in the world with its abundant monsoon precipitation, has numerous rivers and rivulets but because of the deterioration of the channel beds over time, their drainage system is very poor and undefined. As a result, the rivers fail to drain the huge quantity of silt laden run-off passing through them during the monsoon. Therefore, on an average, about 1/5 of land area of the country gets inundated every year to a depth of 30 feet in the low lying areas by the uncontrolled flood water and causes direct and indirect losses to a large number of people living in the rural areas.

Almost all the districts in Bangladesh are affected by the annual phenomenon of floods, though the intensity of flooding and the extent of damages varies from region to region and in a given region from year to year. Table 2.14 records the cropped area damaged by floods and/or cyclones over the 16 year period, 1962-77, in various districts/regions in Bangladesh. It is readily observed that over this period, although floods damaged crops every year, the extent of crop damage was much heavier in some years than in others. In 1970 and 1973, crop damages worsened as the areas along the coastal belt of Barisal and Patuakhali districts were hit by devastating tidal bores and cyclones. During this 16 year period, on an average, 13.18 lakh acres of cropped land i.e. roughly 4.3% of the total cropped area in Bangladesh was damaged completely due to floods and cyclones. The year to year variability of crop damages also appear to be quite high ranging from 1.68 lakh acrea in 1967 to 31.65 lakh acres in 1974. This is also reflected in the computed index of variability (coefficient of variation) of crop damage of .82.

Table 2.14 also shows considerable variation in cropped area damaged among different regions/districts in this period. Average damage of cropped area varies from .07 lakh acres in Chittagong Hill Tract to 2.86 lakh acres in Sylhet district. The proportion of cropped area damaged also varies considerably across regions/districts, ranging from .8% in Dinajpur district to 12.2% in Sylhet district. Proportion of cropped area damaged is also quite high in Pabna (8.6%) and Faridpur (6.7%) districts. From the regional point of view, it appears that the Eastern Region is more susceptible to crop damage, with its average yearly crop damages roughly accounting for 7% of total cropped area.

The extent of crop damages also varied significantly from year to year in each region/district over this period. This is reflected in the estimated coefficient of variation of crop damages for different regions/districts as presented in Table 2.14. The estimated coefficients appear to be quite high, exceeding unity in all cases. What may be more interesting to note, however, is the fact that different regions/districts are exposed to differential degrees of variability of crop damages over this period. This variability seem to be more pronounded in the Eastern and Southwestern regions. In the Northwestern region, the extent of crop damages is quite low (2.7%), in an average year, and its variability is also observed to be the lowest (1.09) among four regions.

Table 2.14

Area Damaged by Floods and Cyclones in Different Districts in Bangladesh

(1962 - 1977) (in lakh acres)

Regions/ Districts	Year 1962	1963	1964	1965	1966	1967	1968
I. Northwest Region	9.83	.29	.21	.30	2.08	.79	5.88
1. Rangpur	1.59	.04	.01	-	1.13	-	2.19
2. Pabna	5.34	.21	.07	-	.87	.79	1.43
3. Bogra	2.72	.02	-	-	.08	-	.46
4. Rajshahi	.18	.02	.13	.30	-	-	.83
5. Dinajpur	-	-	-	-	-	-	.97
II. Central Region	10.75	.09	.79	-	2.66	.28	3.64
6. Dacca	3.91	.02	.26	-	1.61	-	.27
7. Mymensingh	6.84	.07	.53	-	1.05	.28	3.47
8. Tangail	-	-	-	-	-	-	-
III. Southwest Region	2.90	.31	2.16	1.20	.32	.13	9.41
9. Kushtia	-	.05	-	-	.02	-	.64
10. Faridpur	2.90	-	1.32	.09	.33	.13	4.82
11. Khulna	-	-	.50	.20	-	-	1.34
12. Barisal	-	-	.34	.91	-	-	1.87
13. Patuakhali	-	-	-	-	-	-	-
14. Jessore	-	.16	-	-	-	-	.74
IV. Eastern Region	4.65	2.63	4.88	1.19	8.36	.48	5.81
15. Chittagong	.20	.40	-	.75	.45	.31	2.22
16. Sylhet	4.45	1.22	4.36	.20	7.84	.15	1.47
17. Comilla	-	.67	.25	.22	-	.02	.60
18. Ct. Hill Tract	-	.13	-	-	-	-	.16
19. Noakhali	-	.21	.07	.02	.07	-	1.36
Total :	28.13	3.22	7.84	2.69	13.45	1.68	24.84

Table 2.14 (Cont.)

Regions/ Districts	1969	1970	1971	1972	1973	1974	1975
I. Northwest Region	.38	2.81	3.62	1.74	5.20	4.69	.31
1. Rangpur	-	.44	-	.33	.33	2.04	.02
2. Pabna	.04	1.60	1.48	1.39	2.77	1.40	.29
3. Bogra	-	.59	-	-	-	.13	-
4. Rajshahi	.34	.17	2.14	.01	1.55	.52	-
5. Dinajpur	-	.01	-	.01	.55	.60	-
II. Central Region	.18	7.64	.03	1.02	4.78	1.67	-
6. Dacca	-	2.24	.03	.26	.22	1.67	-
7. Mymensingh	.18	1.71	-	.58	2.73	5.09	-
8. Tangail	-	3.69	-	.18	1.83	.98	-
III. Southwest Region	2.84	17.04	5.32	.03	6.92	2.96	.49
9. Kushtia	.29	.33	1.76	.01	.14	.27	.33
10. Faridpur	1.03	3.16	2.68	.02	1.36	1.61	.16
11. Khulna	1.36	4.02	-	-	-	.06	-
12. Barisal	.09	3.98	-	-	2.84	1.02	-
13. Patuakhali	-	4.60	-	-	2.58	-	-
14. Jessore	.07	.95	.88	-	-	-	-
IV. Eastern Region	1.45	3.52	.01	3.87	4.42	16.26	1.01
15. Chittagong	.28	1.33	.01	-	.04	.57	.09
16. Sylhet	.66	.31	-	3.86	1.69	7.23	.50
17. Comilla	.02	.12	-	.01	1.30	5.89	.01
18. Ctg. Hill Tract	.13	.07	-	-	-	.02	.16
19. Noakhali	.36	1.69	-	-	1.39	2.55	.25
Total	4.85	31.01	8.98	6.66	21.32	31.65	1.81

Table 2.14 (Cont.)

Regions/ Districts		1976	1977	Total Area Damaged	Average Area Damaged	Total Cropped Area	A	B
I.	Northwest Region	.96	.90	40.00	2.50	91.33	2.7%	1.09
1.	Rangpur	.88	.53	9.60	.60	29.72	2.0%	1.27
2.	Pabna	.08	–	17.76	1.11	12.92	8.6%	1.24
3.	Bogra		–	4.00	.25	10.99	2.3%	2.75
4.	Rajshahi		.35	6.56	.41	21.81	1.9%	1.51
5.	Dinajpur	–	–	2.08	.13	15.89	.8%	2.31
II.	Central Region	2.34	1.41	40.64	2.54	66.64	3.8%	1.39
6.	Dacca	.49	–	10.88	.68	17.91	3.8%	1.63
7.	Mymensingh	1.58	1.34	22.72	1.42	38.63	3.7%	1.46
8.	Tangail	.27	.07	7.04	.44	10.10	4.4%	2.25
III.	Southwest Region	.02	1.24	53.28	3.33	79.31	4.2%	2.35
9.	Kushtia	–	–	3.84	.24	7.65	3.1%	1.88
10.	Faridpur	.02	.04	19.68	1.23	18.32	6.7%	1.46
11.	Khulna	–	–	7.52	.47	12.22	3.8%	2.23
12.	Barisal	–	.86	11.84	.74	16.87	4.4%	1.27
13.	Patuakhali	–	.34	7.52	.47	8.00	5.9%	2.70
14.	Jessore	–	–	2.88	.18	16.25	1.1%	1.89
IV.	Eastern Region	11.53	4.43	74.24	4.64	67.99	6.8%	2.17
15.	Chittagong	1.21	.27	8.16	.51	10.88	4.7%	1.20
16.	Sylhet	8.06	3.76	45.76	2.86	23.50	12.2%	1.00
17.	Comilla	1.69	.30	11.04	.69	17.75	3.9%	2.13
18.	Ctg. Hill Tract	.45	–	1.12	.07	2.76	3.9%	1.71
19.	Noakhali	.12	.10	8.16	.51	13.10	3.9%	1.53
	Total	14.85	7.97	210.88	13.18	306.21	4.3%	.82

Note: A and B represent the proportion of total cropped area damaged and the estimated coefficients of variation for each district respectively.

Source: Compiled from the Year Book of Agricultural Statistics in Bangladesh: 1976-77 Government of Bangladesh.

Table 2.15 shows the crop damages in terms of loss in production due to flood and cyclones in different regions/districts in Bangladesh over the 16 year period. It is observed that for Bangladesh as a whole the average loss in the jute crop during this period amounted to 1.88 lakh bales, which is roughly 3.4% of the total production in the country. Average loss of crops other than jute amounted to 7.15 lakh tons which accounts for about 3.7% of total production in Bangladesh. Variability of these losses over the years are also observed to be quite high as reflected in the estimated coefficients of variation of .94 and .73 for jute and crops other than jute respectively.

These figures are quite comparable to those discussed earlier both with respect to the extent as well as the variability of cropped area damaged in Bangladesh over this period. Also, one obtains a similar picture when one considers the average loss in production and its variability over the years in different regions/districts in Bangladesh. The extent of crop damage, in terms of average loss in production of crops other than jute, appears to be heavier in the Eastern Region (particularly in Sylhet district) and the Southwest Region as compared to the other two regions in Bangladesh.

Table 2.15

Loss in Production of Jute (and all other crops) due to Floods and Cyclones in Different Districts/Regions in Bangladesh (1962-1977)

Regions/ Districts	1962	1963	1964	1965
I. Northwest Region	2.20 (5.54)	.02 (.12)	.01 (.09)	.05 (.53)
1. Rangpur	.43 (1.04)	- (.02)	.01 (-)	- (-)
2. Pabna	.74 (2.45)	.02 (.08)	- (.03)	- (-)
3. Bogra	1.03 (1.33)	- (.01)	- (-)	- (-)
4. Rajshahi	- (.72)	- (.01)	- (.06)	.05 (.53)
5. Dinajpur	- (-)	- (-)	- (-)	- (-)
II. Central Region	2.23 (5.06)	.06 (.04)	.46 (.52)	.09 (.39)
6. Dacca	.93 (1.92)	.02 (.01)	.08 (.34)	.09 (.36)
7. Mymensingh	1.30 (3.14)	.04 (.03)	.38 (.18)	- (.03)
8. Tangail	- (-)	- (-)	- (-)	- (-)
III. Southwest Region	.11 (.14)	- (.42)	.36 (1.25)	.70 (3.19)
9. Kushtia	- (-)	- (.09)	- (-)	- (-)
10. Faridpur	.11 (1.4)	- (-)	.36 (.85)	.24 (.38)
11. Khulna	- (-)	- (-)	- (.22)	.09 (.50)
12. Barisal	- (-)	- (.27)	- (.18)	.37 (2.31)
13. Patuakhali	- (-)	- (-)	- (-)	- (-)
14. Jessore	- (-)	- (.06)	- (-)	- (-)
IV. Eastern Region	.01 (2.42)	.04 (2.36)	- (.29)	.13 (.57)
15. Chittagong	- (.08)	- (1.02)	- (-)	- (.19)
16. Sylhet	.01 (2.04)	.03 (.55)	- (.15)	.01 (.05)
17. Comilla	- (-)	.01 (.61)	- (.11)	.11 (.18)
18. Ctg. Hill Tract	- (-)	- (.09)	- (-)	- (-)
19. Noakhali	- (-)	- (.09)	- (.03)	.01 (.15)
Total	4.55 (12.86)	.12 (2.93)	.83 (2.15)	.98 (4.68)

Table 2.15 (Cont.)

Regions/ Districts	Year 1966	1967	1968	1969
I. Northwest Region	1.10 (.70)	.06 (.36)	.29 (2.52)	- (.23)
1. Rangpur	.91 (.33)	- (-)	.17 (.91)	- (-)
2. Pabna	.13 (.35)	.06 (.36)	.06 (.61)	- (.02)
3. Bogra	.06 (.03)	- (-)	.02 (.18)	- (-)
4. Rajshahi	- (-)	- (-)	.04 (.39)	- (.21)
5. Dinajpur	- (-)	- (-)	- (.43)	- (-)
II. Central Region	2.29 (.59)	.04 (.18)	2.01 (2.43)	- (.13)
6. Dacca	1.95 (.42)	- (-)	.84 (1.05)	- (-)
7. Mymensingh	.34 (.17)	.04 (.18)	1.17 (1.38)	- (.13)
8. Tangail	- (-)	- (-)	- (-)	- (-)
III. Southwest Region	.03 (.29)	.02 (.05)	1.48 (3.83)	.20 (1.62)
9. Kushtia	- (.01)	- (-)	- (.26)	- (-)
10. Faridpur	.03 (.28)	.02 (.05)	1.28 (1.89)	.20 (.44)
11. Khulna	- (-)	- (-)	.09 (.59)	- (1.11)
12. B[illegible]	- (-)	- (-)	- (.79)	- (.04)
13. Patuakhali	- (-)	- (-)	- (-)	- (-)
14. Jessore	- (-)	- (-)	.11 (.30)	- (.03)
IV. Eastern Region	- (5.22)	- (.25)	.09 (1.63)	.13 (.59)
15. Chittagong	- (1.46)	- (.16)	- (.09)	- (.16)
16. Sylhet	- (2.95)	- (.09)	.08 (.62)	- (.34)
17. Comilla	- (.01)	- (-)	.01 (.25)	- (.01)
18. Ctg. Hill Tract	- (-)	- (-)	- (.05)	- (.07)
19. Noakhali	- (.80)	- (-)	- (.62)	.13 (.01)
Total :	[illegible] (6.81)	.12 (.84)	3.87 (10.41)	.33 (2.65)

Table 2.15 (Cont.)

Regions/ Districts	Year 1970	1971	1972	1973
I. Northwest Region	.75 (1.28)	.44 (5.32)	.28 (.56)	1.86 (2.61)
1. Rangpur	.15 (.19)	- (-)	.06 (.13)	1.00 (.90)
2. Pabna	.35 (.67)	.25 (1.49)	.22 (.43)	.79 (1.06)
3. Bogra	.24 (.33)	- (-)	- (-)	.07 (.07)
4. Rajshahi	.01 (.09)	.19 (3.83)	- (-)	- (.55)
5. Dinajpur	- (-)	- (-)	- (-)	- (.03)
II. Central Region	1.81 (3.11)	- (.02)	.43 (.29)	2.23 (1.32)
6. Dacca	.25 (1.17)	- (.02)	.10 (.09)	- (.01)
7. Mymensingh	.47 (.61)	- (-)	.27 (.15)	1.61 (.77)
8. Tangail	1.09 (1.33)	- (-)	.06 (.05)	.62 (.54)
III. Southwest Region	.18 (10.14)	.61 (5.06)	- (-)	.45 (3.54)
9. Kushtia	- (.52)	.29 (3.17)	- (-)	- (.05)
10. Faridpur	.18 (1.69)	.27 (1.56)	- (-)	.45 (.46)
11. Khulna	- (2.29)	- (-)	- (-)	- (-)
12. Barisal	- (2.79)	- (-)	- (-)	- (1.68)
13. Patuakhali	- (2.46)	- (-)	- (-)	- (1.35)
14. Jessore	- (.39)	.05 (.33)	- (-)	- (-)
IV. Eastern Region	.03 (2.87)	- (-)	.06 (1.66)	.67 (2.49)
15. Chittagong	- (1.02)	- (-)	- (-)	- (.02)
16. Sylhet	- (.15)	- (-)	.06 (1.66)	.23 (.65)
17. Comilla	.03 (.04)	- (-)	- (-)	.44 (.88)
18. Ctg. Hill Tract	- (.04)	- (-)	- (-)	- (.03)
19. Noakhali	- (1.62)	- (-)	- (-)	- (.91)
Total :	2.77 (17.40)	1.05 (10.40)	.77 (2.51)	5.21 (9.96)

Table 2.15 (Cont.)

Regions/ Districts	1974	1975	1976	1977
I. Northwest Region	.72 (2.14)	.01 (.09)	- (.61)	.22 (3.17)
1. Rangpur	.51 (.75)	.01 (.01)	- (.03)	.22 (3.17)
2. Pabna	.17 (.95)	- (.08)	- (-)	- (-)
3. Bogra	.02 (.12)	- (-)	- (-)	- (-)
4. Rajshahi	.02 (.23)	- (-)	- (-)	- (-)
5. Dinajpur	- (.09)	- (-)	- (-)	- (-)
II. Central Region	1.57 (3.52)	- (-)	1.12 (.86)	.22 (.80)
6. Dacca	.18 (.77)	- (-)	.14 (.23)	- (-)
7. Mymensingh	1.26 (2.31)	- (-)	.85 (.49)	.22 (.76)
8. Tangail	.13 (.44)	- (-)	.13 (.14)	- (.04)
III. Southwest Region	.26 (2.31)	- (.17)	- (-)	.03 (.29)
9. Kushtia	- (.03)	- (.12)	- (-)	- (-)
10. Faridpur	.26 (1.49)	- (.05)	- (-)	.03 (.02)
11. Khulna	- (.10)	- (-)	- (-)	- (-)
12. Barisal	- (.69)	- (-)	- (-)	- (.10)
13. Patuakhali	- (-)	- (-)	- (-)	- (.17)
14. Jessore	- (-)	- (-)	- (-)	- (-)
IV. Eastern Region	1.24 (7.44)	- (.74)	.26 (5.96)	.25 (2.97)
15. Chittagong	- (.41)	- (.06)	- (.87)	- (.16)
16. Sylhet	.23 (3.08)	- (.17)	.03 (3.81)	- (2.22)
17. Comilla	.94 (2.49)	- (.01)	.23 (.72)	.14 (.32)
18. Ctg. Hill Tract	- (-)	- (.08)	- (.40)	- (-)
19. Noakhali	.07 (1.46)	- (.42)	- (.16)	.11 (.27)
Total :	3.79 (15.41)	.01 (1.00)	1.38 (7.43)	.72 (7.23)

Table 2.15 (Cont.)

Regions/ Districts	Total Loss in Production	Average Loss in Production	Index of Variability S.D.	C.V.
I. Northwest Region	8.00 (25.76)	.50 (1.61)	.68 (1.79)	1.36 (1.11)
1. Rangpur	3.20 (8.00)	.20 (.50)	.34 (.81)	1.70 (1.62)
2. Pabna	2.88 (8.64)	.18 (.54)	.25 (.68)	1.39 (1.26)
3. Bogra	1.44 (2.08)	.09 (.13)	.26 (.33)	2.89 (2.54)
4. Rajshahi	.48 (6.56)	.03 (.41)	.05 (.94)	1.67 (2.29)
5. Dinajpur	- (.48)	- (.03)	- (.11)	- (3.67)
II. Central Region	15.04 (19.36)	.19 (1.21)	.95 (1.51)	1.01 (1.25)
6. Dacca	4.64 (6.40)	.29 (.40)	.53 (.56)	1.83 (1.40)
7. Mymensingh	8.00 (10.40)	.50 (.65)	.56 (.91)	1.12 (1.40)
8. Tangail	2.40 (2.56)	.15 (.16)	.30 (.35)	2.00 (2.19)
III. Southwest Region	3.04 (32.52)	.19 (2.02)	.39 (2.71)	2.05 (1.34)
9. Kushtia	.32 (4.52)	.02 (.27)	.07 (.79)	3.50 (2.93)
10. Faridpur	2.08 (9.28)	.13 (.58)	.15 (.69)	1.15 (1.19)
11. Khulna	.16 (4.80)	.01 (.30)	.03 (.62)	3.00 (2.07)
12. Barisal	.32 (8.80)	.02 (.55)	.09 (.90)	4.50 (1.64)
13. Patuakhali	- (4.00)	- (.25)	- (.68)	- (2.72)
14. Jessore	.16 (1.12)	.01 (.07)	.03 (.14)	3.00 (2.00)
IV. Eastern Region	4.00 (37.12)	.25 (2.32)	.33 (2.19)	1.32 (.94)
15. Chittagong	- (5.76)	- (.36)	- (.46)	- (1.28)
16. Sylhet	.48 (18.40)	.03 (1.15)	.06 (.28)	2.00 (1.11)
17. Comilla	1.92 (5.60)	.12 (.35)	.25 (.64)	2.08 (1.83)
18. Ctg. Hill Tract	- (.80)	- (.05)	- (.10)	- (2.00)
19. Noakhali	1.60 (6.56)	.10 (.41)	.32 (.53)	3.20 (1.29)
Total :	30.08 (114.42)	1.88 (7.15)	1.76 (5.22)	.94 (.73)

Source: Compiled from the Year Book of Agricultural Statistics in Bangladesh, 1976-77, Government of Bangladesh.

Note: The figures in parentheses indicate losses from all crops other than jute.

II.5 Summary and Conclusions

In this chapter, we attempted to provide a brief overview of Bangladesh agriculture - its significance in the economy, the pattern of land utilization, the agrarian structure and finally, a description of its physical environment and climatic conditions that characterises agricultural production in Bangladesh. We observed that since agriculture constitutes the mainstay of economic life in Bangladesh, its sluggish performance in the past largely constrained the overall growth of the economy. An examination of the structure and organization of agricultural production in Bangladesh shows that it is characterised by a predominance of small-holding farms, practicing cultivating techniques which are only marginally different from what they were centuries ago. Very few of the cultivators are large enough to generate the internal surplus which could provide, in the absence of adequate credit facilities, the working capital needed for the adoption of improved technology.

Output per acre is not only low but is subject to great random variability as well. This becomes very evident from our description of the physical environment and the climatic variability, particularly the variability of seasonal rainfall which lends so much of uncertainty facing the production decisions of the typical farm household in Bangladesh. Another factor of great importance is the susceptibility to crop damage due to floods and cyclones which, as we observed earlier, introduce random elements of widely varying magnitudes. Thus it is this great uncertainty with respect to ecological conditions that makes resource allocation decisions so difficult for the small farm households in Bangladesh. This may mean that it is inappropriate to study decision-making behaviour of the low-income farmers in Bangladesh without explicitly taking into account the role of risk. Therefore, in our modelling of resource allocation behaviour of small-holding farms in Bangladesh in the next chapter we shall take this aspect very much into consideration.

FOOTNOTES

1. The use of exchange rates for international comparisons of income or living standards has some limitations. See Usher (1968).

2. According to 1974 Census, an estimated 90.2% of the total population live in rural areas.

3. UN, Demographic Yearbook, 1974.

4. According to 1960 Agricultural Census, average farm size in Bangladesh was 3.5 acres, with a tenure-wise breakdown of 3.1 acres for owner-cultivator, 4.3 acres for owner-cum-tenant and 2.4 acres for tenant cultivator respectively. Today these figures must be considerably lower, particularly for the average farm size for Bangladesh as a whole, which according to a BIDS survey (1974) stood at 2.8 acres.

5. However, if the traditional means of irrigation are also included, the percentage of total cropped acreage irrigated increases to 11.1.

6. This division of the country into four ecological regions and the accompanying description of the physiography, climatic conditions and cropping pattern in each region is based on the Bangladesh Land and Water Resources Sector Study, Vol II (1972) prepared jointly by the World Bank and the International Development Association.

7. Under shifting cultivation at any point in time, about 10-20% of the land is under cultivation, producting a mixture of crops such as aus rice, maize, sesamum and short staple cotton. After one or two years of cropping, the land is left fallow and reverts to grass or shrub for a few years until it is again cleared, burned and hand cultivated.

CHAPTER III

RESOURCE ALLOCATION BEHAVIOUR IN A PEASANT AGRICULTURE UNDER RISK: A SAFETY-FIRST APPROACH

III.1 Introduction

As we discussed in the last chapter, a traditional agriculture like that in Bangladesh represents, in many ways, a prime environment involving uncertainty. Therefore, any serious attempt to explain peasant behaviour in Bangladesh must explicitly take account of uncertainty. In particular, in such studies, it is appropriate to allow explicitly for a disaster-avoidance motive. In our study of resource allocational efficiency of small holding farms in Bangladesh, therefore, we propose to employ the safety-first rules which are based upon a notion of disaster-avoidance by the decision maker.

More specifically, in Section 2 of this chapter, we critically review the literature pertaining to mathematical modelling for decision-making under risk especially in the context of peasant agriculture. In particular, we discuss the limitations of the expected utility approach in modelling farmer behaviour under uncertainty in underdeveloped agriculture and argue instead that the behavioural approach in general and the safety-first rules in particular, although they are not rigorously derived from specific postulates, nevertheless, serve as a more appropriate basis for analysing the decision making behaviour of small holding farmers exposed to uncertain outcomes. In Section 3, therefore, we develop a safety-first model of resource allocation under risk in order to derive the allocative efficiency conditions for the small farm households in Bangladesh exposed to both yield as well as price uncertainty. Based on these efficiency conditions, some testable hypotheses are developed to ascertain whether the subsistence farmers in Bangladesh efficiently allocate their resources among various crop activities in the presence of risk.

In Section 4, we present a modified safety-first model to analyse farmer's crop growing decisions under uncertainty, specifically the acreage allocation between a food crop and a cash crop in subsistence farming in the face of price uncertainty. In particular, we explore the conditions under which risk induces a shift of acreage in favour of the food crop relative to the cash crop in peasant farming in Bangladesh. Section 5 is devoted to making a brief comparison of the allocative efficiency conditions derived under two rival rules for analysing decision-making under uncertainty, expected utility maximisation and risk minimisation under Roy's Safety Principle. This comparison brings out some of the important implications of peasant behaviour towards risk under a safety-first approach. The findings of our analytical exercise are summarised and some concluding observations are made in Section 6.

III.2 Mathematical Modelling of Decision Making Under Risk in Peasant Agriculture

III.2.1. Uncertainty and Economic Theory

There is hardly any mode of economic behaviour which is not affected by uncertainty. Yet it is only recently that serious attempts have been made to analyse the decision-making behaviour of economic agents under conditions of uncertainty. The theory of decision-making under uncertainty, it may be emphasized, attempts to explain the decision-maker's choice among alternative courses of action where an action does not determine the outcome uniquely. Instead, an action is associated with a probability distribution of outcomes. The theory of decision making under uncertainty, therefore, essentially deals with choices among probability distributions of different outcomes.

Such a description of decision-making under uncertainty, of course, implicitly assumes that the decision-maker is either able or willing to assign probabilities to different outcomes which can result from his decisions. Such a need does not arise in deterministic theory since in that case action and outcome have one to one correspondence. Because risky choices imply choices among probability distributions of consequences, it requires the balancing of a number of possible alternative consequences simultaneously. Thus, compared to riskless choice, risky choice is intrinsically more complex.

In appraising risky choices, utility analysis provides the practical means whereby preferences are crystallized and consistence choice simplified. In fact, under certain assumptions, a utility function becomes simply a device for assigning numerical utility values to consequences in such a way that a decision-maker should act to maximise subjective expected utility if he is to be consistent with his expressed preferences. This, of course, implies the use of Bernoulli's Principle or as it is generally known, the Expected Utility Theorem. Before discussing this theorem, however, we consider it appropriate to highlight some of the controversies associated with the definition and measurement of risk in modern decision theory.

III.2.2 Definitions of Risk in Modern Decision Theory

The distinction between risk and uncertainty which is typically attributed to Frank Knight (1921) is that risk refers to a situation where alternative outcomes exist with known probabilities and uncertainty to the case where the probabities are unknown. Modern decision theory, however, does not use the term risk and uncertainty to distinguish between types of decision models according to whether or not the probabilities are known. Rather, as Roumasset (1979) clarifies, uncertainty refers to all situations where a single action may lead to alternative consequences, and risks refers to a characteristics of the subjective probabilities over the consequences associated with an action. In other words, uncertainty is a state of mind in which an individual perceives alternative outcomes to a particular action. Risk, on the other hand, has to do with the degree of uncertainty in a given situation.

Unfortunately, however, there does not seem to have emerged any consensus as how risk should be measured, although the issue is quite important. Both the questions of how to model decision-making under uncertainty and how to determine the role of risk aversion in particular situations hinges crucially on this definition. Sometimes risk has been defined as a measure of dispersion of possible outcomes, e.g., variance. In high theory, risk is what increases when a frequency distribution is changed by a "mean-preserving-spread" - a change in the distribution of random variable which keeps its mean constant and represents the movement of probability density from the center to the tails of the distribution (Rothschild and Stiglitz, 1970). In special cases, of course, this definition of risk is equivalent to variance. Risk has also been defined as the probability that the returns to a given decision will fall below some critical or 'disaster' level. If the disaster level is zero profits, then, risk becomes simply the probability of loss. Under certain situations, as we shall argue later, this may represent a more valid and acceptable definition of risk for modelling decision making under uncertainty.[1]

It may be emphasized here that within the expected utility (Bernoullian) framework, it is not always possible to define risk so as to afford a consistent measure of risk for a given frequency distribution. This becomes evident when one recognises that Rothschild and Stiglitz (1970) in their seminal paper tried to deduce a definition of risk from the definition of risk aversion. In particular, they argue that since risk aversion is characterised by a concave utility function of wealth with diminishing marginal utility of income, risk must be what risk averters pay to avoid. From this, they conclude that of the two frequency distributions with the same mean, the one with the greater 'weight in the tails' is the one with greater risk.[2] The problem, however, arises if the two distributions have different means since in that case one cannot, in general, deduce which is more risky without knowing the exact form of the utility function. In the expected utility approach, therefore, risk cannot be defined independently of risk preferences, and measured independently of the utility function itself (Roumasset, 1979).

III.2.3 The Expected Utility Theorem

Perhaps the most widely used model of individual decision-making behaviour under uncertainty is based on the expected utility theorem or what is otherwise known as the Bernoulli's Principle. According to this theorem, it is possible, given a set of assumptions, to assign cardinal utility values to consequences in such a manner that the expected utility of any action suffices to rank the actions according to individual preferences (Arrow, in McGuire and Radner, 1972). In short, the decision-maker's ordering of actions can be scaled by a numerical function called the expected utility function (Marshak and Radner, 1972).

It all began with David Bernoulli who postulated the principle well over two hundred years ago. Bernoulli's starting point was the St. Petersburg paradox and his objective was to explain why a gambler would be willing to pay only a finite amount for a gamble which offered infinite expected winnings. Bernoulli replaced Pascal's mathematical expectation by the 'moral' expectation or expected utility. This numerical function is synthesized from two other numerical scales: (1) a utility scale U(x) and (2) a subjective probability scale F(x). The expected utility function which the decision-maker is believed to maximize for action a is given by

$$\phi(a) = \int U(x)\, dF_a(x) \qquad \text{.....(A)}$$

and it represents the ordering of actions, i.e.

$$a_i > a_j \text{ if } \phi(a_i) > \phi(a_j)$$

It is, however, with the work of Von Neuman and Morgenstern (1944) that Bernoulli's Principle made its entry into modern decision theory. These authors proved that for any consistent preference ordering over the set S, there exists a utility scale such that the ordering can be represented in the form (A). The corresponding uniqueness theorem ensures that the utility function of the random variable x is defined upto positive monotonic linear transformation.

Essentially, what Von Neumann and Morgenstern have shown is that the Bernoulli's Principle is a logical deduction from a small number of postulates or axioms that most people accept as reasonable. More recently, the axioms have been reformulated in a variety of ways and under different names. Also, several authors [Luce and Raiffa (1957), Radner (1972) and Arrow and Hurwicz (1972)]have provided alternative and increasingly elegant proofs of the theorem.

We discuss below, following Anderson et al. (1977), the axioms on which the theorem is based. In fact, the following set of three axioms is a sufficient basis for deducing Bernoulli's Principle for the case of risky prospects with single-dimensional consequences.

1. Ordering and Transitivity

A person either prefers one of the two risky prospects - a_1 and a_2 - or is indifferent between them. This presumption that people can order prospects is not trivial. The logical extension of the ordering is to transitivity of the ordering of more than two prospects, e.g., a_1, a_2 and a_3. This implies that if a person prefers a_1 to a_2 (or is indifferent between them) and prefers a_2 to a_3 (or is indifferent between them), he will prefer a_1 to a_3 (or be indifferent between them).

Transitivity along with the principle of monotonicity (i.e., the requirement that when two actions each have with the same two consequences, the individual prefers the action with the higher probability of the more favourable outcome) ensures consistency of choice among actions by the decision-maker.

2. Continuity of Preferences

If a person strictly prefers a_1 to a_3, a subjective probability $P(a_1)$ exists (other than zero or one) such that he is indifferent between a_2 and a lottery yielding a_1 with probability $P(a_1)$ and a_3 with probability $1 - P(a_1)$. This implies that faced with a risky prospect involving a good and a bad outcome, a person will take the risk if the chance of getting the bad outcome is low enough. Continuity seems to be a reasonable assumption to make of an orderly thinking person, but the axiom may give rise to operational difficulties when the prospects consist of disparate alternatives. For example, it has been argued that the axiom breaks down when the unfavourable outcome is very bad, e.g., death.

3. Independence

If a_1 is preferred to a_2, and a_3 is any other risky prospect, a lottery with a_1 and a_3 as its outcome will be preferred to a lottery with a_2 and a_3 as outcome when $P(a_1) = P(a_2)$. In other words, preference between a_1 and a_2 is independent of a_3. Put in a slightly different way, this axiom says that the individual decision-maker's ranking of consequences is not dependent on the state in which those consequences occur and his personal probability belief about the likelihood of the states is not dependent on the consequences associated with the states.

It may be emphasized here that it is this requirement which accounts for the separability of the utility of an action into a weighted average of the utilities of the consequences. Again, as Anderson et al. (1977) emphasize, only the sort of practical difficulties of comprehension that lead to intransitivity seem likely to cause problems with this axiom which says, effectively, that preferences persist independently of successive probability resolutions in evaluating compound lotteries.

Bernoulli's principle may be deduced from these axioms and may be stated as follows: a utility function exists for a decision maker whose preferences are consistent with the axioms of ordering and transitivity, continuity and independence; this function U associates a single real number (utility value) with any risky prospect and has the following properties.

1. If a_1 is preferred to a_2, then $U(a_1) > U(a_2)$ and vice versa.
2. The utility of a risky prospect is its expected utility value. This is obtained by evaluating the expected value of the utility function in terms of the risky prospect's consequences, i.e.,

   $$U(a_j) = E[U(a_j)]$$

   the expectation being based on the decision maker's subjective distribution of outcomes. In the case of discrete outcomes,

   $$U(a_j) = \sum_i U(a_j|\theta_i)\ P(\theta_i)$$

   and in the case of a continuous distribution of outcomes

   $$U(a_j) = \int U(a_j|\theta)\ f(\theta)\ d(\theta)$$

   Higher moments of utility are not relevant for decision making. Also, it may be emphasized that the axioms logically imply use of the decision maker's subjective probability distribution for utility evaluation of the risky prospect's outcomes. Thus the axioms lead to both personal probability and Bernoullian utility.
3. The scale on which utility is defined is arbitrary. In particular, the properties of a utility function that are relevant to choice or decision analysis are not changed under a positive linear transformation; i.e., the function U^* will serve as well as the function U where

   $$U^* = aU + b,\ a > 0.$$

The Expected Utility Theorem or Bernoulli's Principle provides the means for ranking risky prospects in order of preference, the most preferred being the one with the highest utility. It thus brings together in an explicit way the decision maker's degrees of belief and his degrees of preference - which, of course, are the important subjective inputs in a decision analysis (Anderson et al., 1977).

III.2.4 Limitations of the Expected Utility Model

Expected utility maximisation like ordinary utility maximisation can be described as a "full optimality model" since they prescribe the best an individual can do, given the relevant constraints. Sharing the common characteristics of a full optimality model, the expected utility model also fails to specify the decision-process which makes the outcomes possible, and thus ignores any important role for decision-costs in analysing decision-making behaviour under uncertainty. Roumasset (1976, 1979) emphasizes this point while discussing the disadvantages of full optimality model in general and the expected utility model in particular as a descriptive tool.

"In other words, where costs of obtaining and processing information are substantial, however, it is not necessarily rational for an individual to act consistently with his underlying preferences. A complete preordering only guarantees that an individual can make binary comparisons. But going from the binary comparisons to the most preferred alternative is not a trivial step. In fact, Kramer (1967) has shown that given a preordering over a set of possible acts it is impossible for a finite information processing device to generate choices consistent with the preordering".

There is, therefore, a growing realisation that full optimality models may not be very useful in analysing decision-making behaviour in many cases, especially where the decisions to be made involves the assessment of uncertain consequences and where the determination of the full optimality solution would be extremely costly and time consuming - in brief, where decision costs are high. On the other hand, in such cases it may be more reasonable to assume that individuals act according to behavioural rules and therefore, it may be more appropriate to build models of rational behaviour accordingly.

Such a recognition of the limitations of the full optimality approach for modelling decision making under uncertainty is not entirely new but can be traced back to suggestions made by Georgescu-Roegen (1958) about two decades ago:

"The farmer has imperfect knowledge for future events in all these areas. Moreover his ability to use the available information in computations is limited. His decisions are, as Simon says, characterised by 'bounded rationality' [March and Simon (1958)]. The consequences of his planned activities are that only a few of the possible alternatives and only a few influencing factors can be taken into account.. It also means that simple rules-of-thumb are used as choice indicators and that satisficing replaces optimising."

One may also raise similar questions regarding the suitability of expected utility theory for normative purposes. In particular, it may be emphasized that even if the full optimality approach is considered useful, various methodological problems associated with the estimation of the utility function specially those related to its sensitivity to interview techniques, would make this approach a weak basis for modelling decision making under uncertainty. This is particularly true for low-income farmers in a subsistence agriculture.[4]

III.2.5 Safety-First Rules-of-Thumb

Critics of the full optimality approach would recommend basing the decision models on some feasible decision processes, typically a rule of thumb. Of particular interest are the models based on decision rules known as safety-first, where risk is defined as the probability that the stochastic variable in question, generally net income, will take on a value less than some critical or disaster level. This definition of risk seems to be more suggestive than the definition of risk as what increases when a frequency distribution is changed by a mean-preserving-spread, and corresponds more closely to the common usage of the term (Roumasset, 1976).

Models based on Safety-First rules are called behavioral because they are based on decision rules which are feasible and practical, and are founded on the principle of 'bounded rationality'.[5] Rationality, it may be emphasized, describes the process by which the decision-maker selects the best possible alternative, given his preference and constraints without regard to what decision process is used or even whether a decision-process exists that makes the rational decision a feasible choice. In contrast, models based on the principle of bounded rationality emphasize the decision process itself, which makes the prescribed outcome possible. According to this approach - as developed by Simon (1966, 1972) and Day (1971) - rationality is a much broader concept than is presupposed by Von Neumann and Morgenstern utility theory. It is not assumed that a farmer thinks in terms of probability or knows the meaning of expected value. Rather, he chooses among a limited number of objectives from his realm of experience by an orderly and finite process of thought which may appropriately be described by rules of thumb. (Roumasset, 1976).

We, therefore, feel that in a peasant agriculture characterised by small holding farmers, the farm family's behaviour is better conceptualised in terms of the decision-making rules known as Safety-First. These rules, it may be emphasized, shape a particular behaviour where the possibility of getting income returns from agricultural activity below some subsistence levels will play an important role in resource allocation decisions. In particular, the characteristics of the ecological and socio-economic environment in which small-holding farmers have to operate makes Safety-First a very appealing criterion for analysing decision-making in subsistence agriculture under conditions of uncertainty. Some of these characteristics are:

i) the low quality of the climatic soil system or relatively high agronomic risk

ii) the relatively large family size in relation to farm size and available productive resources and

iii) the farm-family's relative lack of social power to ameliorate the adverseries of the institutional constraints.[6]

Since under these conditions, it is very likely that uncertainty will exist concerning the possibility of the attainment of a minimum level of farm family's consumption from agricultural activity, one may safely postulate that the behaviour of small holding farmers is more in accordance with the logic underlying the Safety-First rules (Moscardi, 1977). According to these rules, it may be emphasized, an important motivating factor of the farm-family in managing the productive resources it controls is the security of generating returns large enough to cover its subsistence needs. Apart from Moscardi

(1975, 1977), several other authors [(Lipton (1968), Roumasset (1976), Masson (1974), Kunreuther and Wright (1979)] have also emphasized that Safety-First criterion tend to be followed where the disaster avoidance motive is very strong and/or the satisfaction of basic needs may be at risk. We shall, therefore, adopt here the Safety-First rules - in fact, a variant of it attributable to Roy (1952) - in analysing resource allocation behaviour in a peasant agriculture under conditions of uncertainty. Before doing so, however, we would like to examine some of the theoretical properties of the Safety-First rules specicially in the context of modelling decision-making behaviour under uncertainty.

It is well known that the mean-variance approach to portfolio analysis is based on the maximisation of the expected value of a Von neumann-Morgenstern utility function under the assumptions that either (i) the decision-maker's (investor's) utility function is concave and quadratic or (ii) the decision-maker's utility function is concave and the probability distribution is multivariate normal.

The quadratic utility of income function, in spite of its popularity in theoretical work, has several undesirable restrictive and implausible properties and despite its mathematical elegance, the assumption of normally distributed returns is also suspect for analysing decision-making of small holding farmers.[7]

It is, therefore, not surprising that more or less parallel with these developments, there have been attempts to depart from the utility framework altogether and to invoke criterion based on more objective concepts. As the first of these criterion, Roy (1952) suggested that investors have in mind some notion of a disaster level of income and that they behave so as to minimise the probability of their income falling below that disaster level. More specifically, by using the Biname-Tchebycheff inequality, Roy has shown that investors operating on a safety-first principle (i.e., make risky investments so as to minimise the upper bound of the probability that the realised outcome will fall below a preassigned level) should maximise the ratio of the excess of expected portfolio return over the disaster level to the standard deviation of the return on the portfolio i.e., should maximise $\frac{[(\mu_r - d)]}{\sigma_r}$ where μ_r and σ_r represent the expected return and the standard deviation of the portfolio return respectively. This result, of course, does not depend on assumption of multivariate normality and uses a different argument and form of the utility function. Roy also mentioned that when judgemental distributions are multivariate normal, maximisation of the criterion minimises the probability of disaster itself. It should be noted, however, that minimisation of the shortfall from disaster level in this normal case is strictly equivalent to expected utility maximisation under all risk-averter's utility functions. The equivalence is not, as claimed by Roy (1952), restricted to the utility function of the form (0,1); zero if disaster occurs and one if it doesn't (Lintner, 1965).

However, there are reasons to feel a bit skeptical about the demonstration of formal equivalence between these two decision-rules since in one case the individual is trying to make the expected proportion of occurance of disaster as small as possible while in maximising expected utility, he is operating on a level of satisfaction. To quote from Roy (1952):

"Readers, however, are open to interpret the principle in this way if they so desire but the purpose of this discussion is not to suggest that individuals may possess a utility function of peculiar form but rather to find out that implication of a certain mode of behaviour, which appears both plausible and simple. In calling a utility function to our aid, an appearance of generality is achieved at the cost of a loss of practical significance and applicability of results."

Sometimes it has been pointed out that the difficulty of working with a Safety-First rule is the theoretical implications of discontinuous preferences at the crucial level (Anderson, 1973). To this Roy (1952) has the following to say:

"There would appear to be no valid objection to the discontinuity in the preference scale that the existence of a single disaster value implies. In practice, death, bankcruptcy and a prison sentence are likely to be associated with sharp breaks in both our pattern of behaviour and in our scale of preference."

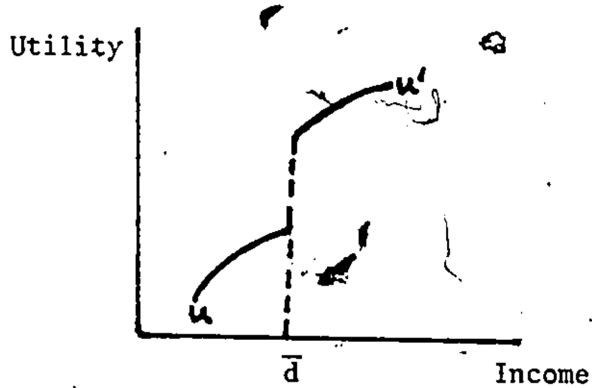
However, it may be useful to define and analyse the disaster avoidance motive using an expected utility model when there is a jump or vertical section (and a consequent non-concavity) in the utility function, the jump representing a large discontinuity associated with the loss of another dollar. Such an utility function has some interesting portfolio implications in that an individual may invest proportionately more of his portfolio as the variance on the project return increases (Masson, 1974). Masson has also demonstrated the empirical relevance of this type of utility function by the use of data on peasant farming in Mexico.

It may be worthwhile to recapitulate some of the agruments presented by Masson (1974). We have already referred to the formal equivalence between the two criterion in terms of a simple form of a utility function with a jump discontinuity. But the function that Roy (1952) discusses lacks inituitive appeal.

It is based, as we have noted, on a discrete utility function with a value of one when decision maker is not bankrupt and a value of zero when he is bankrupt. In this model, therefore, there is no increasing utility for higher incomes when the probability of bankruptcy is zero, and from this flows his simple minimisation-of-disaster criterion. A more plausible formulation, according to Masson (1974), might be a utility function that is a positive monotonic function of income but exhibits a jump discontinuity at some critical income level, as shown in figure 3.1.

Figure 3.1

Utility Function of Income with a Jump Discontinuity



This jump in the utility function could arise from a preference for one state of the world (e.g., not being bankrupt) over another or from a jump in the earnings function due to a discrete change in earning potential associated with a one-time loss that drops income below some critical level.[8]

Masson (1971) has also shown through use of an expected utility maximization model with a continuous differentiable function that an objective function for firm income can be derived which satisfies postulates of expected utility maximisation and which displays the characteristics of a jump discontinuity. Also, Pyle and Turnovsky (1970) have demonstrated that in the absence of a riskless asset, equivalence exists between safety-first criterion and the expected utility approach. However, for any portfolio chosen by any variant of the safety-first rules, there is in general an infinity of expected utility functions that will cause an investor who maximizes expected utility to behave in the same way. Also, it needs to be emphasized here that although these two criteria for analysing risk aversion behaviour have been shown, under certain circumstances, to be operationally indistinguishable, the implicit phychological framework underlying these models may differ. In the expected utility or mean variance framework, a psychological aversion for risk is generally implied whereas under a Safety-First criterion, the individual often is seen as attempting to avoid illiquidity or bankruptcy (Masson, 1972).

It must be emphasized here that although the disaster-avoidance motive which is reflected in safety-first kind of behaviour and which has recently been dubbed by Menezes et al (1980) as aversion to downside risk, is now firmly established in the literature, no general characterisation of this notion of downside risk has been provided. Prevailing studies, it may be mentioned, have focussed mainly on two kinds of measures of downside risk. These are probability loss measures (sometimes referred to as lower partial moments) which formulate downside risk as a probability-weighted function of deviation below some critical outcome, and skewness measures which use the third moment of a distribution about the mean or another predetermined target. The basic limitations of these formulations is that they lack a satisfactory choice-theoretic foundation and fail to distinguish increasing downside risk from other characteristics of distributions, e.g., riskiness.

Recently, Menezes et al. (1980) have tried to overcome these limitations by providing a general characterisation of increasing downside risk.[9] They did it by combining a spread and a contraction of probability weight in such a way that together they result in an unambiguous transfer of risk from the right to the left of a distribution. Such a transfer does not change the overall 'riskiness' of the distribution but simply alters the placement of risk.

In fact, Menezes et al have formulated three definitions of downside risk which have been shown to be equivalent. The first is based on spread-contraction combinations which unambigously transfer risk leftward in a distribution while maintaining the mean and variance.[10] This definition analytically captures the intuitive and empirically relevant notions of downside risk and distinguishes it from other characteristics of distributions, e.g., riskiness. Then, to provide a choice-theoretic foundation for their analysis, they also defined increasing downside risk in terms of the unanimous choice of all individuals with convex marginal utility functions, i.e., all individuals who are decreasingly risk averse. One implication of this result is that both risk averters and risk preferrers can be downside risk averse. Their third definition provides a practical criterion to compare distributions in terms of downside risk. They have also shown how their general approach is related to the prevailing measures of downside risk on the one hand, and various stochastic dominance rankings of distributions on the other.[11]

Before concluding this section it should be emphasized that despite the *a priori* appeal of the safety-first approach in particular and the behavioral approach in general, there still remains some limitations of putting them into practice for the purpose of analysing decision-making behaviour in peasant agriculture.

First, the choice of a decision process or of a rule-of-thumb is necessarily somewhat arbitrary. One can invent new rules of thumb as one wishes. How is it possible then for one rule to be judged more appropriate for a particular decision process than another?

Second, another problem associated with the behavioral approach is that once a behavioral decision model is chosen, there is no well developed method for fitting the decision model to the individual decision maker. Researchers usually develop an *ad hoc* procedure to calibrate the models.

In short, the behavioral approach rests on a somewhat arbitrary selection of decision rules and an *ad hoc* method of calibration. To counter these criticism, one may perhaps maintain that there is probably an undue bias against *ad hocery* in economics. There is essentially nothing wrong with developing procedures that seem appropriate for a specific purpose, even though the procedure may not be rigorously derived from specific postulates (Roumasset et al,1979).

III.3 Allocative Efficiency in Peasant Farming Under Safety-First

In this section, we develop a safety-first model of resource allocation under risk in order to derive explicitly the conditions of allocative efficiency for the small-holding farms exposed to both yield as well as price uncertainty.

The basic ingredient underlying the logic of safety-first rules is the disaster-avoidance motive. The decision-makers have in mind some notion of a disaster level of income, the critical level below which they face starvation or bankruptcy, and that they behave so as to minimise the probability of falling below that disaster level. As we argued in the last section, when a farm household is operating near its survival level, it is more plausible to describe its behaviour as centered around the objective of minimising the chance that it will fall below that survival level.

Three competing specifications of safety-first rules have been proposed in the literature by Roy (1952), Telser (1955-56) and Kataoka (1963). In fact, there are some additional variants attributed to Baumol (1964) and Von Moeseke (1965) but as Roumasset (1976) has shown, they represent reasonble bases of choice only when they are special cases of the rules proposed by Telser and Kataoka, respectively. These three rules, which are described below, differ depending on whether the concern of the decision-maker regarding the disaster income level enters as an objective or as a constraint into the decision model. These are described as:

(i) Min $P(r < \bar{d})$ (Roy's Safety Principle)

(ii) Max μ s.t. $P(r < \bar{d}) \leq \alpha^*$ (Telser's Strict Safety-First Principle)

(iii) Max d s.t. $P(r < d) \leq \alpha^*$ (Kataoka's Safety-Fixed Principle)

where $\bar{d}$ = disaster level of income

r = profit or monetary income, a random variable

α^* = maximum acceptable risk level

μ = mean profit (expected income)

Our proposed model of farmer behaviour is based on Roy's Principle, which has the objective of minimising the probability that some objective function, typically net income, falls below some specified disaster level. It may be emphasized here that for the small farm households in peasant agriculture who are perennially exposed to the dangers of starvation due to risks of crop failure and hence very much preoccupied with maximising the chances of their survival, Roy's Principle does have a special intuitive appeal in modelling resource allocation behaviour under uncertainty.[12] However, before we can incorporate this criterion into a specific resource allocation model, it is necessary to derive an expression for the certainty equivalent of the probability of disaster, $P(r < \bar{d})$. This we can do by the use of the Tchebychev Inequality which permits us to calculate the upper bound of this probability level for any distribution of random variables whose mean and variance is known. In other words, assuming that the decision-maker knows mean profit (expected income), μ_r, and variance, σ_r^2, from his past experience, we can use this inequality as a distribution-free approach to find a certainty equivalent for the probability of disaster.[13] Alternatively, if we can assume that the decision-maker regards $f(r)$ to be a normal density function, we can then make more exact statements. In that case, the distribution of the random variable r can be fully described by its two parameters, mean and variance, and it can be transformed into the standardised variable, $Z = [(r - \mu_r)/\sigma_r]$, which has a distribution function F such that $P(r < \bar{d}) = F[(\bar{d} - \mu_r)/\sigma_r]$. Since F is monotonic, minimising $P(r < \bar{d})$ is exactly equivalent to minimising $[(\bar{d} - \mu_r)/\sigma_r]$ [Pyle & Turnvosky (1970)].

A model of resource allocation under risk is now developed which incorporates Roy's safety-first rule in which resources are allocated in such a way that the farm households minimise the probability of disaster. The farm households possess a set of resources (land, capital, family labour and purchased inputs) which can be used in a set of production processes, each of which has an uncertain outcome. The randomness of net income which the farm households expect to receive can be attributed to both yield as well as price uncertainty. A low-income farmer typically faces known input prices but uncertain product prices and invariably faces uncertainty with respect to some of the factors that influence the quantity and quality of output he produces.

The relation between inputs and output is represented by the following production functions, using two crops and three inputs to illustrate the model.[14]

$$Q_1 = g(L_1, X_1, Y_1)u_1 \qquad \ldots.(3.1)$$

$$Q_2 = h(L_2, X_2, Y_2)u_2 \qquad \ldots.(3.2)$$

where Q_i represents the physical output of crop i (i = 1,2), L_i, X_i and Y_i represents land and two other variable inputs and u_i represent random components associated with the production of Q_i.

Outputs Q_1 and Q_2 are made up of stochastic and non-stochastic components with the respective values given by:[15]

$$E(Q_1) = g(L_1, X_1 Y_1)E(u_1) \quad ....(3.3)$$

$$E(Q_2) = h(L_2, X_2, Y_2)E(u_2) \quad ....(3.4)$$

Similarly, the expected values of prices are:

$$E(P_{Q_1}) = E(P_1 v_1) = P_1 E(v_1) \quad ....(3.5)$$

$$E(P_{Q_2}) = E(P_2 v_2) = P_2 E(v_2) \quad ....(3.6)$$

where v_1 and v_2 represent the random component of the prices of crop 1 and crop 2 respectively.

We assume here that u_1 and u_2 are each independent of both v_1 and v_2; in other words, random disturbances that affect prices have no effect on outputs and vice versa.[16]

Total net income of the farm household in our two-crop model is given by:

$$r = P_{Q_1}Q_1 + P_{Q_2}Q_2 - [w_x(X_1 + X_2) + w_y(Y_1 + Y_2)] \quad ....(3.7)$$

where w_x and w_y represent the prices of input X and Y respectively.

Now, given the above assumption that output and price disturbances are independent of each other, the mean and variance of total net income may be computed as:

$$\mu_r = E(P_{Q_1})E(Q_1) + E(P_{Q_2})E(Q_2) - [w_x(X_1 + X_2) + w_y(Y_1 + Y_2)] \quad ....(3.8)$$

$$\sigma_r^2 = E(P_{Q_1})^2 E(Q_1)^2 \sigma^2_{u_1 v_1} + E(P_{Q_2})^2 E(Q_2)^2 \sigma^2_{u_2 v_2} + 2E(P_{Q_1})E(P_{Q_2})E(Q_1)E(Q_2)\sigma_{12} \quad ....(3.9)$$

where $E(P_{Q_i})^2 E(Q_i)^2 \sigma_{u_i v_i}$ is the variance of income from crop $i(i = 1,2)$ and $2E(P_{Q_1})E(P_{Q_2})E(Q_1)E(Q_2)\sigma_{12}$ is the covariance of income from crop 1 and crop 2.[17]

Finally, in our model we introduce a constraint limiting the total availability of land to the farm-household[18]: $L_1 + L_2 = \bar{L}$ ....(3.10)

In our safety-first model, the farm-family wants to minimize the probability of disaster, $P(r < \bar{d})$, which has been shown to be equivalent to minimizing the certainty-equivalent, $[(\bar{d} - \mu_r)/\sigma_r]$, subject to the constraints imposed by the production functions as well as the total availability of land. Minimizing $[(\bar{d} - \mu_r)/\sigma_r,]$ therefore, with respect to the decision variables L, X and Y yields the following first-order conditions: (Details are shown in Appendix III A).

$$E(VMP_{L_i}) = \lambda[\{(\bar{d} - \mu_r)/\sigma_r^2\}E(P_{Q_i})E(Q_i)\sigma^2_{u_i v_i} + \{(\bar{d} - \mu_r)\sigma_r^2\}E(P_{Q_j})E(Q_j)\sigma_{12} + 1]^{-1} \quad ..(3.11)$$

$$E(VMP_{X_i}) = w_x[\{(\bar{d} - \mu_r)/\sigma_r^2\}E(P_{Q_i})E(Q_i)\sigma^2_{u_i v_i} + \{(\bar{d} - \mu_r)/\sigma_r^2\}E(P_{Q_j})E(Q_j)\sigma_{12} + 1]^{-1} \quad ..(3.12)$$

$$E(VMP_{Y_i}) = w_y[\{(\bar{d} - \mu_r)/\sigma_r^2\}E(P_{Q_i})E(Q_i)\sigma^2_{u_i v_i} + \{(d - \mu_r)/\sigma_r^2\}E(P_{Q_j})E(Q_j)\sigma_{12} + 1]^{-1} \quad .(3.13)$$

In the above set of equations, the left hand side, in each case, represents the expected value of marginal productivity of the respective input, L,X, and Y in the production of crop i. On the right hand side, the input price or the opportunity cost of the respective input is compounded by a risk factor, ϕ_{Q_i}, associated with the use of that input in the production of crop i. It is evident therefore, that the right hand side represents the farmer's perceived cost for each input which he equalizes with the expected value of its marginal productivity to arrive at that allocation of resources which is optimal, given both yield as well as price uncertainty.

The farmers perceived cost of an input will be the same as the input price (the opportunity cost of the input) if $\phi_{Q_i} = 1$, the 'risk-neutral' case in our model.[19]

Based on the efficiency conditions which follow from equations (3.11) - (3.13) several testable propositions can be derived to ascertain whether the small farm households behave efficiently (according to safety-first criterion), in the presence of risk, in their allocation of resources to various crop activities. Before we do so, however, it may be useful to review the efficiency conditions in a world of perfect certainty. It is the difference between the efficiency conditions derived under the alternate behavioural hypotheses, that is the primary focus of this chapter. In the neoclassical world of perfect certainty, if the firms behave in such a way as to maximize profits the following conditions must be met:

(i) the marginal value product of any input equals its price, and therefore,

(ii) the ratio of the marginal physical products of any pair of inputs equals the ratio of the input prices, and

(iii) the marginal value products of any input in two uses are equal.

Since our efficiency condition derived from equation (3.12) is of the form $E(VMP_{X_i}) = w_x \phi_{Q_i}$, for input X used in the production of crop Q_i, the first condition (i) for allocative efficiency under certainty may not hold in an uncertain world. Moreover, since $E(MVP_{X_i}) = w_x \phi_{Q_i}$ implies that $E(VMP_{X_i}) \gtrless w_x$ as $\phi_{Q_i} \gtrless 1$, it follows that risk induces a lesser or greater use of the variable input X as compared to the risk-neutral case depending on whether $\phi_{Q_i} \gtrless 1$. This in turn depends on whether $\bar{d} \lesssim \mu_r$.

However, for a typical farm-household, the assumption of $\bar{d} < \mu_r$ is very much likely to hold because its average income from farming activity will generally be greater than the level of income which it considers its disaster income. And, therefore, as far as this farm household is concerned, the presence of risk will induce a lesser use of variable inputs than in the certainty situation. Consequently, either a price support and/or input subsidy could be used to ensure input use at the profit maximisation level.

Using the efficiency (first-order) conditions under safety-first behaviour for the pair of inputs X and Y in the production of crop i from our equations (3.12) and (3.13) the following ratio is derived:

$$E(VMP_{X_i})/E(VMP_{Y_i}) = w_x\phi_{Q_i}/w_y\phi_{Q_i}$$

$$\text{or} \quad E(MP_{X_i})/E(MP_{Y_i}) = w_x/w_y \qquad \ldots(3.14)$$

This shows that even under yield and (output) price uncertainty, the farmer equates the ratio of the marginal physical products of a pair of inputs, X and Y, in the production of crop i with the input price ratio. Therefore the second condition (ii) of neoclassical profit maximization holds in an uncertain world. That this is so is not at all surprising in view of the fact that the relative riskiness of production associated with the use of a pair of inputs tend to cancel out in the sense of a proportional reduction in the use of both of these inputs as measured by $E(VMP_{X_i})/w_x = \phi_{Q_i} = E(VMP_{Y_i})/w_y$, for a farm household allocating a pair of inputs X and Y in the production of the same crop i. It follows, therefore, that although the farmer's optimum expected output is such that the value of marginal product exceeds the input price, the input-mix at that level of output is cost-efficient (for whatever output produced, cost is minimized).[20]

Finally, for analysing efficiency condition (iii), under safety-first behaviour, we consider the use of input X in the production of two crops, Q_1 and Q_2. Picking the relevant first-order conditions from equations (3.12), we obtain the following ratio:

$$E(VMP_{X_1})/E(VMP_{X_2}) = \phi_{Q_1}/\phi_{Q_2}$$

Thus, it follows that $E(VMP_{X_1}) \gtrless E(VMP_{X_2})$ as $\phi_{Q_1} \gtrless \phi_{Q_2}$ ....(3.15)

The above inequality states that the expected value of the marginal product of any input X into the production of crop 1 is greater than, equal to, or less than the expected value of the marginal productivity of the same input into the production of another crop 2 as the risk factor ϕ_{Q_1} associated with the use of that input into the production of crop 1 is greater than, equal to, or less than the risk factor ϕ_{Q_2}, associated with the use of same input into the production of crop 2. Put simply, the efficiency condition implies that the greater risk involved in the use of an input in a particular crop has to be compensated by a higher marginal return to the input in the production of that crop. The effect of risk, in general, would be to restrict the use of an input in the production of relatively high risk crop. Therefore, the third efficiency condition which follows from profit maximization under certainty also does not hold in an uncertain world.

Similar conclusions have also been derived by Wolgin (1975) using an expected utility model of farmer behaviour. He has shown that a risk-averse utility maximizing entrepreneur will require a higher expected marginal value product from a given input in an application where its contribution to risk is greater. However, this conclusion, as Young (1979) subsequently pointed out while correcting an error in Wolgin's derivation, is dependent upon the specific assumption of risk-aversion ($U_2^* < 0$) and positive marginal risk calculations ($\partial\sigma_y^2/\partial X_1 > 0$) maintained in his study.

Suitable testable hypothesis may easily be developed based on the efficiency conditions of our safety-first model of resource allocation. For example, the efficiency condition, $E(VMP_{X_1}) = w_x\phi_{Q_1}$ implies that we would expect, in general, a systematic divergence of the computed marginal value products of all inputs from their respective input prices across different crops. For the use of a given input across different crops, the degree of this divergence will depend on the risk factors, ϕ_Qs, associated with the production of these crops. However, for different inputs used in the cultivation of a particular crop, the divergence will remain uniform since the risk factors, being crop specific, causes a proportional reduction in the use of all inputs.

Again, following our efficiency condition, $E(VMP_{X_1}) \gtrless E(VMP_{X_2})$ as $\phi_{Q_1} \gtrless \phi_{Q_2}$, we would expect that the ranking of crops by the risk factors, ϕ_{Q_i}, should be identical to a ranking of expected values of the marginal products of any input in the production of these two crops.

These testable propositions along with cost-minimizing condition that the ratio of the marginal physical products of a pair of inputs in each of the two crop-activities equal the ratio of the respective input prices provide tests of whether the behaviour of small farm households in a peasant agriculture is consistent with the model presented above. Using that model as a standard, we can also test whether these farm households behave as efficient entrepreneurs under uncertainty.

Before we move on to the next section to analyse in greater depth the crop-growing decisions in subsistence farming under conditions of uncertainty, let us look a bit more closely, at the underlying decision-making process related to our safety-first modelling of farmer behaviour.

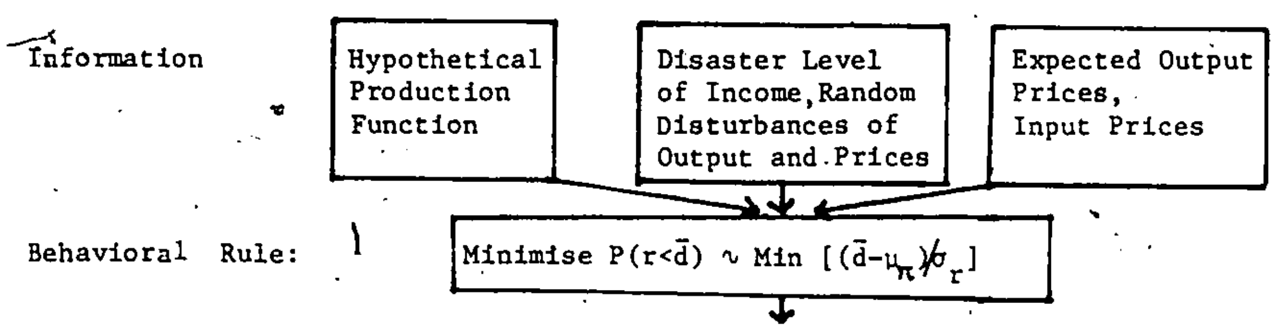
Assuming that the small holding farmers have difficulty in accumulating and processing a large amount of information, the proposition follows that through their accumulated farming-experience, they have acquired basically the following two types of information.

(a) Information related to the average increase in yield for an increase in the levels of factors of production - the information which may be thought of being embodied in a <u>hypothetical production function</u>.

(b) Information related to farm-family's evaluation of its '<u>disaster level of income</u>' and random disturbances associated with output and prices, the latter information being embodied in the <u>variance-covariance matrices of output and price disturbances</u>.

This information together with the information on prices of inputs and output of various crops, constitute the 'inputs' of the behavioral rule of the farm-family from which the optimal decision (most preferred action) is derived.

The decision-process of a farm-family following Roy's criterion can be conceptualized schematically as seen in the following diagram.



Behavioral Condition

$$E(VMP_X) = \phi_{Q_i} w_x \quad \text{where} \quad \phi_{Q_i} = [\{(\bar{d}-\mu_r)/\sigma_r^2\}E(P_{Q_i})E(Q_i)\sigma^2_{u_i v_i} + \{(\bar{d} - \mu_r)/\sigma_r^2\}E(P_{Q_j})E(Q_j)\sigma_{12} + 1]^{-1}$$

↓

Actions

$$X_1^*, X_2^*, \ldots\ldots\ldots\ldots X_k^*$$

III.4 Farmer's Crop Growing Decisions Under Uncertainty

Variants of safety-first models of decision-making are widely used to explain the high proportion of land being devoted to production of food crops in a peasant agriculture. In this section, we try to develop a safety-first model of resource allocation to analyse specifically the acreage decisions for a food crop vis-a-vis cash crop by small-holding farmers, particularly in the face of price uncertainty.[21] Specifically, this model will be used to explore the conditions under which risk induces a shift of acreage in favour of the food crop relative to the cash crop in a subsistence agriculture.[22]

In the model presented earlier, the focus of analysis was on income variability, which is reasonable in a situation where production and consumption decisions can be considered independently of each other. In subsistence agriculture, however, farm households consume a large proportion of their own production and thus have to worry about price fluctuations not only as producers but also as consumers. Therefore, when prices are subject to fluctuations, monetary income can no longer be assumed to be good proxy for consumption; it has to be considered directly. In such a situation, as emphasized by Nowshirvani (1971), there is a basic asymmetry between crops that are grown for the market and those which are consumed on the farm.

Based on these considerations, we introduce appropriate modifications into the objective function of our basic model by replacing the total (net) income variable, r, with a composite variable, $\overset{*}{Q}$, defined in physical terms, which consists of the amount of food crop (Q_f) grown by the farm household plus the amount (of food crop) that can be obtained by selling the cash crop, (Q_c) in the market at a relative price of (P_c/P_f) which has a random component, v. In other words, the relevant variable in terms of which the disaster-level of the farm household is analysed is no longer its total monetary income but a composite term expressing total crop return in physical units of subsistence food crop.

Our decision rule, using Roy's Safety-First criterion, therefore, takes the following form:

$$\text{Min } \alpha^* = P(\overset{*}{Q} < \bar{d}^*) \qquad \text{where} \quad \overset{*}{Q} = [Q_f + (P_c/P_f)Q_c] \quad \ldots.(3.16)$$

Again, the certainty equivalent of $P(\overset{*}{Q} < \bar{d}^*)$ can be represented by $[(\bar{d}^* - \mu^*_Q)/\sigma^*_Q]$, either by the use of Chebychev Inequality or following Pyle and Turnovsky (1970), by the assumption that the stochastic variable $\overset{*}{Q}$ can be fully described by the two parameters μ^*_Q and σ^*_Q. Minimization of the probability of disaster of the farm-family is thus equivalent to minimizing the expression, $[\bar{d}^* - \mu^*_Q)/\sigma^*_Q]$, subject, of course, to the constraints imposed by the production functions of food as well as the cash crop and the total availability of land possessed by the farm household.

The relation between inputs and output, in this model, is represented by a Cobb-Douglas production function which for the two crops and three inputs (for illustrative purposed only) would take the following form:

$$Q_f = A_f L_f^{\alpha_f} X_f^{\beta_f} Y_f^{\gamma_f} u_f \qquad \text{....(3.17)}$$

$$Q_c = A_c L_c^{\alpha_c} X_c^{\beta_c} Y_c^{\gamma_c} u_c \qquad \text{....(3.18)}$$

where Q_f and Q_c represents physical output of food and cash crops, L_f and L_c represent acreage devoted to food and cash crops and X_f, X_c and Y_f, Y_c represent variable inputs, X and Y used in the production of these two crops and u_f and u_c represent the random disturbances associated with their production.

Also, in this model assuming that u_f and u_c are each independent of v, the random component associated with the relative price of food and cash crop, (P_c/P_f), the mean and variance of $\overset{*}{Q}$ is given by:

$$\mu_{\overset{*}{Q}} = E(\overset{*}{Q}) = E(Q_f) + E(P_c/P_f)E(Q_c) \qquad \text{....(3.19)}$$

$$\sigma^2_{\overset{*}{Q}} = \text{Var } \overset{*}{Q} = \{E(Q_f)\}^2\sigma^2_{u_f} + \{E(P_c/P_f)\}^2\{E(Q_c)\}^2\sigma^2_{u_c v} + 2E(P_c/P_f)E(Q_f)E(Q_c)\sigma_{u_f u_c} \qquad \text{....(3.20)}$$

where $\sigma^2_{u_f}$ = variance of u_f, $\sigma^2_{u_c v}$ = variance of joint distribution of random disturbances, u_c and v, and $\sigma_{u_f u_c}$ represents covariance between u_f and u_c.

As noted earlier, since the minimisation of the probability of disaster is shown to be equivalent to minimising the certainty-equivalent. $[\bar{d}^* - \mu^*_Q)/\sigma^*_Q]$, our problem, therefore, reduces to minimising $[(\bar{d}^* - \mu^*_Q)/\sigma^*_Q]$ with respect to the decision variables L_f and L_c subject of course, to the constraint imposed by the total availability of land, $L_f + L_c = \bar{L}$. The resulting first-order conditions are: (details are shown in Appendix III B).

$$(\alpha_f/L_f)E(Q_f) = \lambda\sigma^*_Q[\{(\bar{d}^* - \mu^*_Q)/\sigma^{2*}_Q\}E(Q_f)\sigma^2_{u_f} + \{(\bar{d}^* - \mu^*_Q)/\sigma^{2*}_Q\}E(P_c/P_f)E(Q_c)\sigma_{u_f u_c} + 1]^{-1} \text{..(3.21)}$$

$$(\alpha_c/L_c)E(P_c/P_f)E(Q_c) = \lambda\sigma^*_Q[\{(\bar{d}^* - \mu^*_Q)/\sigma^{2*}_Q\}E(P_c/P_f)E(Q_c)\sigma^2_{u_c v} + \{(\bar{d}^* - \mu^*_Q)/\sigma^{2*}_Q\}E(Q_f)\sigma_{u_f u_c} + 1]^{-1} \text{..(3.22)}$$

In the above set of equations, one can readily detect some asymmetry in the optimal acreage decisions of food and cash crops under uncertainty. This is particularly reflected in the composition of the risk factors, $\phi^*_{Q_f}$ and $\phi^*_{Q_c}$, associated with the production of food and cash crop respectively.

Let us now explore the conditions under which risk-aversion causes farmers to plant too much land to a subsistence crop and too little land to a cash crop in relation to the risk-neutral or expected profit maximising level.

Under expected profit-maximisation, the relative acreage of the food and the cash crop, under optimal allocation, is given by, using the efficiency condition $E(VMP_{L_f}) = E(VMP_{L_c})$, which for a Cobb-Douglas production function takes the form, $E(P_f)\alpha_f E(Q_f)/L_f = E(P_c)\alpha_c E(Q_c)/L_c$

$$(L_f/L_c) = E(P_f/P_c)(\alpha_f/\alpha_c)\{E(Q_f)/E(Q_c)\} \qquad ....(3.23)$$

Under yield as well as price uncertainty, with the decision-maker following the safety-first rule, the efficiency conditions, $(\alpha_f/L_f)E(Q_f) = \lambda\phi^*_{Q_f}$ and $(\alpha_c/L_c)E(Q_c)E(P_c/P_f) = \lambda\phi^*_{Q_c}$ will yield the optimal food to cash crop acreage ratio:

$$(L_f/L_c)^* = E(P_f/P_c)\{E(Q_f)/E(Q_c)\}\ (\alpha_f/\alpha_c)(\phi^*_{Q_c}/\phi^*_{Q_f}) \qquad ..(3.24)$$

Taking the ratio of (3.24) to (3.23), we get

$$(L_f/L_c)^*/(L_f/L_c) = \phi^*_{Q_c}/\phi^*_{Q_f} \qquad ....(3.25)$$

Thus, it follows, in general, that

$$(L_f/L_c)^* \gtrless (L_f/L_c) \text{ as } \phi^*_{Q_c} \gtrless \phi^*_{Q_f} \qquad \ldots.(3.26)$$

In particular, it follows that $(L_f/L_c)^* > (L_f/L_c)$ i.e. risk induces a shift of acreage in favour of food crop relative to cash crop (as compared to the risk-neutral level) if $\phi^*_{Q_c} > \phi^*_{Q_f}$. The issue is, therefore, open to empirical investigation.

To analyse specifically the condition under which price uncertainty induces a shift of acreage in favour of the food crop relative to the cash crop, it may be more appropriate to use the efficiency conditions derived from the version of our safety-first model incorporating only yield uncertainty instead of those derived under expected profit maximisation.

We have already derived in (3.24) the expression for the optimal relative acreage of food and cash crops, using the efficiency (first-order) conditions derived from the safety-first model incorporating both yield and price uncertainty.

Also, using the first-order conditions derived from that version of the safety-first model incorporating only yield uncertainty, the optimal relative acreage of food and cash crop is given by

$$(L_f/L_c)^{**} = (\alpha_f/\alpha_c)E(P_f/P_c)\{E(Q_f)/E(Q_c)\}(\phi^{**}_{Q_c}/\phi^{**}_{Q_f}) \quad \ldots..(3.27)$$

where:

$$\phi^{**}_{Q_f} = \sigma^*_Q[\{(\bar{d}^* - \mu^*_Q)/\sigma^{*2}_Q\}E(Q_f)\sigma^2_{u_f} + \{(\bar{d}^* - \mu^*_Q)/\sigma^{*2}_Q\}E(P_c/P_f)\{\sigma_{Q_fQ_c}/E(Q_f)\} + 1]^{-1}$$

$$\phi^{**}_{Q_c} = \sigma^*_Q[\{(\bar{d}^* - \mu^*_Q)/\sigma^{*2}_Q\}E(Q_c)\sigma^2_{u_c} + \{(\bar{d}^* - \mu^*_Q)/\sigma^{*2}_Q\}\{\sigma_{Q_fQ_c}/E(Q_c)\} + 1]^{-1}$$

Taking the ratio of (3.24) to (3.27), we get

$$(L_f/L_c)^*/(L_f/L_c)^{**} = (\phi^*_{Q_c}/\phi^*_{Q_f})/(\phi^{**}_{Q_c}/\phi^{**}_{Q_f}) \qquad \ldots.(3.28)$$

Thus, it follows, in general, that

$$(L_f/L_c)^* \gtrless (L_f/L_c)^{**} \text{ as } (\phi^*_{Q_c}/\phi^*_{Q_f}) \gtrless (\phi^{**}_{Q_c}/\phi^{**}_{Q_f}) \quad ..(3.29)$$

In particular, it follows that $(L_f/L_c)^* > (L_f/L_c)^{**}$ i.e. price risk would induce a shift of acreage in favour of food crop relative to cash crop if $(\phi^*_{Q_c}/\phi^*_{Q_f}) > (\phi^{**}_{Q_c}/\phi^{**}_{Q_f})$ or if $\phi^*_{Q_c}\phi^{**}_{Q_f} > \phi^{**}_{Q_c}\phi^*_{Q_f}$.[23] This issue, too, is very much open to empirical investigation.

III.5 Peasant Risk Aversion Under Safety-First and Expected Utility Maximisation

We have already observed that safety-first modelling of farmer behaviour, like mean-variance analysis, leads to the optimisation of expressions involving the mean and the standard deviation. This suggests making a comparative analysis of the pattern of optimal resource-use under uncertainty based on the safety-first rule and those obtained under the more conventional approach based on expected utility maximisation.[24] The discussion will serve to highlight some of the important differences and similarities as to how these two rival decision rules incorporate the riskiness of production activities and in particular, the risk preferences of the farm households into resource allocation models in peasant agriculture. To simplify the analysis, our discussion will be limited to the use of a single variable input in a model with two crop activities.

The expected utility model of resource allocation (Wolgin, 1975) implies that when resources are allocated efficiently, the following relationship holds for an input X used in the production of crop Q_1:

$$\text{MFC of } X_1 = P_1 g_2 + (U_2^*/U_1^*)\,(2P_1^2 Q_1^{e^2} \sigma_1^2 + 2P_1P_2Q_2{}^{e}\sigma_{12})g_2$$

Where $U^*(Y^e, \sigma_y^2)$ represents the decision maker's utility function dependent upon mean (expected) income and its variance, and where $U_2^* = \partial U^*/\partial\sigma_y^2 < 0$, $U_1^* = \partial U^*/\partial ye > 0$ so that $(U_2^*/U_1^*) < 0$ and $(2P_1^2 Q_1^{e^2} \sigma_1^2 + 2P_1P_2Q_2^e\sigma_{12}) = \partial\sigma_y^2/\partial Q_1^e > 0$, $g_2 = \partial Q_1^e/\partial X_1 > 0$, so that $(2P_1^2 Q_1^{e^2} \sigma_1^2 + 2P_1P_2Q_2^e\sigma_{12})g_2 = \partial\sigma_y^2/\partial X_1 > 0$

In other words, MFC of X_1 = E(VMP) of $X_1 + (U_2^*/U_1^*)(\partial\sigma_y^2/\partial X_1)$ ....(3.30)

This conforms to the well-known result for a single product case that under uncertainty and risk-aversion, the expected value of marginal product of a variable input will exceed its marginal factor cost by a positive marginal risk deduction that is proportional to the degree of risk-aversion measured by (U_2^*/U_1^*) multiplied by the input's marginal increment to income riskiness measured by $(\partial\sigma_y^2/\partial X_1)$ [Anderson, Dillon & Hardaker (1977)]. If the farmer is risk-averse, given by $(U_2^*/U_1^*) < 0$, then the effect of uncertainty is to reduce the use of each variable input. On the other hand, if the farmer happens to be risk-neutral represented by $(U_2^*/U_1^*) = 0$, then the expected value of the marginal product of an input equals its marginal factor cost even if the input's marginal increment to income riskiness represented by $(\partial\sigma_y^2/\partial X_1)$ is greater than zero. A risk-neutral farmer operating under conditions of uncertainty behaves just like a farmer operating under certainty as far as his input decisions are concerned.

A similar pattern of allocation behaviour is also observed under safety-first modelling of resource allocation, although the interpretation of peasant risk aversion in this case is somewhat different. The optimal resource use for a variable input X in the production of crop Q_1 may be written as:

$$w_x = E(VMP) \text{ of } X_1 + \{(\bar{d} - \mu_r)/\sigma_r^2\}\{E(P_{Q_1})^2 E(Q_1)\sigma_{u_1v_1}^2 + E(P_{Q_1})E(P_{Q_2})$$
$$E(Q_2)\sigma_{12}\}F_x$$

where $F_x = \partial E(Q_1)/\partial X_1$

$\{\cdot\} = \partial\sigma_r^2/\partial E(Q_1)$

which equals, MFC of X_1 = E(VMP) of $X_1 + [\{½(\bar{d} - \mu_r)/\sigma_r^2\}(\partial\sigma_r^2/\partial X_1)]$ ..(3.31)

Again, this shows that for a risk-averse farmer (with $\bar{d} < \mu_r$), the expected value of marginal product of a variable input will exceed its marginal factor cost by a positive marginal risk deduction represented by $[\{½(\bar{d}-\mu_r)/\sigma_r^2\}(\partial\sigma_r^2/\partial X_1)]$ This implies that under uncertainty the optimal input use is lower than in the certainty case. More significantly, a comparison of (3.30) and (3.31) makes it readily evident that $[½(\bar{d}-\mu_r)/\sigma_r^2]$ plays the same role in the safety-first model as (U_2^*/U_1^*) does in the expected utility model. In other words, under the safety-first approach, $[½(\bar{d} - \mu_r)/\sigma_r^2]$ may be interpretated as some sort of a measure of risk preference of the decision-makers. However, two points need to be emphasized here.

First, under the safety-first rule, the decision-makers preference ordering is defined within a mean-standard deviation framework and therefore, the inputs' marginal increment to riskiness may be more appropriately expressed as $\{\partial\sigma_r/\partial X_1\}$ instead of $\{\partial\sigma_r^2/\partial X_1\}$ as generally done in mean-variance analysis. In that case, the degree of risk aversion of the decision-maker following Roy's Safety Principle will be measured by $[(\bar{d} - \mu_r)/\sigma_r]$, and not by $[½(\bar{d} - \mu_r)/\sigma_r^2]$ as shown above.[25]

Second, under the safety-first approach, the risk preference of the decision-maker has to be interpreted in a somewhat different fashion than it is usually done in expected utility analysis. Since the risk aversion coefficient in this framework is defined as $\psi_k = [(\bar{d} - \mu_r)/\sigma_r]$, it is quite evident that the behaviour towards risk of the farm family is determined by the level of disaster income relative to its expected income from farming activity. In other words, the relative magnitude of these two variables, $\bar{d}$ and μ_r, determines whether the farm family is "forced to gamble" or allowed to trade expected return for reduced risk in its choice of crop-portfolio. The innate psychological aversion to risk which is usually associated with the interpretation of the risk aversion coefficient has very little relevance in a world where the decision makers are preoccupied not with maximising income but with maximising their chances of survival. Different choice among farmers do not depend on differences in their attitudes towards risk but on the differences in their subsistence needs, resource endowments and their perceptions of riskiness among competing activities.

For example, if the disaster income level of the farm family happens to be high enough to exceed its expected income from farming operations (thereby yielding a positive value of ψ_k) then in its attempt to minimise the probability of disaster, the farm family is "forced to gamble" in its choice of crop-portfolio. It has to take risk in order to maximise its chances of survival by devoting greater resources to riskier crops. On the other hand, if the farm family's subsistence requirements are lower than its expected income from farming activity (thus yielding a negative value of ψ_k), then the farm family can afford to choose a less risky crop-portfolio with lower expected returns. This, however, does not necessarily mean that this family is psychologically more risk-averse than the former.

Similar patterns of farmer behaviour towards risk in subsistence farming have been discussed by Roumasset (1976) and Wright and Kunreuther (1975, 1979) in a lexicographic safety-first framework. In analysing the optimum use of fertilizer under risk for Filipino rice farmers, Roumasset (1976, p167) has noted.

"A curious aspect of lexicographic safety-first is that for farmers with relatively high disaster levels the optimal solutions are higher than the risk neutral optimum. Thus, while conventional wisdom holds that risk aversion may cause farmers to use less inputs than are needed to maximise expected profits this suggests the opposite result; farmers may use more inputs than at the risk neutral optimum because their target rate of return is so high."[25]

Wright and Kunreuther (1975) also postulate similar behaviour towards risk in explaining the mix between corn and cotton acreage in the postbellum South:

"The safety-first hypothesis is that the farmer maximises expected earnings after assuring that the risk of falling below Z^* (the critical yield level which will just produce minimum tolerable consumption) is less than α^* (the risk level which the farmer is willing to tolerate). But suppose there is no allocation of acreage which satisfies this constraint. In that case, the farmer...must concentrate all his effort on maximising his chances of achieving Z^*.... He is now forced to gamble on the cash crop in order to have any chance of acheiving his critical target yield."

In a more recent paper, Wright & Kunreuther (1979) applied their theoretical modelling of sequential decision-making to subsistence farming in Bangladesh. Using district-level data for different farm sizes, they could clearly distinguish between two classes of farmers, which they identified as safety-firsters and gamblers, according to whether their min $P(r < \bar{d}) = \alpha' \lesseqgtr \alpha^*$.

It should be emphasized here that although gambling behaviour in subsistence farming can be explained in terms of Roy's Safety Principle, modelling farmer behaviour based on Roy's Principle does not necessarily lead to a "gambling-type" of behaviour on the part of the small farm households in their choice of crop portfolio. As we have shown earlier, incorporation of Roy's criterion into a model of resource allocation under risk generated a risk aversion coefficient, $\psi_k = [(\bar{d} - \mu_r)/\sigma_r]$, which may lead to gambling behaviour in crop growing decisions only if the situation is desperate enough for the farm-household (as indicated by $\bar{d}$ being greater than μ_r). The target rate of return based on its subsistence requirements is so high compared to the income earning capacity of the household from its farming activities that it may be forced to gamble in its crop growing decisions. It is forced to grow more of the high return high variance crops in order to maximise the chances of its achieving the target rate of return ($\bar{d}$). However, if the subsistence requirements of the farm family happens to be less than its income earning potential from farming activity (the case of $\bar{d}$ being less than μ_r, yielding a negative value of ψ_k), then the situation for the family is not so desperate as to force it to plunge into more riskier activities. It may now choose a crop-portfolio with lower return and lower variance crop combinations.[26]

Of course, one may argue that for the category of farm households whose $\bar{d}$ is less than its μ_r, it is very plausible that the risk constraint, $P(r < \bar{d}) < \alpha^*$, is satisifed for at least some acreage allocation, and therefore, they do not have to concentrate all their efforts in minimising the probability of disaster, $P(r < \bar{d})$, since their min $P(r < \bar{d}) = \alpha' < \alpha^*$. Thus, it is very likely that in such cases the farm family may be following not Roy's Safety Principle but Telser's Safety-First criterion (Max μ s.t. $P(r < \bar{d}) \leqslant \alpha^*$). In other words, if one can appropriately identify the equivalence between $\bar{d} < \mu_r$ and $\alpha' < \alpha^*$ for a particular farm household in our sample (one with their $\bar{d} > \mu_r$ and the other with $\bar{d} < \mu_r$) then what may be happening for these two categories of farm-households is not simply a switching of behaviour but a switching of the criterion itself.[27]

It is worth emphasizing here that unlike various conceptual and methodological problems which beset empirical estimation of the risk aversion parameter (U_2^*/U_1^*) in peasant farming, a reliable estimate of $\psi_k = [(\bar{d} - \mu_r)/\sigma_r]$, can be more readily obtained. As estimate of $\bar{d}$ in this context should be based on the farm family's evaluation of what they feel is their disaster level of income. However, the term is not completely devoid of any objective interpretation. In fact, to the extent that the disaster income-level also represents the point below which the behaviour of the decision-maker must change, i.e., the farm-household must borrow or sell assets to avoid starvation, this will also be determined by the situation of the decision-maker in a given socio-economic environment.[28]

III.6 Summary and Conclusions

In peasant agriculture characterised by a predominance of small-holding farms, the farm family's behaviour may be conceptualised in terms of a decision-making rule known as safety-first. These rules, as emphasized by Moscardi (1975), shape a particular economic behaviour where the possibility that income from agricultural activity falls below some subsistence level plays an essential role in resource allocation decisions. In particular, the characteristics of ecological and socio-economic environment in which the low-income farmers have to operate makes safety-first a very appealing rule for analysing farmer behaviour in subsistence agriculture. Several other authors have also emphasized that safety-first criterion tend to be followed where the disaster-avoidance motive is very strong and/or the satisfaction of basic needs may be at risk [Lipton(1968), Roumasset (1976), Masson (1974) and Kunreuther and Wright (1979)]. Therefore, in our study of the resource allocation behaviour of the small farm households in Bangladesh, we have employed Roy's Safety Principle which is based upon the notion of disaster-avoidance by the decision maker.[29] The results of our analytical exercise may briefly be summarised as follows:

i) Using a safety-first model of resource allocation, we have derived the conditions for allocative efficiency in a traditional agriculture where the farm households are exposed to both yield and price uncertainty. Our exercise demonstrates that the traditional tests of allocative efficiency based on expected profit maximization are misspecified if the decision maker follows safety-first behaviour. This incidentally reinforces the conclusions derived by Wolgin (1975) earlier using alternative decision criteria. Based on our allocative efficiency conditions, suitab~~le testab~~le hypotheses have been developed to ascertain whether the small-holding farms in Bangladesh are efficient, (according to the safety first criterion) in the presence of risk, in their allocation of resources to various crops.

ii) It is often hypothesized that risk aversion causes farmers to plant too little land to cash crop relative to the risk neutral or efficient acreage allocation. We presented a modified safety-first model to analyse specifically the acreage decisions of a food crop vis-a-vis a cash crop in subsistence farming in the face of price uncertainty. In particular, we explored the conditions under which risk induces a shift of acreage in favour of the food crop relative to the cash crop under the safety-first criterion. We observed that the issue is very much open to empirical investigation.

iii) A comparison of resource allocation behaviour under two rival criterion for analysing decision-making under uncertainty shows that it is possible to analyse the risk preferences of the decision maker in a safety-first model of farmer behaviour much in the same way as in an expected utility model. The interpretation of the risk aversion coefficient, however, will be somewhat different under safety-first. Emphasizing farmer behaviour towards risk, the safety-first approach attempts to explain, in terms of the subsistence requirements and the income-earning potential of the farm household, whether it may be 'forced to gamble' (i.e., grow more of high return-high variance crops) or 'allowed to accept less risk' (i.e., trade expected return for reduced risk) in its choice of crop-portfolio.[30]

It has also been observed that our safety-first approach would permit a more convenient empirical estimation of the risk coefficient capturing farmer behaviour towards risk in peasant farming if valid estimates of disaster incomes of the farm households are obtained presumably through a farm-level sample survey.

FOOTNOTES:

1. Aside from plethora of conceptual and methodological issues concerning whether variance should be subjective or objective and how it should be elicited or measured, two fundamental potential limitations characterise the variance as risk concept as embedded in mean-variance analysis. First, if the decision maker is concerned about higher moments of the action outcome probability distributions, 'risk' should be represented by a vector containing variance of profit, skewness of profit and so on. Secondly, the convenient scalar measure of risk is based on a utility function considering only the single-attribute of profit. Agricultural producers may in fact base their decisions upon such multiple objectives as profit, leisure-work consequences and personal 'aesthetic' considerations, (Young, 1979).

2. More specifically, Rothchild and Stiglitz (1970) define one distribution function, $G(\pi)$, to be riskier than a different distribution $F(\pi)$ if the means of both distributions are the same and if $\int_0^{\pi^*}[G(\pi) - F(\pi)]d\pi > 0$ for any value of π^* in the range of G or F.

3. For risky prospects with multi-dimensioned consequences, a slight but reasonable extension of the axioms is necessary. (Fishburn, 1970).

4. In fact, expected utility theory, as it is generally applied, leads to a contradiction of other aspects of received consumer choice theory. The usual approach to estimating risk preferences involves the implicit assumption that an indirect utility function in one-period money exists but this assumption is likely to contradict the more generally acceptable postulates of consumer choice. In particular, the independence or substitutability axiom is violated (Roumasset, 1979).

5. Other models belonging to behavioralist school that occupy a place of prominence in the literature are those based on Shackle's System of Potential Surprise and Focus Loss (1949, 1961), Cautious Optimising models developed by Singh and Day (1975), the Satisficing model developed by Kunreuther (1974) and the Lexicographic Safety-First model developed by Roumasset (1976) respectively. Formally, however, LSF model is a full optimality model because in it the decision maker acts in accordance with a complete preordering of preferences. Unlike the expected utility model, however, it does specify a decision-process that makes the prescribed outcomes possible.

6. Some of the institutional constraints are: (1) the extension service which is almost non-existent for small-holding farmers (2) the credit service provided by the bank and other govt. agencies are not easily accessible to small farmers and (3) the relatively long distance to input and output markets.

Footnotes Cont.

7. Quadratic utility functions have the unappealing property of increasing absolute risk aversion i.e., they imply that the individual is less willing to accept a given-sized wager at higher levels of wealth. However, for small holding farmers in peasant agriculture, who is not willing to risk his security for the prospect of attaining higher profits, <u>decreasing</u> absolute risk aversion seem to be a more plausible assumption. Also, quadratic utility functions also imply that for all ranges of income, the decision maker is always willing to accept some sacrifice in expected return in order to reduce variance. But as Roumasset (1976) has demonstrated, where decision makers are primarily concerned with security and only secondarily interested in expected returns there are some sets of techniques such that the decision maker will prefer variance.

8. One could also view this derived or indirect utility function as coming from an analysis of a person's multiperiod decision problem. The individual may obtain utility from income and the state of the world. Declaration of bankruptcy could then reduce utility by either or both of the two factors. There could be a direct utility effect due to dispreference for bankruptcy or an indirect utility effect from a discontinuity in future earnings capacity due to declaring bankruptcy. Either or both of these factors could then yield a jump discontinuity in the derived utility function. This derived utility function could be a recursion equation in a dynamic programming formulation of the problem, (Masson, 1974).

9. It may be noted here that the intuitive notion of downside risk is concerned with the 'placement' of risk in a distribution. One distribution is said to have more downside risk than another if it has more dispersion below a specific target or if it is more skewed to the left. The general notion of a pure increase in risk involves the spreading of probability weight from the center to the tails of a distribution, and conversely, a decrease in risk would result from a contraction of probability weight (Menezes et al. 1980).

10. They do this by defining what they call a mean-variance-preserving transformation (MVPT) of a distribution which is essentially a combination or appropriate pairing of two simple probability transfer function- a mean-preserving-spread (MPS) which entails a transfer of weight from the center to the tails of a distribution, and a mean-preserving-contraction (MPC) which is the converse of an MPS. An MVPT can also be defined in terms of spread-contraction combinations in which the MPS comes everywhere before the MPC. This makes the left-ward transfers of risk even more evident.

11. They have shown in particular that the only probability loss measure that is directly related to their definition of downside risk is target semi-variance and that the only stochastic dominance (SD) criterion that is directly related to their definitions of downside risk is third degree stochastic dominance (TSD).

12. Sometimes Roy's Safety Principle is criticized on the grounds that it is inappropriate if the alternatives are all associated with low risk. For example, this Rule will choose an alternative with a probability of failure of .004 over an alternative with a probability of failure of .005 even though the latter may have an expected value of the objective function of ten times the former. In other words, in its attempt to minimise the probability of disaster, the decision-maker may end up sacrificing some highly profitable ventures. However, we do not think this to be a serious problem particularly for analysing decision-making of low-income farmers perennially living perilously close to the subsistence level and hence very much preoccupied with maximising the chances of their survival, especially in the face of vagaries of nature. [See Lipton (1968)].

13. Thus, if net income r is a random variable with mean μ_r and variance σ_r^2, it follows that $P(|r-\mu_r| \geq \mu_r-d) < \sigma_r^2/(\mu_r-\bar{d})$ provided $(\mu_r-d) > 0$. Then a *fortiori*, $P(\mu_r-r > \mu_r-\bar{d}) = P(r < \bar{d}) < \sigma_r^2/(\mu_r-\bar{d})^2$ [Roy (1952)].

14. The structure of our resource-allocation model closely resembles the model developed by Wolgin (1975) to derive the allocation efficiency conditions in the context of expected-utility maximisation. This is done to facilitate a comparison of the prediction statements that can be derived from the two models.

15. The stochastic version of our production functions represents a specific and somewhat simplified way of incorporating multiplicative risk in production function formulation. For a more sophisticated specification of stochastic components of production, see Just and Pope (1979).

16. This is a simplifying assumption which is usually defended on the ground that under the competitive conditions which characterize subsistence farming, there will be little dependence between yield and price that an individual farmer experiences. This would not be true, however, for situations where all farming areas of a country tend to experience the same climatic conditions at the same time so that events like droughts, floods, etc. tend to influence the whole country rather than isolated areas. Again, the assumption can be defended for those export crops, the price of which are usually determined in the world market and the country in question is too small a producer for its output to affect world price. But then, if the country happens to be a monopolist or oligopolist in the world market, the independence assumption again becomes questionable. However, we subsequently relaxed this assumption of stochastic independence between output and prices to incorporate the negative covariance of output and price disturbances and derived the following first-order conditions:

$$E(VMP_{L_i}) = \lambda[\{\bar{d}-\sigma_r^*)/\sigma_r^{*2}\}E(P_{Q_i})E(Q_i)\sigma^{2*}_{u_i v_i} + \{(\bar{d}-\mu_r^*)/\sigma_r^{*2}\}E(P_{Q_j})E(Q_j)\sigma_{ij}^* + \operatorname{cov}(u_i v_i) + 1]^{-1}$$

16. $$E(VMP_{X_i}) = w_x[\{(\bar{d}-\mu_r^*)/\sigma_r^{*2}\}E(P_{Q_i})E(Q_i)\sigma^{2*}_{u_iv_i} + \{(\bar{d}-\sigma_r^*)/\sigma_r^{2*}\}E(P_{Q_j})E(Q_j)\sigma^*_{ij} + cov(u_iv_i) + 1]^{-1}$$

$$E(VMP_{Y_i}) = w_y[\{(\bar{d}-\mu_r^*)/\sigma_r^{*2}\}E(P_{Q_i})E(Q_i)\sigma^{2*}_{u_iv_i} + \{(\bar{d}-\mu_r^*)/\sigma_r^{2*}\}E(P_{Q_j})E(Q_j)\sigma^*_{ij} + cov(u_iv_i) + 1]^{-1}$$

where $\sigma^{2*}_{u_iv_i} = var(u_i)var(v_i) + var(u_i) + var(v_i) + 2cov(u_iv_i) + \{cov(u_iv_i)\}^2$

and $\sigma^*_{ij} = E(u_iv_iu_jv_j) - cov(u_iv_i)cov(u_jv_j) - cov(u_iv_i) - cov(u_jv_j) - 1$

It is quite evident that incorporation of dependencies between output and price disturbances will make the first-order conditions and hence the expressions for risk factors somewhat different from those derived earlier.

17. Under the assumption of stochastic independence between output and price disturbances u_i and v_i, $\sigma^2_{u_iv_i}$ and σ_{12} may be computed as

$$\sigma^2_{u_iv_i} = var(u_i)var(v_i) + var(u_i) + var(v_i)$$

$$\sigma_{12} = cov(u_iv_i)cov(u_jv_j) + cov(u_iv_i) + cov(u_jv_j)$$

18. Since our resource allocation model purports to analyse the problem of crop-growing decisions of the farmer with a given size of cultivated holdings, no attempt has been made here to incorporate elements in the model needed to explain the process of determining the size of the holding through renting in/out of land. Also, there is a vast and growing body of literature dealing with the problem of tenancy, especially sharecropping tenancy, and efficiency of resource allocation in peasant farming.

19. A sufficient condition (though not necessary) for behaviour that corresponds to risk-neutrality in our model is given by $\bar{d} = \mu_r$, describing the cases of those farm households barely meeting their subsistence requirements from farming activity (on average).

20. This is an implication of the structure of our resource allocation model, particularly the way risk has been incorporated (crop-specific and <u>not</u> input-specific) into the model.

21. The argument that small farmers attempt to avoid market-place risks by devoting a large share of their acreage to food crops appears in Behram (1968), Boussard and Petit (1967) and Lipton (1968).

22. The point that deserves emphasis here is that the cash crop is in fact the risky choice for subsistence farmers in almost all the cases. This relationship is not the result of perverse quirk of nature but is inherent in the process of exchange. A farmer who buys food must consider the yield variance of the cash crop as well as the price variance of both the crops; for the farmer who grows and consumes his own crop only the yield variance is relevant (Kunreuther and Wright, 1979).

23. A comparison of the various components of the four risk-factors, $\phi^*_{Q_f}$, $\phi^*_{Q_c}$, $\phi^{**}_{Q_f}$ and $\phi^{**}_{Q_c}$ reveals that if $E(v) = 1$, $\phi^*_{Q_f}$ equals $\phi^{**}_{Q_f}$. Also, with $E(v) = 1$ and $E(v^2) > 1$, makes $\phi^*_{Q_c} > \phi^{**}_{Q_c}$ assuming $\bar{d} < \mu^*_Q$. And if $\phi^*_{Q_f} = \phi^{**}_{Q_f}$ and $\phi^*_{Q_c} > \phi^{**}_{Q_c}$, this leads to $\phi^*_{Q_c}\phi^{**}_{Q_f} > \phi^{**}_{Q_c}\phi^*_{Q_f}$, which is a sufficient condition for $(L_f/L_c)^* > (L_f/L_c)^{**}$.

24 For a more elaborate discussion on this in the context of portfolio analysis, see Pyle and Turnovsky (1970).

25. Also, this is more consistent with the measure of risk aversion, $[d\mu_r/d\sigma_r]$, suggested by Magnusson (1969). It is easily verified that for $V = [(\bar{d} - \mu_r)/\sigma_r]$, $dV = 0$ leads to $[d\mu_r/d\sigma_r] = [(\bar{d} - \mu_r)/\sigma_r$.

26. Translated into Roy's framework particularly expressed in terms of our risk factors, this implies that $d > \mu_r$ leads to $\psi > 0$, which generally yields a value of the risk factor of less than unity thereby leading to greater use of inputs relative to the risk-neutral case. We say generally because the magnitude of the risk factors also depends on the estimates of the variance-covariance matrices of income disturbances, particularly the sign and magnitude of the covariance terms. Conversely, of course, $d < \mu_r$ leads to $\psi < 0$, which yields a value of risk factors greater than unity, thereby resulting in restricted use of resources under uncertainty.

27. This is an issue which perhaps cannot be settled a priori but should be tested empirically in terms of the explanatory/predictive power of modelling farmer behaviour with these two alternative versions of the safety-first criterion. However, it has not been the purpose of this study to determine which choice model is a more accurate representation of farmer behaviour in subsistence farming. Our objective has been to explore, based on Roy's Principle, whether the small farm-households behave efficiently, in the presence of risk, when allocating resources to various crops.

28. Also, this approach is consistent with the procedure followed by Roumasset (1976) in computing the risk-sensitivity-index (RSI) to take account of the risk preference of the low-income farmers in Philippines. The rationale behind this approach lies in the recognition that risk attitudes should not be determined by questions that attribute deviations from the risk-neutral optimum to risk preferences. On the other hand, this must be derived from the in-

28. stitutional and social environment that a farmer lives in, his wealth position, the credit terms available to him, his investment possibilities, and so on. Thus, instead of asking about preferences among gambles, the farmer is asked more fundamental questions, e.g. "How do you take care of your family if your rice is cut down by 50% due to floods and/or cyclones?" (Roumasset et al, 1979).

29. Attempts have also been made to define disaster-avoidance in the context of expected-utility maximisation, which introduce a jump or discontinuity in the decision-maker's utility function. For a discussion of the likelihood of this occuring in peasant farming, see Masson (1974).

30. It should be emphasized here, however, that the contrast in modelling farmer farmer behaviour based on these two decision criteria becomes more pronounced in those situations where the farm family is forced to choose a riskier crop portfolio in order to maximise its chances of survival - the so-called gambling-type behaviour sometimes observed among poorer farmers in peasant agriculture.

CHAPTER IV

SURVEY PROCEDURES AND GENERAL CHARACTERISTICS OF DATA

IV.1 Introduction

The estimation of safety-first models which were developed in Chapter III to analyse resource allocation behaviour of small-holding farms in Bangladesh under conditions of uncertainty ideally requires farm-level time series data on inputs, output and prices. The availability of such a data-set would enable us to estimate both the cross section production functions as well as the variance-covariance matrices of random disturbances associated with both output and prices. However, the generation of micro-level time-series data requires repeated field surveys for a number of years, an expensive and time consuming process. Such a data-set, therefore, is not normally available, particularly in a resource-poor country like Bangladesh.

Fortunately, however, resources were available to conduct a single period sample survey that would gather the necessary information for the estimation of cross-section production functions for various crops in different regions in Bangladesh. This chapter discusses the survey procedures as well as the nature of information collected in the field survey. It also summarizes the major findings with respect to data characteristics in the survey areas. More specifically, Section 2 of this chapter discusses in detail the sampling techniques actually adopted including the selection of sampling areas and the nature of information collected including a brief discussion of the questionnaire actually used in the field survey. It also discusses, in brief, the reliability of the information collected in the field survey, and presents some general characteristics of the survey areas.

Section 3, on the other hand, presents the findings of the field survey particularly with respect to major data characteristics in the sampling areas. This reveals both the data characteristics in the individual sampling region and permits a comparative evaluation of the same among different regions where the surveys were actually carried out. Here attempts will also be made, wherever possible, to make a comparison with all-Bangladesh characteristics. The major findings are summarised and some concluding observations are made in Section 4.

IV.2 Survey Procedures and Nature of Data

The main source of information used in this study is a field survey conducted by the author from September, 1979 to January, 1980 in four selected regions of Bangladesh. The basic purpose of the survey was to collect information with respect to (a) socio-economic and structural characteristics of the farm households, and (b) input and output combination of various crops grown during the year preceding the survey. In conducting the field survey, a stratified random sampling technique was adopted, the prime stratification being done on the basis of ecology of Bangladesh. Based on a World Bank Sector Study on Land and Water Resources in Bangladesh (1972), the following primary ecological regions were first identified, each possessing distinctive climatic and hydrological characteristics.[1]

(i) The Eastern Region, comprising of Sylhet, Comilla, Noakhali, Chittagong and Chittagond Hill Tracts districts

(ii) The Northwest Region, comprising of Dinajpur, Rangpur, Pabna, Rajshahi and Bogra districts

(iii) The Southwest Region, comprising of Kushtia, Jessore, Faridpur, Khulna, Barisal and Patuakhali districts

(iv) The Central Region, comprising of Dacca, Tangail and Mymensingh districts

Subsequent stratification was done within each Region, i.e., sub-regions were selected on the basis of the factors that makes agricultural production so risky in Bangladesh. Among these factors, the most important are: (a) variability of seasonal rainfall and (b) incidence of floods/cyclones. On the basis of appropriate statistical indices (coefficient of variation of seasonal rainfall and average cropped area damaged due to floods and cyclones) computed from seasonal rainfall and annual crop damage data, the following sub-regions (districts) were selected from each of the ecological region for conducting our field survey.

(i) Sylhet District in the Eastern Region

(ii) Pabna District in the Northwest Region

(iii) Faridpur District in the Southwest Region

(iv) Mymensingh District in the Central Region

Further sampling stratification was done in the selection of thana in each district (two thanas selected in each district) based on cropping intensity as well as cropping pattern representative of the district concerned. In each of the selected thana, four or five villages were selected randomly with the help of random number table from the complete list of villages compiled from the 1974 District Census Report in Bangladesh. And finally, in each of the selected villages farm households were chosen randomly subject to the condition that the farm size of the selected household did not exceed three acres, the generally accepted limit of farm size for a 'small farm' in Bangladesh. In all 202 farm households were interviewed, the number of households interviewed in each district remaining more or less the same at fifty. This also means that in each of the eight selected thana, roughly 25 households were interviewed. The names of the selected thanas in each district, those of selected villages in each thana, and the number of households surveyed in each thana in different districts are shown in Appendix IVA.

In conducting the field survey, the author was assisted by four field investigators. After recruitment, the basic objectives of the survey were carefully explained to each of them. In particular, the entire questionnaire which was designed earlier was thoroughly discussed in every detail so that no ambiguities existed in the minds of the investigators as to the nature and type of information to be collected from the farm households during the field survey. After a few initial field trips made to interview the farm households, the investigators were mostly left on their own to conduct the survey. The author, however, made periodic visits to the field to ensure supervision and particularly, for checking the filled-in questionnaires for any inconsistency and suspected inaccuracies. In doubtful cases, the questionnaires were returned for rechecking with the respondents concerned.

In the process of conducting the field survey, the team received considerable assistance for the local government officials and the elected members of the Thana Council. They assisted the survey team both in locating the selected villages as well as in establishing contact with the local villagers who are normally very shy and reserved particularly with an outsider.

Considerable time and effort was devoted to the design of the questionnaire itself. The questionnaire was prepared to cover various aspects of farm household's operations with particular emphasis on detailed information on input and output combination of various crops grown in the survey areas. The initial draft of the questionnaire was prepared by the author at McMaster University in consultation of his thesis supervisory committee. However, in giving final shape to the questionnaire, advice was sought and consultations were made with a number of experts in rural sample survey work in various research organizations in Bangladesh. Also, to assess the accuracy of the questions, their sequence and their consistency, a pre-testing of the questionnaire was done in a village in Dacca district. Some important modifications in the questionnaire were made in the light of this pretesting experience.

The questionnaire was divided into a number of sections starting from general background information of the households in section I to valuation of their assets in the last section. Other sections contained questions relating to demographic and occupational characteristics, structure of land ownership and tenurial conditions, the pattern of land use, detailed information on input and output combinations for various crops grown, the disposal of crop output, the valuation of agricultural tools and implements possessed by the farm households, income from sources other than crop production, the pattern of consumption expenditures and amount and sources of borrowing. While most of the questions sought quantitative answers, provisions were made for some qualitative answers as well. Suitable provisions for cross-checks were also made while designing the questionnaire. A translated version of the questionnaire is presented in Appendix IVB.

In peasant societies with low levels of educational background, farm households do not usually keep any records of their business activities and transactions. Hence, unless data are collected on events as they occur (requiring frequent visits to the households by the investigator) several errors are likely to creep into a survey like ours. In fact, as Hussain (1977) so rightly emphasizes, two types of errors are very common in these kinds of surveys.

The first arises from what we may call "taxing the respondent's memory too much". As mentioned above, the peasant households do not usually keep records on their farm business, and hence it is very likely that some of the answers to the questions related to past events may be quite arbitrary, particularly when the reference period is one full year. As a matter of fact, it has been noticed that although the farmers may remember quite accurately such broad magnitudes as those connected with ownership of land and tenure of holdings, land allotment to different crops and output produced and the amount and sources of credit, they may not always remember the various details of their activities such as application of inputs for different operations on crops grown during the year, and hence answers to these types of questions may not be very accurate. It is only through conducting multiple interview surveys, i.e., visiting the sampling units more frequently and collecting information on events as they occur, that one can hope to ensure reliability of information to these types of questions.

The second type of error arises from what we may call "willful hiding of facts" by the respondents. If for certain reasons, the respondents are unwilling to reveal certain facts, they tend to distort the information they provide in the way they think best suits their interests. As a matter of fact, it is often very difficult to convince the farms in traditional agriculture about the true purpose of the survey. Many of them suspect that they are going to benefit or lose something individually if the information is correctly reported and hence they tend to misreport according to their expectations. For example, large farmers fearful of expropriation of land or agricultural taxation might understate the amount of land owned or incomes earned, and tend to overstate their expenditures and costs. Smaller farms, on the other hand, in expectation of getting ownership rights to the land leased-in or obtaining government subsidies might overstate the amount of land leased-in or their minimum consumption needs, and tend to understate their assets and incomes. Errors from this source can produce biased results as they are unlikely to be distributed evenly over the sample.

To minimize such errors arising from misreporting and wilful hiding of facts, the questionnaire was designed to contain a few similar questions in different sections, so that cross-checks could be made. For example, cultivated land was checked against cropped acreage which is likely to be roughly twice as high as cultivated acreage. Similarly, land reported to be leased-in was checked with the land leased-in cultivated under different crops and total wage cost on hired labour was checked against the sum-total of wage cost incurred on hired labour used in cultivation of different crops.

IV.3 General Characteristics of Data

IV.3.1 Distribution of Land and Tenurial Conditions

In traditional pre-capitalist agriculture, land is not only the basic means of production, but ownership of land also constitutes a critical element in achieving political power and social prestige. We present below some information on the distribution of land ownership and cultivation in four districts in which the survey was carried out. In particular, the size distribution of land ownership in the four districts is compared. It should, however, be mentioned here that since our survey was limited to the farms of 3 acres or less, we can only give a very partial and incomplete picture of the distribution of land ownership and agricultural holdings in the survey areas.

The distribution of farms and farm-areas are classified here on the basis of two alternative measures of size, acres owned and acres cultivated, and are shown in Table 4.1. The following important features emerge from the data classified in this Table.

(i) The percentage of farms belonging to the lowest size-group (those owning less than one acre) is much smaller than that of farms belonging to the other two larger groups. This is true for all the survey districts.
(ii) There is considerable variation in the proportion of farms belonging to the middle (1-2 acres) and the upper (2-3 acres) groups across the four districts. While in Mymensingh, the percentage of farms belonging to the middle group is 58% as compared to 40% in the upper group, the corresponding figures in Faridpur is calculated to be 35% and 61% respectively.
(iii) Even among the small farms, one finds some evidence of inequality in the ownership distribution of land. This is most pronounced in Mymensingh district where the top 40% of farms comprise more than 55% of total farm area. This degree of concentration, however, is much lower than the all-Bangladesh figure where the top 2% of land-owners own about 20% of total farm area in the country.

Three tenure classes have been identified in our sample: (i) part-operator, those cultivating part of their land and renting out the rest, (ii) owner-operator, those cultivating all their land and (iii) owner-cum-tenant, those owning some land and renting-in additional land. Now the extent of tenancy can be viewed in two ways, first, the importance of hired land in total cultivated holding and second, the importance of cultivators

Table 4.1

Percentage Distribution of Farms and Farm Area by Size for the Selected Regions

Size Class	Sylhet		Pabna		Faridpur		Mymensingh	
	Farms	Farm Area	Farms	Farm Area	Farms	Farm Area	Farms	Farm Area
Acres Owned:								
0.00 - 1.00	6	2.20	2	.02	4	1.30	2	.70
1.00 - 2.00	50	40.30	39	29.30	35	26.60	58	43.80
2.00 - 3.00	44	57.50	59	70.50	61	72.10	40	55.50
All Farms	100.0	100.00	100.0	100.00	100.0	100.00	100.0	100.00
Areas Cultivated:								
0.00 - 1.00	6	2.50	2	1.10	-	-	-	-
1.00 - 2.00	48	38.60	54	43.00	44	33.10	42	24.10
2.00 - 3.00	42	49.80	39	47.00	47	51.70	42	43.90
3.00 - 4.00	4	9.10	5	8.90	7	11.20	14	20.50
Above 4.00	-	-	-	-	2	4.00	2	11.50
All Farms	100.0	100.00	100.0	100.00	100.0	100.00	100.0	100.00

dependent on rented land. Based on these criteria, the following conclusions can be drawn from the data collected and presented in Table 4.2.

(i) An examination of the data on rented-in land reveals that tenancy is not very important in the four districts in which the survey was carried out, though one notices some regional variation. For example, in Mymensingh district the amount of land rented-in by the cultivators was about 28% of their total cultivated land covered by the sample; the figure drops to about 20% for the cultivators in Faridpur district. The picture is similar to that revealed by 1960 Agricultural Census in Bangladesh, which indicated that about 21% of total cultivated area was operated by non-owners.[2]

It may, however, be pointed out that to those who actually rented-in land (the owner-cum-tenant class), the importance of rented-in land is much greater than the preceding figures indicate. For example, to the owner-cum-tenant class in Mymensingh and Sylhet districts, the proportion of rented-in land is more than 50%; the figure is only slightly lower in Pabna and Faridpur districts, averaging about 42%.

(ii) Though owner-farming is predominant in all survey areas, the dependence of farmers on rented-in land (mostly as tenants) is found to be quite extensive in the four districts. Except in Pabna, the owner-cum-tenant class accounted for about 40% of the total number of farms. As expected, in a small farm sample survey like ours, the importance of part-operators as a tenure class in quite negligible. In fact, this tenure class is virtually absent both in Sylhet and Mymensingh districts while in Pabna and Faridpur, the percentage of farmers belonging to this tenure class is only about 5%. In Faridpur, however, part-operators rented-out 26% of their

Table 4.2

Percentage Distribution of Farms and Farm Area Owned, Cultivated and Rented by Tenure Class for the Selected Regions

Region and Tenure Class	Farms	Area Owned	Area Cultivated	Owned Area Rented Out	Cultivated Area Rented In
I. Sylhet					
Part Operator	-	-	-	-	-
Owner Operator	60	66	52	-	-
Owner cum Tenant	40	34	48	-	50.20
All Farms	100.0	100.0	100.0	-	24.30
II. Pabna					
Part Operator	6	7	5	15.30	-
Owner Operator	70	73	65	-	-
Owner cum Tenant	24	20	30	-	42.40
All Farms	100.0	100.0	100.0	2.30	26.50
III. Faridpur					
Part Operator	5	7	4	26.0	-
Owner Operator	54	59	49	-	-
Owner cum Tenant	41	34	47	-	42.0
All Farms	100.0	100.0	100.0	1.60	19.70
IV. Mymensingh					
Part Operator	-	-	-	-	-
Owner Operator	61	61	47	-	-
Owner cum Tenant	39	39	53	-	51.80
All Farms	100.0	100.0	100.0	-	27.80

land as compared to 15% in Pabna district.

(iii) Sharecropping with the landlord's rent of one-half of the crop and no provision for the sharing of input costs is the dominant form of rental arrangement in all four districts. In fact, only very scanty evidence of cash renting and input sharing was found in the survey areas.

(iv) Average acres owned, rented and cultivated are shown by tenure class in Table 4.3. The average farm size owned by the cultivators shows little variation among the four districts. The highest average farm size (recorded in Pabna district - 2.16 acres) is only about 15% higher than the lowest average farm size (recorded in Mymensingh district - 1.99 acres). The average size of agricultural holdings is greater than the average farm size owned in three out of four districts surveyed. This indicates the moderating influence of tenancy on the distribution of cultivated land among different group of farmers. The average size of rented-in land shows some regional variation as the figure varies from as high as .60 of an acre in Mymensingh to .27 of an acre in Pabna.

(v) Another important feature of the data is that the dependence on rental markets, for tenants, is inversely related to the size of ownership. In all four districts, the average size of farm owned is found to be greater for owner-operator as compared to owner-cum-tenants indicating that it is the poorly endowed farms which are relatively more dependent on rental markets for land. In addition, in our survey areas the owner-cum-tenant group, through its participation in the rental markets, has an operational farm size which is greater than that possessed by the owner-operators.

(vi) Finally, it is observed that from the point of view of average data characteristics, Sylhet shares some common features with Mymensingh and Pabna

Table 4.3

Average Acres Owned, Rented and Cultivated for Farm

by Tenure for the Selected Regions

Region and Tenure Class	Average Acres Per Farm			
	Owned (1)	Rented Out (2)	Rented In (3)	Cultivated (4) = (1)* - (2) + (3)
I. Sylhet				
Part Operator	-	-	-	-
Owner Operator	2.06	-	-	1.67
Owner cum Tenant	1.64	-	1.20	2.39
All Farms	1.89	-	.48	1.96
II. Pabna				
Part Operator	2.32	.35	-	1.49
Owner Operator	2.26	-	-	1.97
Owner cum Tenant	1.83	-	1.11	2.62
All Farms	2.16	.02	.27	2.09
III. Faridpur				
Part Operator	2.85	.63	-	1.94
Owner Operator	2.28	-	-	2.06
Owner cum Tenant	1.78	-	1.12	2.66
All Farms	2.11	.03	.45	2.30
IV. Mymensingh				
Part Operator	-	-	-	-
Owner Operator	1.88	-	-	1.64
Owner cum Tenant	1.89	-	1.51	2.91
All Farms	1.88	-	.59	2.14

Note: In deriving the figures for cultivated land (4), adjustments have also been made for the amount of owned land not available for cultivation (5). In fact, (1)* = (1) - (5), and hence (4) = (1) - (2) + (3) - (5).

with Faridpur. This is particularly true with respect to average farm size owned, proportion of farms belonging to a particular tenure class as well as size group, and finally, proportion of cultivated area rented-in by the relevant tenure class.

IV.3.2 Size-Composition of the Farm Family and the Average Land-Man Ratio

The size and composition of the farm family constitute important determinants of many activities in an agrarian economy. The average family sizes in the four survey districts with breakdown between male and female as well as between adult and minor are shown in Table 4.4. The following major characteristics can be identified from the tabulated data.

(i) The average family size in our small farm sample shows remarkable similarity across the four districts - the average number of family members is 6.5 in Sylhet, 6.6 in Faridpur and 6.7 in both Pabna and Mymensingh districts. The existence of such a large family size relative to their farm size obviously puts a tremendous burden on the farm households in their effort to eke out a subsistence level of income, particularly with low farm productivity and limited off-farm employment opportunities. This is also reflected in the very low land-man ratio (ranging from .28/acre to .32/acre) prevalent in all the four districts.

(ii) The composition of the farm family both with respect to the breakdown between male and female as well as between adults and minors also gives a remarkably similar picture across the four districts. The average number of adult male members was found to be greater than that of adult female members in three out of four districts; the lone exception being Faridpur, which shares an equal number of members belonging to each sex. However, the minor members in all the districts show equal representation of both of the sex

Table 4.4

Land-Man Ratio and Average Family Size with Breakdown Between Male and Female, Adult and Minor for the Selected Regions

Region	Acres Owned Per Head	Acres Cultivated Per Head		Average Family Size Male	Female	Total
Sylhet	.29	.30	Adult:	2.6	1.8	4.4
			Minor:	1.1	1.0	2.1
			Total:	3.7	2.8	6.5
Pabna	.32	.31	Adult:	2.1	1.6	4.2
			Minor:	1.2	1.3	2.1
			Total:	3.8	2.9	6.6
Faridpur	.32	.35	Adult:	2.3	2.2	4.5
			Minor:	1.0	1.1	2.1
			Total:	3.3	3.3	6.6
Mymensingh	.28	.32	Adult:	2.6	2.0	4.6
			Minor:	1.2	0.9	2.1
			Total:	3.8	2.9	6.7

Note: In our field survey, 'minors' have been identified as those below twelve (12) years of age.

categories.

One of the striking features of our data is the predominance of adult members - both in the male and female categories - in the composition of the average farm family in all the survey districts. The average number of adult members was found to be over twice the number of minors in three out of four districts.

IV.3.3 Fixed Capital and Labour Use of Different Categories

Work animals as well as tools and farm equipment including plough, yoke, spade, ladder and sickle, constitute the main components of fixed capital in all the survey districts. Also, the bullock represents the main source of power in all four districts. In both Pabna and Mymensingh districts, every farm-household surveyed owned at least one pair of animals. In Faridpur and Sylhet districts, the proportion of surveyed farm-households owning at least one pair of animals was 98% and 94% respectively.

More significant to note is the overwhelming importance of work animals, as shown in Table 4.5 in the total valuation of fixed capital of the farm households in all four districts. Work animals account for 91% for the total fixed capital in Mymensingh, 88% in Sylhet, and 86% in both Pabna and Faridpur districts.

In a typical rural economy, labour is generally supplied by three categories of farm workers: family workers, permanent hired workers and casually hired workers. Permanent hired workers are usually hired on a annual basis after which employment is reconsidered. In other cases, employment is for a crop season. In either case, the workers usually live with the farm family and are paid wages irrespective of whether they are

Table 4.5

Average Number Work/Milch Animals per Farm, Value per Animal and Average Value of Fixed Capital for the Selected Regions

Region	Number of Animals per Farm	Value per Animal (Taka)	Average Value of Fixed Capital Per Farm: Work Animals (taka)	(%)	Tools and Equipment (Taka)	(%)	Total (Taka)	(%)
Sylhet	2.5	1302.0	3256.0	88	444.0	12	3700.0	100
Pabna	2.1	1288.3	2705.4	86	326.1	14	3031.5	100
Faridpur	2.1	1282.3	2692.9	86	323.3	14	3016.2	100
Mymensingh	2.5	1492.0	3686.3	91	404.9	9	4091.2	100

used or not. Wages are paid in cash plus meals and sometimes clothing as well. Casual or temporary hired workers, on the other hand, are employed on a day to day basis and are paid a wage prevailing in the market at the time of employment. The relative importance of these various categories of workers, it may be mentioned, generally depends on natural factors such as land levels, the type of soil, and rainfall. These natural factors affect cropping intensity and cropping pattern, which in turn determine the seasonality of work. The relative importance of these categories can also depend, as Hussain (1977) emphasizes, on the nature of land distribution in the area.

The following major characteristics regarding use of different categories of labour by the surveyed farm households emerge from the data collected in the four districts.

(i) The actual flow of labour from different categories of farm workers is shown in Table 4.6. It is quite evident, as expected in a small-farm survey like ours, that family labour constitutes the most significant source of labour in agricultural production. In both Pabna and Faridpur districts, about 80% of total labour was supplied by family workers. The figures are somewhat lower in Sylhet and Mymensingh districts (60% and 57% respectively) showing their relatively greater dependence on hired labour.[3]

The second most important source of labour was casual hired workers, supplying between 18% to 38% of total labour used in the four districts. Workers hired on a permanent basis supplied only between 1% to 6% of total labour in three out of four districts surveyed; in Sylhet, the figure is somewhat larger.

Table 4.6

Percentage Share of Labour Use of Different Categories for the Selected Regions

Region	Family Labour	Hired Labour Permanent	Hired Labour Temporary	Hired Labour Total	Total
Sylhet	61.3	13.8	24.9	38.7	100.0
Pabna	79.7	1.4	18.9	20.3	100.0
Faridpur	80.4	3.4	16.2	19.6	100.0
Mymensingh	56.6	5.8	37.6	43.4	100.0

Percentage Share of Labour Use

Table 4.7

Proportion of Farms Using Different Purchased Inputs in the Selected Regions

Percentage of Farms Using Different Purchased Inputs

Region	Hired Labour Permanent	Hired Labour Temporary	Seed/Fertilizer	Irrigation	Others
Sylhet	31	88	92	16	48
Pabna	9	61	91	13	20
Faridpur	9	68	95	11	28
Mymensingh	18	96	94	65	-

Note: Others include the hiring of ploughs and bullocks.

(ii) Table 4.7 shows the proportion of farm households utilizing hired labour for cultivation. One of the striking features of our data is that an overwhelming majority of small cultivators participated in the casual labour market as employers. This is true for all the four districts, though there is some regional variation. In Mymensingh 96% of the farm households hired temporary workers for crop cultivation; the figure is only slightly lower (88%) in Sylhet. In Pabna and Faridpur, the degree of this labour market participation is somewhat less pronounced, with figures of 61% and 68% respectively. This demonstrates that the traditional rice technology which is dependent on monsoom rains forces even the small cultivators to depend on the labour market for temporary hired workers.[4]

As expected among small cultivators, the proportion of farm households employing permanent hired workers is rather low. In both Pabna and Faridpur districts, only 9% of farms used permanent workers; the figures are somewhat higher in Mymensingh and Sylhet districts.

IV.3.4 Cropping Patterns, Intensity of Cropping and Average Yields

Although crop production constitutes the major agricultural activity in an agrarian economy, considerable variation exists, because of physiographical and economic factors, both in the pattern as well as intensity of cropping among different regions. The following major characteristics, with respect to crop combinations and yields, can be identified in the data collected from the four survey areas.

(i) The average acreage devoted to various crops and the proportion of farms producing each of these crops, in the survey districts, are shown in Table 4.8.

Table 4.8

Average Acres per Farm and Proportion of Farms Producing Different Crops for the Selected Regions

Region	Aus Local	Aus HYV	Aman Local	Aman HYV	Boro Local	Boro HYV	Jute	Wheat	Sugarcane	Pulses	Oilseeds
	(Acres per Farm)										
Sylhet	1.47	.03	1.55	-	-	-	-	-	-	-	-
Pabna	1.51	.07	1.25	-	-	-	.35	.14	.14	.72	.30
Faridpur	1.61	.03	1.82	-	-	-	.31	.38	-	1.20	.14
Mymensingh	.26	.61	1.75	.19	.51	.58	.15	-	-	.08	.02
	(Per Cent of Farms Producing)										
Sylhet	98	13	96	-	-	-	-	-	-	-	-
Pabna	100	7	85	-	-	-	57	28	17	83	43
Faridpur	98	5	95	-	-	-	54	46	-	86	19
Mymensingh	24	47	86	16	31	29	33	-	-	8	4

So far as the cropping pattern is concerned, Sylhet stands apart from the other three survey districts in that farmers in this area devote their land exclusively to the production of two varieties of rice, aus and aman. In fact, more than 95% of the farm households in this district produce these two crops, with an average acreage of 1.47 and 1.55 per farm household respectively.

The cropping pattern in the other three survey districts is more diversified. Jute is the sole cash crop in both Mymensingh and Faridpur districts with an average acreage of .15 and .31 respectively, and with 33% and 54% of the farm households in these two regions producing this crop. Pabna, on the other hand, in addition to producing jute (with an average acreage of .35 and with 57% of the farmers cultivating this crop), produces sugarcane as well, with an average acreage of .14 and 17% of the farm households producing the crop.

In the cultivation of the major food crops, namely aus, aman and boro rice, Mymensingh displays a pattern dissimilar to the other survey districts. Local aus and aman rices constitute the main food crops in Sylhet, Pabna and Faridpur districts. The average acreage per farm for aus and aman rice are 1.51 and 1.25 in Pabna, and 1.61 and 1.82 in Faridpur. Also, all farm households in Pabna and 98% of farms in Faridpur cultivate aus rice, while the proportion of farms cultivating the aman crop in these two districts is found to be 85% and 95% respectively. In Mymensingh district, on the other hand, although the local aman rice remains the major food crop with an average acreage of 1.75 and with 86% of the farm households cultivating the crop, the importance of local aus as food crop appears to be rather small, both in terms of average acreage (.26) and the proportion of farms cultivating the crop (24%). In fact, in their crop portfolio, aus rice has been replaced by local and high yielding varieties of the winter rice crop, boro with an average acreage of .50 and .58 respectively. About 30% of the farms in this region cultivate these varieties. It is significant to note that no farm in our sample in any of the other three districts produces either variety of the winter rice crop.

Among minor winter crops, pulses and oilseeds are important in the crop portfolios of the farms in both Pabna and Faridpur districts. However, while pulses are found to be more important in Faridpur district (both in terms of the average acreage as well as the proportion of farms cultivating the crop), oilseeds remain more significant in the crop portfolio in Pabna. Neither of these two crops, however, is prominent in the cropping pattern in Mymensingh.

Another winter food crop is wheat, which is cultivated in Pabna and Faridpur, but not in Mymensingh district. The average acreage is .14 and .38 in Pabna and Faridpur respectively, while the proportion of farms cultivating the crop is 28% and 56% respectively.

(ii) The proportion of cropped and cultivated acreage of different crops, as well as the cropping intensity for the four survey districts are shown in Table 4.9. The salient features of the data collected are presented below.

(a) As expected in a survey of small farms, the farm households in all the districts are seen to devote an overwhelming proportion of their total cropped

Table 4.9

Proportion of Cropped and Cultivated Acreage Covered by Different Crops and Intensity of Cropping for the Selected Regions

Region	Aus Local	Aus HYV	Aman Local	Aman HYV	Boro Local	Boro HYV	Jute	Wheat	Sugarcane	Pulses	Oilseeds	Others	Total
(% of Cropped Acreage)													
Sylhet	43	5	47	-	-	-	-	-	-	-	-	5	100
Pabna	32	2	28	-	-	-	8	3	2	16	7	2	100
Faridpur	28	1	30	-	-	-	6	7	-	21	2	5	100
Mymensingh	6	19	40	5	11	13	3	-	-	1.5	.5	1	100
(% of Cultivated Acreage)													
Sylhet	70	7	76	-	-	-	-	-	-	-	-	8	161
Pabna	73	5	62	-	-	-	17	7	5	36	16	4	225
Faridpur	73	2	77	-	-	-	15	19	-	56	6	13	261
Mymensingh	12	38	78	10	22	25	7	-	-	3	1	1	197

acreage to the cultivation of rice, the staple food crop in Bangladesh. One notices, however, some regional variation. The proportion of land used for rice cultivation varies from as high as 95% in Sylhet and Mymensingh districts to about 60% in Pabna and Faridpur districts.

(b) In Pabna, 10% of total cropped acreage was devoted to cash crops (jute and sugarcane) as compared to 6% in Faridpur (jute only), and 3% in Mymensingh (jute only). Sylhet, as mentioned earlier, does not produce either of these cash crops.

(c) An important feature to note is the relatively minor proportion of total cropped acreage devoted to high yielding varieties of rice in our sample. Except in Mymensingh district, where 37% of cropped acreage is devoted to the high yielding varieties of aus, aman and boro rice, the figures are very low for all other districts surveyed. This points to the overwhelming dependence of the subsistence farmers in Bangladesh on traditional varieties of rice.

(d) With respect to the intensity of cropping, it is observed that each acre of cultivated land was used 2.61 times in Faridpur duirng the year as compared to 2.25 times in Pabna, 1.97 times in Mymensingh and 1.61 times in Sylhet district. Compared to all-district figures from national surveys of 1.53, 1.50, 1.66 and 1.32 respectively, this indicates that the small farmers in our sample used their land more intensively than the average farmer in Bangladesh.

(iii) The average per acre yield of different crops in various districts are shown in Table 4.10. The following major characteristics are seen in the tabulated data.

Table 4.10

Average Yield Per Acre of Major Crops for the Selected Regions

Region	Aus		Aman		Boro		Jute	Wheat	Sugarcane	Pulses	Oilseeds
	Local	HYV	Local	HYV	Local	HYV					
(Yield Per Acre in Mds.)											
Sylhet	15.9	23.8	15.2	-	-	-	-	-	-	-	-
Pabna	12.4	15.1	15.5	-	-	-	14.7	9.6	75.7	9.9	5.6
Faridpur	9.4	24.2	13.2	-	-	-	14.6	11.0	-	8.7	7.0
Mymensingh	16.6	30.0	22.6	35.9	24.9	37.0	17.1	-	-	13.9	10.6

Note: 1 maund = 37 Kg and 1 acre = .4 hectre

(a) The most striking feature of our data is the very low average yield though not by Bangladesh standards, for almost all crops in every survey district.[5] This is a reflection of very low land productivity characterising most peasant economies in South Asia.

(b) A comparison of average yield figures for different crops across the four districts reveals that the productivity of land in Mymensingh is higher than productivity in the other survey districts. No further ranking can, however, be made with respect to the remaining three districts as one or the other district might appear more productive in relation to a particular crop.

IV.3.5 Gross Value of Output, Farm Income and Structure of Variable Cost

In this study, the gross value of output is defined as the gross value of crops plus miscellaneous earnings including the sale of agricultural labour and bullock power. The rationale of including the sale of labour services as a component of gross value of output is that the farm households could have used this fixed resource for producing crops on owned land or rented land but instead have hired out these services to other farms. Gross farm income is defined here as gross value of output plus rent received on rented-out land minus rent paid out on rented-in land. It is quite obvious that for owner-cultivators, gross output and gross income are the same because they do not pay or receive rent. And finally, net farm income is defined as gross farm income minus variable costs, which includes wage costs (for both casually hired and permanent hired labour), the cost of seeds (even homegrown), manure, fertilizer and pesticides, the hire charges of mechanical irrigation and the cost of hiring bullocks and ploughs. Net farm income, therefore, represents a return for the services of land owned, family labour and fixed capital possessed by the farm households. The following major characteristics can be identified in the data collected from the survey areas.

(i) The gross value of output, rent received and paid, gross farm income variable cost and net farm income per farm (both total and per acre) are shown in Table 4.11.

The highest value of the gross value of output (Tk. 13,376) is recorded in Mymensingh district, followed by Pabna and Faridpur, with values of Tk. 9457 and Tk. 9232 respectively. The lowest value of gross output (Tk. 7706) is recorded in Sylhet district, which may be explained by its lower cropping intensity. As observed earlier, farmers in Sylhet raise only three crops during the year. Farmers in Mymensingh in contrast, raise as many as ten crops in a year, with a cropping intensity of 1.97. The fact that per acre yield of all crops is higher in Mymensingh, as compared to other three districts, also helps explain why gross value of output has been recorded to be the highest in this district.

As expected, the average value of rental payments are much higher than the average value of rental receipts, indicating the small farmer's greater dependence on renting-in land as compared to renting-out land for cultivation. In fact, in two of the four districts surveys (Sylhet and Mymensingh), none of the farmers in the sample rented-out land. The average value of rental payments, however, shows considerable variation across the four districts surveyed. For example, the average value of rental payments in Mymensingh district (Tk. 1540) is about three times as high as that recorded in Faridpur

Table 4.11

Gross Value of Output, Gross Farm Income and Net Farm Income per Farm for the Selected Regions

(Taka)

Region	Gross Output (1)	Rent Received (2)	Rent Paid (3)	Gross Income (4) = (1)+(2)-(3)	Variable Cost (5)	Net Farm Income (6) = (4)-(5)	Net Farm Income Per Acre (7)
Sylhet	7706	-	766	6940	2486	4454	2781
Pabna	9458	59	698	8819	1145	7674	4036
Faridpur	9232	55	542	8745	1508	7237	3375
Mymensingh	13377	-	1540	11837	2329	9508	5198

district (Tk 542). This may be partly explained (partly because under sharecropping land productivity is also a major determinant of total rental payments made) in terms of the proportion of rented-in land in total cultivation which is much higher in Mymensingh (28%) as compared to Faridpur district (20%). In Pabna and Sylhet, this proportion is calculated to be around 25% in each district, which is also reflected in their average value of rental payments of Tk. 766 and Tk. 698 respectively.

Across the four districts surveyed, the average value of gross income per farm shows the same ordering as that of gross output, which is perhaps explained by the identical crop rental share as well as similar pattern of rental situation prevailing in all four districts. What is more significant to note is that the average rental payments constitute, in all the districts (with some regional variation), a very small proportion of gross farm income indicating that tenancy is not very important even for small farmers in Bangladesh. The proportion, however, will be much higher if we consider only those farmers who actually rented-in land.

The total variable cost per farm also displays considerabel variation across the four districts surveyed. In Sylhet district, the cost figure is estimated to be Tk. 2486 which is almost twice as high as that estimated in Pabna (Tk. 1145). The cost figures in Mymensingh and Faridpur districts are estimated to be Tk. 2329 and Tk. 1508 respectively. The reasons for these regional variations have to be sought in the variations of the individual components that make up the total variable cost, which is explained in the next section.

It should be mentioned that the ordering of cost figures across the four districts, which differs from the ordering of gross output and gross income, fails to disturb the ordering of net income (total and per acre) figures computed for the four districts. For example, Mymensingh, the district with the highest gross output and gross income figures also comes out with the highest net farm income figures as well. Sylhet, the district with the lowest gross output and gross income figures also experiences the lowest net income figures. It also follows that the region with the highest land productivity, namely Mymensingh also emerges as the region where the farmers reap the highest return on their owned land, family labour and fixed capital.

(ii) The total expenditure on purchased inputs per farm, along with the share accounted for by the different inputs in four districts are shown in Table 4.12. The following major characteristics emerge from the data. In the recorded expenditure figures on purchased inputs, including both casual and permanent hired labour, seeds/fertilizers/pesticides, mechanical irrigation and bullock/ploughs (hiring charges), two district levels are identified. For example, the expenditure figures in Sylhet and Mymensingh districts are recorded to be Tk. 1807 and Tk. 1677 respectively, which are almost three times as high as those recorded in both Pabna and Faridpur districts, with expenditure figures of Tk. 622 and Tk. 562 respectively. The reason for this inter-district two-tier variations is not difficult to explain. A look at the different components of total expenditure makes it evident that it is the greater weight of expenditures on hired labour, both casual and permanent labour that accounts for this much higher level of total expenditures in the former two districts as compared to the latter.

The share of other components of expenditures on purchased inputs

Table 4.12

Expenditure on Purchased Inputs and Share of Different Components for the Selected Regions

Region	Expenditure on Purchased Inputs (Taka)	Share of Different Components of Purchased Inputs: Hired Labour Temporary	Hired Labour Permanent	Seed/Fertilizer/Pesticides	Irrigation	Others
Sylhet	1807	35.2	23.3	27.5	.8	13.2
Pabna	622	31.2	8.0	47.8	2.8	10.2
Faridpur	562	36.0	6.8	46.9	.8	2.1
Mymensingh	1677	47.6	12.7	23.1	16.6	0

Note: Others include the hiring charges for plough and bullocks.

also shows considerable variation, though their implication are not very clear. While the share of expenditure on irrigation is as high as 16.6% in Mymensingh as compared to only .8% in both Pabna and Faridpur districts, the share of expenditure on hiring of bullocks/ploughs, on the other hand, is 13.2% in Sylhet followed by 9.3% in Pabna and 4.9% in Faridpur district. The share is zero for this item of expenditure in Mymensingh district.

IV.3.6 Sources of Income and Pattern of Expenditure

Although the peasant household derives its subsistence from crop production, it was found to be engaged in other economic activities as well. These are undertaken mainly to supplement the crop income that enables the household to purchase the necessary non-agricultural goods from the market and to diversify its activities in an attempt to help cushion the impact of possible crop failures. The other economic activities include other agricultural activities such as the selling of fruits, vegetables and poultry products, non-agricultural activities such as petty business, the sale of home-made goods and services and finally, the sale of agricultural labour to other farms during the peak period of agricultural production. The major characteristics of data collected in the four districts with respect to the total income of farm household along with its breakdown into the different sources, as mentioned above, are described below.

(i) The average value of total cash income per household and its breakdown by different categories is shown in Table 4.13. With respect to the total value of income per household, the districts fall into two brackets, with Pabna and Mymensingh falling in the upper bracket (with values of Tk. 6235 and Tk. 6036 respectively) and Faridpur and Sylhet in the lower bracket

Table 4.13

Average Annual Cash Income Per Farm Household and its Breakdown by Different Categories for the Selected Regions

Region	Average Value of Income (Taka)	Relative (Percentage) Share of Different Categories			
		Income from Sale of Crops	Income from Other Agricultural Activities	Income from Non-Agricultural Activities	Income from Sale of Agricultural Labour
Sylhet	4219	24.7 (38)	23.8 (48)	28.5 (33)	23.0 (24)
Pabna	6235	48.3 (96)	10.3 (76)	16.6 (37)	24.8 (57)
Faridpur	4587	46.6 (91)	11.3 (58)	13.4 (30)	28.7 (60)
Mymensingh	6036	51.9 (78)	7.8 (55)	23.3 (41)	17.0 (31)

Note: The figures in the parentheses indicate the proportion of farmers deriving income from this source during the period.

(with values of Tk. 4587 and Tk. 4218 respectively). The figures in the lower bracket are about 25% smaller than those in the upper bracket. The reasons for differences in income recorded in the four districts are not very clear, though one may perhaps identify the income from the sale of crops as the major factor contributing to this variation.

With respect to the relative contribution of different sources of income, it is observed that in three out of four districts surveyed income from sale of crops constitutes the major source, with an average contribution of about 50%. Also, an overwhelming proportion of farm households (96% in Pabna, 91% in Faridpur and 78% in Mymensingh) in these three districts derive part of their income from this source. The income from 'other agricultural activities' contributes least to the total income of the households (about 10%) in three out of four districts surveyed, again excepting Sylhet. That only 25% of Sylhet's cash income (as compared to about 50% in other districts) is derived from sale of crops is perhaps explained by the fact that farmers in this district as we observed earlier, produce only food crops and that these small farms have hardly any surplus of food crops left after self-consumption particularly with large family size and low productivity.

(ii) The average yearly expenditures per farm household and its breakdown into different items in the four districts are shown in Table 4.14. The following major characteristics can be identified from the tabulated data.

The farm households in Sylhet record the highest level of expenditures (Tk. 5661) followed by Pabna and Faridpur with figures of Tk 4825 and Tk. 4482 respectively. The lowest level of expenditure is recorded for the household

Table 4.14

Average Annual (Cash) Expenditure per Farm Household and its Breakdown by Different Items of Expenditure for the Selected Regions

Region	Average Value of Consumption Expenditure (Tk)	Percentage Share of Different Items					
		Foodgrains	Clothing	Medicine	Education	Social Ceremony	Others
Sylhet	5661	47.4 (100)	15.9 (100)	5.0 (70)	3.0 (31)	3.6 (55)	25.4 (100)
Pabna	4826	64.6 (100)	11.9 (96)	2.8 (74)	2.8 (43)	2.7 (57)	15.2 (100)
Faridpur	4482	68.6 (100)	9.0 (100)	1.6 (58)	1.7 (35)	1.2 (47)	17.9 (100)
Mymensingh	2635	39.4 (100)	17.5 (100)	3.4 (71)	5.0 (55)	3.5 (61)	31.2 (100)

Notes: (i) The figures in the parentheses indicate the proportion of farms incurring expenditures on this item during the period.

(ii) 'Others' includes expenditures on items such as salt, kerosene, soap/soda, tobacco, bidi/cigarettes, tea, sugar/gur, gifts to friends/relatives and litigation.

in Mymensingh, with a value of only Tk. 2635. This is less than 50% of the level recorded in Sylhet. The reason for this low level of yearly expenditure by the farm households in Mymensingh may be attributed to their relatively lower level of expenditure on foodgrains (the average level of expenditure on foodgrains in Mymensingh is shown to be Tk. 1038 as compared to Tk. 2683, Tk. 3074 and Tk. 3117 in Sylhet, Faridpur and Pabna respectively). The lower level of cash purchase of foodgrains in Mymensingh is not surprising in view of its being the region with the highest level of land productivity. The highest level expenditure by the farm households in Sylhet, on the other hand, is perhaps explained by the fact that although the average level of expenditure on foodgrains is somewhat lower in Sylhet as compared to Pabna and Faridpur as noted above, this is more than offset by their much higher level of expenditures in both clothing (Tk. 900 in Sylhet as compared to Tk. 574 in Pabna and Tk. 403 in Faridpur) and 'others' (Tk. 1415 in Sylhet as compared to Tk. 733 in Pabna and Tk. 802 in Faridpur) categories.

As for the relative contribution of different items of expenditure, it is observed that expenditures on foodgrains claims, by far, the largest share in all the districts, ranging from as high as 69 % in Faridpur to about 40% in Mymensingh district. The next most important item of expenditure is the composite item, 'others' by virtue of inclusion of many essential consumption items such as salt, kerosene, sugar, tobacco, soap, etc., the share varying from about 31% in Mymensingh to about 15% in Pabna district. The household expenditures on clothing claims the third largest share in each district, the share varying between 16% and 18% in Sylhet and Mymensingh and between 9% and 12% in Faridpur and Pabna districts. Expenditures on medicine, education and social ceremony are the items with the lowest shares

- the share ranging between 1% and 5% in each district. None of these items, individually, claims more than 5% of total expenditure in any of the districts surveyed.

A great deal of uniformity is observed across the four districts with respect to the proportion of farm households incurring expenditures on different items. As expected, all households incurred expenditure on essential items like foodgrains, clothing and 'others' in every district surveyed. Also, a high proportion of households in each district incurred expenditures on medicine (between 58% and 74%) and social ceremonies (between 47% and 61%). It is only on education that the expenditure pattern shows considerable variation across the four districts. The proportion of farms incurring expenditure on this item varies from 55% in Mymensingh to as low as 31% in Sylhet.

One of the striking features of our data regarding the expenditure pattern of rural households is that although the relative share of each item varied over different regions, the importance of different items (as indicated by the ranking of their respective shares) in each region remained nearly the same across four regions.

IV.3.7 Credit Situation and Property Valuation

Rural credit markets in traditional agriculture have many imperfections, the most prominent of which is the multiplicity of markets across which the terms of credit vary enormously. Markets for credit in rural Bangladesh are no exception. We may, however, broadly classify these multiple sources of credit under the following two headings:

(1) Institutional Sources, consisting of various cooperative societies, the Agricultural Development Bank and other government sponsored agencies. It should be mentioned that although they supply inexpensive credit, because of their inability to recover loans, these institutions do not operate successfully in Bangladesh.

(2) Non-Institutional Sources, which are composed of money lenders, traders and shopkeepers, large land-owners, and friends and relatives. Of course, these are not mutually exclusive categories. Since non-institutional sources dominate the rural credit market in Bangladesh, we briefly describe the mode of operation of each of these sources separately, drawing on our general experience in the survey areas. Moneylenders are those who earn their livelihood mainly from making loans and are generally the lender of last resort in rural credit market in Bangladesh. They advance loans against security of family assets such as jewelry and land and charge very high rates of interest. However, since most of the professional moneylenders in pre-partition Bengal were Hindus, and thus most of whom subsequently migrated to India, they play a minor role in the rural credit in Bangladesh today. The major part of credit is now provided by the wealty people in rural areas to whom moneylending represents a subsidiary activity and only a supplementary source of income. The rates of interest they charge vary enormously, from zero to 200 per cent depending on the personalised nature of transactions between the creditor and the debtor involved. An important category is 'friends and relatives', among which are the individuals who provide credit at soft terms; in many cases, they do not charge interest at all.

The credit situation in the survey areas, particularly the dependence of the rural households on the credit markets and the relative importance of different sources of credit are described below.

(i) The proportion of farm households with debt, the average value of loans per household and the sources of borrowing are shown in Table 4.15. It is observed that in three out of the four districts surveyed (except Sylhet), quite a large proportion of households, ranging between 50% and 67%, relied on the credit market. Again excepting Sylhet district, the average value of debt per household showed little variation across three of the four districts surveyed. Considering only those who actually incurred debt, the highest value per farm household is recorded in Mymensingh district (Tk. 845) followed by Faridpur and Pabna districts with values of Tk. 833 and Tk. 780 respectively. In Sylhet, while only 17% of the farm households resorted to borrowing, the average value of the loan to those who actually incurred debt is recorded at Tk. 1626. This is almost double the amount recorded in the other districts.

What is more significant to note, however, is the relative contribution of the institutional and non-institutional sources of credit in the areas surveyed, as the cost of credit is generally lower in the former as compared to the latter. It is quite obvious that Pabna fares worst in this respect since 97% of total credit in this district is obtained from non-institutional sources. This may indicate a dismal performance by the government sponsored credit in this district.[7] The situation is only marginally better in Sylhet district with 68% of total credit being supplied by non-institutional sources. Thus, in Sylhet district, for those who actually borrowed during the period, not only the average value of loan is higher, but the cost of credit is

Table 4.15

Proportion of Farms with Debt and Average Value of Loans per Farm and Sources of Borrowing for the Selected Regions

Region	Percentage of Farms with Debt	Value of Loans per Farm a (Tk)	Value of Loans per Farm b (Tk)	Sources of Borrowing: Institutional	Sources of Borrowing: Non-Institutional
Sylhet	16.7	1626.1	271.0	32%	68%
Pabna	50.0	780.4	390.2	3%	97%
Faridpur	57.9	833.3	482.5	45%	55%
Mymensingh	66.7	845.6	563.7	50%	50%

Note: a: excluding non-borrowers, b: including non-borrowers

Table 4.16

Average Property Value of the Farm Household and Relative Share of Homestead and Agricultural Land for the Selected Regions

Region	Average Property Value Per Farm (Tk)	Relative Share of: Homestead	Relative Share of: Agricultural Land
Sylhet	51462.0	31.7%	68.3%
Pabna	52456.5	28.3%	71.7%
Faridpur	36012.3	27.5%	72.5%
Mymensingh	100176.5	27.5%	72.5%

quite high as well. In Mymensingh and Faridpur districts, the credit situation seems to be much better as compared to the other two districts as about 50% of the total credit in these districts has been procured from institutional sources. As credit from institutional sources is cheaper, this also means that the small farm households in both Pabna and Sylhet had to depend relatively more on the high cost non-institutional sources for their supply of credit.[8]

(ii) The average property value per household along with its break-down between household and agricultural land are shown in Table 4.16. It is observed that there is considerable variation in average property value possessed by the farm households across the four districts surveyed. The highest value is recorded in Mymensingh district with a figure of Tk. 100,176 which is about three times as high as that recorded in Faridpur district with a figure of Tk. 36,012. The average property values of the farm households in both Sylhet and Pabna district are more or less same, the figures recorded being Tk. 51,462 and 52,456 respectively, which are about half the values of that recorded in Mymensingh. The fact that the farm households in Mymensingh are wealthier as compared to those in other districts surveyed is also reflected in their higher value of expenditures on purchased inputs particularly those on irrigation and hired labour which in turn is reflected in their higher productivity of land.

Regarding the relative share of homestead and agricultural land in total property value of the farm households, a high degree of uniformity is observed across the four districts surveyed, with homestead claiming a share of 28% to 32% of total property value in each district. This also indicates that the highest value of property as recorded in Mymensingh should be attributed to the higher per unit value of agricultural land in this district which is calculated to be Tk. 46,857 per acre as compared to Tk. 13,888 per acre, Tk. 20,441 per acre and Tk. 23,749 per acre in Faridpur, Pabna and Sylhet districts respectively.

IV.3.8 Estimates of 'Disaster Incomes'

Although a more detailed and rigorous analysis of disaster income estimates is carried out later in Chapter VI, we may still make some preliminary observations here regarding the data characteristics in our sample. The concept of a disaster level of income occupies a central position in safety-first modelling of farmer behaviour. The disaster level of income is usually associated with that income level below which the farm family faces either starvation or bankruptcy and/or the discomfort of adjusting to a significantly lower standard of living. It should be emphasized here that it is the farm family's evaluation of what it feels the disaster income level is that affects its behaviour. Therefore, the level of income reported by the farm households as their disaster incomes in the field survey should ideally be used. However, as discussed in Chapter VI, the farm family may have a tendency to overreport its disaster income. To provide a check for this, an alternative estimate of disaster incomes has been computed based on other factual information collected from the farm households in the field survey.[9] In fact, these objective estimates have been computed on the basis of three factors: minimum consumption needs (MCN) plus urgent debt (UD) minus resale value of liquid assets of the household (LA).

Table 4.17 shows the average value of the reported and computed

Table 4.17

Average 'Reported' and 'Computed' Disaster Level of Income per Farm Household for the Selected Regions

Region	Disaster Income Level Reported(R) (TK)	Computed(C) (TK)	Percentage Difference (R-C)/Rx100
Sylhet	8707.8	6919.0	21
Pabna	9876.8	7058.0	28
Faridpur	8906.7	7060.0	21
Mymensingh	6963.2	6748.2	3

Note: 'Reported' ones are those collected directly from the farm households in the field survey while the 'computed' ones are calculated on the basis of information related to minimum consumption need of foodgrains, urgent debts and resale value of liquid assets of the farm households in each sampling region.

disaster incomes of the farm households along with their percentage differences in the four sampling regions. It is observed that the average value of the disaster incomes as reported by the households shows some variation across the four districts surveyed. The highest disaster income level is recorded in Pabna district with a value of Tk. 9877 which is about 30% higher than the value recorded in Mymensingh district (Tk. 6963). The farm households in both Sylhet and Faridpur report roughly the same disaster income level, with a value of Tk. 8708 and Tk. 8908 respectively. However, lesser variations are observed in the computed disaster income levels across the four districts. In Sylhet, Pabna and Faridpur districts, the disaster income level computed for the households roughly centers around the value of Tk. 7000. The figure is only slightly lower in Mymensingh district.

As expected, the reported disaster income levels are observed to be higher than the computed levels in each of the four districts surveyed. In addition, the difference between the two estimates is more or less similar in three out of four districts surveyed, as reflected in the percentage difference figures ranging between 21% to 28%. The difference is, however, much smaller (only 3%) in Mymensingh district pointing to the relatively greater reliability of the estimate as reported by the farm households in this district.

IV.3.9 Overall Income-Expenditure Position

Neither total net farm income nor total cash income gives a correct picture of total earning capacity of the farm households. This is equally true for the expenditure side as well. The total cash expenditure of the households, with its breakdown into various categories by no means provides a complete picture of the total consumption of goods and services of the households. However, we may piece together the information provided in Tables 4.11 , 4.12 and 4.14 (and discussed in the previous sections) in order to obtain a better picture of the overall income-expenditure position of the farm households in different regions.

The total income of the farm households (TIFH) is computed here as total net farm income (NFI) including income from sale of agricultural labour and income derived from other agricultural activities plus income derived from non-agricultural activities (INAG).[10] The total household expenditure (THE), on the other hand, has two main components: (a) total food consumption expenditure (CEF), which is computed as cash purchase of foodgrains (CRF) plus the value of consumption of foodgrains out of own production (VCFSP), and (b) other household expenditure (OHE). A comparative analysis of different components of total farm income (TIFH) and total household expenditure (THE), therefore, will bring out the overall average economic performance of the farm households in four different regions, in the period in which the survey was carried out. The comparisons are made below.

Table 4.18 shows the average value of total household income and total household expenditure along with their breakdown into different components in the selected regions. The following major characteristics emerge from the data collected.

(i) It is observed that despite considerable variations in its level, across the four districts, the total income of the farm households is mainly determined by the level of net farm income in each district. This shows that the non-agricultural activities play a rather limited role in the

Table 4.18

Average Value of Total Income and Expenditure per Farm Household and its Breakdown into Different Categories for the Selected Regions

Region	Total Household Income (Taka): Crop Income (1)	Non-Crop Income (2)	Total Farm Income (3) = (1)+(2)	Income from Non-Agricultural Activities (4)	Total Household Income (5) = (3)+(4)
Sylhet	3480 (64%)	1978 (36%)	5458	1203 (18%)	6661
Pabna	6128 (74%)	2188 (26%)	8316	1035 (11%)	9351
Faridpur	5920 (76%)	1858 (24%)	7778	615 (7%)	8393
Mymensingh	8500 (85%)	1497 (15%)	9979	1406 (12%)	11385

Region	Total Household Expenditure: Cash Purchase of Foodgrains (6)	Consumption out of Own Production (7)	Total Consumption of Foodgrains (8) = (6)+(7)	Other Household Expenses (9)	Total Household Expenses (10) = (8)+(9)
Sylhet	2683 (52%)	2442 (48%)	5125	2978 (37%)	8103
Pabna	3118 (50%)	3116 (50%)	6234	1708 (22%)	7492
Faridpur	3074 (45%)	3827 (55%)	6901	1408 (17%)	8309
Mymensingh	1038 (16%)	5349 (84%)	6387	1579 (20%)	7984

development of the earning potential of the small-holding farms in rural Bangladesh. The shares of income derived from non-agricultural activities vary between 7% in Faridpur and 18% in Sylhet district. This also points to the extreme vulnerability of the small farmers in Bangladesh to the risks of crop failure. This becomes more apparent when one considers the relative contribution of crop income to the total net farm income in the various districts which ranges from 64% in Sylhet to as high as 86% in Mymensingh district. The picture looks all the more dismal when one observes that the major share of non-crop income, the other component of farm income is derived from the sale of agricultural labour, the demand for which is also uncertain as it is linked, to a significant extent, to the vagaries of nature.

(ii) As expected in a small-farm survey like ours, the consumption of foodgrains claims the lion's share of the total expenditure of the households in each district. This share varies from as high as 83% in Faridpur district to about 63% in Sylhet. According to Engel's Law, the share of consumption of foodgrains in total household income should vary inversely with the level of income in a cross sectional data set. Our data set seems to satisfy this law as the share varies from 82% in Faridpur with an income level of Tk. 8393 per family to 67% in Pabna with an income level of Tk. 9351 to 56% in Mymensingh with an income level of Tk. 11385.[11]

Another important feature exposed by our data is the small farm household's dependence on the market to meet its consumption need of foodgrains. Except in Mymensingh district, roughly 50% of the total consumption of foodgrains is met from the household's own production. The rest is purchased from the market. When one adds the household's need to meet other expenditures, it becomes obvious that the farm households must have various farm as well as non-farm activities in order to generate the necessary cash incomes and to match their income-expenditure flows. The extent to which the farm households in our survey districts have succeeded in achieving this balance is discussed below.

(iii) With a total household expenditure of Tk. 8103 against a total income of Tk. 6661, the farm households in Sylhet district record an average deficit of Tk. 1442 in their income-expenditure flows. Since the average value of outstanding loan for the farm households during this period is recorded to be Tk. 271, one may naturally have some doubts regarding the reliability of some of the estimates used in deriving the income-expenditure figures. We have reasons to believe that the estimates of income derived from non-agricultural activities have been underreported or what is more likely, particularly in case of Sylhet district, a source of income, that of repatriated money from abroad, has not been reported at all. It is also very likely that the estimates of other household expenditures have been overreported since the figure for this district is recorded to be almost twice as high as those recorded in the other three districts.

Looking at the different components of the balance sheet, it is observed that even with a relatively lower level of crop income of Tk. 3480, the total farm income of Tk. 5458 was sufficient to meet the total consumption of foodgrains of Tk. 5125 which incidentally is lower relative to the other three districts. However, the income derived from non-agricultural activities of Tk. 1203 was grossly insufficient to meet the other household expenditure of Tk. 2978 thereby leaving an overall deficit of Tk. 1442.

With a total household expenditure of Tk. 7942 against a total income level of Tk. 9351 and therefore, with a resulting surplus of Tk. 1409, the farm households in Pábna gives a picture which is exactly the opposite of what we have just observed in Sylhet. This huge surplus in their income-expenditure flows is not difficult to explain. The average value of total net farm income in this district (Tk. 8316) was much more than was needed to meet the total consumption demand of foodgrains of Tk. 6234. In fact, the income derived from sale of crops of Tk. 3012 was almost sufficient to cover the cash purchase of foodgrains of Tk. 3118 in this district. As a result, the entire non-crop income (Tk. 2188) as well as the income derived from non-agricultural activities (Tk. 1035) could be made available to meet the other household expenditure of Tk. 1708, thereby leaving an overall surplus of Tk. 1409. It is not, however, very clear why with such a large surplus, the farm households in Pabna recorded an average outstanding loan of Tk. 390 during the period.[12]

With a total household expenditure of Tk. 8309 against a total income of Tk. 8393, the farm households in Faridpur district seem to have succeeded in perfectly balancing their income-consumption flows. This has been made possible by the fact that the income derived from the sale of crops of Tk. 2093 together with the non-crop income of Tk. 1858 (which includes the income derived from sale of agricultural labour of Tk. 1316 and that derived from other agricultural activities of Tk. 542) was more than sufficient to finance the cash purchase of foodgrain of Tk. 3074, leaving them with a surplus of Tk. 877. Alternatively, we have said that the total net farm income of Tk. 7778 was more than enough to meet the total consumption of foodgrains of Tk. 6901, thereby again leaving a surplus of Tk. 877. This surplus of Tk. 877 together with the income derived from non-agricultural activities was just sufficient to meet the other household expenditure of Tk. 1408. Again, in the face of such a balancing of average income-expenditure flows, it is difficult to explain the average outstanding debt of Tk. 564 in Faridpur unless they have been carried over from the previous period.

With a total expenditure of Tk. 7984 against a total income level of Tk. 11385, the farm households in Mymensingh district gives a very comfortable picture of an average surplus of Tk. 3401 in their income-expenditure flow. This must be attributed to the much higher crop income accruing to the farm households in this district. In fact, the crop income (Tk. 8500) was so high that even with a relatively lower level of non-crop income of Tk. 1497, it could meet the total consumption of foodgrains of Tk. 6387 and still leave a surplus of the magnitude of Tk. 3592. The income derived from crop-sale of Tk. 2113 alone was more than double the amount required to finance the cast purchase of foodgrains of Tk. 1038, which itself was relatively lower since 84% of total consumption of foodgrains was met from own production. And most of this surplus was kept intact since the other household expenditure of Tk. 1579 could be met almost entirely from income derived from non-agricultural activities of Tk. 1497. Again, our data does not provide an answer to why with such a huge surplus, the farm households in this district record an average outstanding loan of Tk. 564.

IV.4 Summary and Conclusions

In this chapter, we discussed in detail the nature and characteristics of the basic data set used in this study. To meet the data requirements of our safety-first model of resource allocation under risk, a field survey was conducted among the small-holding farms in four regions in Bangladesh. We described the survey procedures in this chapter and also analysed in depth the various data characteristics in the sample.

Our analysis of the distribution of land shows that even among the small-holding farms, there exists considerable inequality in the ownership of land. Understandably, however, the degree of inequality is much less as compared to the all-Bangladesh figure. An examination of the importance of hired land in total cultivated land shows that tenancy is not very important in the four areas in which the survey was carried out. The picture is similar to that revealed by Agricultural Census in Bangladesh (1960) which indicated that only 1/5 of the total cultivated land was operated by non-owners. It should, however, be emphasized here that although owner farming is predominant in the survey areas, the dependence of farmers on rented-in land is found to be quite extensive. Also, our data pointed to the moderating influence that tenancy has on the distribution of land cultivated by different groups of farmers in Bangladesh.

Regarding the size-composition of the farm-family, our data shows that the average family size is quite high in all four survey areas, ranging from 6.5 in Sylhet to 6.7 in Pabna and Faridpur regions. Such a large family size relative to the average farm size of 1.96 to 2.30 acres, certainly poses a great problem to the small farm households in Bangladesh in their effort to meet the subsistence requirements from farming activities particularly in the face of low land productivity. Our data also reveals two important features of the composition of farm family in the survey areas: (a) the number of adult males is greater than that of adult females and (b) the number of adults (both male and female) is greater (more than twice) than that of the number of minors.

An overwhelming proportion of the total valuation of fixed capital in the survey areas is accounted by work animals; mainly bullockswhich represents the main source of power in rural Bangladesh. In fact, our data shows that almost every household owned at least one pair of work animals. As expected in a small farm survey like ours, family labour constitutes the most significant source of labour in crop cultivation. This dependence on family labour is more pronounced in Pabna and Faridpur where almost 80% of total labour used in cultivation was provided by the farm family. The next most important source of labour is casual or temporary hired labour supplying between 16% (in Faridpur) to 38% (in Mymensingh) of total labour used in the survey areas. Workers hired on a permanent basis supplied only between 1-5% in three out of four survey areas; only in Sylhet is the figure (14%) somewhat higher.

It should, however, be emphasized here that although the proportion of hired labour in total labour used is quite low, a large number of small farmers in the survey areas participated in the labour market as employers. The figure ranges from as high as 96% in Mymensingh to 61% in Pabna. This shows that with the traditional rice technology which is dependent on the monsoon even the small cultivators have to depend on the labour market for temporary hired workers.

Our data shows some differences in the cropping pattern in four survey areas. The farm households in Sylhet concentrate solely on the cultivation of food crops, aus rice and aman rice. The cropping pattern in the other three regions, however, is more diversified. In addition to the cultivation of aus and aman rice (also, IRRI aus and boro rice in Mymensingh), the farm households in the other regions also produce jute as a cash crop. Also, pulses, oilseeds and wheat are important in the crop portfolios of the households in both Pabna and Faridpur regions. It is significant to note that except in Mymensingh region, the number of farm households producing high yielding varieties of rice is extremely small in the survey areas. This points to the overwhelming dependence of subsistence farmers in Bangladesh on traditional varieties of rice.

There are some regional variations in the intensity of cropping as well. The figure varies from a low of 1.6 in Sylhet to about 2.6 in Faridpur. Compared to the all-Bangladesh survey figures of 1.3 in Sylhet and 1.5 in Faridpur, this indicates that the small farmers in our sample used their land more intensively than the average farmers in Bangladesh. Another noticeable feature of our data is very low average yield of various crops in all survey areas, though in Mymensingh region the productivity of land is observed to be higher as compared to the other three regions.

Physical and institutional aspects of farming activities in the survey areas are reflected in the computed average values of total gross and net farm incomes as well as the structure of variable costs in four regions. The total gross as well as net farm incomes for the farm households in Mymensingh are recorded to be twice as high as those in Sylhet. This should be attributed to the higher land productivity in Mymensingh combined with low cropping intensity in Sylhet. The total rental payments constitute a very low proportion (with some regional variations) of the total gross farm incomes in four regions, again indicating that tenancy is not very important for the small farmers in Bangladesh. The proportion, however, would be much higher if we consider only those farm households who actually rented-in land for cultivation. The average values of the total variable costs for the farm households in Sylhet and Mymensingh are almost twice the values of those estimated in Pabna and Faridpur regions. The much greater dependence (and also expenditures) on hired labour, both casual and permanent labour in Sylhet and Mymensingh accounts for these variations.

An examination of the various sources of total cash income for the farm households in different regions shows that the income from the sale of crops constitutes the major source, representing about 50% of total income in all regions excepting in Sylhet. The farmers in Sylhet, as we observed earlier, produce only food crops for which there is hardly any surplus left over after home consumption, particularly with large family size and low land productivity. Also, an overwhelming proportion of the farm households (80% - 95%) in these regions (again, except Sylhet) derive their cash incomes from this source. The most important other source is the sale of agricultural labour services which roughly accounts for about one-fourth (with some regional variations) of the total cash incomes in the survey areas. In terms of dependence on this source of income, however, there is considerable regional variation in that the proportion of farm households deriving income from the sale of agricultural labour in Pabna and Faridpur is almost twice that recorded in Sylhet and Mymensingh. Income from non-agricultural activities also constitute an important source of cash incomes in the survey areas with about 30% - 40% of the farm households deriving their incomes from this source. The income from non-crop but other agricultural activities such as selling of fruits, vegetables and poultry products contribute the least to the total cash incomes of the households. Nevertheless, quite a significant proportion of the farm households (48% - 76%) derive some of their cash incomes from these types of farming activities.

The expenditure pattern show considerable variation across the four regions. An examination of the importance of different items in total expenditure shows that the expenditure on foodgrains claims the largest share, the figures varying from 40% in Mymensingh to about 70% in Faridpur region. The next most important items are salt, kerosene, sugar, tobacco and soap which together account for a share varying between 15% and 30% in these regions. Expenditure on clothing claims the third largest share, the share varying from 9% in Faridpur to 18% in Mymensingh. Expenditures on medicine, education and social ceremonies are items with the lowest share, the share ranging from 1% to 5% for each in the four regions. It may be emphasized here that although the relative shares of different items of expenditure show considerable variation across regions, the proportions of household incurring expenditures on different items do not. Also, the importance of different items as indicated by the rankings of respective shares remains almost the same across the four regions.

Our data also provide information regarding the credit situation in the survey areas. Except in Sylhet, quite a large number of households in the sampling regions seem to rely on the rural credit market. The average values of debt incurred show little variation across the regions, again excepting Sylhet. In Sylhet region, although only about one-fifth of the farm households resorted to borrowing, the average value of loan of those who actually borrowed is almost twice the amount of those recorded in the other three survey areas. In Pabna, almost the entire demand for credit was met from the non-institutional sources where the cost of credit is generally much higher than the institutional sources. The situation is somewhat better in Sylhet, and much better in Pabna and Faridpur as about 50% of total credit needs in these two regions are met from institutional sources.

Our data regarding the property values in the survey areas shows that Mymensingh stands apart from other three regions, with the average property value of the farm households being three times as high as that in Faridpur and almost twice as high as those in Sylhet and Pabna regions. With home-steads claiming less than 1/3 of the total property values, such variations across regions are largely attributed to the differences in the valuation of the agricultural land in the four regions.

The concept of disaster level of income occupies a place of prominence in modelling farmer behaviour based on safety-first rules. The average values of disaster incomes as reported by the households show some variation across the four regions. The highest value of disaster incomes is recorded for the farm households in Pabna which is almost 30% higher than that recorded in Mymensingh. However, lesser regional variation is observed in the alternative set of disaster income estimates, computed on the basis of information regarding minimum consumption needs, urgent debt and resale value of liquid assets of the farm family as obtained in the field survey. As expected, the reported disaster income estimates are observed to be much higher than those computed in all four sampling regions.

Analysis of total cash income and expenditures provides only an incomplete picture of the total earning capacity and/or total consumption of the farm households in the survey areas. These need to be supplemented on the income side, by information on net farm income including those derived from sale of agricultural labour and crops produced on the farm, and on the consumption side, information about consumption of foodgrains out of own production. Attempts have been made in our study to make a comparative analysis of different components of total farm income and total consumption expenditure of the household in order to reveal the overall economic performance of the farm households in the four sampling regions. It is observed that the total income of the farm household, despite some regional variation, is mostly determined by the incomes originating from farming activities including the sale of agricultural labour services in each region. This points to the minor role of non-farming activities, and hence to the extreme vulnerability of the small farmers in Bangladesh to the risks of crop failure.[13] The consumption of foodgrains, on the other hand, claims the largest share of total consumption expenditure of the farm households in four regions, the share varying from 80% in Faridpur to about 60% in Sylhet region. What is more significant to note is the heavy dependence of the farm households in our sample on market purchases to meet their consumption need of foodgrains. In order to meet this as well as other necessary household expenditures, the small farmers in Bangladesh engage in various farming (particularly production/sale of cash crops, and sale of agricultural labour) and non-farming activities to match their income and expenditure flows. Any imbalances on this account often compels the small-holding farms to resort to borrowing, particularly from the non-institutional sources.

Finally, we may sum up the major findings in our field survey by concluding that although the data-characteristics in our aample show some regional variations, they are generally indicative of a subsistence-type of farming and traditional nature of agriculture prevalent in Bangladesh.[14] Large family size relative to farm size leading to a very low land-man ratio, overwhelming dependence on family-owned/based inputs, particularly for land and labour, very low cash expenditures on modern inputs used in cultivation and very low investment in fixed capital - both contributing to very low land productivity, overwhelming dependence on a single subsistence crop, relatively insignificant role of non-farming activities thereby exposing the farm households to the risks of crop failure, high percentage of consumption expenditures on foodgrains, and finally the predominance of non-institutional sources in meeting the credit needs of the farm family - all these data characteristics in our sample tend to support this view.

Our next task is to utilise these field survey data in estimating the various parameters of our safety-first model of resource allocation presented in Chapter III, and also in analysing the results derived therefrom, particularly those related to the testing of hypotheses involving resource allocation behaviour under risk of the small-holding farms in Bangladesh. This will be taken up in the subsequent chapters of this study.

FOOTNOTES:

1. For a more detailed description of the physiographic and climatic conditions which has a close bearing on the cropping patterns of these regions, see Chapter II.

2. The all Bangladesh figures include all farm size classes and therefore, is not strictly comparable to our survey data which has been limited to small farm size (up to 3 acres) only.

3. The amount of labour has been measured here in terms of the number of mandays (one adult female = .7 manday and one minor = .5 manday) worked. In fact, our procedure was to sum up the mandays of family and hired (both permanent and temporary) labour used in different crops produced by the farm households and then to compute the relative (percentage) contribution of each of them.

4. In rice cultivation, once operations like transplanting, harvesting and in some cases weeding are started on a plot of land, they have to be completed within a short period of time. In the absence of controlled water, work schedules are determined by the timing, depth and distribution of rainfall. For this reason, even those cultivators who cannot provide adequate employment to family workers, have to hire-in casual workers for at least a few days of the year. It is in fact quite common to find cultivators who at different times, hire-in as well as hire-out labour. The number of days for which casual workers are required each day are, of course, dependent on the size of the farm and the number of family workers as well as permanent hired workers on the farm.

5. The average yield of these crops in Bangladesh has been calculated to be 12.2 maund/acre for rice, 14.1 maund/acre for jute, 7.0 maund/acre for pulses and 8.1 maund/acre for oilseeds.

6. With an average family size of 6.5 per farm household, the average net farm income per household member (average across four sampling areas) is estimated to be about Tk. 592 per year, which yields a monthly per capita farm income of Tk. 50 ($3.3) among the small farmers in Bangaldesh.

7. Of course, this may alternatively mean that most of the farm households in Pabna needed 'emergency consumption credit' which the institutional sources do not usually provide. Informal lenders, in contrast, often provide emergency credit.

8. This is not merely a question of differential access to institutional, and hence cheaper sources of credit among different regions but the nature of credit needs may have been quite different in different regions.

9. Later in Chapter VI, a more comprehensive formula [based on a modified Roumasset (1976) RSI formula] is used to derive the estimates of disaster incomes for the farm households in each sampling region.

10. Total Farm Income may further be subdivided into Total Crop Income and Total Non-Crop Income, the latter including income derived from the sale of agricultural labour and income from other agricultural activities.

11. Sylhet is excluded from the set because the share of consumption of foodgrains by the farm households in this region is too high to satisfy this law.

12. Perhaps these loans were incurred for purchase of capital items such as bullocks rather than for consumption purposes. Alternatively, the aggregate nature of data and the source of loan (non-institutional) may have resulted in these numbers.

13. It should, however, be emphasized here that although the weight of non-agricultural incomes in the total incomes of the farm households is quite low, it nevertheless, has great importance for small farmers in Bangladesh who live so perilously close to the subsistence level so that any additions to income are considered to be very significant.

14. Some of the major limitations of our field survey are:

    (a) The single interview nature of our survey naturally casts some doubt on the reliability of our data, particularly those related to input-output data of various crops in the survey areas. Accuracy of data could be substantially improved through conducting a multiple-interview survey requiring several visits to the farm households, and collecting data on events as and when they occur, e.g. in sowing and harvesting seasons for each crop grown.

    (b) The narrow coverage of our survey, (confining to farm size not exceeding 3 acres) though, quite adequate to serve the basic purpose of this study, does not allow us to study the differential data-characteristics and more importantly, the differential behaviour of farm households of different size-groups, which have undoubtedly, some interesting policy implications.

CHAPTER V

EMPIRICAL RESULTS

V.1 Introduction

In this chapter, we discuss the estimation of the basic components of our resource allocation model presented in Chapter III. This involves the estimation of (a) cross section production functions and (b) variance-covariance matrices of output and price disturbances of various crops in each sampling region. While the cross section production functions were estimated using the farm-level data collected earlier in the field survey, the estimation of variance-covariance matrices of random disturbances associated with both output and prices were carried out, in the absence of the availability of micro time series data on output and prices, utilising the aggregate district-level time series data in Bangladesh. The methodology of estimation adopted in this study and the resulting set of estimates of various parameters involving those of cross section production functions are presented in Section 2 and those of variance-covariance matrices of output and price disturbances in Section 3 of this chapter respectively. Section 4 summarises the main results and makes some concluding remarks.

V.2 Estimation of Cross Section Production Function

Production function analysis using farm-level data represents an integral part of any study dealing with the problem of allocative efficiency in a traditional agriculture. The cross sectional estimates of the technical coefficients of production provide the necessary technological information for analysing resource allocation behaviour of the farm households in various crop activities. Therefore, using the farm-level input/output data collected earlier in the field survey, different sets of production functions were estimated for various crops in different regions in Bangladesh. We present below an account of our empirical work focussing in this section on the following two issues:

a) First, the regional nature of the production function is explored with respect to major crops produced in Bangladesh. This essentially involved testing the validity of a variety of restrictions imposed across regression equations representing different regions.

b) Secondly, the data set is further analysed by first treating each minor input such as fertilizer, pesticide, manure and irrigation, separately and then by aggregating them together in the estimation of production function.

The production function estimated in this study is of the Cobb-Douglas type $Q_j = A_j \Pi X_{ij}^{\alpha_{ij}} u_j$ which can be expressed in log-linear for as:

$$\log Q_j = \log A_j + \alpha_{lj} \log L_j + \alpha_{nj} \log N_j + \alpha_{sj} \log S_j + \alpha_{bj} \log B_j + \alpha_{fj} \log F_j + \alpha_{pj} \log P_j + \alpha_{mj} \log M_j + \alpha_{ij} \log I_j + \log u_j \quad \text{....(5.1)}$$

where Q_j = physical output of crop j

A_j = technical efficiency parameter

L_j = acreage devoted to cultivation of crop j

N_j = human labour (mandays) used in the cultivation of crop j

S_j = amount of seed used in the cultivation of crop j

B_j = bullock labour (bullock-pair days) used in the cultivation of crop j

F_j = amount of fertilizer used in the cultivation of crop j

P_j = amount of pesticide used in the cultivation of crop j

M_j = amount of manure used in the cultivation of crop j

I_j = expenditures incurred on irrigation in the cultivation of crop j

Ordinary least squares method was used throughout for estimating the production function of each crop (e.g. aus rice, aman rice, jute, pulses, wheat, oilseeds, IRRI boro and IRRI aus) in four different regions in Bangladesh, namely Sylhet, Pabna, Faridpur and Mymensingh districts.[1]

It may be noted here that the estimation of the Cobb-Douglas form gives rise to computational difficulties when the sample contains zero observations since the logarithmic transformation for zero values is not defined in real space. A commonly adopted procedure is to replace the zero values by figures of arbitrary small sizes. This, however, as Heady (1961) emphasizes, may induce non-negligible errors in our estimation if the zero observations occur quite frequently in the sample. Johnson and Raisser (1970) have also shown that replacement of zero values by small positive constants results in a small bias in estimated parameters. In our estimation, therefore, we used a dummy variable technique, explained below, to deal with this problem of zero observations as they occur quite frequently in our data set particularly with respect to the minor inputs identified earlier.

The use of this dummy, $R_i^{\alpha_i d_i}$ where R_i represents the input with zero observation for at least some farm households in the sample is rather simple and straightforward. We set $d_i = 0$ when $R_i = 0$ (i.e. when the sample records zero observation for this input) which gives $R_i^{\alpha_i d_i}=1$ or in log-linear form, $\alpha_i d_i \cdot \log R_i=0$. Prior to carrying out this step, however, each zero observation in the sample is replaced by a positive constant. And we put $d_i = 1$ when R_i is positive, which gives $R_i^{\alpha_i d_i} = R_i^{\alpha_i}$ or in log-linear form, $\alpha_i d_i \log R_i=\alpha_i \log R_i$ which guarantees that the variable is treated like any other variable with non-zero observations in production function estimation.

Also, the problem of missing observations was faced in our empirical work, particularly with respect to bullock labour and other minor inputs. Fortunately, the problem of missing observations did not arise in any case involving major inputs in the sample. To generate the missing observations on bullock labour, the first-order regression method was used.[2] For minor inputs, the missing observations were treated like zero observations in our estimation.

V.2.1 Regional Nature of the Production Function

Although the climatic and other physical factors lend certain uniformity to the agricultural scene in Bangladesh, there are still some variations in regional patterns of cultivation. Some regions are more suited, climatically and otherwise, to the production of certain crops than others. Therefore, it becomes necessary to ascertain for each of the crops produced in more than one region, whether there exists significant regional differences in production functions in Bangladesh.[3] This was done in this study on the basis of a series of statistical tests undertaken to examine the validation of a set of restrictions imposed across regressions representing different regions. To carry out this exercise, the following three sets of production functions were estimated for each crop in different sampling regions in Bangladesh.

a) First, the production functions were estimated for various crops in each of the four sampling regions, to the extent data were available, as shown in Table 5.1.

Table 5.1

Crop Choice in Four Sampling Regions

Crops	Sampling Regions			
1. Aus Rice	Sylhet	Pabna	Faridpur	X
2. Aman Rice	Sylhet	Pabna	Faridpur	Mymensingh
3. Jute	X	Pabna	Faridpur	Mymensingh
4. Pulses	X	Pabna	Faridpur	X
5. Wheat	X	Pabna	Faridpur	X

This represents the set of regressions without restrictions as it allows differential slopes as well as intercept coefficients across different regions.

b) Secondly, production functions were estimated, for each crop, with pooled data across different regions and incorporating regional shift dummies to account for differences in the intercept coefficients across different regions.[4]

c) And, finally, the production functions were estimated with pooled data across different regions without incorporating any regional shift dummies. This represents the most restricted set of regressions in our exercise as it imposes the restriction of common slope as well as intercept coefficient across different regions.

Based on the above three sets of estimated production functions, the following three types of statistical tests were carried out.

I. Test of Restriction of Equality of Both Intercept and Slope Co-Efficients across Different Regions.

This involved testing (c) against a), with the appropriate F-statistic defined as:

$$F^* = \frac{\Sigma e_p^2 - \Sigma e_1^2 + \Sigma e_2^2 + \ldots + \Sigma_s^2)/(s-1)k}{(\Sigma e_1^2 + \Sigma e_2^2 + \ldots + \Sigma e_s^2)/(N - sk)}$$

where: Σe_p^2 = residual sum of squares from the pooled regression,

Σe_1^2 = residual sum of squares of regression containing the first sample,

Σe_s^2 = residual sum of squares of regression containing the s-th sample,

k = number of estimated parameters in the regression,

N = number of observations in the pooled sample,

and s = number of sampling regions.

The Null hypothesis in this case is given by:

$$H_0: b_{1i} = b_{2i} = \ldots = b_{si}; \quad i = 0, 1, \ldots, k$$

i.e., set of coefficients obtained from different samples (regions) are equal.

II. Test of Restriction of Equality of Intercept Coefficient (assuming Common Slope Coefficients) across Different Regions.

This involved testing (c) against b), with the F-statistic defined as:

$$F^* = \frac{(\Sigma e_{WD}^2 - \Sigma e_D^2)/(s-1)}{(\Sigma e_D^2)/\{N - (s + k-1)\}}$$

where: Σe_{WD}^2 = residual sum of squares of regressions without regional dummies,

Σe_W^2 = residual sum of squares of regressions with regional dummies,

N,k and s represent the number of observations, the number of parameters estimated in the pooled regressions, both with and without dummies, and the number of sampling regions, respectively.

The Null Hypothesis in this case is given by:

$$H_0: \ b_{01} = b_{02} = \ldots = b_{0s}$$

(i.e., intercept coefficients are equal across regions.)

III. Test of Restriction of Common Slope Coefficient Across Regions.

This involved testing (b) against a), with the F-statistic defined as:

$$F^* = \frac{(\Sigma e_D^2) - (\Sigma e_1^2 + \Sigma e_2^2 + \ldots + \Sigma e_s^2)/(s-1)(k-1)}{(\Sigma e_1^2 + \Sigma e_2^2 + \ldots + \Sigma e_s^2)/(N-sk)}$$

where: Σe_D^2 = residual sum of squares of regressions with regional dummies,

Σe_1^2 = residual sum of squares of regressions representing the i-th sampling region,

N, s and k = same as defined earlier.

The Null Hypothesis in this case is given by:

$$H_0: \ b_{j1} = b_{j2} = \ldots = b_{js} \qquad j = 1,\ldots,k$$

It should be mentioned here that in each case, if our calculated F^* is greater than $F_{.01}$ with the respective degrees of freedom, then we reject the Null Hypothesis (at 1% level of significance) of equality, across regions, of both slope and intercept coefficients in case of I, of equality of only intercept coefficients in case of II, and of equality of only slope coefficients in case of III. This would, in turn, enable us to conclude that there exists significant differences in both slope and intercept coefficients, only in intercept coefficients or only in slope coefficients of the production functions across different regions in Bangladesh. On the other hand, if our calculated F^* happens to be less than $F_{.01}$, we cannot, then, reject the Null Hypothesis in any of these cases at the stated level of significance.

Our empirical findings based on these tests are put in a tabular form below, in Table 5.2A, 5.2B, 5.2C and in Table 5.3 respectively.

Table 5.2A

Computed F-Ratio and Critical Values of $F(v_1, v_2)$ with their respective Degrees of Freedom for Chow Test (I)

	Crops	Degrees of Freedom	Computed F-Ratio	Critical Values of $F(v_1,v_2)$ 1% level	5% level
1.	Aus Rice	(20,119)	2.27	2.03	1.66
2.	Aman Rice	(30,140)	1.80	1.70	1.46
3.	Jute	(20,44)	2.38	2.34	1.80
4.	Pulses	(10,66)	1.43	2.62	1.98
5.	Wheat	(10,27)	.42	3.07	2.21

Table 5.2B

Computed F-Ratio and Critical Values of $F(v_1,v_2)$ With their respective Degrees of Freedom for Dummy Variable Test (II).

Crops	Degrees of Freedom	Computed F-Ratio	Critical Values of $(F(v_1,v_2)$ 1% level	5% level
1. Aus Rice	(2,135)	11.45	4.61	3.00
2. Aman Rice	(3,164)	12.78	3.78	2.60
3. Jute	(2,61)	5.70	4.98	3.15
4. Pulses	(1,74)	1.71	7.02	3.98
5. Wheat	(1.35)	.64	7.54	4.13

Table 5.2C

Computed F-Ratio and Critical Values of $F(v_1 v_2)$ with their respective Degrees of Freedom for Dummy Variable Test (III)

Crops	Degrees of Freedom	Computed F-Ratio	Critical Values of $F(v_1 v_2)$ 1% level	5% level
1. Aus Rice	(18,119)	1.35	2.03	1.66
2. Aman Rice	(27,140)	.68	1.74	1.49
3. Jute	(18,44)	1.88	2.37	1.84
4. Pulses	(9,66)	1.47	2.70	2.03
5. Wheat	(9,27)	.42	3.20	2.25

Table 5.3

Summary of Test Results for Different Crops

Crops	Chow Test (I)	Dummy Variable Test (II)	Dummy Variable Test (III)
1. Aus Rice	NH rejected at 1% level	NH rejected at 1% level	NH not rejected even at 5% level
2. Aman Rice	NH rejected at 1% level	NH rejected at 1% level	NH not rejected even at 5% level
3. Jute	NH rejected at 1% level	NH rejected at 1% level	NH rejected at 5% but not at 1% level
4. Pulses	NH not rejected even at 5% level	NH not rejected even at 5% level	NH not rejected even at 5% level
5. Wheat	NH not rejected even at 5% level	NH not rejected even at 5% level	NH not rejected even at 5% level

Our findings with respect to statistical testing of hypotheses as summarized in Table 5.3 above suggest the following:

a) The Chow test rejects the Null Hypothesis of equality of both intercept and slope coefficients across regions for aus rice, aman rice and jute. For pulses and wheat, however, the Null Hypothesis could not be rejected even at 5% level of significance. This is also true for Dummy Variable Test(II).

b) In case of Dummy Variable Test (III), the Null Hypothesis of common slope coefficients allowing intercept to vary across regions could not be rejected for any of the crops produced. This is true for aus rice, aman rice, jute as well as for pulses and wheat.

Based on the results of these tests, therefore, we may draw the following conclusions concerning the regional nature of production functions for various crops in Bangladesh.

i) For aus rice, aman rice and jute the results of the tests are not very conclusive. Although the Chow test and Dummy Variable Test (II) both reject the Null Hypothesis of equality of slope as well as intercept co-efficients in case of the latter, the Dummy Variable Test (III) demonstrated that the Null Hypothesis of equality of slope coefficients across regions could not be rejected for any of the crops at 1% level of significance.

The implication of this is that for aus rice, aman rice and jute, the intercept coefficients are significantly different across regions but the slope coefficients are not. This, therefore, calls for estimation of production functions for these crops with pooled data across regions but incorporating regional shift dummies to account for differential intercept coefficients. These significantly different intercepts may reflect environmental differences across the four sampling regions.

ii) In cases of pulses and wheat, the results of our tests are quite conclusive. All three tests carried out, demonstrated that the Null Hypothesis of common slope and intercept coefficients either together, or separately, could not be rejected at 1% level of significance. It is, therefore, not meaningful in our sample to speak of regional production functions for these two crops in Bangladesh.

Thus, to the extent that there does not seem to exist any significant differences either in slope or intercept coefficients across regions, the production functions for these crops would appropriately be estimated with data pooled across regions and without incorporating any regional dummies.

Before concluding this section, it should be mentioned here that in our empirical exercise, we also carried out a statistical test of a restriction imposed on a parameter of the regression equation to decide how to utilise the crop damage data in our regression analysis.[5] The choice was between incoporating crop damage data as a separate explanatory variable in the regressions and adjusting actual output by the percentage of crop damage so that potential output emerges as the dependent variable. This could make it possible to estimate what we may call 'no-damage' production functions for various crops in Bangladesh. The test was carried out in the following way.

With crop damage incorporated as a separate variable, the regression equation would take the form:

$$\log Q_j = \log A_j + \Sigma\alpha_{ij}\log X_{ij} + \alpha_{CD}\log (1 - CD_j) \qquad \ldots.(5.2)$$

With the effect of crop damage incorporated as adjustment to actual output, $Q_j^* = Q_j/(1 - CD_j)$, where Q_j^* represents the potential output in the absence of any crop damage, the regression equation can be written as

$$\log Q_j^* = \log A_j + \Sigma\alpha_{ij}\log X_{ij}$$

or

$$\log Q_j = \log A_j + \Sigma\alpha_{ij}\log X_{ij} + \log(1 - CD_j) \qquad \ldots.(5.3)$$

A comparison of (5.2) and (5.3) shows that regression equation (5.3) imposes a restriction of unity on the coefficient of its crop damage variable i.e., a restriction of $\alpha_{CD} = 1$. We may test for this restriction with the following Null Hypothesis:

H_0: $\alpha_{CD} = 1$ i.e., the coefficient of crop damage variable is equal to one.

against

H_1: $\alpha_{CD} \neq 1$ i.e., the coefficient of crop damage variable is not equal to one.

The appropriate F-statistics in this case is defined as

$$F^* = \frac{(\Sigma e_3^2 - \Sigma e_2^2)}{(\Sigma e_2^2)/(N - k)}$$

with $v_1 = 1$ and

$v_2 = (N - k)$ represent degrees of freedom respectively

where: Σe_2^2 = residual sum of squares from regression (5.2)

Σe_3^2 = residual sum of squares from regression (5.3)

Our data set strongly rejects the Null Hypothesis for each crop indicating that the coefficient of crop damage variable in each case is significantly different from unity. This in turn implies that in our estimation of production functions of different crops in each region, the crop damage data should be incorporated as a separate explanatory variable in the regression equations.

Regression Results

We discussed above how the regional nature of production function was explored for various crops produced in Bangladesh. In particular, it was examined for each crop whether data should be pooled across regions in the estimation of production function with or without regional dummies or whether production functions should be estimated for each region separately. We may now analyse the estimated production functions in greater detail.

As mentioned earlier, we have specified the variables of the Cobb-Douglas production functions in our estimation process in two ways.

i) One is a disaggeregated version, which incorporates as many as eight variable inputs (land, human labour, bullock labour, seed, fertilizer, pesticide, manure and irrigation) in the specification of the production functions. This is represented by equation (5.1)

ii) The second is an aggregated version, which maintains the 'major' inputs such as land, human labour, bullock labour and seed as separate variables but merges the 'minor' inputs (fertilizer, pesticide, manure and irrigation) into a single variable, "expenditure on current inputs" (ECI). In fact, we have estimated the following six variants of the aggregated version of the production functions in this study.

$$\log Q_j = \log A_j + \alpha_L \log L_j + \alpha_N \log N_j + \alpha_B \log B_j + \alpha_{ECI} \log ECI + \alpha_{CD} \log (1 - CD_j) \quad \ldots (5.4)$$

$$\log Q_j = \log A_j + \alpha_L \log L_j + \alpha_{FN} \log FN_j + \alpha_{HN} \log HN_j + \alpha_B \log B_j + \alpha_{ECI} \log ECI + \alpha_{CD} \log (1 - CD_j) \quad .(5.5)$$

$$\log Q_j = \log A_j + \alpha_L \log L_j + \alpha_N \log N_j + \alpha_B \log B_j + \alpha_S \log S_j + \alpha_{ECI} \log ECI^* + \alpha_{CD} \log (1 - CD_j) \quad ....(5.6)$$

$$\log Q_j = \log A_j + \alpha_L \log L_j + \alpha_{FN} \log FN_j + \alpha_{HN} \log HN_j + \alpha_B \log B_j + \alpha_S \log S_j + \alpha_{ECI} \log ECI^* + \alpha_{CD} \log (1 - CD_j) .(5.7)$$

$$\log Q_j = \log A_j + \alpha_L \log L_j + \alpha_{FN} \log FN_j + \alpha_B \log B_j + \alpha_{ECI} \log ECI' + \alpha_{CD} \log (1 - CD_j) \quad ....(5.8)$$

$$\log Q_j = \log A_j + \alpha_L \log L_j + \alpha_{FN} \log FN_j + \alpha_B \log B_j + \alpha_{ECI} \log ECI^{*\prime} + \alpha_S \log S_j + \alpha_{CD} \log (1 - CD_j) \quad ....(5.9)$$

where: ECI = sum of expenditures on seed, fertilizer, pesticide, manures and irrigation

ECI^* = ECI minus expenditures on seed

ECI' = ECI plus the expenditures on hired labour

$ECI^{*\prime}$ = ECI' minus the expenditures on seed

Table 5.4 presents the regression results for the disaggregated version of the production functions for various crops grown in Bangladesh. For all the functions estimated, R^2, the coefficient of determination suggests that a major proportion of interfarm variation in output of these crops is explained by the included explanatory variables. Looking at the estimated coefficients of different inputs, it is observed that the coefficients of the land input (L_j) have the correct sign and are statistically significant, usually at the 1% level, in the cases of all crops, except oilseeds. The magnitude of these input elasticities, however, shows considerable variation across the crops from as high as 1.00 for IRRI aus to a low of .25 for pulses.[6]

Table 5.4

Estimated Production Function for Various Crops in Bangladesh

	Aus Rice	Aman Rice	Jute	Pulses
Constant	---	---	---	.19 (.69)
1. Land (L)	.51 (4.07)***	.74 (9.06)***	.55 (4.89)***	.25 (2.94)***
2. Human Labour (N)	.17 (1.70)*	.09 (1.57)	.19 (2.20)**	.40 (4.78)***
3. Bullock Labour (B)	.08 (1.47)	.03 (.91)	.15 (1.76)*	.34 (5.07)***
4. Seed (S)	.18 (2.36)**	.04 (.70)	.01 (.17)	.01 (.83)
5. Fertilizer (F)	.01 (.25)	.02 (.41)	.02 (.28)	.0 (0)
6. Pesticides (P)	-.13 (2.15)**	-.07 (2.35)**	-.09 (.81)	0 (0)
7. Manure (M)	-.01 (.51)	-.01 (.49)	-.11 (2.35)**	-.01 (.14)
8. Irrigation (I)	.08 (1.16)	.06 (1.26)	0 (0)	0 (0)
9. Crop Damage Variable (CD)	.58 (9.75)***	.57 (7.53)***	.47 (4.69)***	.46 (5.54)***

Table 5.4 (Cont.)

	Aus Rice	Aman Rice	Jute	Pulses
Regional Shift Dummies				
Z_1	2.22	2.58	--	-
	(5.67)***	(11.04)***		
Z_2	1.98	2.49	1.97	-
	(5.08)***	(10.19)***	(4.84)***	
Z_3	1.83	2.44	1.65	-
	(5.02)***	(11.23)***	(4.28)***	
Z_4	-	2.88	1.69	-
		(12.14)***	(4.20)***	
R^2	.75	.74	.74	.90
N	149	180	74	86

Table 5.4 (Cont.)

	Wheat	Oilseeds	Irri Aus	Irri Boro
Constant	2.03	.28	5.02	2.72
	(4.76)***	(.17)	(3.22)***	(3.47)***
1. Land (L)	.85	.32	1.00	.52
	(4.82)***	(.72)	(2.05)***	(2.37)***
2. Human Labour (N)	.31	.70	-.18	-.04
	(2.09)**	(2.92)***	(.80)	(.25)
3. Bullock Labour (B)	-.22	-.19	-.13	.53
	(1.91)*	(.30)	(.32)	(3.99)***
4. Seeds (S)	-.02	.05	.21	-.01
	(.61)	(.97)	(.83)	(.04)
5. Fertilizer (F)	-.40	.08	-.15	.03
	(.75)	(.24)	(.78)	(.26)
6. Pesticides (P)	0	0	-.07	-.01
	(0)	(0)	(1.00)	(.31)
7. Manure (M)	-.01	.21	.09	0
	(.06)	(1.21)	(1.25)	(0)
8. Irrigation (I)	0	0	-.002	-.008
	(0)	(0)	(.03)	(.11)
9. Crop Damage Variable (CD)	.91	.48	1.47	1.57
	(4.43)***	(1.44)	(4.59)***	(11.20)***

Regional Shift Dummies				
Z_1	-	-	-	-
Z_2	-	-	-	-
Z_3	-	-	-	-
Z_4	-	-	-	-
R^2	.74	.76	.89	.99
N	47	22	24	15

Notes: (1) The number in parentheses is the t-statistic of the respective coefficient.

(2) ***, ** and * indicates that the respective coefficient is significantly different from zero at 1%, 5% and 10% probability levels respectively.

The coefficients of human labour (N_j) have the correct signs and are statistically significant in five out of eight crops estimated in our study. For IRRI aus and IRRI boro, the two high-yielding varieties of rice in Bangladesh, the coefficients have unexpected signs but are statistically insignificant even at 10% level. The coefficients of bullock labour (B_j) have positive signs in most cases but are significant only for pulses, IRRI boro and jute. For wheat, the coefficient has not only unexpected signs, but it is significant (at 5% level) as well. The same is true in the case of seed (S_j) whose coefficients, though positive in six out of eight crops estimated, are statistically significant only in the case of aus rice. In the two cases where they have the wrong signs, they are statistically insignificant even at the 10% level. Both bullock labour and seed are linearly related to land size and this collinearity may have been responsible for the wrong signs and/or of statistical insignificance of the coefficients.

The estimated coefficients of the minor inputs like fertilizer, pesticide, manure and irrigation are seldom, if ever, significant. In the few cases where the coefficients are significant, they have the wrong sign, e.g., the coefficient of pesticides in the case of aus and aman rice. Also, in some cases the estimated coefficients are very small. The most plausible explanation of all these may be attributed to the fact that only a very small number of farm households in our sample employ these inputs. This is also reflected in the very low level of their average use as shown in Table 5.5.

Table 5.5

Average Level of Input Use Per Acre for Various Crops in Bangladesh

Inputs	Aus Rice	Aman Rice	Jute	Pulses	Wheat	Oilseeds
1. Human Labour (mandays)	32.24	31.14	46.62	21.29	21.11	22.79
2. Bullock Labour (pair days)	11.62	13.71	12.43	15.72	9.10	12.23
3. Seed (lb.)	2.22	1.68	.26	1.14	1.76	.38
4. Fertilizer (lb.)	.38 (26%)	.38 (29%)	.56 (30%)	- (-)	.08 (4%)	.18 (14%)
5. Pesticide (lb.)	.06 (7%)	.008 (5%)	.004 (1%)	- (-)	- (-)	- (-)
6. Manure (mds)	4.90 (27%)	1.41 (14%)	4.11 (12%)	.40 (2%)	1.47 (4%)	1.36 (5%)
7. Irrigation (000 taka)	.003 (3%)	.006 (5%)	.001 (1%)	- (-)	- (-)	- (-)

Note: The figures in parentheses indicate the proportion of farms actually using the minor input in various crops in our sample.

Thus, the lack of use of some of these inputs, their lack of variation across the sample, significant measurement errors and a high degree of collinearity among these inputs - all contributed towards poor estimates of the coefficients of these inputs in our study.

The coefficients of the Crop Damage Variable are both positive and highly significant in all cases excepting that for oilseeds. This demonstrates that even within a region where the farm households are exposed to roughly identical climatic conditions, they experienced considerable variations in the incidence of crop damage which was systematically related to the actual output of various crops.[7]

The coefficient of the shift dummies incorporated to account for different regional intercepts producing aus rice, aman rice and jute was highly significant. The magnitudes of the coefficients, however, does not show much variation across four regions indicating that the productivity differential for these crops are not very pronounced in different regions in Bangladesh. In a given region, though, one notices some variation across crops produced in that region.

The regression results for the aggregated version of our production function estimates are presented in Table 5.6 through Table 5.11. The estimated coefficients of the production function parameters from the six variants of the aggregated version are analysed below. Two topics are of particular interest.

(a) Performance of the composite input variable, ECI representing expenditures on current inputs and

(b) Significance of family labour vis-a-vis hired labour characterising seasonality of labour use in crop production.

Table 5.6

Estimated Production Function for Various Crops in Bangladesh (Aggregate Version-I)

	Aus Rice	Aman Rice	Jute	Pulses	Wheat	Oilseeds
Constant	–	–	–	.63 (2.02)**	2.18 (5.66)***	.01 (.003)
1. Land (L)	.66 (5.94)**	.72 (9.08)***	.54 (4.73)***	.23 (2.88)***	.76 (4.75)***	.35 (.84)
2. Human Labour (N)	.16 (1.59)	.09 (1.56)	.21 (2.42)**	.35 (4.43)***	.37 (2.89)***	.64 (2.97)***
3. Bullock Labour (B)	.08 (1.34)	.04 (1.03)	.17 (2.03)**	-.32 (5.15)***	-.24 (2.37)**	-.10 (.15)
4. Expenditure on Current Inputs (ECI)	.07 (.98)	.08 (1.57)	.03 (.57)	.01 (2.79)***	.14 (1.75)*	-.07 (.48)
5. Crop Damage Variable (CD)	.59 (9.73)***	.56 (7.46)***	.50 (5.03)***	.47 (6.17)***	.86 (4.72)***	.60 (2.01)*
Regional Shift Dummies						
Z_1	2.38 (5.69)***	2.70 (10.21)***	1.70 (3.99)***	–	–	–
Z_2	2.14 (4.99)***	2.61 (9.17)***	1.40 (3.47)***	–	–	–
Z_3	1.99 (4.97)***	2.56 (10.01)***	1.43 (3.28)***	–	–	–
Z_4	–	2.99 (10.93)***	–	–	–	–
R^2	.73	.73	.72	.90	.75	.72

Note: ***,** and * indicate that the respective coefficient is significantly different from zero at 1%, 5% and 10% probability levels.

Table 5.7

Estimated Production Function for Various Crops in Bangladesh (Aggregate Version-II)

	Aus Rice	Aman Rice	Jute	Pulses	Wheat	Oilseeds
Constant	-	-	-	.66 (2.30)**	2.33 (6.23)***	2.37 (.89)
1. Land (L)	.76 (8.43)***	.75 (10.17)***	.52 (4.71)***	.23 (2.91)***	.77 (4.73)***	.57 (1.11)
2. Family Labour (FN)	.01 (.47)	.01 (1.23)	.20 (2.76)***	.34 (4.66)***	.33 (2.77)***	.22 (.64)
3. Hired Labour	.09 (1.01)	.001 .10)	-.01 (1.61)	-.003 (.42)	.01 (.80)	.06 (1.59)
4. Bullock Labour	.09 (1.49)	.04 (1.12)	.17 (2.07)**	.32 (5.26)***	-.23 (2.24)**	-.37 (.46)
5. Expenditure on Current Inputs (ECI)	.09 (1.38)	.09 (1.91)*	.02 (.33)	.11 (3.05)***	.14 (1.69)*	.005 (.03)
6. Crop Damage Variable (CD)	.60 (9.85)***	.58 (7.63)***	.41 (4.08)***	.46 (6.14)***	.85 (4.54)***	.70 (1.78)*
Regional Shift Dummies						
Z_1	2.96 (16.63)***	3.02 (23.76)***	-	-	-	-
Z_2	2.72 (13.85)***	2.91 (16.82)***	1.79 (5.05)***	-	-	-
Z_3	2.52 (14.57)***	2.86 (20.27)***	1.50 (4.49)***	-	-	-
Z_3	-	3.32 (24.91)***	1.64 (4.72)***	-	-	-
R^2	.73	.73	.74	.91	.75	.64

Table 5.8

Estimated Production Function for Various Crops in Bangladesh (Aggregate Version-III)

	Aus Rice	Aman Rice	Jute	Pulses	Wheat	Oilseeds
Constant	-	-	-	.19 (.69)	1.94 (4.95)***	.98 (.68)
1. Land (L)	.55 (4.53)***	.72 (8.81)***	.55 (4.47)***	.25 (2.98)***	.85 (5.11)***	.44 (1.09)
2. Human Labour (N)	.15 (1.53)	.10 (1.82)*	.22 (2.49)**	.40 (4.89)***	.34 (2.54)**	.62 (2.91)***
3. Bullock Labour (B)	.08 (1.48)	.04 (1.18)	.15 (2.07)**	.34 (5.17)***	-.22 (2.07)**	-.38 (.69)
4. Seed (S)	.18 (2.39)**	.06 (1.12)	.02 (.39)	.01 (.85)	-.02 (.73)	.05 (1.08)
5. Expenditure on Current Inputs (ECI*)	.02 (.78)	-.01 (.38)	.03 (1.05)	.01 (.13)	-.05 (.75)	-.05 (.57)
6. Crop Damage Variable (CD)	.59 (9.81)***	.57 (7.62)***	.47 (4.63)***	.46 (5.54)***	.90 (4.58)***	.56 (1.85)*
Regional Shift Dummies						
Z_1	2.30 (6.04)***	2.49 (10.62)***	-	-	-	-
Z_2	2.06 (5.52)***	2.40 (9.93)***	1.76 (4.42)***	-	-	-
Z_3	1.92 (5.39)***	2.36 (11.01)***	1.47 (3.87)***	-	-	-
Z_4	-	2.80 (11.71)***	1.54 (3.84)***	-	-	-
R^2	.74	.73	.72	.90	.74	.74

Note: ***, ** and * indicate that the respective coefficient is significantly different from zero at 1%, 5% and 10% probability levels.

Table 5.9

Estimated Production Function for Various Crops in Bangladesh (Aggregate Version-VI)

	Aus Rice	Aman Rice	Jute	Pulses	Wheat	Oilseeds
Constant	-	-	-	.23 (.89)	2.09 (5.28)***	3.59 (1.89)*
1. Land (L)	.64 (6.20)***	.76 (9.91)***	.52 (4.36)***	.25 (2.96)***	.86 (5.15)***	.65 (1.41)
2. Family Labour (FN)	.01 (.65)	.01 (1.34)	.20 (2.72***	.40 (5.16)***	.30 (2.46)**	.10 (.32)
3. Hired Labour (HN)	-.06 (.65)	.001 (.26)	-.01 (1.55)	.002 (.25)	.01 (.83)	.08 (2.23)**
4. Bullock Labour (B)	.09 (1.61)	.05 (1.33)	.18 (2.04)**	.33 (5.17)***	-.21 (1.97)**	-.62 (1.00)
5. Seed (S)	.19 (2.58)**	.07 (1.39)	.01 (.08)	.02 (1.01)	-.02 (.78)	.09 (1.62)
6. Expenditure on Current Inputs (ECI*)	.01 (.57)	-.01 (.29)	-.01 (.20)	.01 (.23)	-.05 (.72)	-.09 (.65)
7. Crop Damage Variable (CD)	.61 (9.90)***	.59 (7.89)***	.42 (4.03)***	.45 (5.40)***	.89 (4.48)***	.62 (1.81)*
Regional Shift Dummies						
Z_1	2.80 (16.26)***	2.85 (29.42)***	-	-	-	-
Z_2	2.56 (15.22)***	2.72 (19.93)***	1.74 (4.77)***	-	-	-
Z_3	2.37 (15.35)***	22.67 (25.81)***	1.44 (4.15)***	-	-	-
Z_4	-	3.15 (31.96)***	1.57 (4.48)***	-	-	-
R^2	.74	.73	.74	.90	.74	.71

Table 5.10

Estimated Production Function for Various Crops in Bangladesh (Aggregate Version-V)

	Aus Rice	Aman Rice	Jute	Pulses	Wheat	Oilseed
Constant	-	-	-	.56 (2.07)**	2.30 (6.34)***	.83 (.32)
1. Land (L)	.72 (7.73)***	.73 (10.17)***	.56 (5.11)***	.21 (2.64)**	.74 (4.59)***	.58 (1.06)
2. Family Labour (FN)	.01 (1.05)	.02 (1.76)*	.20 (2.68)***	.37 (5.43)***	.33 (2.81)***	.35 (.99)
3. Bullock Labour (B)	.09 (1.56)	.04 (1.13)	.15 (1.84)	.32 (5.24)***	-.20 (2.09)**	-.10 (.13)
4. Expenditure on Current Inputs (ECI*)	.12 (2.03)**	.12 (2.64)***	-.02 (.43)	.10 (2.98)***	.18 (2.18)**	-.04 (.19)
5. Crop Damage Variable (CD)	.59 (9.69)***	.58 (7.83)***	.45 (4.40)***	.45 (6.10)***	.83 (4.59)***	.38 (1.03)
Regional Shift Dummies						
Z_1	2.91 (18.14)***	2.99 (27.61)***	-	-	-	-
Z_2	2.70 (15.56)***	2.91 (18.82)***	1.83 (5.49)***	-	-	-
Z_3	2.54 (16.94)***	2.86 (23.15)***	1.53 (4.89)***	-	-	-
Z_4	-	3.28 (31.35)***	1.64 (5.13)***	-	-	-
R^2	.73	.74	.73	.91	.76	.58

Note: ***,** and * indicate that the respective coefficient is significantly different from zero at 1%, 5% and 10% probability levels.

Table 5.11

Estimated Production Function for Various Crops in Bangladesh (Aggregate Version-VI)

	Aus Rice	Aman Rice	Jute	Pulses	Wheat	Oilseeds
Constant	-	-	-	.26 (.98)	2.09 (5.66)***	1.71 (.96)
1. Land (L)	.65 (6.30)***	.76	.54	.26	.90	.60
2. Family Labour (FN)	.01 (.70)	.02 (1.48)	.19 (2.64)***	.38 (4.97)***	.29 (2.38)**	.24 (.70)
3. Bullock Labour (B)	.09 (1.56)	.04 (1.09)	.14 (1.71)*	.34 (5.36)***	-.23 (2.17)**	-.30 (.46)
4. Seed (S)	.19 (2.57)**	.07 (1.51)	.01 (.08)	.02 (1.19)	-.02 (.81)	.06 (1.06)
5. Expenditure on Current Inputs (ECI)	.02 (.62)	.06 (2.84)***	.03 (1.27)	.01 (.44)	-.02 (.82)	-.11 (1.09)
6. Crop Damage Variable (CD)	.60 (9.96)***	.61 (8.28)***	.44 (4.44)***	.45 (5.75)***	.89 (4.49)***	.40 (1.13)
Regional Shift Dummies						
Z_1	2.80 (16.69)***	2.96 (27.41)***	-	-	-	-
Z_2	2.57 (15.06)***	2.85 (20.44)***	1.95 (5.61)***	-	-	-
Z_3	2.40 (16.09)***	2.81 (25.05)***	1.65 (5.00)***	-	-	-
Z_4	-	3.26 (32.88)***	1.82 (5.26)***	-	-	-
R^2	.74	.74	.73	.90	.74	.63
N	149	180	74	86	47	22

Note: ***,** and * indicate that the respective coefficient is significantly different from zero at 1%, 5% and 10% probability levels.

(a) Performance of Composite Input Variable (ECI)

The coefficients of the composite input variable representing expenditures on current inputs performed rather poorly in the aggregated version of the estimated production functions in all of its variants across different crops in our sample. In variant-I, where it represents the five 'minor' inputs, seed, fertilizer, pesticide, manure and irrigation aggregated together, the coefficients are significant only in two (pulses and wheat crops) out of six cases, one of which is again significant only at the 10% level. The picture improves somewhat in variant-II where the coefficient of the composite input variable becomes significant for aman rice as well, though at the 10% level. In variants-III and IV, where the composite variable is redefined to exclude expenditures on seed from the aggregate figure, the estimated coefficient is never significantly different from zero for any of the crops produced, even at 10% level.

It would thus appear that it is the performance of the seed input which contributed towards the statistical significance of the composite variable in the earlier variants noted above. This also demonstrates that the other 'minor' inputs failed to add much to the explanation of the variation in crop output in our sample, either separately or aggregated together. The reason, of course, as earlier, probably lies in their very limited use in cultivation by the small-holding farms in Bangladesh, particularly in the areas surveyed for this study.

This becomes more evident when we compare the coefficients of the composite variable, ECI in variant-V and VI. In variant-V, when the composite variable includes both the expenditure on seed as well as that on hired labour in addition to expenditure on other 'minor' inputs, the estimated coefficients turn out to be significant in four out of six cases. But in variant-VI where the expenditure on seed is excluded, the coefficients cease to become statistically significant in all cases even at 10% level, except in aman rice. Even the inclusion of hired labour in the composite variable does not make these coefficients significant, a fact which also suggests poor performance of this variable input in our sample. This is an important issue which is discussed in more detail below.

(b) Significance of Family vis-a-vis Hired Labour in Crop Cultivation

Agricultural production is characterised by marked seasonal variation in the level of activity. It is, therefore, not surprising to observe that even though family labour may remain idle for much of the year during the slack season, the farm households depend on hired labour in the peak sowing and harvesting periods which are characterised by intense activity. Family labour including permanent hired labour is used throughout the year (in both peak and slack seasons) while the casually hired labour is generally used only in the peak season.

In the six variants of our aggregate version of production function, the coefficients of total human labour (N) have been estimated in variants I and III, of family and hired labour separately in variants II and IV, and of family labour alone in variants V and VI where the expenditures on hired labour (HN) is merged with the composite input variable.

The estimated coefficients of these three categories of labour across different crops show a distinct pattern. The coefficients of total labour (N) are highly significant in most of the cases in both variants I and III. Of the twelve estimated coefficients, seven are found to be significant at 1% level, two at 5% level and the remaining three at 10% level. The estimated coefficients of family labour (FN), on the other hand, are found to be significant in three (jute, pulses and wheat crops) out of six crops in variant III, and in four cases (also in aman rice, though at 10% level) in variant IV. The picture remains roughly the same in variants V and VI, where only the coefficients on family labour are estimated.

Casual hired labour, however, performs very poorly in our sample. The coefficients are seldom significant even at the 10% level, for all the variants estimated in our study. Moreover, the coefficients have the wrong sign in the case of jute in variant II and IV, though they are significant only at 10% level.

How do we interpret these results in the light of the observed seasonal nature of agricultural production and perhaps more importantly in the relative use of different categories of labour by the farm households in our sample?

To the extent that responses of agricultural output to inputs differ significantly over different parts of the crop year, the marginal product of casually hired labour which is primarily or exclusively used in peak seasons is expected to be higher than that of family labour used in both the slack as well as in peak seasons. In our study, however, such a comparison cannot be made since the estimated coefficients of hired labour are insignificant in almost all the cases. The variation in crop output could hardly be related systematically to variation in this category of labour input for any of the crops studied (excepting oilseeds). This may be attributed to the very low proportion of hired labour to total human labour used (also the lack of variability of this input use across our sample of small farm households) in the cultivation of different crops in the sample as shown in Table 5.12.

Table 5.12

Family and Hired Labour Input as Percentage of Total Human Labour

Crops	Family Labour	Hired Labour
Aus Rice	77%	23%
Aman Rice	72%	28%
Jute	86%	14%
Pulses	95%	5%
Oilseeds	92%	8%
Wheat	94%	6%

Source: Small Farm Sample Survey (1979)

It may be mentioned here that because of very low land/man ratio in Bangladesh agriculture, the small farm households in most cases are observed to be net suppliers of agricultural labour in the rural labour market. In fact, a significant proportion of their income is derived from the sale of agricultural labour services to the relatively larger land-holders. Also, to supplement their meagre farm incomes, the small farm households often engaged in off-farm activities particularly during the slack season. All these may explain why the interelationship between the seasonality in labour demand and labour productivity could not be captured in our sample of small-holding farms in Bangladesh.[8]

Before concluding this section, it may be noted that the estimated co-efficients of the major inputs such as land, human labour and bullock labour in our aggregated version are very much comparable to those obtained under the more disaggregated versions of the production functions as discussed earlier. For example, the coefficients of land input are significant in all cases except in oilseeds. Similarly, the estimated coefficients of human labour are only slightly better under the aggregated version while those of bullock labour are no better than they were before.

V.2.2 Testing of Hypotheses about Alternative Functional Form

Our discussion, in the preceding section, of production functions for different crops in Bangladesh was based on estimates using the Cobb-Douglas functional form. Although this form is widely used for estimation of agricultural production functions, we thought that it would be useful to examine the validity of alternative functional forms in our study. In fact, we explored two alternative functions- in addition to Cobb-Douglas- namely, Transcendental and Translog production functions and tested for each crop which one provided a better fit to our input/output data collected in the field survey.

The exercise was carried out in the following two steps:[9]

(i) Testing of transcendental function against Cobb-Douglas

(ii) Testing of translog function against Cobb-Douglas

The methodology and the empirical results for each of these tests are discussed below in greater detail.

i) Testing of Transcendental Function Against Cobb-Douglas

The transcendental production which may be written in the form, $Q_j = \Pi X_{ij}^{\alpha_{ij}} e^{\beta_{ij} X_{ij}} u_{ij}$ represents a generalisation of the Cobb-Douglas function as suggested by Halter et al (1957). Although like the Cobb-Douglas, the transcendental form restricts the elasticity of substitution between any two inputs to be equal to one, it does, unlike the former, permit the elasticity of output with respect to an input to vary. This property of the transcendental function may be greatly desirable for many purposes.

Using transcendental specification, the production functions were estimated for each of the seven crops produced, namely, aus rice, aman rice, jute, pulses, wheat, oilseeds and IRRI aus. The estimated production functions of different crops and the respective input-elasticities computed on the basis of estimated production function parameters are presented in Table 5.14 and Table 5.15 respectively.

The next step was to carry out the following test using these estimated functions, in addition to those obtained earlier using Cobb-Douglas form, in order to ascertain, for each crop, which form provides a better fit to our data.

The test was carried out in the following way.

The Cobb-Douglas production function in log-linear form may be written as

$$\log Q_{ij} = \log A_{ij} + \alpha_{1j} \log X_{1j} + \alpha_{2j} \log X_{2j} + \ldots + \alpha_{kj} \log X_{kj} + \log u_j \qquad \ldots(5.10)$$

And, the transcendental function in log-linear form may be represented as

$$\log Q_{ij} = \log A_{ij} + \alpha_{1j} \log X_{1j} + \beta_{1j} X_{1j} + \alpha_{2j} \log X_{2j} + \beta_{2j} X_{2j} + \ldots + \alpha_{kj} \log X_{kj} + \beta_{kj} X_{kj} + \log u_j \qquad \ldots(5.11)$$

A comparison of (5.10) and (5.11) shows that the Cobb-Douglas form imposes a restriction of $\beta_{ij} = 0$ for each X_{ij}. We may, therefore, test for this restriction with the following Null Hypothesis:

$$H_0: \beta_{1j} = \beta_{2j} = \ldots\ldots\ldots\ldots = \beta_{kj} = 0$$

i.e., the coefficient of each X_{ij} is zero.

The appropriate F-statistic in this case is defined as

$$F = \frac{(\Sigma e_{CD}^2 - \Sigma e_{TD}^2)/(k_2 - k_1)}{(\Sigma e_{TD}^2)/(N - k_2)}$$

with $v_1 = (k_2 - k_1)$ and $v_2 = (N - k_2)$ degrees of freedom respectively.

The results of this test are summarised below in Table 5.13

Table 5.13

Computed Test Statistic (F-Ratio) and Critical Values of $F(v_1,v_2)$ with Respective Degrees of Freedom for Different Crops in Bangladesh

Crop	Degrees of Freedom	Computed F-Ratio	Critical Values of $F(v_1,v_2)$ at 1%	at 5%	Inference
1. Aus Rice	(9, 128)	1.74	2.41	1.88	NH not rejected even at 5% level
2. Aman Rice	(9, 158)	1.27	2.41	1.88	"
3. Jute	(9, 53)	5.67	2.78	2.07	NH rejected at 1% level
4. Pulses	(9, 67)	2.35	2.70	2.04	NH rejected at 5% level but not at 1% level
5. Wheat	(9, 28)	.90	3.29	2.24	NH not rejected even at 5% level
6. Oilseeds	(9, 5)	.14	27.30	8.81	"
7. Irri Aus	(9, 5)	.26	10.20	4.77	"

It is quite evident from the results presented in Table 5.13 above that except in case of jute, our data-set could not reject, at 1% level of significance, the restrictions imposed by the Cobb-Douglas function against the transcendental. The transcendental functional form, therefore, does not provide a statistically better fit to our data as compared to the Cobb-Douglas functional form for any crop except jute.

Table 5.14

Estimated Production Functions for Various Crops in Bangladesh

(Transcendental Specification)

	Aus Rice	Aman Rice	Jute
Constant	-	-	-
1. Log Area Sown (Log L)	.29 (1.01)	.61 (3.71)***	-.27 (1.26)
2. Area Sown (L)	.18 (.85)	.10 (1.13)	2.30 (4.80)***
3. Log Human Labour (Log N)	.50 (1.88)*	-.02 (.12)	.06 (.31)
4. Human Labour (N)	-.01 (1.23)	.003 (.91)	.004 (.44)
5. Log Bullock Labour (Log B)	-.16 (1.46)	.09 (1.56)	.69 (3.97)***
6. Bullock Labour (B)	.01 (2.35)**	-.004 (1.66)*	-.11 (3.85)***
7. Log Seed (Log S)	.33 (1.62)*	.15 (1.52)	.03 (.44)
8. Seed (S)	-.13 (.97)	-.12 (1.55)	-.42 (.71)
9. Log Fertilizer (Log F)	.03 (.59)	.001 (.03)	-.003 (.06)
10. Fertilizer (F)	-.08 (1.48)	.06 (1.47)	-.01 (.07)
11. Log Pesticide (Log P)	-.11 (1.84)*	-.06 (1.80)*	251.01 (1.78)*
12. Pesticides (P)	.37 (2.09)**	-.20 (.57)	-15070.5 (1.78)*
13. Log Manure (Log M)	-.02 (.44)	-.11 (1.69)*	.25 (1.36)
14. Manure (M)	.01 (.24)	-.01 (1.56)	-.04 (1.90)*
15. Log Irrigation (Log I)	-.002 (.02)	.06 (1.09)	0 (0)

Table 5.14 (Cont'd)

	Aus Rice	Aman Rice	Jute
Constant			
16. Irrigation (I)	.43 (.28)	.15 (.37)	0 (0)
17. Log Crop Damage Log (1-CD)	.55 (4.78)***	.76 (2.29)**	-.40 (1.53)
18. Crop Damage (1-CD)	.20 (.61)	-.42 (.69)	1.72 (3.26)***
Regional Shift Dummies			
Z_1	1.52 (1.62)	3.16 (3.82)***	-
Z_2	1.25 (1.36)	3.12 (3.79)***	.32 (3.44)***
Z_3	1.06 (1.13)	3.05 (3.71)***	-.09 (.96)
Z_4	-	3.43 (4.09)***	0 (0)
R^2	.78	.76	.87
N	149	180	74

Notes: 1) The number in parentheses are the t-statistic of the respective coefficient.

2) ***, ** and * indicate that the respective coefficient is significantly different from zero at 1%, 5% and 10% probability levels respectively.

Table 5.14 (Cont.)

Estimated Production Functions for Various Crops in Bangladesh

(Transcendental Spécification)

	Pulses	Wheat	Oilseeds	IRRI Aus
Constant	-1.96 (2.78)***	-2.64 (1.42)	-5.64 (.48)	6.48 (.69)
1. Log Area Sown (Log L)	.21 (1.37)	.38 (.73)	-.69 (.20)	-.63 (.20)
2. Area Sown(L)	.06 (.31)	.51 (.71)	5.21 (.49)	1.12 (.43)
3. Log Human Labour (Log N)	.45 (3.03)**	.67 (1.65)*	-.44 (.27)	-2.34 (1.01)
4. Human Labour (N)	-.001 (.15)	-.02 (.84)	.07 (.66)	.03 (.92)
5. Log Bullock Labour (Log B)	.47 (5.00)***	-.36 (1.46)	4.39 (.57)	.93 (.40)
6. Bullock Labour(B)	-.01 (1.52)	.02 (.59)	-1.02 (.64)	-.06 (.44)
7. Log Seed (Log S)	-.01 (.53)	-.05 (1.28)	.07 (.60)	.25 (.19)
8. Seed (S)	.14 (1.91)*	.25 (.81)	1.92 (.59)	.10 (.08)
9. Log Fertilizer (Log F)	0 (0)	-.68 (.84)	.56 (.53)	.56 (.53)
10. Fertilizer (F)	0 (0)	.25 (.70)	1.68 (.65)	-.04 (.19)
11. Log Pesticide (Log P)	0 (0)	0 (0)	0 (0)	.07 (.33)
12. Pesticide (P)	0 (0)	0 (0)	0 (0)	-.22 (.53)
13. Log Manure (Log M)	-.51 (1.98)**	.14 (.50)	.05 (.14)	.06 (.19)

Table 5.14 (Cont.)

		Pulses	Wheat	Oilseeds	IRRI Aus
14.	Manure (M)	-.06 (1.96)*	-.01 (.37)	0 (0)	.01 (.25)
15.	Log Irrigation (Log I)	0 (0)	0 (0)	0 (0)	-.05 (.25)
16.	Irrigation (I)	0 (0)	0 (0)	0 (0)	-.43 (.44)
17.	Log Crop Damage Log (1-CD)	-.57 (1.96)*	-1.20 (1.23)	-1.09 (.38)	.17 (.05)
18.	Crop Damage (1-CD)	1.93 (3.82)***	3.58 (2.23)**	2.96 (.52)	2.82 (.45)
	Regional Shift Dummies				
	Z_1	-	-	-	-
	Z_2	-	-	-	-
	Z_3	-	-	-	-
	Z_4	-	-	-	-
	R^2	.92	.80	.83	.93
	N	86	47	22	24

Notes: 1) The number in parentheses are the t-statistic of the respective coefficient.

2) ***, ** and * indicate that the respective coefficient is significantly different from zero at 1%, 5% and 10% probability levels respectively.

Table 5.15

Input Elasticities of Various Categories of Inputs under Transcendental Specification

Inputs	Crops						
	Aus Rice	Aman Rice	Jute	Pulses	Wheat	Oilseeds	IRRI aus
1. Land	.57	.79	.95(56.67)**	.28	.75	2.80	.89
2. Human Labour	.20	.15	.16 (4.17)*	.42	.37	.61	-.11
3. Bullock Labour	-.19	-.01	-.03 (.33)	.28	-.23	-3.97	-.39
4. Seed	.10	-.03	0 (0)	.09	.09	.32	.35
5. Pesticides	-.10	-.06	0 (0)	0	0	0	.04
6. Fertilizers	.01	.02	-.01 (0)	0	-.69	.66	-.07
7. Manure	.06	-.14	.16 (8.00)**	-.54	.13	.05	.09
8. Irrigation	0	.06	0 (0)	0	0	0	-.11

Notes: i) The input elasticities (η_{ij}) have been computed on the basis of the estimated parameters, α_{ij} and β_{ij} at the mean level of respective input used for each crop in Bangladesh. In fact, $\eta_{ij} = \alpha_{ij} + \beta_{ij}\bar{X}_{ij}$

ii) The figures in parentheses indicate F-ratios (details in Appendix VA). ** and * indicate that the estimated elasticity coefficient is significantly different from zero at 1% and 5% prob. levels respectively. Evidently, the test has been carried out only for jute crop in our sample.

It may be worthwhile to take a closer look at the computed input elasticities under transcendental specification for different crops as recorded in Table 5.15. It is evident that the estimated elasticities with respect to land were of positive signs in case of all crops. The same is true for human labour where again the estimated elasticities came out with the correct signs in all cases except in IRRI aus. These results are very much comparable to those obtained earlier using the Cobb-Douglas function.

In case of bullock labour, however, the picture becomes quite disturbing as the estimated elasticities had incorrect signs in all cases except that for oilseeds. In fact, the situation is worse than for the Cobb-Douglas cases where this input did not perform well due to alleged collinearity with land. The picture, however, improves considerably in the case of seed where five out of seven computed elasticities were of the correct signs. Similar results were obtained in the case of manure which incidentally performed more satisfactorily than in the Cobb-Douglas case.

With respect to other minor inputs such as fertilizer, pesticide and irrigation, the elasticity coefficients generally had incorrect signs. Moreover, in a good number of cases particularly in case of irrigation, the estimated coefficients were zero. The erratic performance of these inputs may be attributed to, as mentioned in the case of Cobb-Douglas estimates, their lack or very low level of use by the small farm households in our sample.

In the case of the jute crop where this function does provide a better statistical fit than does the Cobb-Douglas form, it may be interesting to compare the estimated coefficients. It is readily observed that while the estimates are quite comparable in the case of human labour, the coefficient of land is recorded to be almost twice that estimated under the Cobb-Douglas form. With respect to minor inputs there isn't much to differentiate between the two sets as the estimated coefficients are of wrong signs and/or are statistically insignificant (excepting for manure under transcendental form) in most cases.

ii) Testing of Translog Production Function Against Cobb-Douglas

The transcendental logarithmic (or what is simply called 'translog') production function which may be written as $\log Q_j = \log A_j + \sum_i \alpha_{ij} \log X_{ij} + 1/2 \sum\sum_{ij} \gamma_{ij} \log X_i \log X_j$ is a member of a class of functions known as a general quadratic flexible form. This form has the attractive property of being linear in parameters yet imposing no <u>a priori</u> restrictions on the elasticity of substitution among factor inputs.

Our test of the translog functional form against Cobb-Douglas to ascertain for each crop which functional specification provides a more adequate fit to our data was carried out in the following way.

The Cobb-Douglas production function in log-linear form may be written as

$$\log Q_m = \log A_m + \sum_i \alpha_{im} \log X_{im} + \log u_m \quad \ldots.(5.12)$$

The translog production function which is also linear in parameters is written as:

$$\log Q_m = \log A_m + \sum_i \alpha_{im} \log X_{im} + 1/2 \sum_i \sum_j \gamma_{ij} \log X_{im} \log X_{jm} + \log u_m \quad .(5.13)$$

A comparison of (5.12) and (5.13) makes it readily evident that the Cobb-Douglas function imposes a restriction of $\gamma_{ij} = 0$ for $\log X_{im} \log X_{jm}$ for each i and j. We may, therefore, test the validity of this restriction with the following Null Hypothesis.

$$H_0: \gamma_{1j} = \gamma_{2j} = \dots\dots\dots\dots = \gamma_{kj} = 0$$

i.e., the coefficients of $\log X_{im} \log X_{jm}$ is zero for each i and j.

The appropriate test statistic (F-ratio) in this case is defined as

$$F = \frac{(e^2_{CD} - e^2_{TL}) / (k_c - k_t)}{(e^2_{TL}) / (N - k_c)}$$

with $v_1 = (k_c - k_t)$ and $v_2 = (N - k_t)$ degrees of freedom respectively.

To carry out this test, we first estimated the production functions using translog specification, for each of seven crops produced, namely aus rice, aman rice, jute, pulses, wheat, oilseeds and IRRI aus. The estimated production functions for these crops and the resulting input elasticities are shown in Tables 5.17 and 5.18 respectively. The next step was to compute the test-statistic (F-ratio) using the residual sum of squares of regression representing the Cobb-Douglas and translog functions respectively. The results of this test are summarised below in Table 5.16.

It is quite evident from the test results presented in Table 5.16 above that the restrictions imposed by the Cobb-Douglas function against the translog functional form was validated by our data set in case of aman rice, pulses, wheat, oilseeds and IRRI aus but were rejected again at 1% level in case of aus rice and jute. Thus, only for aus rice and jute crops, does the translog form provide a better fit to our data than does the Cobb-Douglas function.

Table 5.16

Computed Test Statistic (F-Ratio) and the Critical Values of $F(v_1, v_2)$ with Respective Degrees of Freedom for Different Crops in Bangladesh

Crops	Degrees of Freedom	Computed F-ratio	Critical Values of $F(v_1 v_2)$ at 1%	at 5%	Inference
1. Aus Rice	(15, 126)	2.72	2.18	1.67	NH rejected at 1% level
2. Aman Rice	(15, 156)	1.15	2.04	1.67	NH not rejected even at 5% level
3. Jute	(15, 51)	6.21	2.43	1.88	NH rejected at 1% level
4. Pulses	(15, 65)	1.87	2.50	1.84	NH rejected at 5% but not at 1% level.
5. Wheat	(15, 26)	1.33	2.89	2.07	NH not rejected even at 5% level
6. Oilseeds	(15, 1)	3.07	6157.00	246.00	NH not rejected even at 5% level
7. Irri Aus	(15, 3)	2.63	26.90	8.70	NH not rejected even at 5% level

We may, therefore, draw the following conclusions with respect to the choice of functional form for estimation of production functions of various crops in Bangladesh. The conclusions are based on our testing of the validity of the set of restrictions imposed by the Cobb-Douglas functional form vis-a-vis both transcendental and translog forms as discussed above.

Against the transcendental functional form, the Cobb-Douglas restrictions were validated by our data set for all crops excepting jute. Against the translog function, the Cobb-Douglas restrictions were validated by our data for all crops excepting aus rice and jute. It is thus appropriate to conclude that the Cobb-Douglas function provides a better fit to our data set as compared to both transcendental and translog functions for all crops excepting aus rice and jute. In the case of aus rice, the translog form evidently provides a better fit. In the case of jute, however, our two-stage test could not produce any conclusive evidence in favour of any particular functional form as the Cobb-Douglas restrictions were rejected against both transcendental and translog forms. To resolve this issue, it is necessary to conduct an additional test to ascertain which specification provides a better fit to our data in the case of the jute crop.

The computed input elasticities on the estimated production function parameters under the translog specification are shown in Table 5.18. It is observed that the computed elasticities with respect to land input came out with correct signs and were statistically significant in four out of five crops. The results, therefore, are very much comparable to those obtained earlier using the Cobb-Douglas functional form. In case of human labour, however, the computed input elasticities under translog performed rather poorly particularly in comparison

Table 5.17

Estimated Production Function for Various Crops in Bangladesh

(Translog Specification)

	Aus Rice	Aman Rice	Jute
Constant	-	-	-
1. Log Area Sown (Log L)	1.65 (1.48)	.87 (1.13)	2.50 (2.09)**
2. Log Human Labour (Log N)	-.93 (.66)	-.65 (.81)	-.67 (.66)
3. Log Bullock Labour (Log B)	.65 (.92)	.63 (1.73)*	.73 (.88)
4. Log Expenditure on Current Inputs (Log ECI)	.22 (.22)	.11 (.17)	-.86 (1.77)*
5. Log Crop Damage Variable (Log $(1-CD_i)$)	.35 (.26)	.36 (.40)	1.29 (1.44)
6. 1/2 $(\text{Log } L)^2$	.14 (.31)	.18 (.51)	.90 (1.77)*
7. Log L Log N	-.17 (.85)	-.03 (.14)	-.46 (1.89)*
8. Log L Log B	.17 (.85)	-.05 (.47)	.19 (.75)
9. Log L Log ECI	.28 (1.17)	-.01 (.04)	-.10 (.51)
10. Log L Log $(1-CD_i)$	.58 (1.95)*	-.16 (.05)	.19 (.51)
11. 1/2 $(\text{Log } N)^2$	.54 (1.29)	.18 (1.18)	.26 (1.00)
12. Log N Log B	-.40 (2.34)**	.0003 (.003)	.19 (1.05)
13. Log N Log ECI	.23 (.99)	-.11 (.80)	.20 (2.08)**

Table 5.17 (Cont.)

	Aus Rice	Aman Rice	Jute
14. Log N. Log $(1-CD_i)$	.31 (1.02)	.12 (.73)	.24 (1.01)
15. $1/2$ $(\text{Log } B)^2$	.22 (1.66)	-.16 (2.12)**	-.88 (4.02)***
16. Log B Log ECI	-.003 (.02)	.15 (2.59)***	-.02 (.26)
17. Log B Log $(1-CD_i)$	-.65 (3.21)***	-.04 (.42)	-.56 (3.19)***
18. $1/2$ $(\text{Log ECI})^2$	-.28 (1.44)	.002 (.04)	-.06 (.43)
19. Log ECI Log $(1-CD_i)$	-.44 (2.39)**	.09 (.44)	-.005 (.04)
20. $1/2$ $(\text{Log } (1-CD_i))^2$	.06 (.63)	.04 (.12)	.18 (1.69)*
Regional Shift Dummies			
Z_1	3.60 (1.41)	3.18 (1.57)	-
Z_2	3.35 (1.32)	3.22 (1.60)	2.75 (1.17)
Z_3	3.15 (1.24)	3.08 (1.69)*	2.32 (.98)
Z_4	-	3.43 (1.69)*	2.43 (1.04)
R^2	.80	.76	.90
N	149	180	74

Note: i) The figures in parentheses are the t-statistic of the respective coefficient.

ii) ***, ** and * indicate that the coefficient is significantly different from zero at 1%, 5% and 10% prob. levels respectively.

Table 5.17 (Cont.)

	Pulses	Wheat	Oilseeds	IRRI Aus
Constant	1.36 (.46)	1.84 (.80)	-356.36 (1.66)*	32.09 (1.83)*
1. Log Area Sown (Log L)	.71 (.73)	-4.29 (2.01)**	-102.50 (1.89)*	17.34 (1.22)
2. Log Human Labour (Log N)	-.76 (.55)	2.07 (1.22)	-17.20 (.94)	-6.91 (.75)
3. Log Bullock Labour (Log B)	1.04 (1.52)	1.13 (.83)	328.58 (1.55)	-9.57 (1.19)
4. Log Expenditure on Current Inputs (Log ECI)	.35 (.57)	3.62 (2.53)**	-16.10 (1.38)	-1.88 (-.51)
5. Log Crop Damage Variable (Log $(1-CD_i)$	-1.94 (1.26)	3.00 (1.13)	-140.41 (1.87)*	-16.69 (1.78)*
6. 1/2 (Log L)2	-.02 (.09)	-1.44 (1.11)	17.44 (.86)	1.66 (.18)
7. Log L Log N	-.38 (1.36)	1.12 (1.88)*	-1.16 (.26)	-1.80 (.46)
8. Log L Log B	.26 (1.18)	1.02 (1.83)*	40.18 (1.57)	-2.43 (.76)
9. Log L Log ECI	.09 (.51)	.27 (.52)	-5.35 (1.32)	-.76 (.58)
10. Log L Log $(1-CD_i)$	-.73 (1.57)	-.13 (.10)	-43.96 (1.73)*	9.52 (1.51)
11. 1/2 $(\text{Log } N)^2$	.60 (1.55)	-.12 (.20)	-1.24 (.52)	.26 (.12)
12. Log N Log B	-.20 (.97)	-1.13 (1.78)*	5.61 (1.15)	1.57 (.52)
13. Log N Log ECI	-.01 (1.05)	-.44 (1.18)	-2.22 (1.78)	.12 (.14)

Table 5.17 (Cont.)

	Pulses	Wheat	Oilseeds	IRRI Aus
14. Log N Log $(1-CD_i)$	.45 (1.61)	-.62 (.55)	-5.14 (2.16)**	-7.76 (2.25)**
15. $1/2$ $(\text{Log B})^2$	-.12 (.49)	.62 (1.01)	-174.53 (1.47)	1.57 (.35)
16. Log B Log ECI	-.10 (1.05)	-.49 (1.83)*	8.54 (1.55)	.51 (.97)
17. Log B Log $(1-CD_i)$	.43 (1.14)	.29 (.42)	63.24 (2.04)**	4.39 (1.94)*
18. $1/2(\text{Log ECI})^2$	-.01 (.16)	.51 (2.10)**	-.72 (1.14)	-.42 (1.30)
19. Log ECI Log $(1-CD_i)$	-.12 (.93)	-.06 (.07)	-1.91 (1.53)	.56 (.65)
20. $1/2$ $(\text{Log } (1-CD_i))^2$	.11 (.68)	.73 (1.10)	1.86 (.59)	-4.96 (.80)
Regional Shift Dummies				
Z_1	-	-	-	-
Z_2	-	-	-	-
Z_3	-	-	-	-
Z_4	-	-	-	-
R^2	.93	.87	.99	.99
N	86	47	22	24

Notes: i) The figures in parentheses are the t-statistic of the respective coefficients.

ii) ***, ** and * indicate that the coefficient is significantly different from zero at 1%, 5% and 10% probability levels respectively.

Table 5.18

Input Elasticities of Various Inputs Under Translog Specification for Different Crops in Bangladesh

Inputs	Crops					
	Aus Rice	Aman Rice	Jute	Pulses	Wheat	IRRI Aus
1. Land	.67 (8.24)***	.77 (7.34)*	1.20 (13.40)***	.32 (2.08)	.30 (4.21)*	.46 (1.46)
2. Human Labour	.29 (1.80)	.15 (.53)	.04 (1.49)	.37 (2.98)**	.43 (3.64)**	1.02 (2.79)
3. Bullock Labour	.13 (3.59)***	-.05 (2.45)**	-.05 (7.53)***	.17 (2.94)**	-.12 (1.44)	-.93 (4.24)
4. Expenditure on Current Inputs	.02 (1.93)	.07 (1.72)	-.09 (1.02)	.17 (.51)	.45 (2.21)	.23 (.67)

Notes: i) The input elasticities have been computed on the basis of estimated production function parameters, α_{ij} and γ_{ij} at the mean level of input use for each crop. In fact, $\eta_i = \alpha_i + \Sigma\gamma_{ij}\bar{X}_{ij}$

ii) The figures in parentheses are the computed F-ratio (details in Appendix VB) of the respective coefficients.

iii) *,**,and *** indicates that the respective coefficient is significantly different from zero at 1%, 5% and 10% probability level respectively.

to Cobb-Douglas as the elasticity coefficients, although, of the correct signs, were statistically significant only in two cases namely pulses and wheat, and that again at 5% level. The computed input elasticities with respect to bullock labour performed even worse because although the estimated coefficients were of correct signs and statistically significant in two crops namely aus rice and pulses (at the 1% and 5% levels respectively), the elasticity coefficients came out with incorrect signs in case of three other crops, namely aman rice, jute and wheat, of which two were statistically significant. The picture is hardly better with respect to the composite input variable, ECI where the estimated elasticity coefficients came out mostly with correct signs but never statistically significant even at the 5% level.

V.3 Estimation of Variance-Covariance Matrices of Random Disturbances

In estimating the variance-covariance matrices of random disturbances associated with both output and prices, one would, ideally, like to have time series of farm-level data on output and prices for various crops, from which we could extract the actual random disturbances over time. Our decision model postulates that the farm households in their endeavour to minimise the probability of disaster possess appropriate knowledge of the moments of random components of output and prices. This knowledge presumably comes from observations of these variables by the farm households over a long period of time. So if we had the same information as possessed by the farm households, we could derive the same moments that enter their economic calculus and analyse their allocation decisions accordingly.

Unfortunately, however, we do not have the time series data on farm-level inputs, output and prices and hence we cannot compute the random disturbances in the way one would ideally have done as noted above. We have, therefore, been forced to devise some alternative procedures utilising the information that we had at our disposal. Our general approach has been to try to extract the systematic portion from the aggregate time series so that we are left with the estimates on the disturbance terms from which we can compute the relevant variance-covariance matrices. The statistical procedures adopted in our study and the resulting set of estimates are described below both with respect to output and price disturbances.

V.3.1 Estimation of Output Disturbances

Our objective, as noted above, is to extract the random component associated with output taking into account the effect that various controllable inputs may have on output. Since controlled experiments are often not feasible in economic research, regression analysis is often used as a substitute (Roumasset, 1976). One of the most frequently used approaches to derive econometrically the probability distribution of yields is to simply assume that aggregate regional or district level data correctly reflect yield variations at farmer's field levels.[10] Our procedure thus involves the direct estimation of aggregate production functions using district level time series data on crop output, acreage and rainfall, both annual and monthly, for various crops in each of the four regions in Bangladesh. By fitting production functions to time series data, one can obtain not only an estimate of the mean of the frequency distribution of yields for a given set of inputs but also can examine the residuals from the fitted equations for a given range of inputs to obtain estimates of higher moments. This is essentially the approach adopted in our study.

The functional form chosen in our estimation of aggregate production function was of the Cobb-Douglas variety, $Q_j = A\, L_j^{\alpha}\, e^{\beta T}\, u_j$ where Q_j represents physical output of crop j, L_j represents acreage devoted to crop j and $e^{\beta T}$ represents the growth of complimentary inputs like labour and other purchased inputs for which no crop-wise time series were available. With rainfall data (both annual and monthly) incorporated, different versions of our estimating equations took the following log-linear forms

$$\text{(i)} \quad \log Q_j = \log A_j + \alpha \log L_j + \beta T + \gamma \log (AR_t/\bar{AR}_t) + \log u_j \qquad \ldots\ldots(5.10)$$

$$\text{(ii)} \quad \log Q_j = \log A_j + \alpha \log L_j + \beta T + \gamma_1 \log AR_t + \gamma_2 (\log AR_t)^2 + \log u_j \qquad \ldots\ldots(5.11)$$

$$\text{(iii)} \quad \log Q_j = \log A_j + \alpha \log L_j + \beta T + \sum_{i=1}^{12} \delta_i \log (MR_t/\bar{MR}_t) + \log u_j \qquad \ldots\ldots(5.12)$$

$$\text{(iv)} \quad \log Q_j = \log A_j + \alpha \log L_j + \beta T + \sum_{i=1}^{k} \delta_{1i} \log MR_t + \sum_{i=1}^{k} \delta_{2i} (\log MR_t)^2 + \log u_j \qquad \ldots\ldots(5.13)$$

where AR_t, MR_t, $\bar{AR}_t$ and $\bar{MR}_t$ represents the annual and monthly rainfall data and their respective mean levels, T represents time-trend and k represents the crucial months identified for a particular crop on the basis of a priori knowledge regarding the sowing and harvesting periods of the crop.

It is quite evident that (ii) and (iv) incorporate the annual and the crucial monthly rainfall data in quadratic form, which is rationalised in terms of some 'ideal' rainfall level(m), the deviation from which in either direction reduces crop output in a given period. This is illustrated below.

$$\log Q_j = \log A_j + \alpha \log L_j + \beta T - \gamma (\log AR_t - m)^2$$

or

$$\log Q_j = \log A_j + \alpha \log L_j + \beta T + \gamma_1 \log AR_t + \gamma_2 (\log AR_t)^2$$

where $\log A' = \log A_j - \gamma m^2$

$\gamma_1 = 2\gamma m$

$\gamma_2 = -\gamma$

These equations were estimated using aggregate time series on crop output, acreage and rainfall for the period, 1948-49 to 1976-77, for different crops in each of the four selected regions in Bangladesh. The regression results are shown in Appendix VC. It is quite evident that although the coefficients of land and those of the time trend capturing the growth of other coplimentary inputs were usually significant, the estimated coefficients of rain fall, either in annual or monthly form were seldom statistically significant in any of the regions studied.[11] Perhaps the length of time period was not sufficient enough to capture the significance of the rainfall variable in explaining the variability of output for any of the crops estimated.

In computing the regression residuals, $\hat{u}_{jt}$ as $(\log Q_{jt} - \log \hat{Q}_{jt})$ where $\log \hat{Q}_{jt} = \log A_j + \hat{\alpha} \log L_j + \hat{\beta}T$, therefore, we have decided to generate two alternative sets of estimates of output disturbances in this study.

i) Set I includes rainfall as an independent variable. Of the four versions estimated, the one with the highest R^2 was chosen for each crop in all four regions. In computing u_j's, of course, the fitted values of output were derrived using the estimated coefficients of the controllable inputs only so that the regression residual reflect the random component of output fluctuations over time.

ii) Set II excludes rainfall data. This alternative set of output disturbances were computed to check for any bias in the estimated coefficients that the omission of weather variables from the regression equation might cause.

Table 5.19A

Estimated Variance-Covariance Matrix for Sylhet Region

(Output Disturbances)

	Set I		Set II	
	Local Aus	Local Aman	Local Aus	Local Aman
Local Aus	.013	.002	.012	.005
Local Aman	.002	.024	.005	.007

Table 5.19B

Estimated Variance-Covariance Matrix for Pabna Region

(Output Disturbances)

	Set I				
	Local Aus	Local Aman	Jute	Pulses	Oilseeds
Local Aus	.036	.015	.015	-.005	-.005
Local Aman	.015	.035	.007	-.005	-.001
Jute	.015	.007	.039	-.004	-.005
Pulses	-.005	-.005	-.004	.006	-.001
Oilseeds	-.004	-.001	-.005	.001	-.007

Table 5.19B (Cont.)

Set II

	Local Aus	Local Aman	Jute	Pulses	Oilseeds
Local Aus	.035	.013	.014	-.004	-.004
Local Aman	.013	.031	.008	-.005	-.002
Jute	.014	.008	.038	-.004	-.005
Pulses	-.004	-.005	-.004	.006	.001
Oilseeds	-.004	-.002	-.005	.001	.007

Table 5.19C

Estimated Variance-Covariance Matrix for Faridpur Region

(Output Disturbances)

Set I

	Local Aus	Local Aman	Jute	Pulses	Wheat
Local Aus	.010	-.003	.003	-.0002	-.002
Local Aman	-.003	.026	.006	-.003	-.006
Jute	.003	.006	.032	-.044	-.0001
Pulses	-.0002	-.003	-.004	-.006	-.005
Wheat	-.002	-.006	-.0001	.005	.034

Table 5.19C (Cont.)

Set II

	Local Aus	Local Aman	Jute	Pulses	Wheat
Local Aus	.009	-.005	.002	-.0001	-.0005
Local Aman	-.005	.026	.006	-.003	-.006
Jute	.002	.006	.029	-.003	-.0008
Pulses	-.0001	-.003	-.003	.006	.005
Wheat	-.0005	-.006	-.0008	.005	.034

Table 5.19D

Estimated Variance-Covariance Matrices for Mymensingh Region

(Output Disturbances)

	Set I			Set II		
	Local Aman	Jute	IRRI Boro	Local Aman	Jute	IRRI Boro
Local Aman	.014	.0002	-.003	.012	.0007	-.004
Jute	.0002	.037	.002	.0007	.036	.0002
IRRI Boro	-.003	.002	.017	-.004	.0002	.017

Based on these two sets of estimates of output disturbances, $\hat{u}_{jt}$'s then, the following sets of variance-covariance matrices were computed for the relevant crop portfolio in each of our four sampling regions in Bangladesh.

Based on these estimated variances and covariances of output disturbances of different crops in four sampling regions, we may make the following observations:

a) Ranking of crops in terms of estimated variances of output disturbances (average of four regions) shows that jute (.036) occupies the top position, followed by wheat (.034), aman rice (.025), aus rice (.019), IRRI boro (.017), oilseeds (.007) and pulses (.006). This may give some idea of relative yield riskiness of different crops in Bangladesh.

b) A good number of covariance terms record negative values in the estimated matrices, particularly in Pabna and Faridpur regions. These mainly occur in those cases pairing with pulses and oilseeds in Pabna, and Pulses and wheat in Faridpur.

c) Between the two sets of estimated matrices (I and II), one does not observe any significant differences either in the magnitudes of estimated variances or in the sign and magnitudes of estimated covariances in any of the regions studied. This shows that the omission of weather variables did not cause any significant bias in the estimated coefficients.

V.3.2 Estimation of Price Disturbances

From statistical point of view, the estimation of price disturbances is easier than the estimation of output disturbances because the regional time series presumably do not differ appreciably from the time series of farm-gate prices. In estimating the price disturbances of different crops, using regional time series of grower's prices, we employed a variant of the Nerlovian expectation model which yields an estimating equation of the following form:

$$\log P_{it} = B_0 + \delta T + \gamma \log P_{i,\ t-1} + v_{it} \qquad .....(5.14)$$

where $\log P_{it}$ and $\log P_{i,\ t-1}$ represent logarithm of the regional price of the ith crop at period t and t-1 respectively, T represents time trend and v_{it} represents the random disturbances affecting the price of ith crop at time t.

As with output disturbances, estimates of price disturbances, $\hat{v}_{it}$ were derived as $(\log \hat{P}_{it} - \log P_{it})$ where $\log \hat{P}_{it}$ represents the fitted values, and using these point estimates, the relevant variance-covariance matrices for each region were computed.

Using a time series covering the period between 1963-64 and 1978-79, the coefficients were estimated for each crop in four sampling regions and the regression results are presented in Appendix VD. It is evident that the coefficients of lagged price are hardly significant, the exception being the jute crop and pulses (motor variety in Pabna and Faridpur regions).[12] No evidence of the formation of farmer's price expectation, naive or otherwise, could, therefore, be established in our data set.

The estimated coefficient of the time trend variable, on the other hand, were found to be highly significant in almost all the cases. Our measure of price change variability as captured in the regression residuals, $\hat{v}_{it}$ should thus be viewed as random flactuations around the trend values over a given time period.[13] Based on these estimates of price disturbances, the following set of variance-covariance matrices were computed for the relevant crop portfolio in each of our four sampling regions.

Table 5.20A

Estimated Variance-Covariance Matrices for Sylhet Region

(Price Disturbances)

	Local Aus	Local Aman
Local Aus	.068	.077
Local Aman	.077	.103

Table 5.20B

Estimated Variance-Covariance Matrices for Pabna Region

(Price Disturbances)

	Local Aus	Local Aman	Jute	Pulses(K)	Pulses(M)	Oilseeds
Local Aus	.070	.072	.030	.058	.042	.067
Local Aman	.072	.087	.015	.059	.030	.074
Jute	.030	.015	.099	.037	.095	.057
Pulses(K)	.058	.059	.037	.129	.101	.110
Pulses(M)	.042	.030	.095	.101	.174	.089
Oilseeds	.067	.074	.057	.110	.089	.122

Table 5.20C

Estimated Variance-Covariance Matrix for Faridpur Region

(Price Disturbances)

	Local Aus	Local Aman	Jute	Pulses(K)	Pulses(M)
Local Aus	.072	.071	.030	.070	.037
Local Aman	.071	.082	.011	.081	.025
Jute	.030	.011	.099	.027	.097
Pulses(K)	.070	.081	.027	.141	.095
Pulses(M)	.037	.025	.097	.095	.166

Table 5.20D

Estimated Variance-Covariance Matrix for Mymensingh Region

(Price Disturbances)

	Local Aman	Jute	IRRI boro
Local Aman	.087	.022	.071
Jute	.022	.099	.011
IRRI boro	.071	.011	.071

Based on these estimated matrices of variance and covariances of price disturbances for different crops, we may make the following observations:

a) Ranking of crops in terms of the estimated variances of price disturbances (average in four regions) shows that now pulses (.153) occupies the top position, followed by oilseeds (.122), jute (.099), aman rice (.090), IRRI boro (.071) and aus rice (.070). This may give some idea of the relative 'price riskiness' of different crops in Bangladesh. It is significant to note that pulses and oilseeds which were ranked in the bottom in terms of output disturbances occupy top two positions, in terms of variability of price disturbances.

b) The magnitudes of estimated variances (also covariances) of price disturbances are observed to be much higher compared to those of output disturbances. This is true for all crops in the four sampling regions. Therefore, 'price risk' of different crops in Bangladesh is observed to be much greater than the 'yield risk' in our study.

c) Unlike output disturbances, all the estimated covariance terms of different crop-pairs for price disturbances record positive values in each region. Since the magnitudes of covariances associated with price disturbances are much greater than those associated with output disturbances, this means that the sign of income covariances will be for the most part dictated by the positive values of price covariances.

Even though farmers are interested in the variability of crop returns (and not simply output or price variability) and ultimately in the variability of returns from a particular crop portfolio, some preliminary observations about the riskiness of output and price of various crops across different regions may be made based on these estimated variance-covariance matrices.[14] To do so, however, it becomes necessary to rearrange the information contained in these matrices to reflect the relative variability of output and prices in different regions. This is done below in Table 5.21 and Table 5.22 respectively.

Table 5.21

Relative Output Variability of Different Crops in Various Regions in Bangladesh.

Regions	Crops						
	Aus Rice	Aman Rice	Jute	Pulses	Oilseeds	Wheat	IRRI Boro
(a) Sylhet	.012 (10.96%)	.077 (8.45%)	-	-	-	-	-
(b) Pabna	.034 (18.13%)	.029 (16.81%)	.040 (19.94%)	.006 (7.61%)	.006 (7.93%)	-	-
(c) Faridpur	.009 (9.65%)	.026 (15.96%)	.023 (15.20%)	.006 (7.70%)	-	.033 (17.88%)	-
(d) Mymensingh	-	.013 (10.59%)	.030 (17.00%)	-	-	-	.016 (12.43%)

Note: The figures in the parentheses indicate coefficient of variation of random components of output for each crop in different regions.

i) It is evident from Table 5.21 that the relative variability as captured in the coefficients of variation of two varieties of rice, namely aus and aman (the former harvested in summer season and the latter, in winter) is very similar in both Sylhet and Pabna regions. Only in Mymensingh does aman show greater variability as compared to the aus rice.

ii) The output variability of jute crop, on the other hand, is slightly higher compared to both aus and aman rice in Pabna. In Faridpur, the output variability of jute, though very much comparable to aman, is decidedly higher than that estimated for aus rice, its competing crop in the summer season. In Mymensingh region, again, the variability of jute is recorded to be much higher as compared to aman rice. Unfortunately, however, we do not have any estimate for the output variability of aus in Mymensingh, with which to make a more meaningful comparison with jute.

iii) The output variability of pulses is the lowest compared to all three other crops in both Pabna and Faridpur regions. Such is the case with oilseeds in Pabna region.

Wheat, the other winter crop has, rather surprisingly, a relatively greater output variability in Faridpur region, while the estimated coefficients for IRRI boro, a high yielding variety of rice also harvested in winter, records a lower value as compared to jute crop in Mymensingh.

Table 5.22

Relative Price Variability of Different Crops in Various Regions in Bangladesh.

Region	Crops					
	Aus Rice	Aman Rice	Jute	Pulses	Oilseeds	IRRI Boro
(a) Sylhet	.093 (29.39%)	.227 (44.85%)	-	-	-	-
(b) Pabna	.109 (31.78%)	.204 (42.88%)	.192 (41.46%)	.190(40.96%) .329(52.45%)	.167 (38.47%)	-
(c) Faridpur	.113 (32.34%)	.167 (38.98%)	" (")	.192(40.56%) .329(52.45%)	-	-
(d) Mymensingh		.158 (37.97%)	" (")	-	-	.110 (31.92%)

Note: The figures in parentheses indicate the coefficient of variation of random components of price for each crop in different regions.

i) It is quite evident from Table 5.22 that the estimates of price variability of aman rice are larger as compared to aus rice in all three regions, namely Sylhet, Pabna and Faridpur where such comparisons could be made. The price variability of jute crop, on the other hand, though very much comparable to that of aman rice, is observed to be much higher, in both Pabna and Faridpur regions, than that recorded for aus rice, its competing crop in the summer season. This may have some implicatons for acreage decisions for food vis-a-vis cash crop for the small-holding farms in Bangladesh in so far as the relative price variability of the two crops affect their allocation decisions.

ii) The two varieties of pulses, namely khesari and motor show considerable variation in their estimates of price variability, the latter variety displaying greater variability in both Pabna and Faridpur regions. Also, this variety is observed to show a degree of price variability which is much higher compared to all other crops in these regions. The estimate of the price variability of oilseeds in Pabna, on the other hand, is very much comparable to those obtained for all crops except of course, motor pulse and aus rice in the region. The estimate of price variability for IRRI boro is the lowest among all three crops recorded in Mymensingh region.

iii) As observed earlier, the estimates of price variability of different crops are much higher in each of the four regions studied. Also, for each crop, the degree of variability seems to be more uniform across the four regions for price disturbances as compared to output disturbances.

Admittedly, our estimates of output variability contain some downward bias introduced by the use of aggregate (time series) data which tend to underestimate year to year variability in farmer's yields. However, this may not account for such a large differential in the estimates of variability between these two types of disturbances. It may be more plausible to conclude that for the small farm households in Bangladesh, the relative riskiness of different crops as measured by their price variability is perhaps greater than those measured by their output variability.[15]

Before concluding this section, it may be mentioned here that in addition to the estimation of variance-covariance matrices of output and price disturbances separately, a third set of matrices were also estimated to take account of interdependencies between these two types of disturbances. While the former two sets of matrices would enable us to compute the variance-covariance matrices of joint distribution of output and price disturbances, i.e., combined disturbances affecting farmer's income under the assumption of stochastic independence between output and price disturbance, the estimation of the latter set i.e. covariance matrices involving these two types of disturbances becomes necessary to explore whether there exists any significant interdependencies between them. If there is evidence of dependencies between output and price disturbances in our sample, then these estimates of covariance are to be used subsequently to compute the variance-covariance matrices of disturbances affecting farmer's income. The procedures adopted in this study to compute the variance-covariance matrices under both set of assumptions and the resulting set of estimates are discussed in the next chapter.

V.4 Summary and Conclusions

In this chapter, we described the methodology of estimation and then presented the resulting set of estimates of two basic components of our resource allocation model under risk developed earlier. These are:

(a) Cross section production function parameters

(b) Variance-covariance matrices of random disturbances associated with output and prices.

In the estimation of cross section production function of different crops using farm-level data collected earlier, both alternative regional specifications and functional forms were adequately explored. This essentially involved testing the validity of a variety of restrictions imposed on the coefficients of different regression equations. In the exploration of the regional nature of production functions in Bangladesh (i.e., whether data whould be pooled across regions, with or without regional dummies or whether production functions should be estimated for each region separately), our results indicate that for pulses and wheat crops, there was no evidence of any significant differences in the technical coefficients of production for these two crops across the four regions. However, for aus rice, aman rice and jute crops our study found evidence of statistically significant differences in the shift coefficients across four regions, though not in the slope coefficients. This, therefore, suggests that in estimating production functions for these crops data from all four regions be pooled and appropriate regional shift dummies be incorporated.

Although Cobb-Douglas form is generally used in estimating agricultural productions functions, we tested two alternative functional forms, namely transcendental and translog functions in this study. The results of our tests indicated that for most of the crops, namely aman rice, pulses, wheat, oilseeds, IRRI aus and IRRI boro, the Cobb-Douglas restrictions were validated in our sample. For aus rice, the translog form was found to be the most appropriate form in our study. For jute crop, however, our tests failed to produce any conclusive results as the Cobb-Douglas restrictions were rejected against both transcendental and translog functional forms.

An examination of our regression results shows that for most of the crops, the estimated coefficients of land and human labour had the expected (positive) signs and were statistically significant. The magnitudes of the coefficients (which under Cobb-Douglas specification also represent the respective input elasticities), however, vary considerably across crops, varying from as high as 1.00 for IRRI boro to .25 for pulses in case of land, and from .70 for oilseeds to .09 for aman rice in case of human labour. In the case of bullock labour and seed, while the estimated coefficients had the expected signs in most cases, they were seldom statistically significant. This may be attributed to the highly collinear relationship of these two inputs to land use in crop cultivation. The estimated coefficients of various 'minor' inputs such as fertilizer, pesticide, manure and irrigation in our study were seldom statistically significant, which may primarily be explained in terms of the very limited use of these purchased inputs among the small farm households in our sample.

The variance-covariance matrices of random disturbances associated with both output and prices of different crops were estimated in our study, in the absence of availability of farm-level time series on inputs and output, utilising the district level aggregate time series data in four sampling regions. The general procedure adopted was to extract the systematic portion of aggregate time series so that the residuals represented the estimates of random components from which the relevant variance-covariance matrices were subsequently computed.

In estimating the output disturbance of different crops, an aggregate production function of Cobb-Douglas variety incorporating both annual and monthly rainfall data was employed. However, although the coefficients of land and time trend variable were found to be highly significant in most cases, our exercise failed to capture the significance of rainfall variables in explaining the variations of aggregate output in any of the regions studied. Ranking of crops in terms of the estimated variances of output disturbances show that jute (.036) occupies the top position, followed by wheat (.034), aman rice (.025), aus rice (.019), IRRI boro (.017), oilseeds (.007) and pulses (.006). This gives some idea of the relative 'yield riskiness' of different crops in Bangladesh.

In estimating price disturbances of different crops using regional time series of grower's prices, a variant of a Nerlovian expectation model was used. No evidence of formation of farmer's price expectation, naive or otherwise, could be established in our data set, except in the case of jute and pulses. The estimated coefficients of the time trend variable, however, was found to be highly significant in almost all cases, implying that our estimates of price disturbances should be viewed as random fluctuations around the trend values over this period. Again, ranking of crops in terms of estimated variances of price disturbances showed that pulses (.153) occupies the top position, followed by oilseeds (.122), jute (.099), aman rice (.090), IRRI boro (.071) and aus rice (.070). This may give some idea of the relative 'price riskiness' of different crops in Bangladesh. It is significant to note that pulses and oilseeds which were ranked in the lowest categories in terms of 'yield riskiness' now occupies the top positions when ranking is done in terms of 'price riskiness'.

It is quite evident that the 'price risk' of different crops are greater than their 'yield risk' in four regions studied in Bangladesh. However, the relative riskiness of different crops should be studied not in terms of variances of output disturbances or price disturbances alone, but in terms of disturbances affecting farmer's income. This is a matter which will be taken up in the next chapter while estimating the risk factors associated with different crops in our study.

FOOTNOTES

1. We also tried some alternative estimating techniques, namely two-stage least squares to take care of the simultaneous equation bias inherent in direct OLS estimation of producation functions. However, our TSLS estimates did not show any improvement presumably because of lack of adequate number of instruments in our data set. An alternative approach involves the use of a profit function.

2. The first-order regression method works in two stages: at first, the coefficients are estimated by regressing bullock labour on crop acreage using the subset of observations on these variables in our sample. Subsequently, the (missing) observations are generated utilising these coefficients on the corresponding crop acreages. This, however, implies fixed proportionality between bullock labour and land inputs, which is later contradicted in the use of the Cobb-Douglas production function having unitary elasticity of substitution.

3. Our conclusions with regard to the regional nature of production function is strictly valid for the regions in which the survey was actually carried out. However, to the extent the selected regions were representative of the four broader ecological regions of Bangladesh, the validity of our empirical exercise is more general than it would otherwise appear.

4. Pooling of data across regions was not possible for crops like oilseeds, IRRI aus and IRRI boro since data were available only for a single region for each of these three crops.

5. Also, in our study, we tested for one of the stylised facts concerning the nature of technology in peasant agriculture - the important assumption of constant returns to scale. Our test results showed that the restrictions imposed by the CRS could not be rejected for any of the crops studied in our sample.

6. In the Cobb-Douglas function estimated in log-linear form, the regression coefficients, α_{ij}, represent the respective input elasticities.

7. One plausible explanation of this lies in the locational disadvantage of the farms occupying relatively low-lying areas. These farms are more prone to crop damage due to floods which is a recurring phenomenon in Bangladesh.

8. One way of capturing this interrelationship between the seasonality of labour demand and productivity is to expand our sample to include larger farm households as well. This will ensure both greater proportion of hired labour in total labour use and more importantly allow greater variation in the use of this input across the sample.

8. (Cont) However, a more rigorous analysis of the seasonality of labour productivity requires further decomposition of labour input by types of agricultural operations performed e.g., sowing, land preparation, transplanting, harvesting etc. A study carried out along this line by Ahmed (1981) indicated that different crops in Bangladesh are characterised by different 'peak seasons' of labour demand - harvesting in aus rice, transplanting in aman rice and harvesting in boro crop. One obviously would expect to find positive and highly significant coefficients of labour input in these peak periods.

9. Ideally, the exercise should be carried out in three stages, incorporating the testing of translog form against transcendental as well. However, to the extent that these two functional forms are not 'nested' such a testing would involve a rather complicated exercise. Moreover in our study, as will be shown later, such a need fortunately did not arise except in one case.

10. Some of the weaknesses associated with this approach are:
(a) Aggregate regional data tend to underestimate year to year variability in farmer's fields.
(b) Farm households' preceived variability of output (subjective probability distribution of yields) may be quite different from the one captured in the regression residuals representing an objective probability distribution of yields.

11. This is also confirmed by our Factor Analysis where no evidence of any significant interrelationship among crop output and acreage on one hand, and the rainfall data, either in annual or monthly form, on the other, were found in our data set.

12. As no regional breakdown of time series of prices were available for jute crops, the regressions were run for Bangladesh as a whole, though covering a longer time period.

13. Admittedly, price change variability represents a crude measure of price uncertainty and a more sophisticated analysis might contain an explicit model of formations of price expectations based on the stochastic properties of the time series (B. Klein, 1978).

14. This is because their actual acreage choice among different crops would depend, among others, on the relationship between expected return and the variability of returns of alternative crop portfolios.

15. As emphasized earlier, what is important for analysing acreage decisions of the farm households under uncertainty is neither output nor price variability separately but the variability of farmers income from different crops or more significantly, of alternative crop portfolios relative to their expected as well as disaster level of incomes.

CHAPTER VI

MEASUREMENT OF RISK COEFFICIENTS AND RISK FACTORS

VI.1 Introduction

In the last chapter, we discussed the estimation of cross section production function parameters as well as those of variance-covariance matrices of output and price disturbances of different crops in each of our four sampling regions in Bangladesh. However, for statistical testing of the hypotheses involving resource-use efficiency, what we need are the estimates of 'risk factors' (ϕ_{Q_i}) associated with different crops for the farm households in each region. Also, it is necessary to estimate the 'risk coefficients' (Ψ_K) in order to analyse peasant behaviour towards risk in subsistence farming as in Bangladesh. In Section 2, therefore, we discuss the estimation of various components subsequently used in computing both the risk factors and the risk coefficients capturing peasant behaviour towards risk for the small farm households in Bangladesh. This involves estimation of (a) variance-covariance matrices of disturbances affecting farmer's income, (b) disaster income levels of the farm households and (c) mean and variance of crop portfolio for each farm household in the four sampling regions.

Section 3 analyses in terms of the estimated risk coefficients (Ψ_K), differential peasant behaviour towards risk across different regions and more importantly, across farm households in Bangladesh. Section 4 presents the estimates of risk factors (ϕ_{Q_i}) which capture the effect of risk in factor allocations for different crops in four sampling regions in Bangladesh. The main results are summarised and some concluding observations are made in Section 5.

VI.2 Estimation of Different Components of Risk Coefficients (Ψ_K) and Risk Factors (Φ_{Q_i}) of Different Crops in Each Region

The estimation of the risk factors as well as the coefficients capturing peasant behaviour towards risk involves, among others, the estimation of the following:-

(a) An estimation of the variance-covariance matrices of the random disturbances affecting farmer's income, which in turn are based on the variance-covariance matrices of random disturbances associated with output and prices respectively.

(b) An estimation of the 'disaster level of income' for different farm households in each region.

(c) An estimation of the mean and variance of net income for different farm households in each region.

The methodology of estimation and the resulting set of estimates for each of these three categories is discussed below in greater detail.

VI.2.1 Estimation of Variance-Covariance Matrices of Disturbances Affecting Farmer's Income

In the last chapter, we described the estimated set of variance-covariance matrices of both output and price disturbances for various crops in each sampling region. To compute the risk coefficients and risk factors, however, it is necessary to combine these estimates in order to derive the variance-covariance matrices of the joint disturbances affecting income of the farm households in each region. And the way one can combine these separate matrices of output and price disturbances depend on the assumed interrelationship between these two types of disturbances. If the output and price disturbances are stochastically independent from each other then the resulting set of matrices will be different from those computed if interdependencies exist. The procedures for computing the alternate set of variance-covariance matrices are described below.

(i) Variance-Covariance Matrices of Disturbances affecting Farmer's Income under the Assumption of Stochastic Independence between Output and Price Disturbances

Following the statistical properties of the products of two independent random variables (Goodman, 1960), the variance and covariance of the product of output and price disturbances are given by

$$\sigma^2_{u_i v_i} = \text{var}(u_i)\ \text{var}(v_i) + \text{var}(u_i)\ E(v_i)^2 + \text{var}(v_i)\ E(u_i)^2 \qquad (6.1)$$

$$\sigma_{ij} = \text{cov}(u_i u_j)\ E(v_i)\ E(v_j) + \text{cov}(v_i v_j)\ E(u_i)\ E(u_j) + \text{cov}(u_i u_j)\ \text{cov}(v_i v_j) \qquad (6.2)$$

where $\sigma^2_{u_i v_i}$ represents the variance of product of output and price disturbances, i.e., the disturbances affecting farmer's income from crop i and σ_{ij} represents the covariance of product of output and price disturbance, i.e., disturbances affecting farmer's income from crop i and crop j.

Using these expressions for variance and covariances, and the set of matrices of output and price disturbances estimated earlier, the variance-covariance matrices of disturbances affecting farmer's income were computed for different crops in each sampling region. The estimated set of matrices are presented in Table 6.1A through Table 6.1D. It may be mentioned here that since we estimated two sets of matrices of output disturbances - one incorporating the rainfall data and the other without, in the estimating equation for generating output disturbances - we have thus computed two sets of matrices of disturbances affecting farmer's income as well.

Table 6.1A

Estimated Variance-Covariance Matrix for Sylhet Region

(Income Disturbances)

	Set I		Set II	
	Local Aus	Local Aman	Local Aus	Local Aman
Local Aus	.120	.135	.108	.139
Local Aman	.135	.263	.139	.239

Note: Set I is based on output disturbances that were estimated incorporating the rainfall variables in the regression equations, while Set II is based on output disturbances estimated without incorporating rainfall variables.

Table 6.1B

Estimated Variance-Covariance Matrix for Pabna Region

(Income Disturbances)

Set I

	Local Aus	Local Aman	Jute	Pulses (K)	Pulses (M)	Oilseeds
Local Aus	.156	.163	.054	.086	.039	.139
Local Aman	.163	.256	.024	.120	.017	.104
Jute	.054	.024	.252	.009	.211	.056
Pulses (K)	.086	.120	.009	.245	.090	.127
Pulses (M)	.039	.017	.211	.090	.331	.093
Oilseeds	.139	.104	.056	.127	.093	.187

Set II

	Local Aus	Local Aman	Jute	Pulses (K)	Pulses (M)	Oilseeds
Local Aus	.158	.161	.051	.093	.040	.103
Local Aman	.161	.261	.025	.120	.017	.146
Jute	.051	.025	.264	.008	.007	.056
Pulses (K)	.093	.120	.008	.204	.090	.128
Pulses (M)	.040	.017	.007	.090	.411	.094
Oilseeds	.103	.146	.056	.128	.094	.180

Table 6.1C

Estimated Variance-Covariance Matrix for Faridpur Region

(Income Disturbances)

Set I

	Local Aus	Local Aman	Jute	Pulses (K)	Pulses (M)
Local Aus	.126	.129	.035	.102	.035
Local Aman	.129	.209	.008	.131	.009
Jute	.035	.008	.205	.014	.223
Pulses (K)	.102	.131	.014	.228	.087
Pulses (M)	.035	.009	.223	.087	.335

Set II

	Local Aus	Local Aman	Jute	Pulses (K)	Pulses (M)
Local Aus	.134	.127	.034	.102	.035
Local Aman	.127	.204	.010	.136	.009
Jute	.034	.010	.227	.016	.222
Pulses (K)	.102	.136	.016	.201	.087
Pulses (M)	.035	.009	.222	.087	.340

Table 6.1D

Estimated Variance-Covariance Matrix for Mymensingh Region

(Income Disturbances)

Set I

	Local Aman	Jute	IRRI Boro
Local Aman	.176	.017	.124
Jute	.017	.238	.008
IRRI Boro	.124	.004	.130

Set II

	Local Aman	Jute	IRRI Boro
Local Aman	.176	.018	.122
Jute	.018	.237	.002
IRRI Boro	.122	.002	.131

Note: Set I is based on output disturbances that were estimated incorporating the rainfall variables in the regression equations, while Set II is based on output disturbances estimated without incorporating rainfall variables.

The following observations can be made based on these income variances and covariances of different crops in each sampling region.

(a) Ranking of crops in terms of estimated income variances (average of different regions) show that pulses (.285) occupies the top position followed by jute (.238), aman rice (.226), oilseeds (.187), aus rice (.134) and IRRI boro (.131). This gives some idea of relative riskiness of different crops in Bangladesh.

(b) The estimated income covariances for all pair of crops in each region record positive values. This is what we expected in view of the fact that all our estimates of price covariances are positive and also, greater in magnitudes than those of output covariances, some of which, as we observed earlier, came out with negative values. The fact that our estimates of income covariances are all positive implies that the marginal income riskiness of production for all crops $[\partial\sigma_r^2/\partial E(Q_i)]$ is positive, which in turn ensures that $\phi_{Q_i} \gtrless 1$ as $\Psi \lessgtr 0$, i.e., as $\bar{d} \lessgtr \mu_r$.

(c) Since the alternative sets of matrices of output disturbances – one incorporating the rainfall variables (Set I), and the other (Set II), without – did not show much variation, the corresponding set of matrices of income disturbances also reveal only marginal differences. This is also reflected in the ranking of crops which remain invariant in terms of either set of income variances.

(ii) Variance-Covariance Matrices of Disturbances affecting Farmer's Income incorporating Interdependencies between Output and Price Disturbances

Our second set of variance-covariance matrices of disturbances affecting farmer's income do not assume any stochastic independence between output and price disturbances, but are based on the calculated covariances between these two types of disturbances. Following the statistical properties of the product of two dependent random variables (Goodman, 1960), the expressions for variance and covariance in this case is given by:

$$\sigma^2_{u_i v_i} = var(u_i)\ var(v_i) + var(u_i)\ E(v_i)^2 + var(v_i)\ E(u_i)^2 + 2cov(u_i v_i)\ E(u_i)\ E(v_i) + cov(u_i v_i)^2 \quad (6.3)$$

$$\sigma_{ij} = E(u_i v_i u_j v_j) - cov(u_i v_i)\ cov(u_j v_j) - cov(u_i v_i)\ E(u_j)\ E(v_j) - cov(u_j v_j)\ E(u_i)\ E(v_i) - E(u_i)\ E(v_i)\ E(u_j)\ E(v_j) \quad (6.4)$$

It is clear from the above expressions for $\sigma^2_{u_i v_i}$ and σ_{ij} that to compute these variance and covariances we need, in addition to the estimates of variance-covariance matrices of output and price disturbances, the covariance matrices between output and price disturbances as well. These matrices are estimated and presented below for four sampling regions in Table 6.2A through Table 6.2D respectively. And finally, based on these matrices, in addition to those estimated earlier involving output and price disturbances separately, the variance-covariance matrices of disturbances affecting farmer's income taking into consideration the interrelationship between output and price disturbances are estimated for various crops in each region and presented in Table 6.3A through Table 6.3D.[1]

Table 6.2A

Estimated Covariance Matrix for Sylhet Region

(Between output and price disturbances)

	Set I		Set II	
	Local Aus	Local Aman	Local Aus	Local Aman
Local Aus	.027	.083	.024	.027
Local Aman	-.004	-.004	.001	-.004

Note: Set I is based on output disturbances that were estimated incorporating the rainfall variables in the regression equations, while Set II is based on output disturbances estimated without incorporating rainfall variables.

Table 6.2B

Estimated Covariance Matrix for Pabna Region

(Between output and price disturbances)

Set I

	Local Aus	Local Aman	Jute	Pulses (K)	Pulses (M)	Oilseeds
Local Aus	-.001	-.013	.053	-.019	.038	.005
Local Aman	.014	.008	.026	.018	.021	.020
Jute	-.015	-.024	.016	-.029	.004	-.022
Pulses	-.016	-.018	-.030	-.012	-.033	-.022
Oilseeds	.001	.001	.0001	.002	.0004	-.022

Set II

	Local Aus	Local Aman	Jute	Pulses (K)	Pulses (M)	Oilseeds
Local Aus	-.004	-.016	.047	-.028	.029	-.002
Local Aman	.017	.012	.033	.027	.034	-.027
Jute	-.015	-.024	.016	-.029	.004	-.022
Pulses	-.016	-.018	-.030	-.012	-.033	-.022
Oilseeds	.001	.0003	-.022	.011	-.022	-.044

Table 6.2C

Estimated Covariance Matrix for Faridpur Region

(Between output and price disturbances)

Set I

	Local Aus	Local Aman	Jute	Pulses (K)	Pulses (M)
Local Aus	-.003	-.003	-.009	-.007	-.017
Local Aman	-.010	-.015	.015	-.005	.021
Jute	-.021	-.026	-.010	-.024	-.021
Pulses	-.006	-.007	.009	.002	.016
Oilseeds	-.002	-.006	-.010	-.019	-.023

Set II

	Local Aus	Local Aman	Jute	Pulses (K)	Pulses (M)
Local Aus	-.004	-.003	-.013	-.006	.021
Local Aman	-.010	-.015	.014	-.006	.020
Jute	-.017	-.021	-.005	-.023	-.016
Pulses (K)	-.006	-.006	.009	.003	.016
Oilseeds	-.004	-.010	-.009	.022	-.023

Table 6.2D

Estimated Covariance Matrix for Mymensingh Region

(Between output and price disturbances)

	Set I			Set II		
	Local Aman	Jute	IRRI Boro	Local Aman	Jute	IRRI Boro
Local Aman	.0003	-.001	-.001	-.001	.005	-.003
Jute	-.011	.028	-.011	-.019	.020	-.016
IRRI Boro	-.013	-.004	-.012	-.014	-.007	-.014

It is quite evident from these estimates of covariances between output and price disturbances that although the magnitudes of these estimates are rather small in most cases, for the most part they have negative signs which conforms to _a priori_ expectations for _own_ covariances (i.e. covariance between output and price disturbances of a particular crop). For _cross_ covariances (i.e. covariances between output disturbance of one crop and price disturbance of another crop), however, no such definite statement can be made since their signs, for any pair of crops, will depend on the substitutability/complementarity relationship both on the supply and demand sides.

Table 6.3A

Estimated Variance-Covariance Matrix for Sylhet

(Income Disturbances)

	Set I		Set II	
	Local Aus	Local Aman	Local Aus	Local Aman
Local Aus	.218	.182	.199	.194
Local Aman	.182	.247	.194	.230

Note: Set I is based on output disturbances that were estimated incorporating the rainfall variables in the regression equations, while Set II is based on output disturbances estimated without incorporating rainfall variables.

Table 6.3B

Estimated Variance-Covariance Matrix for Pabna

(Income Disturbances)

Set I

	Local Aus	Local Aman	Jute	Pulses (K)	Pulses (M)	Oilseeds
Local Aus	.133	.137	.099	.049	.052	.114
Local Aman	.137	.265	.009	.118	.013	.181
Jute	.099	.009	.347	-.049	.200	.048
Pulses (K)	.049	.118	-.049	.185	.068	.108
Pulses (M)	.052	.013	.200	.068	.179	.075
Oilseeds	.114	.181	.048	.108	.075	.179

Table 6.3B (contd.)

Set II

	Local Aus	Local Aman	Jute	Pulses (K)	Pulses (M)	Oilseeds
Local Aus	.118	.139	.092	.041	.045	.105
Local Aman	.139	.278	.016	.128	.023	.190
Jute	.092	.016	.344	-.050	.198	.045
Pulses (K)	.041	.128	-.050	.198	.068	.108
Pulses (M)	.045	.023	.198	.068	.219	.075
Oilseeds	.105	.190	.045	.108	.075	.177

Table 6.3C

Estimated Variance-Covariance Matrix for Faridpur

(Income Disturbances)

Set I

	Local Aus	Local Aman	Jute	Pulses (K)	Pulses (M)
Local Aus	.117	.116	.004	.090	.008
Local Aman	.116	.149	-.004	.125	.016
Jute	.004	-.004	.238	-.006	.245
Pulses (K)	.090	.125	-.006	.232	.124
Pulses (M)	.008	.016	.245	.124	.425

Table 6.3C (contd.)

Set II

	Local Aus	Local Aman	Jute	Pulses (K)	Pulses (M)
Local Aus	.116	.116	.002	.092	.004
Local Aman	.116	.149	-.001	.125	.016
Jute	.002	-.001	.245	-.003	.253
Pulses (K)	.092	.125	-.003	.235	.125
Pulses (M)	.004	.016	.253	.125	.425

Table 6.3D

Estimated Variance-Covariance Matrix for Mymensingh

(Income Disturbances)

	Set I			Set II		
	Local Aman	Jute	IRRI Boro	Local Aman	Jute	IRRI Boro
Local Aman	.203	.002	.108	.193	.002	.105
Jute	.002	.362	-.015	.002	.327	-.020
IRRI Boro	.108	-.015	.091	.105	-.020	.088

Note: Set I is based on output disturbances that were estimated incorporating the rainfall variables in the regression equations while Set II is based on output disturbances estimated without incorporating rainfall variables.

Based on these estimates of variances and covariances of disturbances affecting farmer's income in four regions, we may make the following observations:

(a) Ranking of crops in terms of estimated income variance (average of different region) shows that jute (.316) now occupies the top position, followed by pulses (.256), aman rice (.216), oilseeds (.177), aus rice (.156) and IRRI boro (.091). This, therefore, implies that the relative riskiness of different crops does not change except for jute and pulses which switch positions, under the alternative set of assumptions concerning the interrelationship among output and price disturbances.

(b) Even with incorporation of interdependencies between output and price disturbances, only four out of twenty-seven estimates of income covariances in our study record negative values for different crop-pairs in four regions. This is mainly because, as observed earlier, although most of the estimated covariances between output and price disturbances are negative, their magnitudes are too small to affect the sign of estimates of income covariances in all but four cases.

(c) As expected, the two sets of matrices of income disturbances (I and II) - one that incorporates the rainfall variables and the other, does not - show only marginal differences in their estimates.

(d) A comparison between two sets of matrices - with and without the assumption of stochastic independence between output and price disturbances - shows that although the latter set of matrices record higher values for the estimates of variance and covariances, this differential may not be significant enough to result in substantial differences in the computation of risk factors and/or risk coefficients based on these matrices. In fact, our exercise of testing the significance of correlation coefficients of output and price disturbances for every pair of crops in each region shows that most of these estimated coefficients are not significantly different from zero even at the 5% level. This explains why the variance-covariance matrices estimated incorporating the interdependencies between output and price disturbances do not differ appreciably from those estimated under the assumption of stochastic independence between these two types of disturbances.

As in the last chapter, we will examine below the relative riskiness of different crops in terms of their relative income variability computed under both sets of assumptions.[2] To do so, however, it becomes necessary to rearrange the information contained in these matrices to reflect the income variability of different crops as done in Table 6.4 and Table 6.5. The following observations may be made based on these estimates.

(i) It is evident from Table 6.4 that the variability of aman rice is much greater than that of aus rice in all three regions where such comparisons could be made. The degree of divergence, however, varies from region to region.

(ii) The income variability of jute crop in Pabna region is very close to that of aman rice and therefore, is high relative to aus rice, its competing crop in the summer season. In Faridpur and Mymensingh regions, however, the variability of jute income is greater than that of aman rice, although this is less pronounced in case of Faridpur. This incidentally makes jute income variability in Faridpur relative to aus rice comparable to that obtained in Pabna region.

(iii) The greater price variability of 'motor' pulses relative to the

Table 6.4

Relative Income Variability(I) of Different Crops in Four Regions in Bangladesh

Regions	Crops					
	Local Aus	Local Aman	Jute	Pulses	Oilseeds	IRRI Boro
(a) Sylhet	.108 (31.57%)	.239 (45.89%)	-	-	-	-
(b) Pabna	.158 (37.69%)	.261 (47.81%)	.264 (47.76%)	(a) .204 (42.07%) (b) .411 (58.34%)	.180 (39.84%)	-
(c) Faridpur	.134 (35.10%)	.204 (42.58%)	.227 (44.52%)	(a) .201 (41.76%) (b) .340 (53.18%)	-	-
(d) Mymensingh	-	.176 (39.76%)	.237 (45.35%)	-	-	.131 (34.61%)

Note: The figures in parentheses represent the coefficients of variation of random disturbances affecting farmer's income, assuming that output and price disturbances are stochastically independent. Also, (a) represents 'khesari' variety of pulses and (b) represents 'motor' variety.

Table 6.5

Relative Income Variability(II) of Different Crops in Four Regions in Bangladesh

Regions	Crops					
	Local Aus	Local Aman	Jute	Pulses	Oilseeds	IRRI Boro
(a) Sylhet	.199 (41.66%)	.230 (44.93%)	-	-	-	-
(b) Pabna	.118 (32.76%)	.278 (47.87%)	.344 (53.93%)	(a) .185 (40.35%) (b) .219 (43.52%)	.177 (39.31%)	-
(c) Faridpur	.116 (32.78%)	.149 (36.90%)	.245 (46.47%)	(a) .235 (45.03%) (b) .425 (58.60%)	-	-
(d) Mymensingh	-	.193 (41.70%)	.327 (52.30%)	-	-	.088 (28.75%)

Note: The figures in parentheses represent the coefficients of variation of random disturbances affecting farmer's income, taking into consideration the interdependencies that may exist between output and price disturbances. Also, (a) represents 'khesari' variety of pulses and (b) represents 'motor' variety.

'khesary' variety is also reflected in the estimates of relative income variability in both Pabna and Faridpur regions.

The income variability of oilseeds in Pabna region is greater than the variability of aus rice but lower than the variability of all three other crops grown in this region. The same is true for IRRI boro in Mymensingh region where the estimate of income variability of this crop is low as compared to both aman and aus rice.

(iv) A look at the estimates recorded in Table 6.5 makes it readily evident that the picture of relative riskiness of different crops across different regions as measured by their income variability depicted above remains very much the same when one considers the estimates which incorporate the interdependencies between output and price disturbances. This is not surprising in view of the lack of significant evidence of correlation between these two types of disturbances among the crops grown in our sampling region.

VI.2.2 Estimation of 'Disaster Level of Income' for Different Farm Households in Each Region

In a safety-first model of farmer behaviour, the disaster level of income is usually associated with that income below which the decision-maker (i.e., the farm family) faces either bankcruptcy or starvation or the discomfort of adjusting to a significantly lower standard of living. It needs to be emphasized here that it is the farm family's evaluation of the level of disaster income which should ideally be incorporated for the empirical testing of the hypotheses embodied in the models designed to analyse the farm family's decision-making behaviour. In other words, it is what the farm family feels or thinks their disaster income is that matters. Therefore, the level of incomes reported by the farm households in the field survey as their disaster incomes ideally should be used in our empirical study.

However, the information obtained from the sample survey may not accurately reflect what the farm family feels their disaster income is. This is because, first, in peasant societies with low educational background, it is often very difficult to convince the respondents of the purpose of the survey; in particular, it becomes very difficult to explain properly the nature and type of information required because of the communication gap that exists between the interviewer and interviewee. And secondly, even if the respondents properly understand the nature of the information requested, they may willfully hide facts if they suspect that they are going to benefit or lose something individually as a result of correct reporting. This may result in a tendency on the part of the farm households to bias their responses according to their expectations. For example, if they think that the government is contemplating the initiation of an action programme to support rural incomes in times of either partial or complete crop failure due to floods and cyclones, and if the level of such support provided by the government is considered to be based on the information regarding their disaster incomes as they report it, then there will be a natural tendency for the respondents to overreport their disaster incomes.

To provide a check against such biases, we propose to compute an alternative, 'objective' measure of the disaster income based on other information provided by the surveyed households and/or similar information collected from rural surveys conducted earlier. It should be emphasized here, however, that these objective estimates of disaster income are proposed for use as a substitute for estimates reported by the farm households in our field survey. The purpose for deriving these estimates is to provide an indication of the direction and magnitudes of biases in the reported disaster income series, and also, to test whether these biases are statistically significant or not. We may also check whether there exists any consistent bias between the objective measure and the respondent's subjective measure of disaster income.

If the difference between the two disaster income series does not happen to be statistically significant, it should not make any difference which series we use in the computation of risk factors to be subsequently employed in testing the hypotheses embodied in our safety-first model of resource allocation under risk. Alternatively, if there is evidence that the two disaster income series are significantly different from each other, then it is suggested that both series will be retained as alternative estimates of disaster incomes thereby serving as candidates for sensitivity analysis in our study.

Following Roumasset (1976), the disaster incomes will be computed here as $\overline{d}$ = MCN + UD - LA - OFI, where MCN represents the minimum consumption need of the farm family, UD represents urgent debt, LA is the resale value of the farm family's liquid assets and OFI represents off-farm income of the farm household.[3] MCN consists of two components: minimum consumption bundle of food items valued at current market prices (MFN) and other minimum consumption requirements (OMCR). MFN is based on the value of the minimum consumption bundle of food items normally consumed in the rural area in Bangladesh.[4] On the basis of 1978/79 prices, this figure comes out to be Taka 1209.00. The estimate of other minimum consumption requirements (OMCR) can be derived by multiplying the actual consumption of items other than foodgrains as reported in the field survey (OCR), by the parameter which is computed by dividing the MFN by the total actual foodgrain consumption in 1979 by the households (FC_{1979}).

In other words, OMCR = α_kOCR where α_k = MFN/FC_{1979}. Therefore, the disaster income series is computed as

$$CD_k = (\text{Tk. } 1209 \times FS_k) + \alpha_k OCR_k + UD_k - LA_k - OFI_k. \tag{6.5}$$

The disaster incomes thus computed are presented below along with the reported ones for each farm household in our four sampling regions in Table 6.6A through Table 6.6D.

Table 6.6A

Reported and Computed 'Disaster Incomes' for the Farm Households in Sylhet Region

(Taka)

Farm Household	Reported Income (RD_k)	Computed Income (CD_k)	Calculated Bias (RD_k-CD_k)
1	29000.00	18008.00	10992.00
2	500.00	979.00	-479.00
3	7295.00	6840.00	455.00
4	2500.00	3298.00	798.00
5	12200.00	8689.00	3511.00
6	n.a.	9711.00	-
7	9292.00	10710.00	-1418.00
8	5850.00	3789.00	2061.00
9	8230.00	6586.00	1644.00
10	11500.00	9630.00	1870.00
11	10250.00	6881.00	3369.00
12	6000.00	6932.00	-932.00
13	2520.00	2745.00	-225.00
14	8480.00	6491.00	1989.00
15	8400.00	7975.00	425.00
16	6350.00	6317.00	33.00
17	3350.00	5488.00	-2138.00

Table 6.6A (contd.)

Farm Household	Reported Income (RD_k)	Computed Income (CD_k)	Calculated Bias (RD_k-CD_k)
18	7632.00	5660.00	1972.00
19	3750.00	5080.00	-1330.00
20	1700.00	7005.00	-5305.00
21	5674.00	6605.00	-931.00
22	6300.00	9274.00	-2974.00
23	2400.00	5776.00	-3376.00
24	5580.00	3219.00	2361.00
25	-3400.00	-2054.00	-1346.00
26	-3500.00	-6758.00	3258.00
27	7200.00	8475.00	1275.00
28	5820.00	3748.00	2072.00
29	6050.00	1787.00	4263.00
30	7700.00	3888.00	3812.00
31	7500.00	5747.00	1753.00
32	4010.00	2123.00	1987.00
33	11410.00	9918.00	1492.00
34	9200.00	7634.00	1566.00
35	13900.00	11977.00	1923.00
36	-6700.00	1943.00	-8643.00
37	5086.00	5254.00	-168.00
38	9370.00	4846.00	4524.00
39	2200.00	4121.00	-1921.00
40	1100.00	1482.00	-382.00
41	11200.00	7137.00	4063.00
42	1900.00	2301.00	-401.00
43	4300.00	4925.00	-625.00
44	5170.00	2664.00	2506.00
45	2500.00	-3558.00	6058.00
46	3400.00	1544.00	1856.00
47	2520.00	6240.00	-3720.00
48	-3600.00	-258.00	-3342.00

Table 6.6B

Reported and Computed Disaster Incomes for the Farm Households in Pabna Region

(Taka)

Farm Household	Reported Income (RD_k)	Computed Income (CD_k)	Calculated Bias (RD_k-CD_k)
1	6840.00	5676.00	1164.00
2	1000.00	2886.00	-1886.00
3	220.00	1385.00	-1165.00
4	-1050.00	653.00	-1703.00
5	2790.00	6593.00	-3803.00
6	2920.00	4024.00	-1104.00
7	2850.00	3131.00	-281.00
8	2700.00	4070.00	-2270.00
9	1910.00	2356.00	-446.00
10	4000.00	3092.00	908.00
11	6200.00	5041.00	1159.00
12	8400.00	8445.00	-45.00
13	10000.00	6845.00	3155.00
14	6449.00	3765.00	2684.00
15	2950.00	2286.00	664.00
16	4000.00	5295.00	-1295.00
17	5780.00	4589.00	1191.00
18	3770.00	1840.00	1930.00
19	8200.00	8091.00	109.00
20	4360.00	2946.00	1414.00
21	6241.00	3496.00	2745.00
22	3880.00	1980.00	1900.00
23	5050.00	2676.00	2374.00
24	8200.00	6519.00	1681.00
25	4460.00	3974.00	486.00
26	7950.00	7621.00	1229.00
27	5700.00	3033.00	2667.00
28	5400.00	5854.00	-454.00
29	2870.00	3944.00	-1074.00
30	5680.00	5297.00	3383.00
31	2850.00	5755.00	-2905.00
32	8200.00	6004.00	2196.00
33	3880.00	5743.00	-1863.00
34	9640.00	7174.00	2466.00
35	7250.00	7298.00	-48.00
36	8410.00	5943.00	2467.00
37	5500.00	5288.00	212.00
38	9440.00	5852.00	3588.00
39	5560.00	3455.00	2105.00
40	-3720.00	-4540.00	820.00
41	8100.00	5626.00	2474.00

Table 6.6B (contd.)

Farm Household	Reported Income (RD_k)	Computed Income (CD_k)	Calculated Bias ($RD_k - CD_k$)
42	5090.00	2826.00	2264.00
43	13200.00	9711.00	3489.00
44	3600.00	3263.00	337.00
45	11651.00	8747.00	2904.00
46	3750.00	4370.00	-620.00

Table 6.6C

Reported and Computed 'Disaster Incomes' for the Farm Households in Faridpur Region

(Taka)

Farm Household	Reported Income (RD_k)	Computed Income (CD_k)	Calculated Bias ($RD_k - CD_k$)
1	6840.00	4064.00	2776.00
2	6040.00	3536.00	2504.00
3	2050.00	2680.00	-630.00
4	8010.00	4840.00	3170.00
5	2050.00	1710.00	340.00
6	5350.00	4563.00	787.00
7	3720.00	2948.00	772.00
8	5250.00	3195.00	2055.00
9	7700.00	3503.00	4197.00
10	4550.00	1727.00	2823.00
11	11600.00	7135.00	4465.00
12	7300.00	1306.00	5994.00
13	5200.00	2295.00	2905.00
14	5800.00	5889.00	-89.00
15	7180.00	5208.00	1972.00
16	4560.00	1162.00	3398.00
17	7680.00	4204.00	3476.00
18	-1900.00	2243.00	-4143.00
19	8450.00	2853.00	5597.00
20	1530.00	2251.00	-721.00
21	7750.00	7525.00	225.00
22	5750.00	3491.00	2269.00
23	4180.00	2454.00	1726.00
24	2350.00	n.a.	-
25	2150.00	849.00	1301.00
26	6340.00	3122.00	3218.00
27	2550.00	3686.00	-1136.00
28	7620.00	3804.00	3816.00
29	7820.00	4312.00	3508.00
30	11220.00	5623.00	5597.00
31	5580.00	3544.00	2036.00
32	6640.00	3799.00	2841.00
33	4510.00	2799.00	1711.00
34	4900.00	5836.00	-936.00
35	5310.00	2150.00	3160.00
36	10860.00	5851.00	5009.00
37	5599.00	3536.00	2063.00
38	6100.00	6580.00	-480.00
39	4760.00	6485.00	-1725.00
40	5120.00	5477.00	-357.00
41	5900.00	6585.00	-685.00
42	4780.00	7230.00	-2450.00

Table 6.6C (contd.)

Farm Household	Reported Income (RD_k)	Computed Income (CD_k)	Calculated Bias (RD_k-CD_k)
43	4480.00	4145.00	335.00
44	8180.00	5338.00	2842.00
45	7700.00	5684.00	2016.00
46	8620.00	7279.00	1341.00
47	10860.00	7985.00	2695.00
48	8200.00	6645.00	1555.00
49	7980.00	4527.00	3453.00
50	7700.00	5461.00	2239.00
51	4300.00	3795.00	505.00
52	11280.00	5236.00	6044.00
53	5300.00	4411.00	2719.00
54	6200.00	5417.00	783.00
55	2700.00	2445.00	255.00
56	4240.00	4394.00	-194.00
57	5630.00	2730.00	2910.00

Table 6.6D

Reported and Computed 'Disaster Incomes' for the Farm Households in Mymensingh Region

(Taka)

Farm Household	Reported Income (RD_k)	Computed Income (CD_k)	Calculated Bias (RD_k-CD_k)
1	1220.00	9325.00	2875.00
2	1220.00	2366.00	-1146.00
3	6650.00	5543.00	1107.00
4	3230.00	6839.00	-3609.00
5	5760.00	8555.00	-2795.00
6	6500.00	6905.00	-405.00
7	3540.00	2652.00	888.00
8	7250.00	4567.00	2683.00
9	8800.00	6326.00	2474.00
10	4480.00	3842.00	638.00
11	6180.00	492.00	5688.00
12	7600.00	4192.00	3408.00
13	6700.00	7817.00	-1117.00
14	n.a.	6143.00	–
15	4650.00	1965.00	2685.00
16	4000.00	2757.00	1243.00
17	2100.00	1908.00	192.00
18	n.a.	3560.00	–
19	3300.00	4348.00	-1048.00
20	1590.00	2506.00	-916.00
21	3900.00	2978.00	922.00
22	4720.00	7052.00	-2332.00
23	2040.00	2310.00	-270.00
24	1550.00	1917.00	-367.00
25	5550.00	4667.00	881.00
26	6900.00	5698.00	1202.00
27	10000.00	6713.00	3287.00
28	5450.00	6987.00	-1537.00
29	4880.00	4932.00	-52.00
30	3500.00	5556.00	-2056.00
31	3800.00	4960.00	-1160.00
32	6000.00	6420.00	-420.00
33	7900.00	1962.00	6038.00
34	3800.00	4289.00	-489.00
35	6300.00	5483.00	817.00
36	3880.00	3707.00	173.00
37	3850.00	4328.00	-478.00
38	2800.00	5883.00	-3083.00
39	4500.00	3464.00	1036.00
40	3400.00	3858.00	-458.00

Table 6.6D (contd.)

Farm Household	Reported Income (RD_k)	Computed Income (CD_k)	Calculated Bias ($RD_k - CD_k$)
41	5300.00	6271.00	-971.00
42	5600.00	7180.00	-1580.00
43	4000.00	57.00	3943.00
44	2310.00	4474.00	-2164.00
45	3200.00	3705.00	-505.00
46	1710.00	3272.00	-1562.00
47	8830.00	6592.00	2238.00
48	2600.00	-346.00	2946.00
49	3400.00	4140.00	-746.00
50	6950.00	5773.00	1177.00
51	5200.00	6039.00	-839.00

Our next task is to test whether the computed disaster incomes are significantly different from the disaster incomes as reported by the farm households in our field survey. This is tantamount to testing whether the expected positive bias in the reported disaster incomes is statistically significant (significantly different from zero) or not. This test was carried out in the following way.

We tested whether the two independent samples came from the same normal population. In other words, we tested the hypothesis of equality of the two population means based on two independent random samples of RD_k and CD_k with mean μ_{rd} and μ_{cd}, standard deviations s_{rd} and s_{cd}. To carry out the test, the t-statistic was computed as

$$t = \frac{(\mu_{rd} - \mu_{cd})}{S\sqrt{1/n_1 + 1/n_2}} \quad \text{with } (n_1 + n_2 - 2) \text{ degrees of freedom}$$

where

$$S = \sqrt{1/(n_1 + n_2 - 2)\ \{(n_1 - 1)s^2_{rd} + (n_2 - 1)s^2_{cd}\}}$$

The Null Hypothesis (H_0: $\mu_{rd} = \mu_{cd}$) was tested against the alternate Hypothesis (H_1: $\mu_{rd} \neq \mu_{cd}$). If our calculated t-statistic was greater than the t-statistic associated with a 1% level of significance with $(n_1 + n_2 - 2)$ degrees of freedom, then, we reject the Null Hypothesis of equality of the two sample means, and conclude that the two income series are significantly different from each other. Conversely, if our calculated t-statistic was less than the theoretical $t_{.01}$ with $(n_1 + n_2 - 2)$ degrees of freedom, we cannot reject the Null Hypothesis of equality of two sample means at 1% level of significance, and must conclude, therefore, that the difference between the two income series is not statistically significant.

Since our data are paired (i.e. $n_1 = n_2$), an alternative way of testing the same hypothesis is to compute the difference between the two disaster income series, and then, to test whether or not this difference is significantly different from zero. Our t-statistic in this case is

$$t = \frac{\mu_{\bar{d}}}{S/\sqrt{n}} \text{ with } (n - 1) \text{ degrees of freedom and}$$

where

$$\bar{d}_k = (RD_k - CD_k) \text{ and } S = \sqrt{1/(n-1)\, \Sigma\, (d_k - \bar{d})^2}$$

Our Null Hypothesis in this case is $\mu_{\bar{d}} = 0$ and is tested against the alternate hypothesis, $\mu_{\bar{d}} \neq 0$. Again, if our calculated $t > t_{.01}$ with $(n - 1)$ degrees of freedom, then we reject the Null Hypothesis of $\mu_{\bar{d}} = 0$, and conclude that the difference between the two income series is significantly different from zero i.e. the positive bias in the reported income series is statistically significant. On the other hand, if $t < t_{.01}$ we cannot then reject the Null Hypothesis, and conclude, therefore, that the difference between the two income series (or the positive bias in the reported income series) is not statistically significant.

The results of both these tests are presented below for our four sampling regions in Table 6.7.

Table 6.7

Computed and Theoretical Values of t-statistic in Four Regions

Regions	Computed Values of t		Theoretical Values of $t_{.01}$		Inference
	I test	II test	I test	II test	
a) Sylhet	.29	1.54	2.37	2.41	Both tests indicate that we cannot reject the Null Hypothesis.
b) Pabna	3.38	2.68	2.36	2.41	Both tests indicate that we reject the Null Hypothesis
c) Faridpur	4.45	6.39	2.36	2.38	Both tests indicate that we reject the Null Hypothesis
d) Mymensingh	.61	1.18	2.36	2.41	Both tests indicate that we cannot reject the Null Hypothesis

Thus, it is quite evident from test results presented in Table 6.7 that the disaster incomes as reported by the farm households are significantly different from the ones computed using a modified Roumasset (1976) formula in both Pabna and Faridpur regions. In these two regions, the upward bias in the reported income series is statistically significant and warrants this conclusion. It will be important therefore, to examine the extent to which our computation of risk coefficients as well as risk factors of different crops and farm households, and more importantly, the results of our hypotheses testing involving resource-use efficiency á la Roy's Safety Principle is sensitive to the particular disaster income series used. In case of Sylhet and Mymensingh regions, however, both our tests indicate that the difference between the two income series is not statistically significant even at the 5% level. This means that in these two regions, we would not expect our estimated risk coefficients/risk factors, and hence the results of our hypotheses testing to be sensitive to the choice of either set of estimates of disaster incomes.

VI.2.3 Estimation of Mean and Variance of Net Income for Different Farm Households in Each Region

In addition to estimation of variance-covariance matrices of disturbances affecting farmer's income and disaster levels of income, the computation of the risk coefficients as well as the risk factors of different crops for each farm household also requires the estimation of mean net income (μ_r) and variance of net income (σ_r^2) of crop portfolio for each farm household in four sampling regions. We discuss the estimating procedures and the resulting set of estimates for each one of these below.

(a) Estimation of Mean Net Income (μ_r) of the Farm Household

For a farm household producing n crops, its mean (expected) net income is estimated as[5]

$$\mu_r = \sum_i E(P_{Q_i}) E(Q_i) - \sum_k w_k X_k \qquad (6.6)$$

where $E(P_{Q_i})$ represents expected price of crop i

$E(Q_i)$ represents expected output of crop i

w_k represents the price of kth variable input

X_k represents the amount of kth input used.

In estimating expected output for each crop, the cross sectional crop damage data collected earlier in the field survey was suitably adjusted to conform to its average level using aggregate time series estimates of output disturbances. More specifically, expected output of ith crop for kth farm household is computed as

$$E(Q_{ik}) = \log Q_{ik} - \hat{\beta}_i \log(1 - CD_{ik}) - \log \hat{u}_i \qquad (6.7)$$

where $\hat{\beta}_i$ represents cross sectional regression coefficient of crop damage variable of ith crop

$\hat{u}_i$ represents estimate of output disturbance of the year in which the field survey was carried out[6].

Derivation of expected prices of different crops was comparatively easier in that district-level prices should not differ appreciable from farm-gate prices. Therefore, using aggregate time series regressions estimated earlier, the expected price for each crop in four regions was computed as the trend price corresponding to the year in which the field survey was carried out. In other words,

$$E(P_{Q_i}) = a_i + b_i \, T \qquad (6.8)$$

where a_i and b_i represent the estimated coefficients of time series regressions using district-level data, and T represents time trend.

Finally, the estimation of mean net income also required the expenditures on variable inputs used by each farm household in four regions. This was derived from the information collected in the field survey.

(b) Estimation of Variance of Net Income (σ_r^2) of Farm Household

For a farm household producing n crops, the variance of net income of its crop-portfolio is computed as

$$\sigma_r^2 = \Sigma E(P_{Q_i})^2 E(Q_i)^2 \sigma_{u_i v_i}^2 + \frac{1}{2} \underset{ij}{\Sigma\Sigma} 2E(P_{Q_i})E(P_{Q_j})E(Q_i)E(Q_j)\sigma_{ij} \qquad (6.9)$$

where $\sigma_{u_i v_i}^2$ represents the variance of disturbances affecting farmer's income from crop i, and

σ_{ij} represents the covariance of disturbances affecting farmer's income from crop i and crop j.

Therefore, the estimation of variance of net income of crop-portfolio for each farm household requires, in addition to the data needed for the computation of mean net income, the estimates of variance-covariance matrices of disturbances affecting farmer's income as well. It may be recalled here that we have two sets of such matrices, depending of the assumption we make about the relationship between output and price disturbances. Thus, we have two sets of estimates of variance of net incomes corresponding to these two sets of variance-covariance matrices - one which assumes that price and output disturbances are stochastically independent (I), and the other which incorporates the interdependencies between these two types of disturbances (II).

Based on the procedures outlined above in (a) and (b), and utilising the estimates of expected prices, expected outputs and those of variance-covariance matrices of different crops, the mean as well as variance of net income for each farm household were estimated in four sampling regions. The resulting set of estimates for each region are presented below in Table 6.8A to Table 6.8D.

Table 6.8A

Estimated Values of the Mean and Standard Deviation of Net Income for the Farm Households in Sylhet Region

(Taka)

Farm Household	Estimated Parameters (I)		Estimated Parameters (II)	
	Mean (μ_r)	S.D. (σ_r)	Mean (μ_r)	S.D. (σ_r)
1	9114.72	4021.55	9202.30	4406.93
2	4167.08	1839.30	4204.82	2004.96
3	3645.00	1677.17	3728.81	2057.52
4	5083.80	2819.66	5168.64	3198.32
5	3576.75	2496.93	3583.22	2524.17
6	8297.76	4126.49	8356.72	4381.55
7	8946.60	4238.26	9127.85	5058.07
8	1816.23	1495.61	1842.08	1608.29
9	2688.43	1753.90	2769.23	2120.06
10	9178.78	4554.69	9337.95	5269.61
11	3729.43	2657.06	3795.63	2950.09
12	5135.73	2685.06	5216.32	3044.74
13	5090.57	3231.40	5137.61	3435.03
14	6937.74	3567.24	6988.02	3784.66
15	2083.86	1161.43	2150.61	1464.36
16	2637.51	1691.91	2641.59	1709.07
17	1778.12	2093.24	1805.57	2211.68
18	1117.16	2344.61	1154.19	2505.40
19	2871.71	1905.58	2895.31	2007.17
20	3996.60	2065.12	4004.82	2099.76
21	3184.10	2176.24	3207.56	2276.81
22	2251.10	1709.42	2295.72	1907.32
23	2396.13	1701.81	2426.23	1833.11
24	3780.56	1990.60	3835.90	2236.72
25	1290.25	1463.64	1318.41	1586.90
26	1547.30	1719.06	1551.60	1737.15
27	5580.03	2845.53	5647.18	3142.06
28	2974.91	1864.09	3002.76	1948.78
29	3422.52	1775.20	3484.03	2051.39
30	5022.03	2478.76	5078.77	2729.00
31	3747.98	3031.02	3805.77	3283.87
32	7373.08	3675.76	7506.58	4276.30
33	1584.31	1462.89	1642.06	1723.44
34	3432.33	2071.06	2483.94	2294.90
35	17598.40	9169.04	17687.70	9551.06
36	896.30	944.14	904.54	979.25
37	3910.69	2050.90	3951.36	2229.13
38	3824.63	2777.90	3904.47	3133.54
39	6458.22	3492.88	6531.04	3812.69
40	3754.71	2068.22	3758.51	2084.21
41	9602.36	5395.34	9735.69	5985.26

Table 6.8A (contd.)

Farm Household	Estimated Parameters (I)		Estimated Parameters (II)	
	Mean (μ_r)	S.D. (σ_r)	Mean (μ_r)	S.D. (σ_r)
42	5527.39	2766.88	5642.54	3287.28
43	2889.16	2130.85	2935.93	2336.71
44	3630.70	1710.36	3686.76	1961.51
45	8343.51	4023.98	8413.35	4328.38
46	3232.42	1777.92	3371.00	2396.35
47	375.46	462.98	385.43	506.84
48	4042.42	2041.13	4091.72	2259.07

Note: The estimated parameters under (I) assume that the price and output disturbances are stochastically independent, while those under (II) incorporate the correlation between these two types of disturbances.

Table 6.8B

Estimated Values of the Mean and Standard Deviation of Net Income for the Farm Households in Pabna Region

(Taka)

Farm Household	Estimated Parameters (I)		Estimated Parameters (II)	
	Mean (μ_r)	S. D. (σ_r)	Mean (μ_r)	S.A. (σ_r)
1	12209.30	3568.69	12304.70	4207.25
2	7315.56	2626.20	7386.39	2765.98
3	3975.55	1675.06	3964.72	1693.53
4	12231.30	2462.93	12281.10	2637.85
5	3628.55	1643.51	3665.11	1869.93
6	11066.60	4373.74	11179.50	4924.97
7	30227.60	13083.00	30608.10	14989.30
8	7379.93	3294.17	7458.50	3522.97
9	7068.72	2112.17	7107.22	2191.84
10	6416.25	3041.35	6419.19	3046.28
11	27515.60	11193.70	27782.90	13029.50
12	14856.30	5648.73	14967.40	5939.21
13	4056.56	1156.51	4016.43	1097.32
14	22080.60	8901.71	22311.10	10119.20
15	4904.89	1849.82	4936.29	1922.75
16	6430.42	2368.20	6476.64	2446.17
17	10871.50	3976.38	10935.90	4118.84
18	15776.80	5956.20	15984.00	6752.96
19	17450.10	5685.79	17571.30	6006.74
20	5875.00	2161.99	5885.38	2114.30
21	6469.55	3116.78	6475.45	3081.60
22	2670.68	1231.71	2641.87	1100.83
23	7873.59	2895.26	7927.32	3188.28
24	11328.20	3782.26	11361.50	4140.18
25	4878.78	1938.89	4885.54	1849.98
26	9776.42	3382.02	9820.72	3445.66
27	3127.81	1292.76	3093.19	1171.44
28	9707.23	3595.49	9709.27	3895.33
29	4687.24	1764.46	4702.54	1986.61
30	4204.47	3010.81	4224.83	2901.08
31	2871.78	2849.58	2893.02	2734.46
32	10167.40	4383.22	10153.80	4410.04
33	8527.78	3651.76	8483.04	3841.22
34	8734.82	4271.53	8784.22	4169.18
35	15367.10	4219.87	15467.80	4449.70
36	8207.80	3395.06	8179.73	3420.89
37	4718.69	2752.58	4728.78	2695.71
38	8009.47	2371.33	8071.79	2791.37
39	10765.70	4030.21	10818.40	4284.34
40	9442.93	4259.15	9496.93	4198.34
41	6794.84	3220.00	6763.28	3285.57

Table 6.8B (contd.)

Farm Household	Estimated Parameters (I) Mean (μ_r)	Estimated Parameters (I) S.D. (σ_r)	Estimated Parameters (II) Mean (μ_r)	Estimated Parameters (II) S.D. (σ_r)
42	3327.65	1405.48	3352.59	1569.05
43	5432.10	2511.22	5396.52	2375.33
44	8026.61	3013.78	8056.62	3058.49
45	10085.20	4368.52	10204.60	4741.37
46	6541.17	2430.66	6605.09	2566.51

Note: The estimated parameters under (I) assume that the price and output disturbances are stochastically independent, while those under (II) incorporate the correlation between these two types of disturbances.

Table 6.8C

Estimated Values of the Mean and Standard Deviation of Net Income for the Farm Households in Faridpur Region

(Taka)

Farm Household	Estimated Parameters (I) Mean (μ_r)	Estimated Parameters (I) S.D. (σ_r)	Estimated Parameters (II) Mean (μ_r)	Estimated Parameters (II) S.D. (σ_r)
1	13086.80	4316.02	12987.90	4243.09
2	11326.70	4260.74	11237.60	4017.16
3	9245.57	2845.84	9166.60	2717.35
4	7801.20	2901.26	7730.34	2577.35
5	7085.87	709.57	7071.74	663.57
6	4401.90	1439.25	4362.69	1363.12
7	6047.49	2140.73	6015.71	2046.92
8	3355.68	1555.76	3338.34	1479.52
9	3960.89	1963.98	3940.21	1873.30
10	7002.75	2971.30	6958.80	2781.69
11	8978.67	4021.66	8925.74	3784.28
12	5812.37	2562.93	5767.20	2367.04
13	3159.53	1594.35	3133.94	1496.48
14	8655.08	2628.66	8602.61	2595.55
15	7724.49	2666.58	7662.44	2594.20
16	6551.36	3095.52	6471.36	2740.01
17	7946.66	2922.06	7897.09	2750.04
18	5595.38	1051.42	5569.53	962.96
19	13101.10	4832.77	12976.50	4648.07
20	1971.51	583.90	1959.12	543.76
21	5458.07	866.65	5463.67	852.62
22	4693.31	1776.07	4670.99	1690.37
23	7860.92	2844.59	7794.10	2589.36
24	12686.10	4089.33	12555.90	3950.72
25	7305.97	2368.73	7230.89	2218.01
26	10847.50	3998.09	10739.00	3893.23
27	6277.97	2146.10	6215.98	1937.50
28	5087.42	2127.29	5057.61	1993.82
29	8013.86	2830.58	7969.75	2636.92
30	8177.17	2867.55	8145.48	2774.63
31	6893.02	2740.15	6871.38	2755.19
32	5738.51	2206.16	5710.79	2085.09
33	3998.86	1767.17	3984.52	1706.36
34	10264.50	2978.39	10198.60	2729.50
35	4251.35	1654.87	4226.24	1544.94
36	9207.00	3478.39	9156.67	3257.88
37	11587.50	3032.95	11509.80	2868.79
38	7548.00	2358.65	7504.40	2183.50
39	3913.54	1772.08	3892.89	1694.10
40	4888.00	1728.38	4868.94	1634.67
41	10958.30	3436.94	10867.30	3083.24

Table 6.8C (contd.)

Farm Household	Estimated Parameters (I) Mean (μ_r)	S.D. (σ_r)	Estimated Parameters (II) Mean (μ_r)	S.D. (σ_r)
42	7907.89	2119.94	7834.66	1995.75
43	7633.84	2143.77	7569.41	2015.42
44	8793.28	2930.22	8729.93	2769.89
45	7634.28	2598.56	7589.25	2403.62
46	9289.09	2869.16	9246.40	2672.79
47	7933.39	3193.56	7871.40	2926.78
48	6440.35	2553.04	6405.90	2437.13
49	9082.80	2803.52	9040.66	2631.67
50	5162.45	1515.15	5141.10	1387.20
51	6084.10	2292.25	6063.97	2226.20
52	8440.90	2978.42	8399.25	2804.41
53	5095.10	1737.62	5045.84	1578.26
54	5008.13	1710.91	4952.34	1537.05
55	5878.49	1947.46	5818.19	1834.33
56	5067.95	1249.75	5036.80	1162.66
57	6034.30	1774.34	5983.29	1602.75

Note: The estimated parameters under (I) assume that the price and output disturbances are stochastically independent, while those under (II) incorporate the correlation between these two types of disturbances.

Table 6.8D

Estimated Values of the Mean and Standard Deviation of Net Income for the Farm Households in Mymensingh Region

(Taka)

Farm Household	Estimated Parameters (I) Mean (μ_r)	S.D. (σ_r)	Estimated Parameters (II) Mean (μ_r)	S.D. (σ_r)
1	35779.40	11550.60	35730.30	11736.70
2	10379.80	4418.56	10377.50	4221.75
3	14074.00	3906.20	14133.90	3920.94
4	11593.10	5004.83	11571.30	5092.15
5	15806.60	4705.01	15801.20	4883.68
6	31148.40	3787.86	3114.70	3817.24
7	7349.78	2855.30	7422.32	2734.52
8	15934.40	5623.05	16085.40	5395.00
9	41169.40	14337.80	40925.00	14986.20
10	24620.30	7690.03	24553.30	8060.72
11	28004.30	8856.98	27991.20	8966.66
12	13058.10	2931.88	13158.90	2644.37
13	26527.60	6509.36	263.99	6913.69
14	5976.10	2225.28	5965.41	2275.62
15	26960.80	6413.55	26915.60	6671.77
16	9486.22	2513.21	9387.89	2340.11
17	5901.03	1344.71	5901.93	1252.09
18	4664.07	1917.20	4660.50	1879.53
19	4357.69	1602.87	4406.74	1497.60
20	3386.19	1401.03	3422.44	1322.69
21	7738.70	1797.13	7739.90	1673.35
22	17893.30	5268.53	17868.50	5383.05
23	2368.58	1251.29	2365.37	1241.40
24	3028.11	1352.63	3024.16	1349.54
25	16636.10	5580.34	16699.50	5595.96
26	10440.00	3991.71	10345.00	4355.58
27	18851.50	7472.63	18683.20	8086.54
28	8872.39	3660.00	8855.36	3736.67
29	8600.34	2812.07	8599.57	2673.18
30	10803.00	2590.48	10780.10	2699.83
31	5826.37	1761.01	5770.76	1946.76
32	20148.40	8206.34	19964.80	8871.65
33	21424.60	8163.90	21343.60	8680.78
34	9647.55	3810.20	9555.55	4166.55
35	17162.50	2686.82	17164.30	2501.76
36	12623.30	5179.34	12604.50	5221.20
37	10270.30	4115.40	10324.10	4192.80
38	5897.63	1340.67	5893.97	1333.64
39	5423.01	2408.57	5411.63	2460.92
40	14664.50	3479.79	14732.10	3448.69
41	6945.40	1492.77	6946.39	1389.96

Table 6.8D (contd.)

Farm Household	Estimated Parameters (I) Mean (μ_r)	S.D. (σ_r)	Estimated Parameters (II) Mean (μ_r)	S.D. (σ_r)
42	8135.00	3327.96	8125.08	3323.31
43	13919.20	6566.93	13894.40	6632.63
44	15330.80	5615.69	15406.10	5655.12
45	15033.30	4940.17	15097.70	5041.47
46	16179.40	5486.78	16134.20	5754.31
47	9942.74	3214.22	9868.37	3852.58
48	12205.80	2813.25	12095.00	3286.17
49	4862.24	1115.68	4862.98	1038.84
50	11067.20	3504.51	10992.70	3750.18
51	11757.10	4482.37	11699.30	4611.96

Note: The estimated parameters under (I) assume that the price and output disturbances are stochastically independent, while those under (II) incorporate the correlation between these two types of disturbances.

VI.3 Peasant Behaviour Towards Risk and Socioeconomic and Structural Characteristics of the Farm Family

We have now at our disposal all the necessary ingredients for estimating the risk factors (Φ_{Q_i}) associated with different crops for the farm households in each region. The estimated risk factors will be subsequently used in testing the hypotheses embodied in our safety-first model of resource allocation under risk. Before we do so, however, we would like to analyse, based on our estimates of risk coefficients (Ψ_K), peasant behaviour towards risk in subsistence farming like that in Bangladesh.

Our empirical exercise has enabled us to derive a quantitative measure of peasant behaviour towards risk which measures the degree to which peasants in general and subsistence farmers in particular, react to the pervasive uncertainty of their environment. As discussed earlier, under Roy's criterion, peasant behaviour towards risk may be captured in the coefficient, $\Psi_K = [(\bar{d} - \mu_r)/\sigma_r]$, where $\bar{d}$ = disaster income of the farm household, μ_r = expected (mean) net income from farming activity and $\sigma_r = (\text{variance})^{\frac{1}{2}}$ of net income of crop portfolio. Therefore, based on these estimates of $\bar{d}$, μ_r and σ_r, a quantitative estimate of this coefficient is derived for each farm household in our sample, and the frequency distribution of the same is presented below for each sampling region in Table 6.9A through 6.9D. It may be mentioned here that corresponding to two sets of estimates for disaster incomes (reported and computed), we have two sets of estimates of risk coefficients (Ψ_K^R and Ψ_K^C) as well.

Table 6.9A

Frequency Distribution of Ψ_K for the Farm Households in Sylhet Region

Class Interval	Number of Farm Households		Percentage of Farm Households		Cumulative Percentage of Farm Households	
	Ψ_K^R	Ψ_K^C	Ψ_K^R	Ψ_K^C	Ψ_K^R	Ψ_K^C
Below -7.50	1.0	0.0	2.1	0.0	2.1	0.0
-7.50 to -5.00	0.0	0.0	0.0	0.0	2.1	0.0
-5.00 to -2.50	3.0	3.0	6.3	6.3	8.4	6.3
-2.50 to 0	10.0	16.0	20.8	33.2	29.2	29.6
0 to 2.50	25.0	25.0	52.1	52.1	81.3	91.8
2.50 to 5.00	7.0	1.0	14.5	2.1	95.8	93.7
5.00 to 7.50	2.0	2,0	4.2	4.2	100.0	100.0
Above 7.50	0.0	1.0	0.0	2.1	100.0	100.0
Total:	48.00	48.00	100.00	100.00	-	-

Mean of Ψ_K^R: .66 Mean of Ψ_K^C: .73

S.D. of Ψ_K^R: 2.50 S.D. of Ψ_K^C: 2.58

Note: Ψ_K^R and Ψ_K^C represent the coefficients capturing peasant behaviour towards risk corresponding to reported and computed disaster incomes of the farm households.

Table 6.9B

Frequency Distribution of Ψ_K for the Farm Households in Pabna Region

Class Interval	Number of Farm Households		Percentage of Farm Households		Cumulative Percentage of Farm Households	
	Ψ_K^R	Ψ_K^C	Ψ_K^R	Ψ_K^C	Ψ_K^R	Ψ_K^C
Below -7.50	0.0	0.0	0.0	0.0	0.0	0.0
-7.50 to -5.00	1.0	0.0	2.2	0.0	2.2	0.0
-5.00 to -2.50	1.0	2.0	2.2	4.4	4.4	4.4
-2.50 to 0	32.0	28.0	69.5	82.6	73.9	87.0
0 to 2.50	11.0	6.0	23.9	13.0	97.8	100.0
2.50 to 5.00	0.0	0.0	0.0	0.0	97.8	100.00
5.00 to 7.50	1.0	0.0	2.2	0.0	100.0	100.0
Above 7.50	0.0	0.0	0.0	0.0	100.0	100.0
Total:	46.00	46.00	100.00	100.00	-	-

Mean of Ψ_K^R: -.76   Mean of Ψ_K^C: -1.01

S.D. of Ψ_K^R: 1.60   S.D. of Ψ_K^C: 1.20

Note: Ψ_K^R and Ψ_K^C represents the coefficient capturing peasant behaviour towards risk corresponding to reported and computed disaster incomes of the farm households.

Table 6.9C

Frequency Distribution of Ψ_K for the Farm Households in Faridpur Region

Class Interval	Number of Farm Households		Percentage of Farm Households		Cumulative Percentage of Farm Households	
	Ψ_K^R	Ψ_K^C	Ψ_K^R	Ψ_K^C	Ψ_K^R	Ψ_K^C
Below -7.50	0.0	1.0	0.0	1.8	0.0	1.8
-7.50 to -5.00	2.0	0.0	3.5	0.0	3.5	1.8
-5.00 to -2.50	2.0	3.0	3.5	5.2	7.0	7.0
-2.50 to 0	29.0	44.0	50.9	77.2	57.9	84.2
0 to 2.50	23.0	9.0	40.3	15.8	98.9	100.0
2.50 to 5.00	1.0	0.0	1.8	0.0	100.0	100.0
5.00 to 7.50	0.0	0.0	0.0	0.0	100.0	100.0
Above 7.50	0.0	0.0	0.0	0.0	100.0	100.0
Total:	57.00	57.00	100.00	100.00	-	-

Mean of Ψ_K^R: -.49   Mean of Ψ_K^C: -1.11

S.D. of Ψ_K^R: 1.70   S.D. of Ψ_K^C: 1.32

Note: Ψ_K^R and Ψ_K^C represents the coefficient capturing peasant behaviour towards risk corresponding to reported and computed disaster incomes of the farm households.

Table 6.9D

Frequency Distribution of Ψ_K for the Farm Households in Mymensingh Region

Class Interval	Number of Farm Households		Percentage of Farm Households		Cumulative Percentage of Farm Households	
	Ψ_K^R	Ψ_K^C	Ψ_K^R	Ψ_K^C	Ψ_K^R	Ψ_K^C
Below -7.50	0.0	0.0	0.0	0.0	0.0	0.0
-7.50 to -5.00	1.0	1.0	2.0	2.0	2.0	2.0
-5.00 to -2.50	9.0	11.0	17.6	21.5	19.6	23.5
-2.50 to 0	40.0	38.0	78.4	74.5	98.0	98.0
0 to 2.50	1.0	1.0	2.0	2.0	100.0	100.0
2.50 to 5.00	0.0	0.0	0.0	0.0	100.0	100.0
5.00 to 7.50	0.0	0.0	0.0	0.0	100.0	100.0
Above 7.50	0.0	0.0	0.0	0.0	100.0	100.0
Total:	51.00	51.00	100.00	100.00	-	-

Mean of Ψ_K^R: -1.86 Mean of Ψ_K^C: -1.84

S.D. of Ψ_K^R: 1.13 S.D. of Ψ_K^C: 1.27

Note: Ψ_K^R and Ψ_K^C represents the coefficients capturing peasant behaviour towards risk corresponding to reported and computed disaster incomes of the farm households.

Based on these frequency distributions of Ψ_K as presented in Tables 6.9A, 6.9B, 6.9C and 6.9D above, we may draw the following conclusions regarding behaviour towards risk for the farm households in each of our four sampling regions.

(a) Most of the farm households (70% based on Ψ_K^R and 60% based on Ψ_K^C) in Sylhet region should display 'gambling type' of behaviour in their crop growing decisions. This is also reflected in the modal group of the distribution which is identified to be (0.0 to 2.50) for both these sets of estimates. The two distributions of Ψ_K record similar mean values of .66 and .73 respectively. Our t-test also shows that the two distributions do not significantly differ from each other. This is not surprising in view of the fact that the two sets of disaster incomes on which these estimates are based do not significantly differ either.

(b) The picture that emerges for the farm households in Pabna region is the opposite of that obtained in Sylhet. Most of the farm households (75% in the case of Ψ_K^R and 87% in case of Ψ_K^C) possess a negative coefficient implying that for these farm households the situation is not so desparate (as reflected in their disaster income being less than their expected incomes from farming activity) as to force them into growing more of high return-high variance crops. The modal group is appropriately identified to be (-2.50 to 0.0) for both sets of Ψ_K, which records a mean value of -.76 and -1.01 respectively. Contrary to our expectations, however, the two distributions of Ψ_K are not found to be significantly different from each other, even at the 5% level.[7]

(c) The farm households in Faridpur region display similar behaviour towards risk as that displayed in Pabna. Most of the farm households (60% for Ψ_K^R and 85% for Ψ_K^C) record negative values of the risk coefficient Ψ_K, the minimum consumption needs of the farm family being less than their income earning capacity from farming activity thereby allowing them to accept less risky activities. The modal group is again identified to be (-2.50 to 0.0) though in this case there exists evidence of the two distributions being significantly different from each other, with mean values of -.49 and -1.11 respectively.

(d) The behaviour towards risk as captured in the coefficient (Ψ_K), for the farm households in Mymensingh region is similar to that described in Pabna and Faridpur regions, though the behaviour is more 'pronounced' in this case. An overwhelming proportion (98% in both cases) of the farm households now record a negative value of Ψ_K, which allows them to accept less risk in their choice of crop-portfolio. Also, this is reflected in the magnitudes of the estimated coefficients, with mean values of -1.83 and -1.81 respectively.

As expected, the two distributions of Ψ_K are not found to be significantly different from each other as our t-test shows that we could not reject the hypothesis of the equality of two sample means of Ψ_K - similar to the conclusion we reached earlier in case of two sets of disaster incomes in Mymensingh region. This implies that we would not expect our computation of risk factors, and hence the results of our hypotheses-testing involving resource-use efficiency under uncertainty to be sensitive to the use of either set of estimates.

It may be worthwhile at this stage to carry out a formal test of significance of the estimated coefficients, Ψ_K in each sampling region. The null hypothesis to be tested is that H_0: $\Psi_\mu = 0$ against the alternative hypothesis of H_1: $\mu_\Psi > 0$ in Sylhet region, and of H_1: $\mu_\Psi < 0$ in three other regions. The results of our tests are presented below in Table 6.10.

Table 6.10

Computed and Theoretical Values of t-Statistic in Four Sampling Regions

Regions		Mean (μ_Ψ)	S.D. (σ_Ψ)	d.f.	Computed Values of t	Critical Values of t: 1% level	Critical Values of t: 5% level
Sylhet	(a)	.66	2.50	48	(a) 1.83	2.40	1.68
	(b)	.73	2.58	48	(b) 1.97	2.40	1.68
Pabna	(a)	-.76	1.60	46	(a) 3.22	2.40	1.68
	(b)	-1.01	1.20	46	(b) 5.71	2.40	1.68
Faridpur	(a)	-.49	1.70	57	(a) 2.18	2.39	1.67
	(b)	-1.11	1.32	57	(b) 6.34	2.39	1.67
Mymensingh	(a)	-1.86	1.13	51	(a) 11.09	2.40	1.67
	(b)	-1.84	1.27	51	(b) 10.34	2.40	1.67

Note: (a) and (b) represent estimates of Ψ_K based on reported and computed disaster incomes respectively.

It is quite evident from the results presented in Table 6.10 that the estimated coefficients of Ψ_K (both sets) are statistically significant in all four regions, though at the 5% level in Sylhet. We may therefore, expect to display, in our sample, 'gambling-type' behaviour by the farm households in Sylhet region, and 'risk-averse' behaviour by those in Pabna, Faridpur and Mymensingh regions.

Before concluding this section, it may be worthwhile to examine the differential behaviour towards risk across different regions, particularly examining why the farm households in Sylhet should display 'gambling-type' behaviour in their choice of crop-portfolio, which is reflected in the positive mean value of Ψ_K in this region. Although a more rigorous analysis of this differential behaviour across farm households in each region is carried out in the next section, we may make some preliminary observations here to account for variations in behaviour towards risk across different regions. This is done by identifying the factors that influences $\bar{d}$ and μ_r, which in turn determines whether $\Psi \lesseqgtr 0$. Since $\Psi_K = [(\bar{d} - \mu_r)/\sigma_r]$, it is readily observed that for $\bar{d} \lesseqgtr \mu_r$ leads to $\Psi_K \lesseqgtr 0$, while $\sigma_r > 0$ has only a scale effect on Ψ_K.

Among the set of variables that goes towards fixing the target income $(\bar{d})$ are family size and off-farm income. Those mainly affecting the determination of expected income from farming activity (μ_r) are farm size and cropping intensity, which together determine the 'effective cultivated holdings' of the farm households in each region. The average value of these variables are presented below in Table 6.11 for our four sampling regions.

It is quite evident from Table 6.11 that although the average family size, one of the major determinants of $\bar{d}$, does not show much variation across regions, the average 'effective' farm size which mainly determines μ_r is much lower in Sylhet as compared to the three other regions. This perhaps explains why for most of the farm households in Sylhet region, the minimum consumption needs of the family is high relative to its income earning capacity from farming activity, thereby leading to their $\bar{d}$ being greater than

Table 6.11

Average Values of Variables Affecting Ψ_K in Each Region

Region	Family Size	Farm Size (acres)	Cropping Intensity	Effective Farm Size (acres)	Off Farm Income (Taka)
Sylhet	6.5	1.96	1.61	3.16	3177.00
Pabna	6.7	2.09	2.25	4.70	3223.00
Faridpur	6.6	2.30	2.61	6.00	2477.00
Mymensingh	6.5	2.14	1.97	4.22	2903.00

Source: The Small Farm Sample Survey (1979).

μ_r which in turn makes $\Psi_K > 0$. The situation is desperate enough for most of these farm households to resort to 'gambling-type' behaviour in their choice of crop-portfolio.

We have discussed above how a quantitative estimate of the coefficients capturing peasant behaviour towards risk in subsistence farming can be obtained using Roy's Safety Principle. In particular, we could broadly identify, in our sample of small farm households in Bangladesh, two types of behaviour. One, with $\bar{d} > \mu_r$, that forces the household to plunge into riskier activities, and the other, with its $\bar{d} < \mu_r$ leading to $\Psi_K < 0$, which allows the farm family to choose a less risky crop-portfolio. In this section, we introduce a number of socio-economic and other structural characteristics of the farm households in order to explain the variability of this risk coefficient across different farm households in each sampling region. In particular, we explore the possibility of establishing a systematic relationship between the farmer behaviour toward risk as captured in the coefficient, Ψ_K, and a number of socio-economic variables that characterise the peasant households and their access to income-generating opportunities. This will help in identifying the factors that influence peasant behaviour towards risk in subsistence farming as in Bangladesh.

We have identified here two classes of variables as defining the socio-economic and structural characteristics of the farm households.[8] There are:

(a) Household Characteristics, which include age, schooling and family size

(b) Income-Generating Opportunities, which include farm size, off-farm income and total assets of the farm household.

In the first category, we would expect the family size to have a positive impact on Ψ_K; the larger the family size, the greater will be the total consumption needs of the farm family. To the extent, however, that larger family size also augments the total labour supply of the farm household and thereby enhances its income-generating potential, the effect of larger family size on Ψ_K may be somewhat neutralised.

In the second category, all the three variables identified will have a negative relationship with Ψ_K, as they contribute positively towards augmenting the income earning capacity of the farm households.

Our risk-predictive equation thus takes the following form:

$$\Psi_K = b_o + b_1 AG + b_2 FMYSZ + b_3 EDN + b_4 FS + b_5 OFI + b_6 TASTHD$$

with $b_2 > 0$, $b_4 < 0$, $b_5 < 0$ and $b_6 < 0$.

where AG = age, FMYSZ = family size, EDN = education, FS = farm size, OFI = off-farm income and TASTHD = total assets of the farm household.

The results of our multiple regression exercise for each sampling region is presented below.

I. Sylhet Region

(a) $\Psi_K^R = 1.38 - .001AG + .57FMYSZ - .30EDN - 1.38FS - .58OFI + .01TASTHD$

$(1.34) \quad (.05) \quad (4.78)^{***} \quad (.61) \quad (3.23)^{***} \quad (8.77)^{***} \quad (1.27)$

$R^2 = .67$
df = 42

(b) $\Psi_K^C = .64 + .05AG + .45FMYSZ - .07END - 1.89FS - .44OFI + .01TASTHD$

$(.47) \quad (1.64) \quad (2.80)^{***} \quad (.10) \quad (3.26)^{***} \quad (4.96)^{***} \quad (.67)$

$R^2 = .43$
df = 42

II. Pabna Region

(a) $\Psi_K^R = 1.81 - .05AG + .13FMYSZ + .21EDN + .20FS - .29OFI + .02TASTHD$

$(1.42) \quad (1.80)^{*} \quad (.69) \quad (.43) \quad (.65) \quad (3.26)^{***} \quad (1.34)$

$R^2 = .35$
df = 40

(b) $\Psi_K^C = .33 - .03AG + .15FMYSZ - .18EDN - .08FS - .24OFI + .01TASTHD$

$(.34) \quad (1.31) \quad (1.09) \quad (.49) \quad (.34) \quad (3.46)^{***} \quad (1.29)$

$R^2 = .35$
df = 40

III. Faridpur Region

(a) $\Psi_K^R = .55 - .01AG + .17FMYSZ + .11EDN - .37FS - .52OFI + .07TASTHD$

$(.43) \quad (.26) \quad (1.10) \quad (.22) \quad (1.28) \quad (3.95)^{***} \quad (.46)$

$R^2 = .32$
df = 51

(b) $\Psi_K^C = -.96 - .01AG + .31\ FMYSZ - .12EDN - .40FS - .470FI + .01TASTHD$
$(1.01)\ (.86)\ (2.68)^{***}\ (.34)\ (1.86)^{*}\ (4.86)^{***}\ (1.02)$
$R^2 = .39$
af = 51

IV. Mymensingh Region

(a) $\Psi_K^R = -1.25 - .03AG + .27FMYSZ - .32EDN - .32FS + .040FI - .001TASTHD$
$(1.51)\ (1.70)^{*}\ (2.30)^{**}\ (.94)\ (2.53)^{**}\ (.45)\ (.18)$
$R^2 = .22$
df = 45

(b) $\Psi_K^C = -1.54 - .02AG + .31FMYSZ - .06EDN - .04FS - .0020FI - .004TASTHD$
$(1.66)\ (.79)\ (2.33)^{**}\ (.15)\ (2.80)^{***}\ (.03)\ (.91)$
$R^2 = .22$
df = 45

Note: ***, ** AND * indicate that the respective coefficient is significantly different from zero at 1%, 5% and 10% probability levels respectively.

It is clear from above that in Sylhet region, the explanatory power of the risk-predictive equation is quite satisfactory as reflected in its high R^2 (.67), particularly in case of Ψ_K^R. Also, the coefficient of major explanatory variables like family size, farm size and off-farm income came out with expected signs in both cases, and were statistically significant at 1% level. The coefficient of total assets neither came out with expected signs nor were statistically significant even at 10% level in either of the cases.

In Pabna region, both family size and off-farm income had the expected signs, although only the latter was statistically significant in both cases. The coefficient of farm size had the wrong sign in both cases but was not statistically significant. Total assets had the expected sign in both cases, and was statistically significant, at 10% level, only in the case of Ψ_K^R. The explanatory power of the equation was rather low in the cases of both Ψ_K^R and Ψ_K^C.

In Faridpur region, the estimated coefficients of all three major explanatory variables had the expected signs and were statistically significant in case of Ψ_K^C. For Ψ_K^R, only the coefficient of off-farm income is statistically significant. The coefficient of total assets had the wrong sign in both cases, though not statistically significant. The explanatory power of the equation was rather low.

In Mymensingh region, the coefficient of family size and farm size came out with expected signs and were statistically significant at 1% level in the cases of both Ψ_K^R and Ψ_K^C. The estimated coefficient of off-farm income came out with wrong sign in case of Ψ_K^R, though not statistically significant in any of the cases. The coefficient of total assets came out with expected signs in both cases, though not statistically significant. The explanatory power of the equation was quite low, in both cases.

It is thus quite evident from our above discussion that our attempts to explain the variations in the estimates of our risk coefficient, Ψ_K, across farm households or more importantly, to establish significant relationships between the estimates of Ψ_K and the set of socio-economic and structural variables of the farm households were, on the whole, successful.[9] Although the explanatory power of the risk-predictive equations was not very high, the major explanatory variables like family size, farm size and off-farm income had the expected signs in most cases, and were statistically significant at 1% level.

We were thus able in our study to establish a systematic relationship between the coefficient capturing farmer behaviour towards risk and the factors which purport to explain its variation across the farm households in each region. Therefore, the explanation of differential peasant behaviour towards risk in subsistence farming - in particular, whether the farm households are forced to gamble or not in their choice of crop-portfolio - has to be mostly sought from among this set of variables characterising the farm households in peasant agriculture.

VI.4 Estimation of Risk Factors of Different Crops for the Farm Households in Each Region

In the last section, we analysed in detail peasant behaviour towards risk in a subsistence farming economy like Bangladesh. In particular, we estimated the coefficient (Ψ_K) capturing the behaviour towards risk as defined under Roy's safety-first rule for different farm households in each sampling region. An attempt was also made to explain the variations of Ψ_K both across regions and across farm households within each region.

However, for testing the hypotheses involving efficiency of resource use in peasant agriculture under uncertainty, what we need are the estimates of risk factors (Φ_{Q_i}) associated with different crops for the farm households in each sampling region. These risk factors, it may be recalled, are based on the first-order conditions of our safety-first model of resource allocation under risk, and represent an adjustment to factor cost to account for uncertainty. The value of these risk factors will, in general, be greater or less than unity depending on whether the disaster incomes of the farm households exceed or fall short of their expected incomes from farming activity. The actual magnitudes of the risk factors, however, will depend on a number of interaction terms, especially those related to variance and covariances of income from different crops.

It may be emphasized here that while our risk coefficient (Ψ_K), which captures farmer's general behaviour towards risk is household-specific, our risk factors (Φ_{Q_i}) which characterises farmer's resource allocation behaviour in a particular activity, in the presence of risk, are both household and crop-specific. Therefore, utilising our estimates of disaster incomes, mean and variance of net farm incomes and those related to expected outputs and prices of different crops as well those of variance-covariance matrices of disturbances affecting farmer's income, the risk factors of different crops have been computed for each farm household in four sampling regions.[10] The estimating equations of these risk factors for each region are given below.

I. Sylhet Region

$$\Phi_{QLA}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^2\}_K(82.04)(EQLA)_K(.120) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(97.88)(EQLN)_K(.13) + 1.00]^{-1}$$

$$\Phi_{QLN}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^2\}_K(97.88)(EQLN)_K(.263) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(82.04)(EQLA)_K(.135) + 1.00]^{-1}$$

where Φ_{QLA} and Φ_{QLN} represent the risk factors of aus rice and aman rice for the K-th farm household in Sylhet region.

II. Pabna Region

$$\Phi_{QLA}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^2\}_K(86.22)(\overline{E}QLA)_K(1.56) + \{(\bar{d} - \mu_r/\sigma_r^2\}_K(104.22)(EQLN)_K(.163) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(216.07)(EQO)_K(.104) + \{(\bar{d} - \mu_r^2)/\sigma_r^2\}_K(100.00)(EQW)_K(.001) + 1.00]^{-1}$$

$$\Phi_{QLN}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^2\}_K(104.22)(EQLN)_K(.256) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(86.22)(EQLA)_K (.163) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(126.07)(EQJ)_K(.024) + \{(\bar{d} - \mu_r)/\rho_r^2\}_K(99.56) (EQP)_K(.069)\{(\bar{d} - \mu_r)/\sigma_r^2\}_K(216.07)(EQO)_K(.104)\{(\bar{d} - \mu_r)/\sigma_r^2\}_K(100.00) (EQW)_K(-.005) + 1.00]^{-1}$$

$$\Phi_{QJ}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^2\}_K(126.07)(EQJ)_K(.252) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(86.22)(EQLA)_K (.054) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(104.22)(EQLN)_K(.024) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(99.56) (EQP)_K(.110) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(216.07)(EQO)_K(.056) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K (100.00)(EQW)_K(.001) + 1.00]^{-1}$$

$$\Phi_{QP}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^2\}_K(99.56)(EQP)_K(.288) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(86.22)(EQLA)_K (.063) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(104.22)(EQLN)_K(.069) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K (126.07)(EQJ)_K(.110) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(216.07)(EQO)_K(.110) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(100.00)(EQW)_K(.004) + 1.00]^{-1}$$

$$\Phi_{QO}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^2\}_K(216.07)(EQO)_K(.187) + \{(\bar{d} - \mu_r/\sigma_r^2\}_K(86.22)(EQLA)_K (.104) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(104.22)(EQLN)_K(.104) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K (126.07)(EQJ)_K(.056) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(99.56)(EQP)_K(.110) \{(\bar{d} - \mu_r)/\sigma_r^2\}_K (100.00)(EQW)_K(.004) + 1.00]^{-1}$$

$$\Phi_{QW}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^2\}_K(100.00)(EQW)_K(.034) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(86.22)(EQLA)_K (-.0009) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(104.22)(EQLN)_K(-.005) + \{(\bar{d} - \mu_r)/\sigma_r^2\} (126.07)(EQJ)_K(.001) + \{(\bar{d} - \mu_r)/\sigma_r^2\}_K(99.56)(EQP)_K(.004)\{(\bar{d} - \mu_r)/\sigma_r^2\}_K (216.07(EQO)_K(.004) + 1.00]^{-1}$$

where Φ_{QLA}^{K}, Φ_{QLN}^{K}, Φ_{QJ}^{K}, Φ_{QP}^{K}, Φ_{QO}^{K}, and Φ_{QW}^{K} represent the risk factors for aus rice, aman rice, jute, pulses, oilseeds and wheat respectively for the K-th farm household in Pabna.

III. Faridpur Region

$$\Phi_{QLA}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(89.24)(EQLA)_K(.126) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(78.19)(EQLN)_K(.129) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(126.07)(EQJ)_K(.035) + \{(\bar{d} - \mu_r/\sigma_r^{2}\}_K(100.48)(EQP)_K(.069) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(100.00(EQW)_K(.0009) + 1.00]^{-1}$$

$$\Phi_{QLN}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(78.19)(EQLN)_K(.209) + \{(\bar{d} - \mu_r/\sigma_r^{2}\}_K(89.24)(EQLA)_K(.129) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(126.07)(EQJ)_K(.008) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(100.48)(EQP)_K(.070) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(100.00)(EQW)_K(-.005) + 1.00]^{-1}$$

$$\Phi_{QJ}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(126.07)(EQJ)_K(.205) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(89.24)(EQLA)_K(.035) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(78.19)(EQLN)_K(.008) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(100.48)(EQP)_K(.119) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(100.00)(EQW)_K(.004) + 1.00]^{-1}$$

$$\Phi_{QP}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(100.48)(EQP)_K(.282) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(89.24)(EQLA)_K(.069) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(78.19)(EQLN)_K(.070) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(126.07)(EQJ)_K(.119) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(100.00)(EQW)_K(.004) + 1.00]^{-1}$$

$$\Phi_{QW}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(100.00)(EQW)_K(.034) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(89.24)(EQLA)_K(-.0009) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(78.19)(EQLN)_K(-.005) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(126.07)(EQJ)_K(.001) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(100.48)(EQP)_K(.004) + 1.00]^{-1}$$

IV. Mymensingh Region

$$\Phi_{QLN}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(96.09)(EQLN)_K(.203) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(89.24)(EQLA)_K(.129) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(126.07)(EQJ)_K(.002) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(91.81)(EQIB)_K(.091) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(90.00)(EQIA)_K(.129) + 1.00]^{-1}$$

$$\Phi_{QJ}^{K} = [\{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(126.07)(EQJ)_K(.362) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(89.24)(EQLA)_K(.034) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(96.09)(EQLN)_K(.002) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(91.81)(EQIB)_K(-.005) + \{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(90.00(EQIA)_K(.035)\{(\bar{d} - \mu_r)/\sigma_r^{2}\}_K(96.09)(EQIN)_K(.002) + 1.00]^{-1}$$

$$\Phi_{QIB}^{K} = [\{(\overline{d} - \mu_r)/\sigma_r^2\}_K(91.81)(EQIB)_K(.091) + \{(\overline{d} - \mu_r)/\sigma_r^2\}_K(96.09)(EQLN)_K (.091) + \{(\overline{d} - \mu_r)/\sigma_r^2\}_K(126.07)(EQJ)_K(-.005) + \{(\overline{d} - \mu_r)/\sigma_r^2\}_K (96.09)EQIN)_K(-.108) + 1.00]^{-1}$$

$$\Phi_{QIA}^{K} = [\{(\overline{d} - \mu_r)/\sigma_r^2\}_K(90.00)(EQIA)_K(.126) + \{(\overline{d} - \mu_r)/\sigma_r^2\}_K(96.09)(EQLN)_K (.129) + \{(\overline{d} - \mu_r)/\sigma_r^2\}_K(126.07)(EQJ)_K(.035) + \{(\overline{d} - \mu_r)/\sigma_r^2\}_K(96.09) (EQIN)_K(.129) + 1.00]^{-1}$$

where Φ_{QLN}^{K}, Φ_{QJ}^{K}, Φ_{QIB}^{K} and Φ_{QIA}^{K} represent the risk factors for aman rice, jute, IRRI boro and IRRI aus respectively for Kth farm household in Mymensingh region.

Based on these estimating equations, the risk factors of different crops for the farm households in each region were estimated, and the frequency distributions of the same are presented below in Tables 6.12A through 6.12B, 6.13A through 6.13F, 6.14A through 6.14E, and 6.15A through 6.15D respectively.

Based on these estimates, we may make the following observations regarding the distribution of risk factors of different crops in each of our four sampling regions.

(a) For both aus and aman rice, most of the farm households in Sylhet region record a value of risk factors of less than unity with the implication that the perceived factor cost in the face of risk will be lower for these farm households thereby leading to greater resource use as compared to the expected profit maximisation level. This is not surprising in view of the fact that for a larger proportion of the farm households in this region, as we observed in the last section, the magnitudes of disaster incomes exceeded their expected incomes from farming activities. The situation is desperate enough for these farm households to

Table 6.12A

Frequency Distribution of Risk Factors for Aus Rice in Sylhet

Interval	Number of Farm Household Φ_{LA}^{R}	Number of Farm Household Φ_{LA}^{C}	Percentage of Farm Household Φ_{LA}^{R}	Percentage of Farm Household Φ_{LA}^{C}	Cumulative Percentage of Farm Household Φ_{LA}^{R}	Cumulative Percentage of Farm Household Φ_{LA}^{C}
Less than 0	2	1	4.2	2.1	4.2	2.1
0.00 to 0.50	5	4	10.4	8.3	14.6	10.4
0.50 to 1.00	29	25	60.5	52.1	75.1	62.5
1.00 to 1.50	5	12	10.4	25.0	85.5	87.5
1.50 to 2.00	4	2	8.3	4.2	93.8	91.7
Above 2.00	3	4	6.2	8.4	100.0	100.0
Total:	48	48	100.0	100.0	-	-

Mean of Φ_{LA}^{R}: .82 Mean of Φ_{LA}^{C}: .93

S.D. of Φ_{LA}^{R}: 1.32 S.D. of Φ_{LA}^{C}: .81

Note: The estimation of Φ_{LA}^{R} are based on reported disaster incomes, while those of Φ_{LA}^{C} are based on computed disaster incomes.

Table 6.12B

Frequency Distribution of Risk Factors for Aman Rice in Sylhet

Interval	Number of Farm Household Φ_{LN}^{R}	Number of Farm Household Φ_{LN}^{C}	Percentage of Farm Household Φ_{LN}^{R}	Percentage of Farm Household Φ_{LN}^{C}	Cumulative Percentage of Farm Household Φ_{LN}^{R}	Cumulative Percentage of Farm Household Φ_{LN}^{C}
Less than 0	4	4	8.3	8.3	8.3	8.3
0.00 to 0.50	14	10	29.2	20.8	37.5	29.1
0.50 to 1.00	20	19	41.7	39.6	79.2	68.7
1.00 to 1.50	1	8	2.1	16.8	81.3	85.5
1.50 to 2.00	3	3	6.2	6.2	87.5	91.7
Above 2.00	6	4	12.5	8.3	100.0	100.0
Total:	48	48	100.0	100.0	0	0

Mean of Φ_{LN}^{R}: .78 Mean of Φ_{LN}^{C}: .92

S.D. of Φ_{LA}^{R}: .98 S.D. of Φ_{LN}^{C}: 1.61

Note: The estimation of Φ_{LN}^{R} are based on reported disaster incomes, while those of Φ_{LN}^{C} are based on computed disaster incomes.

Table 6.13A

Frequency Distribution of Risk Factors for Aus Rice in Pabna

Interval.	Number of Farm Household		Percentage of Farm Household		Cumulative Percentage of Farm Household	
	Φ_{LA}^{R}	Φ_{LA}^{C}	Φ_{LA}^{R}	Φ_{LA}^{C}	Φ_{LA}^{R}	Φ_{LA}^{C}
Less than 0	2	2	4.3	4.3	4.3	4.3
0.00 to 0.50	1	0	2.2	0	6.5	4.3
0.50 to 1.00	11	6	23.9	13.0	30.4	17.3
1.00 to 1.50	10	17	21.7	37.0	52.1	54.3
1.50 to 2.00	17	15	37.0	32.7	89.1	87.0
Above 2.00	5	6	10.9	13.0	100.0	100.0
Total:	46	46	100.0	100.0	-	-

Mean of Φ_{LA}^{R}: 1.13 Mean of Φ_{LA}^{C}: 1.25

S.D. of Φ_{LA}^{R}: 2.47 S.D. of Φ_{LA}^{C}: 1.48

Note: The estimation of Φ_{LA}^{R} are based on reported disaster incomes, while those of Φ_{LA}^{C} are based on computed disaster incomes.

Table 6.13B

Frequency Distribution of Risk Factors of Aman Rice in Pabna

Interval	Number of Farm Household Φ_{LN}^{R}	Number of Farm Household Φ_{LN}^{C}	Percentage of Farm Household Φ_{LN}^{R}	Percentage of Farm Household Φ_{LN}^{C}	Cumulative Percentage of Farm Household Φ_{LN}^{R}	Cumulative Percentage of Farm Household Φ_{LN}^{C}
Less than 0	3	2	6.5	4.3	6.5	4.3
0.00 to 0.50	1	0	2.2	0	8.7	4.3
0.50 to 1.00	12	6	26.1	13.1	34.8	17.4
1.00 to 1.50	10	15	21.7	32.6	56.5	50.0
1.50 to 2.00	14	11	30.4	23.9	86.9	73.9
Above 2.00	6	12	13.1	26.1	100.0	100.0
Note:	46	46	100.0	100.0	-	-

Mean of Φ_{LN}^{R}: 1.53 Mean of Φ_{LN}^{C}: 1.63

S.D. of Φ_{LN}^{R}: 4.24 S.D. of Φ_{LN}^{C}: 1.11

Note: The estimation of Φ_{LN}^{R} are based on reported disaster incomes, while those of Φ_{LN}^{C} are based on computed disaster incomes.

Table 6.13C

Frequency Distribution of Risk Factors for Jute in Pabna

Interval	Number of Farm Household		Percentage of Farm Household		Cumulative Percentage of Farm Household	
	Φ_J^R	Φ_J^C	Φ_J^R	Φ_J^C	Φ_J	Φ_J^C
Less than 0	2	3	4.3	6.5	4.3	6.5
0.00 to 0.50	1	0	2.2	0	6.5	6.5
0.50 to 1.00	12	6	26.1	13.0	32.6	19.5
1.00 to 1.50	12	20	26.1	43.5	58.7	63.0
1.50 to 2.00	9	5	19.6	10.9	78.3	73.9
Above 2.00	10	12	21.7	26.1	100.0	100.0
Total;	46	46	100.0	100.0	-	-

Mean of Φ_J^R: 2.01 Mean of Φ_J^C: 1.42

S.D. of Φ_J^R: 7.33 S.D. of Φ_J^C: 8.96

Note: The estimation of Φ_J^R are based on reported disaster incomes, while those of Φ_J^C are based on computed disaster incomes.

Table 6.13D

Frequency Distribution of Risk Factors for Pulses in Pabna

Interval	Number of Farm Household		Percentage of Farm Household		Cumulative Percentage of Farm Household	
	Φ_p^R	Φ_p^C	Φ_p^R	Φ_p^C	Φ_p^R	Φ_p^C
Less than 0	1	1	2.2	2.2	2.2	2.2
0.00 to 0.50	1	0	2.2	0	4.4	2.2
0.50 to 1.00	12	6	26.1	13.0	30.5	15.2
1.00 to 1.50	15	22	32.6	47.8	63.1	63.0
1.50 to 2.00	10	8	21.7	17.4	84.8	80.4
Above 2.00	7	9	15.2	19.6	100.0	100.0
Total:	46	46	100.0	100.0	-	-

Mean of Φ_p^R: 1.35 Mean of Φ_p^C: 1.38

S.D. of Φ_p^R: .85 S.D. of Φ_p^C: .93

Note: The estimation of Φ_p^R are based on reported disaster incomes, while those of Φ_p^C are based on computed disaster incomes.

Table 6.13E

Frequency Distribution of Risk Factors for Oilseeds in Pabna

Interval	Number of Farm Household		Percentage of Farm Household		Cumulative Percentage of Farm Household	
	Φ_0^R	Φ_0^C	Φ_0^R	Φ_0^C	Φ_0^R	Φ_0^C
Less than 0	1	1	2.2	2.2	2.2	2.2
0.00 to 0.50	1	0	2.2	0.0	4.4	2.2
0.50 to 1.00	12	6	26.1	13.0	30.5	15.2
1.00 to 1.50	18	23	39.1	50.0	69.6	65.2
1.50 to 2.00	4	3	8.7	6.5	100.0	100.0
Total:	46	46	100.0	100.0	-	-

Mean of Φ_0^R: 1.28 Mean of Φ_0^C: 1.29

S.D. of Φ_0^R: .81 S.D. of Φ_0^C: 1.02

Note: The estimation of Φ_0^R are based on reported disaster incomes, while those of Φ_0^C are based on computed disaster incomes.

Table 6.13F

Frequency Distribution of Risk Factors for Wheat in Pabna

Interval	Number of Farm Household ϕ_W^R	Number of Farm Household ϕ_W^C	Percentage of Farm Household ϕ_W^R	Percentage of Farm Household ϕ_W^C	Cumulative Percentage of Farm Household ϕ_W^R	Cumulative Percentage of Farm Household ϕ_W^C
Less than 0	0	0	0	0	0	0
0.00 to 0.50	0	0	0	0	0	0
0.50 to 1.00	22	26	47.8	56.5	47.8	56.5
1.00 to 1.50	24	20	52.2	43.5	100.0	100.0
1.50 to 2.00	0	0	0.0	0.0	100.00	100.00
Above 2.00	0	0	0.0	0.0	100.0	100.0
Total:	46	46	100.0	100.0	–	0

Mean of ϕ_W^R: 1.01   Mean of ϕ_W^C: 1.01

S.D. of ϕ_W^R: .02   S.D. of ϕ_W^C: .02

Note: The estimation of ϕ_W^R are based on reported disaster incomes, while those of ϕ_W^C are based on computed disaster incomes.

Table 6.14A

Frequency Distribution of Risk Factors for Aus Rice in Faridpur

Interval	Number of Farm Household		Percentage of Farm Household		Cumulative Percentage of Farm Household	
	Φ_{LA}^{R}	Φ_{LA}^{C}	Φ_{LA}^{R}	Φ_{LA}^{C}	Φ_{LA}^{R}	Φ_{LA}^{R}
Less than 0	2	1	3.5	1.8	3.5	1.8
0.00 to 0.50	0	0	0.0	0.0	3.5	1.8
0.50 to 1.00	24	9	42.2	15.8	45.7	17.6
1.00 to 1.50	19	23	33.3	40.4	79.0	58.0
1.50 to 2.00	6	12	10.5	21.0	89.5	79.0
Above 2.00	6	12	10.5	21.0	100.0	100.0
Total:	57	57	100.0	100.0	-	-

Mean of Φ_{LA}^{R}: 1.13 Mean of Φ_{LA}^{C}: 1.56

S.D. of Φ_{LA}^{R}: .72 S.D. of Φ_{LA}^{C}: .73

Note: The estimation of Φ_{LA}^{R} are based on reported disaster incomes, while those of Φ_{LA}^{C} are based on computed disaster incomes.

Table 6.14B

Frequency Distribution of Risk Factors for Aman Rice in Faridpur

Interval	Number of Farm Household		Percentage of Farm Household		Cumulative Percentage of Farm Household	
	Φ_{LN}^{R}	Φ_{LN}^{C}	Φ_{LN}^{R}	Φ_{LN}^{C}	Φ_{LN}^{R}	Φ_{LN}^{C}
Less than 0	2	2	3.5	3.5	3.5	3.5
0.00 to 0.50	0	0	0.0	0.0	3.5	3.5
0.50 to 1.00	24	9	42.1	15.8	45.6	19.3
1.00 to 1.50	16	17	28.1	29.8	73.7	49.1
1.50 to 2.00	6	9	10.5	15.8	84.2	64.9
Above 2.00	9	20	15.8	35.1	100.0	100.0
Total:	57	57	100.0	100.0	-	-

Mean of Φ_{LN}^{R}: 1.31 Mean of Φ_{LN}^{C}: .92

S.D. of Φ_{LN}^{R}: 1.40 S.D. of Φ_{LN}^{C}: 4.77

Note: The estimation of Φ_{LN}^{R} are based on reported disaster incomes, while those of Φ_{LN}^{C} are based on computed disaster incomes.

Table 6.14C

Frequency Distribution of Risk Factors for Jute in Faridpur

Interval	Number of Farm Household Φ_J^R	Number of Farm Household Φ_J^C	Percentage of Farm Household Φ_J^R	Percentage of Farm Household Φ_J^C	Cumulative Percentage of Farm Household Φ_J^R	Cumulative Percentage of Farm Household Φ_J^C
Less than 0	0	0	0.0	0.0	0.0	0.0
0.00 to 0.50	0	0	0.0	0.0	0.0	0.0
0.50 to 1.00	24	9	42.1	15.8	42.1	15.8
1.00 to 1.50	20	31	35.1	54.4	77.2	70.2
1.50 to 2.00	7	7	12.3	12.3	89.5	82.5
Above 2.00	6	10	10.5	17.5	100.0	100.0
Total:	57	57	100.0	100.0	-	-

Mean of Φ_J^R: 1.51 Mean of Φ_J^C: 1.58

S.D. of Φ_J^R: 1.81 S.D. of Φ_J^C: 1.62

Note: The estimation of Φ_J^C are based on reported disaster incomes, while those of Φ_J^R are based on computed disaster incomes.

Table 6.14D

Frequency Distribution of Risk Factors for Pulses in Faridpur

Interval	Number of Farm Household		Percentage of Farm Household		Cumulative Percentage of Farm Household	
	Φ_P^R	Φ_P^C	Φ_P^R	Φ_P^C	Φ_P^R	Φ_P^C
Less than 0	1	1	1.8	1.8	1.8	1.8
0.00 to 0.50	1	1	1.8	1.8	3.6	3.6
0.50 to 1.00	23	8	40.4	14.0	44.0	17.6
1.00 to 1.50	14	17	24.5	29.8	68.5	47.4
1.50 to 2.00	10	13	17.5	22.8	86.0	70.2
Above 2.00	8	17	14.0	29.8	100.0	100.0
Total:	57	57	100.0	100.0	-	-

Mean of Φ_P^R: 1.59 Mean of Φ_P^C: 2.14

S.D. of Φ_P^R: 2.12 S.D. of Φ_P^C: 2.71

Note: The estimation of Φ_P^R are based on reported disaster incomes, while those of Φ_P^C are based on computed disaster incomes.

Table 6.14E

Frequency Distribution of Risk Factors for Wheat in Faridpur

Interval	Number of Farm Household		Percentage of Farm Household		Cumulative Percentage of Farm Household	
	Φ_W^R	Φ_W^C	Φ_W^R	Φ_W^R	Φ_W^R	Φ_W^C
Less than 0	0	0	0.0	0.0	0.0	0.0
0.00 to 0.50	0	0	0.0	0.0	0.0	0.0
0.50 to 1.00	41	37	71.9	64.9	71.9	64.9
1.00 to 1.50	15	18	26.3	31.6	98.2	96.5
1.50 to 2.00	0	2	0.0	3.5	98.2	100.0
Above 2.00	1	0	1.8	0.0	100.0	100.0
Total:	57	57	100.0	100.0	-	-

Mean of Φ_W^R: 1.13 Mean of Φ_W^C: 1.02

S.D. of Φ_W^R: .91 S.D. of Φ_W^C: .11

Note: The estimation of Φ_W^R are based on reported disaster incomes, while those of Φ_W^C are based on computed disaster incomes.

Table 6.15A

Frequency Distribution of Risk Factors for Aman Rice in Mymensingh

Interval	Number of Farm Household		Percentage of Farm Household		Cumulative Percentage of Farm Household	
	Φ_{LN}^{R}	Φ_{LN}^{C}	Φ_{LN}^{R}	Φ_{LN}^{C}	Φ_{LN}^{R}	Φ_{LN}^{C}
Less than 0	11	12	21.6	23.5	21.6	23.5
0.00 to 0.50	0	0	0.0	0.0	21.6	23.5
0.50 to 1.00	3	3	5.9	5.9	27.5	29.4
1.00 to 1.50	7	11	13.7	21.6	41.2	51.0
1.50 to 2.00	6	3	11.8	5.9	53.0	56.9
Above 2.00	24	22	47.0	43.1	100.0	100.0
Total:	51	51	100.0	100.0	-	-

Mean of Φ_{LN}^{R}: 1.93 Mean of Φ_{LN}^{C}: 1.75

S.D. of Φ_{LN}^{R}: 2.28 S.D. of Φ_{LN}^{C}: 2.62

Note: The estimation of Φ_{LN}^{R} are based on reported disaster incomes, while those of Φ_{LN}^{C} are based on computed disaster incomes.

Table 6.15B

Frequency Distribution of Risk Factors for Jute in Mymensingh

Interval	Number of Farm Household Φ_J^R	Number of Farm Household Φ_J^C	Percentage of Farm Household Φ_J^R	Percentage of Farm Household Φ_J^C	Cumulative Percentage of Farm Household Φ_J^R	Cumulative Percentage of Farm Household Φ_J^C
Less than 0	0	0	0.0	0.0	0.0	0.0
0.00 to 0.50	0	0	0.0	0.0	0.0	0.0
0.50 to 1.00	1	4	1.9	7.8	1.9	7.8
1.00 to 1.50	40	37	78.4	72.5	80.3	80.3
1.50 to 2.00	7	7	13.7	13.7	94.0	94.0
Above 2.00	3	3	6.0	6.0	100.0	100.0
Total:	51	51	100.0	100.0	-	-

Mean of Φ_J^R: 1.32 Mean of Φ_J^C: 1.66

S.D. of Φ_J^R: .51 S.D. of Φ_J^C: 2.65

Note: The estimation of Φ_J^R are based on reported disaster incomes, while those of Φ_J^C are based on computed disaster incomes.

Table 6.15C

Frequency Distribution of Risk Factors for IRRI Aus in Mymensingh

Interval	Number of Farm Household Φ_{IA}^R	Number of Farm Household Φ_{IA}^R	Percentage of Farm Household Φ_{IA}^R	Percentage of Farm Household Φ_{IA}^R	Cumulative Percentage of Farm Household Φ_{IA}^R	Cumulative Percentage of Farm Household Φ_{IA}^R
Less than 0	3	2	5.9	3.9	5.9	3.9
0.00 to 0.50	0	0	0.0	0.0	5.9	3.9
0.50 to 1.00	1	4	1.9	7.8	7.8	11.7
1.00 to 1.50	18	17	35.3	33.3	43.1	45.0
1.50 to 2.00	12	11	23.6	21.7	66.7	66.7
Above 2.00	17	17	33.3	33.3	100.0	100.0
Total:	51	51	100.0	100.0	-	-

Mean of Φ_{IA}^R: 1.36 Mean of Φ_{IA}^C: 1.91

S.D. of Φ_{IA}^R: 3.95 S.D. of Φ_{IA}^C: 1.52

Note: The estimation of Φ_{IA}^R are based on reported disaster incomes, while those of Φ_{IA}^C are based on computed disaster incomes.

Table 6.15D

Frequency Distribution of Risk Factors for IRRI Boro in Mymensingh

Interval	Number of Farm Household		Percentage of Farm Household		Cumulative Percentage of Farm Household	
	Φ_{IB}^{R}	Φ_{IB}^{C}	Φ_{IB}^{R}	Φ_{IB}^{C}	Φ_{IB}^{R}	Φ_{IB}^{C}
Less than 0	4	5	7.8	9.8	7.8	9.8
0.00 to 0.50	0	0	0.0	0.0	7.8	9.8
0.50 to 1.00	1	4	2.0	7.8	9.8	17.6
1.00 to 1.50	20	18	39.2	35.3	49.0	52.9
1.50 to 2.00	15	11	29.4	21.6	78.4	74.5
Above 2.00	11	13	21.6	25.5	100.0	100.0
Total:	51	51	100.0	100.0	-	-

Mean of Φ_{IB}^{R}: 1.59 Mean of Φ_{IB}^{C}: 1.79

S.D. of Φ_{IB}^{R}: 1.02 S.D. of Φ_{IB}^{C}: 1.80

Note: The estimation of Φ_{IB}^{R} are based on reported disaster incomes, while those of Φ_{IB}^{C} are based on computed disaster incomes.

force them to commit greater resources to the riskier crops since only by doing so can they hope to maximise their chances of survival.

The modal group of the distribution for two sets of risk factors - those based on reported and computed disaster incomes - is identified to be (.50 - 1.00) for both aus and aman rice. This is also reflected in the estimated mean values of the risk factors, .82 and .93 for aus rice and .78 and .93 for aman rice respectively.[11] As expected, for neither of the crops, the difference between the distributions of risk factors (those based on reported and computed disaster incomes) is found to be statistically significant.[12]

(b) In Pabna region, most of the farm households record, unlike in Sylhet region, a value of risk factors of greater than unity for all six crops produced implying restricted use of resources under risk as compared to the expected profit maximisation level. This conforms to earlier observations since most of the farm households in Pabna showed negative values of the risk coefficient, Ψ_K, their subsistence needs being less than their income earning capacity from farming activities thereby allowing them to trade lower expected returns for reduced variance in the choice of crop portfolio.

The degree of this restriction, however, varies across crops as reflected in the magnitudes of the estimated risk factors of different crops in this region. A ranking of crops in terms of the mean values of risk factors (those based on reported disaster incomes) shows that jute (2.01) occupies the top ranking, followed by aman rice (1.53), pulses (1.35), oilseeds (1.28), aus rice (1.13) and wheat (1.01).[13] Based on the other set of risk factors (those utilising computed disaster incomes), the ranking becomes only slightly different with aman rice now occupying the top position instead of jute; the ranking of other crops remains undisturbed. This is also supported by our t-test which showed that for all the six crops produced, the computed mean values of the risk factors based on two sets of disaster incomes are not significantly different from each other, even at 5% level.[14]

(c) The distribution of risk factors for various crops in Faridpur region is similar to those obtained for the farm households in Pabna region. For four out of five crops produced (the exception being wheat for both sets of Φ_Q), most of the farm households record a value of risk factors of greater than unity.[15] This is what we would expect on the basis of their demonstrated behaviour towards risk, as analysed in the last section. For most of these households, the minimum consumption need of the family is less than their expected income from farming activities. This allows them to trade expected return for lower variance thereby resulting in restricted resource use in the riskier crops.

A ranking of crops in terms of the mean values of risk factors (those based on reported disaster incomes) shows that pulses (1.59) occupies the top ranking followed by jute (1.51), aman rice (1.31) and aus rice/wheat (1.13). Ranking done in terms of the risk factors based on computed disaster incomes becomes somewhat different in that pulses (2.14) again occupies the top ranking followed by jute (1.81) but the third position now is taken by aus rice (1.56) followed by aman rice (1.40) and wheat (1.02). This is also reflected in our testing for the differences in two distributions of risk factors, which shows that only in the case of the aus crop is the difference statistically significant. In case of the remaining four crops, the two distributions were found not to be significantly different from each other.[16]

(d) Most of the farm households in Mymensingh region, as in Pabna and Faridpur, record a value of risk factors of greater than unity for all four crops produced in this region. The pattern of restricted resource use under uncertainty as implied by these risk factors is consistent with the behaviour of the farm household towards risk in the region analysed earlier.

A ranking of the crops in terms of the estimated mean values of the risk factors based on reported disaster incomes (the mean values of the risk factors for aman rice and IRRI boro have been adjusted for the 'extreme values' in the distributions) shows that aman rice (1.93) occupies the top ranking, followed by IRRI boro (1.59), IRRI aus (1.36) and jute (1.32). Based on the risk factors using computed disaster incomes, however, the ranking becomes somewhat different in that now IRRI aus (1.91) tops the ranking followed by IRRI boro (1.79), aman rice (1.75) and jute (1.66). As expected, our t-test showed that for none of the crops is the difference between the two distributions of risk factors (those based on reported disaster incomes and those on computed incomes) statistically significant.[17]

We have already shown while analysing farmer behaviour towards risk in subsistence farming that our estimated coefficients (Ψ_K) capturing such behaviour were significantly different from zero in each of the four sampling regions. It is equally important to explore whether our estimated risk factors are significantly different from one or not. This is because in the context of our safety-first model, the importance of risk in the resource allocation behaviour of the farm households is explained in terms of the deviation of the estimated risk factors from unity.[18] A value of greater than one implies restricted resource-use under uncertainty while that of less than one signifies a tendency to use more resources as compared to the risk neutral, expected profit maximising level thereby leading to 'gambling-type' behaviour.

We have carried out the tests of significance of our estimated risk factors - four sets differentiated according to which set of disaster incomes used and whether the assumption of stochastic independence between output and price disturbances has been maintained in the computation of variance-covariance matrices of disturbances affecting farmer's income - and the results are presented below for different crops for the farm households in each sampling region in Tables 6.16A, 6.16B, 6.16C and 6.16D respectively.[19]

Table 6.16A

Test of the Means of Estimated Risk Factors for Different Crops in Sylhet Region

Crops	Computed t-statistic		Critical Values of t	
	Assumption I	Assumption II	at 1%	at 5%
1. Aus Rice	a) 1.47 b) .58	a) 1.80 b) .15	2.40	1.68
2. Aman Rice	a) 1.64 b) 1.23	a) .43 b) .80	2.40	1.68

Note: Assumptions I and II distinguishes the cases in which the risk factors have been estimated on the assumption of stochastic independence between output and price disturbances or not. (a) and (b), on the other hand, represent, within this category the test results of the risk factors estimated on the basis of reported and computed disaster incomes of the farm households respectively.

Table 6.16B

Test of the Means of Estimated Risk Factors for Different Crops in Pabna Region

Crops		Computed t-statistic Assumption I	Assumption II	Critical Values of t at 1%	at 5%
1.	Aus Rice	a) .36 b) 1.16	a) 2.06 b) 1.12	2.41	1.68
2.	Aman Rice	a) .84 b) 3.94	a) .18 b) 3.00	2.41	1.68
3.	Jute	a) .94 b) .34	a) .23 b) 1.30	2.41	1.68
4.	Pulses	a) 2.80 b) 2.77	a) .71 b) 2.74	2.41	1.68
5.	Oilseeds	a) 2.33 b) 1.93	a) 1.24 b) 1.65	2.41	1.68
6.	Wheat	a) 3.33 b) 3.33	a) 3.33 b) 3.33	2.41	1.68

Note: Assumptions I and II distinguishes the cases in which the risk factors have been estimated on the assumption of stochastic independence between output and price disturbances or not. (a) and (b), on the other hand, represent, within this category, the test results of the risk factors estimated on the basis of reported and computed disaster incomes of the farm households respectively.

Table 6.16C

Test of the Means of the Estimated Risk Factors for Different Crops in Faridpur Region

Crops	Computed t-statistic Assumption I	Computed t-statistic Assumption II	Critical Values of t at 1%	Critical Values of t at 5%
1. Aus Rice	a) 1.37 b) 5.83	a) 1.13 b) 5.86	2.39	1.67
2. Aman Rice	a) 2.58 b) .63	a) 2.00 b) 5.13	2.39	1.67
3. Jute	a) 2.43 b) 3.86	a) .08 b) .29	2.39	1.67
4. Pulses	a) 2.11 b) 3.16	a) 1.03 b) 2.00	2.39	1.67
5. Wheat	a) 1.08 b) 2.00	a) .98 b) 1.50	2.39	1.67

Note: Assumptions I and II distinguishes the cases in which the risk factors have been estimated on the assumption of stochastic independence between output and price disturbances or not. (a) and (b), on the other hand, represent, within this category the test results of the risk factors estimated on the basis of reported and computed disaster incomes of the farm households respectively.

Table 6.16D

Test of the Means of Estimated Risk Factors for Different Crops in Mymensingh Region

Crops	Computed t-statistic Assumption I	Computed t-statistic Assumption II	Critical Values of t at 1%	Critical Values of t at 5%
1. Aman Rice	a) 2.91 b) 2.03	a) .89 b) .40	2.40	1.68
2. Jute	a) 4.57 b) 1.78	a) .79 b) 1.63	2.40	1.68
3. IRRI Aus	a) .65 b) 4.33	a) 3.21 b) 3.41	2.40	1.68
4. IRRI Boro	a) 4.21 b) 3.16	a) 2.07 b) 2.91	2.40	1.68

Note: Assumptions I and II distinguishes the cases in which the risk factors have been estimated on the assumption of stochastic independence between output and price disturbances or not. (a) and (b), on the other hand, represent, within this category the test results of the risk factors estimated on the basis of reported and computed disaster incomes of the farm households respectively.

It is quite evident from the test results presented in Table 6.16A that for the farm households in Sylhet region, the estimated risk factors were found to be significantly different from one (less than one, to be more specific) in only one out of eight estimates derived for both aus and aman rice and then only at the 5% level. We would, therefore, not expect any conclusive evidence of risk efficiency under safety-first for the farm households in Sylhet region.

In Pabna region, the estimated risk factors are significantly different from one (greater than one, to be more specific) in roughly 50% of the cases, mostly for pulses and wheat crops. Aus rice and jute perform rather poorly in this region as the estimated risk factors are hardly found to be statistically significant (significantly different from one) for either of these crops. One obtains a similar picture for the farm households in Faridpur region with about 50% of the estimated risk factors being found to be significantly different from one (greater than one, to be more specific). Performance with respect to individual crops, however, differs somewhat with wheat crop now performing very poorly as the estimated risk factors are found to be significant in only one out of four cases, and then only at the 5% level. Aman rice and pulses now come out with significant risk factors in most of the cases. The performance of aus rice and jute, however, is more moderate as the estimated risk factors are found to be statistically significant in two out of four cases for both of these crops. In Pabna and Faridpur regions, therefore, we may expect to find some evidence of risk efficiency for the farm households in these regions.[20]

In Mymensingh region, on the other hand, the estimated risk factors were found to be significantly different from one (greater than one, to be more specific) in most of the cases (twelve out of sixteen cases for all crops taken together). In terms of crop-wise performance, IRRI boro does very well (the estimated mean risk factors were significantly different from one in all four cases) followed by IRRI aus (three out of four cases), and aman rice and jute, each having its estimated mean risk factor significantly different from one in two out of four cases. We may, therefore, expect to find some conclusive evidence in favour of risk efficiency (a la safety-first) for the farm households in this region.

VI.5 Summary and Conclusions

In this chapter, we discussed the estimation of various components, namely variance-covariance matrices of income disturbances, disaster incomes and mean and variance of crop portfolio which were subsequently used in the estimation of both our risk coefficients (Ψ_k) as well as risk factors (ϕ_{Q_i}) of different crops for the farm households in four sampling regions. The variance-covariance matrices of disturbances affecting farmer's income were derived by combining the matrices of output and price disturbances estimated earlier. Since the way in which these matrices could be combined depended on the assumed interrelationship between these two types of disturbances, we have, therefore, two sets of matrices of income disturbances, one that assumes stochastic independence between these two types of disturbances and the other, that incorporates interdependencies between them. Ranking of crops in terms of estimated variance of income disturbances show that either jute or pulses (depending on which set of matrices is used) occupies the top position, followed by aman rice, oilseeds, aus rice and IRRI boro. This may give some idea of relative riskiness of different crops in Bangladesh.

Another interesting feature of these matrices is that all the estimated income covariances came out to be positive in the set which assumed stochastic independence between output and price disturbances; and even with incorporation of non-zero covariance between these two types of disturbances, only four out of twenty-seven estimates of income covariances recorded negative values. This implies that the 'marginal increment to riskiness of production' $(\partial\sigma_r^2/\partial E(Q_i))$ is most likely to be positive for all crops which in turn ensures that $\Phi_{Q_i} \gtrless 1$ as $\Psi_k \lesseqgtr 0$, i.e., as $\bar{d} \lesseqgtr \mu_r$.[21]

Since under the safety-first approach, modelling of farmer behaviour is based upon the notion of disaster-avoidance of the farm-family, the estimation of disaster incomes naturally assumes considerable importance in such studies. Ideally, the level of income reported by the farm households in our field survey should be used in testing the hypotheses embodied in our safety-first model of resource allocation. However, since the information obtained from our survey may not accurately reflect the farm-family's evaluation of their disaster incomes, we computed an alternative set of estimates of disaster incomes based on other information provided by the farm-households in our sample as well as similar other field surveys conducted in Bangladesh. This was primarily done to provide an indication of the direction and magnitudes of such biases in the reported disaster incomes, and also, to test whether these biases are statistically significant or not.

The results of our tests indicate that in two out of four regions, namely Pabna and Faridpur the upward bias in the reported income series are statistically significant. It will, therefore, be interesting to examine to what extent the estimation of risk coefficients and risk factors, and more importantly, the results of our hypotheses-testing are affected by the use of alternate disaster income series. In Sylhet and Mymensingh regions, however, the difference between the two series was not found to be statistically significant even at 5% level. We would not, therefore, expect the estimates of our risk coefficients/risk factors and the results of our hypotheses-testing to be sensitive to the choice of either set of estimates.

Our estimates of risk coefficients (Ψ_k) attempted to capture peasant behaviour towards risk in subsistence farming like that in Bangladesh. Evidence of 'gambling-type' behaviour was very pronounced for the farm households in Sylhet region. This could be traced to the inability of these households to generate sufficient incomes to meet their subsistence requirements. In three other regions, however, the situation for most of the farm households was not so desperate as to plunge them into 'gambling-type' behaviour in their choice of crop portfolio. The income earning capacity of most of the households in these regions was sufficient to meet their minimum consumption needs thereby allowing them to accept less riskier activities. This differential behaviour across regions could be explained in terms of the average family size and farm size (adjusted for cropping intensity) in these regions. What is more significant, however, is to explain the differential behaviour towards risk across different farm households in each region. In particular, attempts were made to establish a systematic relationship between the risk coefficients and the socioeconomic and other structural characteristics of the farm households. This is important because such correlation can permit the design of farm technology to match the behaviour towards risk of different categories of farm households according to their socioeconomic and structural characteristics.

Our study showed that although the explanatory power of the 'risk-predictive' equations was not very high (not too low either for cross section data and small sample size), the major explanatory variables like family size, farm size and off-farm income had the expected signs and were statistically significant in most cases.[22]

Our estimates of risk factors of different crops tried to capture the effects of risk in factor allocation by the small-holding farms in Bangladesh. These risk factors, it may be emphasized, indicate the extent to which resource use is reduced or expanded (depending on whether their estimated values are less than or greater than one) in different crops as compared to the (risk-neutral) expected profit maximising level. Our estimates of risk factors of different crops in each region showed that they, for the most part, conformed to our <u>a priori</u> expectations. For those farm households with their $\bar{d} < \mu_r$ and hence $\Psi_k < 0$, the estimated risk factors of different crops had a value of greater than one. On the other hand, for the farm households with their $\bar{d} > \mu_r$ and hence $\Psi_k > 0$, the estimated risk factors recorded a value of less than one, implying greater resource use in the riskier crop. This happened for most of the farm households in Sylhet region, which as we observed earlier, displayed 'gambling-type' behaviour in their choice of crop portfolio.

The expression of our risk factors, it may be recalled, are derived from the first-order conditions of our safety-first model of resource allocation under risk. Therefore, the estimates of risk factors are needed for testing the hypotheses involving both disaster-avoidance behaviour as well as the efficiency of resource use for the small-holding farms in Bangladesh. This is a task we shall address in the next chapter.

FOOTNOTES

1. Again, we have two subsets of such matrices corresponding to two sets of matrices for output disturbances, one incorporating rainfall variables in the estimating equations and the other, without.

2. It may again be emphasized here that it is not even the relative income variability of different crops that affects farmer's allocation decisions under uncertainty. What is crucial especially in the context of our safety-first model of farmer behaviour is the variability of income of alternative crop portfolio relative to their expected as well as disaster level of incomes.

3. In fact, this represents a somewhat modified version - modified to suit our data availability from the field survey - of the formula used by Roumasset (1976) in computing his risk-sensitivity-index (RSI) to test the risk-retards-innovation hypothesis for Filipino rice farmers in the context of LSF models.

4. The minimum consumption bundle is derived on the basis of per adult requirement of food items as reported by the heads of families in rural surveys conducted by the Directorate of Marketing, Govt. of Bangladesh. Food items included are the following: rice (coarse), wheat, potato, sugar ('gur'), pulses ('masoor'), vegetables, fish ('chingri') meat (beef), milk (cow), fats and oil (mustard), and fruits (banana). For an elaborate discussion, see Salimullah and Islam (1976).

5. This, of course, assumes that price and output disturbances are stochastically independent. For those cases where price and output disturbances are correlated, the expression for computing mean income is given by

$$\mu_r = \sum_i E(P_{Q_i})\, E(Q_i) + \sum_i \text{cov}(P_{Q_i} Q_i) - \sum_m w_m X_m .$$

6. In the absence of availability of data on acreage and crop output in 1979-80, an approximation was used in deriving aggregate time-series estimates of output disturbances. Since 1979-80 was characterised by serious draught for most of the year (total rainfall in 1979 was recorded to be 1668 mm. as compared to 2389 mm recorded in 1978), a very low value of $\hat{u}$ was chosen for each crop from its respective time series estimates.

7. Results of our t-test showed that we could not reject the hypothesis of equality of two sample means even at 5% level of significance, though in case of disaster incomes we could.

8. For an elaborate discussion on this, see Moscardi (1977). Also, Scandizzo and Dillon (1979) made similar attempts to relate the risk aversion coefficients to a set of socio-economic variables characterising the small farm households in Northest Brazil.

9. Since the disaster incomes of the households were computed in this study in terms of family size and off-farm income, and since farm size mainly affects the determination of farm income, our attempt to establish a systematic relationship between Ψ_k^C (not Ψ_k^R, of course) and this set of variables is somewhat spurious.

10. It may be mentioned here that corresponding to the two sets of estimates of disaster incomes, we have two sets of risk factors. Also, we may have two additional sets of estimates of risk factors based on the set of estimates of variance-covariance matrices incorporating dependencies between output and price disturbances. In fact, the introduction of this dependency assumption will affect the estimates of mean incomes, variance of net incomes, and the estimating equation for risk factors as well.

11. Since in the computation of mean values of Φ_{Q_i}, adjustments have been made for 'extreme values' in the distribution, the calculated mean figures are somewhat arbitrary.

12. In each case, our t-test shows that the hypothesis of the equality of two sample means cannot be rejected at 1% level. It may be recalled here that our earlier tests also demonstrated that neither the difference between two sets of disturbances nor the two sets of Ψ_K based on these disaster incomes was found to be statistically significant in Sylhet region.

13. Significant downward bias was introduced in the computation of risk factors for wheat crop in that the variance-covariance matrix affecting farmer's income is based only on output disturbances since no time series on prices were available for this crop.

14. This is somewhat surprising (somewhat because we had some hints of the possibility of this occurring while testing for Ψ_K earlier). Our earlier tests concerning the two series of disaster incomes showed that the difference between them was not statistically significant for the farm households in Pabna region. However, since such differences in computed and reported disaster income estimates has not resulted in significant differences in the estimates of risk factors for any of the crops produced, we would not expect the results of our hypotheses-testing to be sensitive to the choice of either set of estimates of disaster incomes.

15. This is more pronounced in case of risk factors estimated on the basis of computed disaster incomes as compared to those based on reported ones. The proportion of farm households recording a value of risk factors greater than one is higher in the former case.

16. Again, this is contrary to our expectations since our earlier tests showed that the disaster incomes series (reported and computed ones) and also the two sets of risk coefficients based on these disaster incomes were significantly different from each other for the sample in Faridpur region. Evidently, such differences in disaster income estimates have not been translated into estimation of risk factors for different crops, excepting aus rice.

17. This conforms to our expectations since neither the two series of disaster incomes nor the two sets of risk coefficients was found to be significantly different for the farm households in Mymensingh region.

18. Such a departure of estimated risk factors from unity also distinguishes the efficiency conditions derived under safety-first from those derived under expected profit maximisation. It is also interesting to note that $\Phi_{Q_i} = 1$ if either (or both) (i) $\Psi_K = 0$ <u>or</u> (ii) $\partial\sigma^2_r/\partial E(Q_i) = 0$, i.e. either the farm family is neutral in its behaviour towards risk <u>or</u> the (incremental) production of crop i do not contribute to the variations of income of the farm households implying that there is no uncertainty either in price or in production (or both) associated with that crop.

19. Our null hypothesis of $H_0: \mu_{\Phi_Q} = 1$ was tested against the alternative hypothesis of $H_A: \mu_{\Phi_Q} < 1$ in Sylhet region, and of $H_A: \mu_{\Phi_Q} > 1$ in Pabna Faridpur and Mymensingh regions.

20. The fact that the estimated risk factors are significantly different from one provides only partial evidence of risk efficiency in our sample. Whether the farm households do behave efficiently in resource allocation in the presence of risk also depend on their actual factor allocation, given both technology and the set of input and output prices.

21. Since $\partial\sigma^2_r/\partial E(Q_i) = 2[E(P_{Q_i})]^2 E(Q_1)\sigma^2_{u_i v_i} + 2E(P_{Q_i}) E(P_{Q_j}) E(Q_j) \sigma_{ij}$,

this will be negative only if both $\sigma_{ij} < 0$ <u>and</u> the absolute value of the second term of this expression is greater than the first term which is very unlikely to be fulfilled in practice. For example, in our study, only four out of twenty-seven estimates of income covariances had the negative signs.

22. It should be mentioned here that there is mixed evidence derived from such efforts to correlate the estimates of risk preferences to the socio-economic and structural characteristics of the farm households in peasant agriculture. While Moscardi & De Janvry (1977) and Scandizzo & Dillon (1979) largely succeeded in establishing such relationships for the small-farm households in Mexico and Brazil, Binswanger (1980), Siller (1980) and Walker (1981) could only poorly correlate the observed socioeconomic traits of the farm households with their estimated indices of risk preferences in India, Phillipines and El Salvador respectively.

CHAPTER VII

RATIONALITY AND ECONOMIC EFFICIENCY IN AN UNCERTAIN WORLD

VII.1 Introduction

In Chapter ~~III, using~~ a safety-first model of resource allocation, we derived the conditions of allocative efficiency for farm households exposed to both yield and price uncertainty. Based on these efficiency conditions, we also put forward a set of testable propositions to ascertain whether the farm households behave efficiently (according to safety-first criterion) in the presence of risk when allocating resources to various crop activities. We argued in particular that in the presence of risk farm-households under optimal safety-first resource allocation, equate the E(VMP) of an input not to its price as profit maximising behaviour would postulate but to its 'perceived cost' - input price adjusted by a risk factor which captures the effect of risk in resource allocation behaviour of the farm households in a peasant agriculture. We have also shown that farm households in their attempt to minimise risk (defined in terms of the probability of disaster) do not equate the E(VMP)'s of an input across a pair of crops (as the profit maximising behaviour would imply) but allocate resources between two crops in such a way that the E(VMP)'s of an input in one crop is greater or less than in the other as the risk factor associated with that crop is greater or less than that of the other crop. In other words, the ranking of crops by the E(VMP) of an input has to be identical to the ranking made in terms of the risk factors of these crops.

In Chapter V, we presented the empirical estimates of our resource allocation model under risk, particularly those related to the technical co-efficients of production (cross sectional production function parameter) and those of variance-covariance matrices of output and price disturbances of various crops in each of our four sampling regions. In Chapter VI, we discussed the estimation of risk factors of various crops using the combined variance-covariance matrices of income disturbances on one hand and the estimates of disaster-incomes as well as those of mean and variance of in-comes of crop-portfolio for the farm households in each sampling region on the other.

Our purpose in this chapter is to carry out a statistical testing of the efficiency conditions put forward in Chapter III based on the estimates of production function parameters and those of risk factors of different crops as presented earlier in Chapter V and VI. In Section 2 of this chapter, we discuss the statistical tests corresponding to the three efficiency con-ditions derived earlier. The test results for various crops in each of our four sampling regions are presented in Section 3. Section 4 summarises the empirical findings and draws conclusions both with respect to the importance of risk in resource allocation decisions and the efficiency of resource use by the small farm households in Bangladesh.

VII.2 Testing "Safety-First" Efficiency of Resource Use Under Uncertainty: The Statistical Framework.

Corresponding to three sets of efficiency conditions, we have developed three statistical tests for ascertaining "safety-first" efficiency in a peasant agriculture under conditions of uncertainty. As shown earlier, in Chapter III, incorporation of risk into a safety-first model of resource allocation yielded the following three efficiency conditions:

(a) $E(VMP_{x_i}) = w_x \phi_{Q_i}$

(b) $\{E(MP_x)/E(MP_y)\}_i = \{w_x/w_y\} = \{E(MP_x)/E(MP_y)\}_j$

(c) $E(VMP_x)_i/E(VMP_x)_j = \phi_{Q_i}/\phi_{Q_j}$

The procedure for statistically testing each of these three efficiency conditions is discussed below in some detail.

Test for Efficiency Condition (a)

A direct and simplified way of testing condition (a) is to test whether the sample mean of E(VMP) for an input differs significantly from its perceived cost, $(w_x\phi_Q)$ where w_x and ϕ_Q also represent the mean values of input prices and risk factors in the sample of farm households in a region. The corresponding t statistic in this case is given by $t = (\mu_{E(VMP_x)} - w_x\phi_Q)/\{\sigma_{E(VMP_x)}/\sqrt{n}\}$ which is then tested for its statistical significance. A problem with this test is that there are factors common to both E(VMP) and ϕ_Q as a result of which the two distributions can not be considered independent. However, since $E(VMP_x) = w_x\phi_Q$ implies $E(MP_x)/\phi_Q = w_x/E(P_Q)$, a more appropriate way of testing condition (a) is to test whether or not $\{E(MP_x)/\phi_Q\}$ significantly differs from k where $k = \{w_x/E(P_Q)\}$. The appropriate t statistic in this case is given by $t = \frac{\mu_\delta - k}{\sigma_\delta/\sqrt{n}}$ where $\delta = \{E(MP_x)/\phi_Q\}$. If our computed t is greater than theoretical $t_{.01}$ then we can reject the null hypothesis of equality of E(VMP) of an input X with its perceived cost, $(w_x\phi_Q)$ thereby implying that our data set fails to validate the efficiency condition (a) for an input X used in a particular crop. On the other hand, if our computed t happens to be less than critical value of $t_{.01}$, we cannot then reject the null hypothesis and conclude, therefore, that the efficiency condition was validated by our data set for this particular input and crop. This test, it may be emphasized, was applied to one input used in a particular crop at a time.

Test for Efficiency Condition (b)

We have argued earlier that the only expected profit maximising test of efficiency that held in our model is that of cost minimisation, i.e., the ratio of expected marginal products of any two inputs into a crop i should be equal to the ratio of expected marginal products of the same pair of inputs into any other crop j. This equality across crops, of course, is achieved through the equality of the ratio of the expected marginal products with the input price ratio in each of the crop produced. We may test this condition by means of a t test of whether the sample mean of the ratio of the expected marginal products of a pair of inputs in a given crop differ significantly from the ratio of the mean input prices.[2] The t statistic in this case, therefore, is given by $t = \frac{(\mu_m - \lambda)}{\sigma_m/\sqrt{n}}$

where $\lambda = (\bar{w}_x/\bar{w}_y)$ and $m = \{E(MP_x)/E(MP_y)\}$

This test was also applied to a particular input pair used in a crop at a time.

Again, if our computed t happens to be greater than the theoretical $t_{.01}$, we could then reject the null hypothesis of equality of the ratio of marginal products with their input price ratio and conclude that the efficiency condition (b) was not validated in the sample. However, if the calculated t becomes less than the theoretical $t_{.01}$, the null hypothesis could not be rejected and the efficiency condition would be considered to be validated by our data set.

Testing for Efficiency Condition (c)

Efficiency condition (c) implies that the ranking of crops by E(VMP) for an input should be identical to the ranking made in terms of the risk factors of these crops. Therefore, this condition should ideally be tested by a ranking test but because of limited number of observations (number of crops in the portfolio) such a test could not be conducted.[3] Two alternative tests are suggested. A two-step test suggests that we may first test a pair of crops for whether or not the estimated risk factors are significantly different (greater or less, to be more specific) from each other. In the second step, we may test each input for whether or not the corresponding E(VMP)'s across these two crops also significantly differ (greater or less) from each other.

This test, however, assumes that the distribution of ϕ_Q and E(VMP) are independent across a pair of crops. This may not be true, particularly for the distribution of E(VMP).[4] We may, therefore, test for this efficiency condition directly in the following way.

Our efficiency condition implies that $\{E(VMP_x)/\phi_Q\}_i = \{E(VMP_x)/\phi_Q\}_j$. Since the distribution of E(VMP) and ϕ_Q may not be independent across a pair of crops, we may test for this equality by computing the difference between the two as $\eta = \{E(VMP_x)/\phi_Q\}_i - \{E(VMP_x)/\phi_Q\}_j$ and then test whether this difference i.e., the sample mean of η is significantly different from zero or not. The t statistic, therefore, is given by $t = \frac{\mu_\eta}{\sigma_\eta/\sqrt{n}}$ and the null hypothesis of H_0: $\mu_\eta = 0$ is tested against the alternative hypothesis of H_A: $\mu_\eta \neq 0$.

Again, this test was applied for a particular input used across a pair of crops at a time.

VII.3 Testing for Efficiency of Resource Use Under Uncertainty-Empirical Results.

In Section 2, we have discussed the statistical procedures for testing the efficiency conditions derived earlier. In this section we present the results of these tests for various crops in each of our four sampling region.

VII.3.1 Test Results for Efficiency Condition (a)

We argued earlier that if risk plays an important role in farmer decision making then the traditional tests of rational behaviour and economic efficiency (based on expected profit maximisation) ask the wrong the question. One should not expect the farm household to equate the E(VMP) of various inputs to the respective input prices but to the 'perceived cost' of these inputs defined as factor cost (input price) multiplied by the risk factors associated with different crops which capture the effect of risk in factor allocation among competing activities. We discussed in Section 2 how this proposition could be tested statistically using our estimates of production function parameters as well as those of the risk factors of various crops and the set of input and output prices.[5] This test was carried out for each of several inputs used in the major crops for the farm-households in our four sampling regions. Tables 7.1A 7.1B, 7.1C and 7.1D contain the results of this test separately for each of the four regions with respect to the efficiency condition derived under both risk minimisation (a la Roy's safety-first) and (expected) profit maximisation.

Table 7.1A

Computed Test Statistic and Critical Values of the t Statistic in Sylhet Region

Inputs	Aus Rice: Computed t values	Aus Rice: Critical $t_{.01}$	Aman Rice: Computed t values	Aman Rice: Critical $t_{.01}$
1. Land	a) 2.97 (2.39) b) 2.17*	2.70	a) 4.22 (3.92) b) 8.05	2.69
2. Human Labour	a) 3.48 (3.00) b) 1.99*	2.70	a) 5.70 (5.64) b) 21.11	2.69
3. Bullock Labour	a) .25*(.10) b) 2.29*	2.70	a) 13.07 (10.82) b) 33.10	2.69
4. Seed	a) - (-) b) -	-	a) 3.50 (3.60) b) 12.92	2.69
5. Fertilizer	a) - (-) b) -	-	a) 1.64 (.83) b) 2.57	2.82

Notes: 1. (a) and (b) represent computed t values corresponding to the efficiency conditions for (a) risk minimization under safety-first and (b) expected profit maximization, respectively. Figures in parentheses in (a) represent those t values calculated utilizing the risk factors based on the computed disaster incomes of the farm households, while those not in parentheses are based on reported disaster income levels.

2. * indicates that the null hypothesis could not be rejected in this case thereby implying that the efficiency condition was validated in our sample.

Table 7.1B

Computed Test Statistic and Critical Values of the t Statistic in Pabna Region

Inputs	Crops					
	Aus Rice		Aman Rice		Jute	
	Computed t values	Critical $t_{.01}$	Computed t values	Critical $t_{.01}$	Computed t values	Critical $t_{.01}$
1. Land	a) .57*(1.17)* b) 4.12	2.69	a) 2.02*(1.90)* b) 13.51	2.72	a) 3.21 (2.31)* b) 3.77	2.78
2. Human Labour	a) .36*(1.50)* b) 2.52*	2.69	a) 9.83 (12.60) b) 5.15	2.72	a) .91*([illegible].29)* b) 3.96	2.78
3. Bullock Labour	a) 3.78 (3.00) b) 1.24*	2.69	a) 57.33 (57.67) b) 48.11	2.72	a) – (–) b) –	–
4. Seed	a) – (–) b) –	–	a) 1.11*(1.56)* b) 2.31*	2.70	a) – (–) –	–
5. Fertilizer	a) – (–) b) –	–	a) 1.74*(1.96)* b) 1.18*	3.71	a) .22*(1.63)* b) 2.09*	3.71

Table 7.1B (continued)

Inputs	Crops					
	Pulses		Oilseeds		Wheat	
	Computed t values	Critical $t_{.01}$	Computed t values	Critical $t_{.01}$	Computed t values	Critical $t_{.01}$
1. Land	a) 2.56*(5.26) b) 2.25*	2.72	a) .82*(2.35)* b) .38*	2.82	a) 8.80 (8.99) b) 8.70	2.90
2. Human Labour	a) 3.38 (2.59)* b) 6.15	2.72	a) 4.00 (4.33) b) 7.83	2.82	a) 8.67 (8.99) b) 8.08	2.90
3. Bullock Labour	a) .76*(.81)* b) 2.53*	2.72	a) - (-) b) -	-	a) - (-) b) -	-
4. Seed	a) 4.68 (3.74) b) 2.03*	2.72	a) 2.14*(1.40)* b) 2.71*	2.82	a) - (-) b) -	-
5. Fertilizer	a) - (-) b) -	-	a) - (-) b) -	-	a) - (-) b) -	-

Notes: 1. (a) and (b) represent computed t values corresponding to the efficiency conditions for (a) risk minimization under safety-first and (b) expected profit maximization, respectively. Figures in parentheses in (a) represent those t values calculated utilizing the risk factors based on the computed disaster incomes of the farm-households, while those not in parentheses are based on reported disaster income levels.

2. * indicates that the null hypothesis could not be rejected in this case thereby implying that the efficiency condition was validated in our sample.

Table 7.1C

Computed Test Statistic and Critical Values of the t Statistic in Faridpur Region

Inputs	Crops					
	Aus Rice		Aman Rice		Jute	
	Computed t values	Critical $t_{.01}$	Computed t values	Critical $t_{.01}$	Computed t values	Critical $t_{.01}$
1. Land	a) .07*(2.38)* b) 4.51	2.67	a) 1.51*(2.65)* b) 7.01	2.67	a) 5.61 (5.68) b) 3.72	2.75
2. Human Labour	a) 1.25*(1.43)* b) 6.76	2.67	a) 3.33 (10.00) b) .64*	2.67	a) 3.07 (1.91)* b) 2.38*	2.75
3. Bullock Labour	a) .50*(2.63)* b) 1.09*	2.67	a) 11.06 (18.18) b) 11.75	2.67	a) – (–) b) –	–
4. Seed	a) – (–) b) –	–	a) 6.30 (15.33) b) 5.45	2.67	a) – (–) b) –	–
5. Fertilizer	a) – (–) b) –	–	a) .34*(.85)* b) 1.05*	3.50	a) .08*(1.80)* b) 1.58*	3.17

Table 7.1C (continued)

Inputs	Crops			
	Pulses		Wheat	
	Computed t values	Critical $t_{.01}$	Computed t values	Critical $t_{.01}$
1. Land	a) 18.33 (29.14) b) 30.40	2.68	a) 12.21 (15.36) b) 16.90	2.75
2. Human Labour	a) 7.29 (4.00) b) 13.04	2.68	a) 7.90 (8.89) b) 8.95	2.75
3. Bullock Labour	a) 1.96*(.86)* b) 3.17	2.68	a) - (-) b) -	-
4. Seed	a) 7.03 (18.50) b) 9.87	2.68	a) - (-) b) -	-
5. Fertilizer	a) - (-) b) -	-	a) - (-) b) -	-

Notes: 1. (a) and (b) represent computed t values corresponding to the efficiency conditions for (a) risk minimization under safety-first and (b) expected profit maximization, respectively. Figures in parentheses in (a) represent those t values calculated utilizing the risk factors based on the computed disaster incomes of the farm households, while those not in parentheses are based on reported disaster income levels.

2. * indicates that the null hypothesis could not be rejected in this case thereby implying that the efficiency condition was validated in our sample.

Table 7.1D

Computed Test Statistic and Critical Values of the t Statistic in Mymensingh Region

Inputs	Aman Rice: Computed t Values	Aman Rice: Critical $t_{.01}$	Jute: Computed t Values	Jute: Critical $t_{.01}$	IRRI Aus: Computed t Values	IRRI Aus: Critical $t_{.01}$
1. Land	a) 6.11 (6.03) b) 7.54	2.69	a) 6.29 (4.77) b) 10.37	2.90	a) .64* (.91)* b) 7.72	2.40
2. Human Labour	a) 21.0 (16.40) b) 1.35*	2.69	a) 2.78*(8.00) b) 4.40	2.90	a) – (–) b) –	–
3. Bullock Labour	a) 14.35 (13.08) b) 1.17*	2.69	a) – (–) b)	–	a) – (–) b)	–
4. Seed	a) 7.72 (6.09) b) 3.18	2.69	a) – (–) b) – (–)	–	a) 4.11 (4.13) b) 6.46	2.40
5. Fertilizer	a) 5.78 (6.14) b) 1.93*	2.86	a) – (–) b) –	–	a) – (–) b) –	–

Table 7.1D (Cont.)

Inputs	Crops	
	IRRI Boro	
	Computed t Values	Critical $t_{.01}$
1. Land	a) 2.73*(3.01)	2.95
	b) 3.24	
2. Human Labour	a) - (-)	-
	b) -	
3. Bullock	a) 2.78*(2.10)*	2.95
	b) 10.26	
4. Seed	a) - (-)	-
	b) -	
5. Fertilizer	a) .75*(.95)*	3.06
	b) 1.39*	

Notes: 1. (a) and (b) represent computed t values corresponding to the efficiency conditions for (a) risk minimization under safety first and (b) expected profit maximization, respectively. Figures in parentheses in (a) represent those t values calculated utilizing the risk factors based on the computed disaster incomes of the farm households, while those not in parentheses are based on reported disaster income levels.

2. * indicates that the null hypothesis could not be rejected in this case thereby implying that the efficiency condition was validated in our sample.

The test results presented above in Table 7.1A through 7.1D permit us to make the following observations with respcet to resource allocation behaviour of the small farm households in our four sampling regions.

a) In Sylhet region, there is clearly evidence of farm-households following expected profit-maximising behaviour in their factor allocations in growing aus rice. The efficiency conditions were validated by our data set for all three inputs - land, human labour and bullock labour - used in the cultivation of this crop. The performance of our safety-first model was less satisfactory as the corresponding efficiency conditions are satisfied fully in the case of bullock labour, only partially in case of land (for risk factor estimates based on computed disaster incomes) and not at all in case of human labour. This relatively insignificant role of risk in resource allocation decisions by the farm households in the cultivation of the aus crop is also confirmed by earlier testing of the estimated risk factor for aus rice which was not found to be significantly different from one in Sylhet region.

For aman rice, the efficiency conditions were not validated by our data set for any of the inputs used in this crop, excepting fertilizer. This is true under both expected profit maximisation and risk minimisation a la Roy's safety-first. Therefore, the resource allocation behaviour of the farm households in Aman season cannot perhaps be explained in terms of either of these two models. However, since in the use of most inputs for cultivation of this crop there is a noticeable tendency by the farm households to employ more relative to (expected) profit maximisation levels (as reflected in the observed E(VMP)'s being less than their respective factor cost) points to some sort of 'gambling type behaviour' on the part of these households for which we found some evidence earlier.

b) In Pabna region, in the cultivation of aus rice there is evidence of the farm household's following safety-first behaviour as the efficiency conditions were validated by the data set with respect to both major inputs used, namely land and human labour. The performance of the expected profit maximisation model is somewhat poorer for the efficiency condition could not be validated with respect to acreage allocation for this crop. This weakness however, was offset at least partially by the demonstrated efficient use of both labour inputs - human as well as bullock labour.

In the cultivation of aman rice, the profit maximising condition could be validated only for seed and fertilizer. The safety-first model performed comparatively better in that the efficiency condition was validated for the acreage allocation, as well as for seed and fertilizer. However, the efficiency conditions were rejected for both types of labour under safety-first as well. In the absence of any evidence of 'gambling type behaviour' in resource allocation among the farm households in Pabna region, such an observed misallocation (overuse relative to the expected profit maximisation level as reflected in the E(VMP) being significantly less than the respective input price) of labour inputs with a predominant family-owned component can perhaps be explained in terms of the 'extended use' of these inputs due to lack of competing crops in the Aman season.

For the jute crop, the profit maximising model again performs very poorly as the efficiency conditions could not be satisfied in case of either major inputs - land and human labour used. On the other hand, there is an indication of the farm households' following safety-first behaviour since the corresponding efficiency conditions were validated with respect to all three inputs used (including fertilizer) in this crop in Pabna region.

For pulses, the profit maximising conditions were validated in case of three out of four inputs used with the exception of human labour. The efficiency conditions under safety-first, on the other hand, were validated in the cases of both land and human labour (but for particular estimates of disaster incomes in either case) as well as that for bullock labour but not for seed. One, therefore, finds mixed evidence. Farm households appear to follow either kind of behaviour in factor allocations for pulses in Pabna region.

One obtains a similar picture in resource allocation decision for the cultivation of oilseeds in Pabna region. Again, the profit maximising conditions were validated by our data set in the case of two out of three inputs used, with the exception of human labour. This is true for safety-first as well, as the efficiency conditions were validated in case of land and seed inputs but not for human labour. Again, one fails to discriminate between these two models on the basis of evidence presented here.

For the wheat crop, none of the efficiency conditions were satisfied for either of these two decision models. However, the test remains somewhat incomplete for the safety-first model as considerable downward bias was introduced in the estimation of risk factor for this crop due to non-availability of aggregate time series of prices (i.e., the price variance was taken to be zero).

To evaluate the relative performance of these two models in resource allocation decisions for the small farm households in Pabna region, we may now consolidate our empirical findings to examine for each input how frequently the efficiency conditions were validated across various crops in the region. It is observed that for acreage allocation, the efficiency condition were satisfied in 80% of the cases under safety-first as compared to only 33% of the cases under expected profit maximisation. In the case of human labour, the corresponding figures were 50% under safety-first modelling of farmer behaviour and only 17% under expected profit maximisation. This implies that although the absolute performance of both these models is relatively poor particularly in the case of human labour, still the safety-first model performed comparatively better. In the case of bullock labour, modelling based on either decision rule performed equally poorly as the efficiency conditions were validated in only 33% cases for each model. For seed and fertilizer inputs, the performance of both are found to be equally good as the efficiency conditions were validated in almost all cases - 100% under expected profit maximisation and 85% under safety-first.

For all inputs taken together, it is observed that the profit maximising conditions were satisfied in 45% of the cases (across different crops) as compared to 65% of the cases in which the efficiency conditions were validated by our data set under risk minimisation a la safety-first. We, therefore, find stronger evidence in favour of the small farm-households' following safety-first behaviour in Pabna region.[6]

c) In Faridpur region, for aus rice there is a clear evidence of risk minimisation, as the corresponding efficiency conditions were validated in case of all three inputs used in the cultivation of this crop. The profit maximising conditions were rejected in the case of both major inputs used in the aus crop. In the Aman season, our sample provides only scanty evidence in support of either behaviour model in the region. Under the safety-first criterion, the efficiency conditions were validated for acreage allocation and for the use of fertilizers but not for human labour, bullock labour or seed. The profit maximising conditions were validated in our sample for human labour and fertilizer, but neither for acreage allocation, nor for the use of bullock labour and seed.

For the jute crop, unlike in Pabna region, a mixed evidence in favour of either of these models is found as the corresponding efficiency conditions were validated, for both models, with respect to the use of human labour and fertilizers but not for acreage allocation. For pulses there is hardly any evidence of the farm households' following either mode of behaviour - risk minimisation or expected profit maximisation - as the efficiency conditions were validated, out of four inputs considered, only in case of bullock labour under safety-first and in no cases under expected profit maximisation.

For the wheat crop, one obtains a similar picture as in Pabna region, with our data set rejecting the efficiency conditions for either of these two models. However, one may perhaps still make some case for safety-first because of the observed E(VMP)'s for both these inputs being greater than their perceived costs, $(w_x \phi_Q)$ and the fact that the risk factor for wheat was grossly underestimated due to the omission of price disturbance terms.

An evaluation of the performance of both the models in terms of the validation of the efficiency conditions with respect to each input across various crops can be made in Faridpur region as well. It is observed that in the case of the acreage allocation, the efficiency conditions were validated in our sample for 50% of the cases under safety-first and for no cases under expected profit maximisation. In the case of human labour, the efficiency conditions were validated for roughly 40% of the cases in both models. In the case bullock labour, the efficiency conditions were validated by the data set for 2/3 of the cases under safety-first and only 1/3 of the cases under expected profit maximisation. In the case of seed and fertilizer inputs, there is nothing to discriminate between the two models as the efficiency conditions were validated in none of the cases for seed and in all cases for fertilizer.

Considering the use of all inputs (across various crops) taken together, it is observed that our data set validated the efficiency conditions in 50% of the cases under safety-first and only 30% of the cases under expected profit maximisation. Therefore, again as in Pabna region, we find evidence in favour of the farm households' following safety-first behaviour (as contrasted with profit maximising behaviour) in their resource allocation decision in crop cultivation in Faridpur region.

d) In Mymensingh region, we find some evidence of the farm households' following profit maximising behaviour in their factor allocations in the cultivation of aman rice as the relevant efficiency conditions are validated in three out of five inputs used, excepting land and seed. None of the efficiency conditions for this crop are satisfied under safety-first. For the jute crop, the efficiency conditions are hardly validated in our sample for either of the behaviour model. For the cultivation of IRRI aus, we have some evidence of the farm households' following safety-first behaviour as the corresponding efficiency conditions are validated in case of the acreage allocation (though not for the other input considered, seed) but neither condition was validated under expected profit maximisation. For IRRI boro, we have strong evidence of risk minimisation in our sample. The efficiency conditions are validated by the data set in case of all three inputs used in this crop under safety-first (though only for reported disaster incomes in the case of acreage allocation) but in the case of only one input (fertilizer) under expected profit maximisation.

An evaluation of the relative performance of the two models for individual inputs across different crops demonstrates that for acreage allocation the efficiency conditions are validated in roughly 40% of the cases under safety-first but none under expected profit maximisation. In case of human labour, the profit maximisation model performs better with the respective efficiency conditions validated in our sample in 50% of the cases as compared to 25% under safety-first. In the case of bullock labour, the efficiency conditions are validated in 50% of the cases in both these models. For the use of seed, both models perform equally badly, as the efficiency conditions are validated by the data set in neither of the cases. And finally, in the case of fertilizer, the profit maximising model seem to have some edge over modelling with the safety-first criterion in that the efficiency conditions are validated in our sample in all cases for the former as compared to 50% of the cases for the latter.

Considering all inputs taken together across various crops, it is observed that the efficiency conditions are validated in our sample in 1/3 of the cases considered for both these models. Therefore, in Mymensingh region, judged by efficiency condition (a), we have no evidence to discriminate, in modelling peasant behaviour, between these two decision criterion, expected profit maximisation and risk minimisation under Roy's safety-first rule.

VII.3.2 Test Results for Efficiency Condition (b)

A necessary condition for economic efficiency in resource allocation is that the correct factor proportions are used in the production of a given level of output. This least-cost combination is achieved if the ratio of expected marginal products of a pair of inputs used in the cultivation of a crop is equal to their input price ratio. The condition should hold irrespective of the decision model used in analysing resource allocation behaviour of the farm households in various competing activities. Following the procedure outlined in Section 2, and using the estimates of production function parameters derived earlier and the set of input prices, we tested this efficiency condition for every pair of inputs used for the different crops examined in each of our four sampling regions. The test results are presented below for four regions in Table 7.2A, 7.2B, 7.2C and 7.2D, respectively.

Based on these empirical findings, we may make the following observations regarding efficiency in resource allocation by the small farm households in our four sampling regions.

a) In Sylhet region, in the cultivation of aus rice, the least cost combination in factor-use was achieved, out of three input-pairs considered, only in the case of the land and human labour pair. The situation seem to be much worse in case of aman rice where out of ten input pairs considered the efficiency condition is validated in our sample for only one input-pair, namely human labour and seed used in this crop.

Such a demonstration of failure to achieve cost efficiency in factor allocations by the farm households in Sylhet, specially in the cultvation of aman rice, may partly be explained in terms of the fact that a significant proportion of various inputs used by these farm households are family-owned and thus their opportunity costs may be different from those reflected in their market prices. This is particularly true in a traditional agricultural economy characterised by seasonality in production activities.

b) In Pabna region, in the cultivation of both aus and aman rice, results similar to those as in Sylhet are obtained. The efficiency conditions are validated in one out of the three input-pairs namely land and human labour for aus, and two out of ten input pairs land and fertilizer and human labour for the aman crop. In cultivation of jute, however, the picture improves appreciably as efficiency in factor-use was achieved in two of the

Table 7.2A

Computed Test Statistic and Critical Values of the t Statistic in Sylhet

Input Pair	Aus Rice: Computed t Values	Aus Rice: Critical $t_{.01}$	Aman Rice: Computed t Values	Aman Rice: Critical $t_{.01}$
1. Land/Human Labour	1.64*	2.70	14.56	2.69
2. Land/Bullock Labour	8.01	2.70	17.01	2.69
3. Land/seed	-	-	14.03	2.69
4. Land/Fertilizer	-	-	2.70	2.69
5. Human Labour/ Bullock Labour	8.20	2.70	8.17	2.69
6. Human Labour/ Seed	-	-	1.67*	2.69
7. Human Labour/ Fertilizer	-	-	27.50	2.69
8. Bullock Labour/ Seed	-	-	8.00	2.69
9. Bullock Labour/ Fertilizer	-	-	26.00	2.69
10. Seed/Fertilizer	-	-	11.75	2.69

Note: * indicate that the null hypothesis could not be rejected in this case thereby implying that the efficiency condition (b) was validated in our sample.

Table 7.2B

Computed Test Statistic and Critical Values of the t Statistic in Pabna

Input Pair	Crops			
	Aus Rice		Aman Rice	
	Computed t Values	Critical $t_{.01}$	Computed t Values	Critical $t_{.01}$
1. Land/Human Labour	2.28*	2.69	11.34	2.72
2. Land/Bullock Labour	8.00	2.69	13.49	2.72
3. Land/seed	-	-	6.87	2.72
4. Land/Fertilizer	-	-	2.17*	2.72
5. Human Labour/ Bullock Labour	5.35	2.69	10.77	2.72
6. Human Labour/ Seed	-	-	3.83	2.72
7. Human Labour/ Fertilizer	-	-	2.90	2.72
8. Bullock Labour/ Seed	-	-	8.67	2.72
9. Bullock Labour/ Fertilizer	-	-	21.78	2.72
10. Seed/Fertilizer	-	-	.02*	2.72

Table 7.2B (Cont.)

Input Pair	Crops					
	Jute		Pulses		Oilseeds	
	Computed t	Critical $t_{.01}$	Computed t	Critical $t_{.01}$	Computed t	Critical $t_{.01}$
1. Land/Human Labour	2.18*	2.69	8.68	2.72	40.70	2.82
2. Land/Bullock Labour	-	-	4.34	2.72	-	-
3. Land/Seed	-	-	3.91	2.72	9.65	2.82
4. Land/Fertilizer	3.08	2.69	-	-	-	-
5. Human Labour/ Bullock Labour	-	-	6.40	2.72		
6. Human Labour/ Seed	-	-	4.41	2.72	3.04	2.82
7. Human Labour/ Fertilizer	1.25*	2.69	-	-	-	-
8. Bullock Labour/ Seed	-	-	5.28	2.72	-	-
9. Bullock Labour/ Fertilizer	-	-	-	-	-	-
10. Seed/Fertilizer	-	-	-	-	-	-

Table 7.2B (Cont.)

Input Pair	Crops: Wheat — Computed t	Crops: Wheat — Critical $t_{.01}$
1. Land/Human Labour	1966*	2.90
2. Land/Bullock Labour	-	-
3. Land/Seed	-	-
4. Land/Fertilizer	-	-
5. Human Labour/ Bullock Labour	-	-
6. Human Labour/ Seed	-	-
7. Human Labour/ Fertilizer	-	-
8. Bullock Labour/ Seed	-	-
9. Bullock Labour/ Fertilizer	-	-
10. Seed/Fertilizer	-	-

Note: * indicate that the null hypothesis could not be rejected in this case thereby implying that the efficiency condition (b) was validated in our sample.

Table 7.2C

Computed Test Statistic and Critical Values of the t Statistic in Faridpur

Input Pair	Aus Rice: Computed t Values	Aus Rice: Critical $t_{.01}$	Aman Rice: Computed t Values	Aman Rice: Critical $t_{.01}$
1. Land/Human Labour	2.23*	2.67	9.31	2.67
2. Land/Bullock Labour	3.03	2.67	12.72	2.67
3. Land/Seed	-	-	10.51	2.67
4. Land/Fertilizer	-	-	1.42*	3.50
5. Human Labour/ Bullock Labour	4.16	2.67	3.27	2.67
6. Human Labour/ Seed	-	-	2.63*	2.67
7. Human Labour/ Fertilizer	-	-	.50*	3.50
8. Bullock Labour/ Seed	-	-	2.17*	2.67
9. Bullock Labour/ Fertilizer	-	-	7.00	3.50
10. Seed/Fertilizer	-	-	.22*	3.50

Table 7.2C (Cont.)

Input Pair	Crops					
	Jute		Pulses		Wheat	
	Computed t	Critical $t_{.01}$	Computed t	Critical $t_{.01}$	Computed t	Critical $t_{.01}$
1. Land/Human Labour	6.11	2.75	88.44	2.68	.37*	2.75
2. Land/Bullock Labour	-	-	33.63	2.68	-	-
3. Land/Seed	-	-	6.07	2.68	-	-
4. Land/Fertilizer	1.54*	3.17	-	-	-	-
5. Human Labour/Bullock Labour	-	-	8.0	2.68	-	-
6. Human Labour/Seed	-	-	10.80	2.68	-	-
7. Human Labour/Fertilizer	2.50*	3.17	-	-	-	-
8. Bullock Labour/Seed	-	-	3.38	2.68	-	-
9. Bullock Labour/Fertilizer	-	-	-	-	-	-
10. Seed/Fertilizer	2.77*	3.17	-	-	-	-

Note: * indicate that the null hypothesis could not be rejected in this case thereby implying that the efficiency condition (b) was validated in our sample.

Table 7.2D

Computed Test Statistic and Critical Values of the t Statistic in Mymensingh

Input Pair	Crops			
	Aman Rice		Jute	
	Computed t	Critical $t_{.01}$	Computed t	Critical $t_{.01}$
1. Land/Human Labour	11.67	2.69	5.23	2.90
2. Land/Bullock Labour	6.09	2.69	-	-
3. Land/Seed	5.46	2.69	-	-
4. Land/Fertilizer	.29*	2.86	-	-
5. Human Labour/ Fertilizer	3.45	2.86	-	-
6. Human Labour/ Seed	7.33	2.69	-	-
7. Human Labour/ Seed	1.78*	2.86	-	-
8. Bullock Labour/ Seed	1.47*	2.69	-	-
9. Bullock Labour/ Fertilizer	2.47*	2.86	-	-
10. Seed/Fertilizer	2.81*	2.86	-	-

Table 7.2D (Cont.)

Input Pair	Crops			
	IRRI Aus		IRRI Boro	
	Computed t	Critical $t_{.01}$	Computed t	Critical $t_{.01}$
1. Land/Human Labour	-	-	59.78	2.95
2. Land/Bullock Labour	-	-	-	-
3. Land/Seed	35.29	2.40	-	-
4. Land/Fertilizer	-	-	.94*	3.06
5. Human Labour/ Bullock Labour	-	-	-	-
6. Human Labour/ Seed	-	-	-	-
7. Human Labour/ Fertilizer	-	-	-	-
8. Bullock Labour/ Seed	-	-	-	-
9. Bullock Labour/ Fertilizer	-	-	4.82	3.06
10. Seed/ Fertilizer	-	-	-	-

Note: * indicates that the null hypothesis could not be rejected in this case thereby implying that the efficiency condition (b) was validated in our sample.

three input pairs considered. The picture is even brighter for the wheat crop as the efficiency condition was satisfied for the only input pair, land and human labour for which test could be conducted. However, in the cultivation of pulses and oilseeds, we find ample evidence of resource misallocations in Pabna since the efficiency conditions were rejected by the data set for every input pair considered for these crops.

c) For Faridpur, in the cultivation of aus rice, jute, pulses and wheat, one gets a picture of factor allocations which is similar to that in Pabna region as the efficiency conditions are validated for 1/3 of the input pairs in aus, 3/4 in jute and in none of the case for pulses. Only in the cultivation of aman rice are the results somewhat different, and considerably improved for the efficiency conditions are now validated for five out of the ten input pairs considered.

d) This improved performance in factor use in the cultivation of aman rice is also evident in our sample in Mymensingh where the efficiency conditions are again satisfied in five of the ten cases (also for a somewhat similar set of input pairs). For IRRI boro, the performance is less satisfactory as the corresponding efficiency conditions are validated in one of the three input pair considered. For the two other crops produced in this region, namely jute and IRRI aus, the evidence is too scanty to permit us to draw any meaningful conclusions.

VII.2.3 Test Results for Efficiency Condition (c)

We have argued earlier that if risk plays an important role in resource allocation decisions, then the farm households, in allocating resources between competing crop activities would equate, for each input used across a pair of crops, not their E(VMP)'s (as expected profit maximisation behaviour would imply) but the E(VMP)'s divided by the risk factors of the respective crops, $[E(VMP_x)_i/\phi_{Q_i} = E(VMP_x)_j/\phi_{Q_j}]$. This follows from the first-order condition of our model of resource allocation under risk which shows that the E(VMP) of an input in the cultivation of a crop i is greater or less than the E(VMP) of the same input in the cultivation of another crop j as the risk factor of crop i is greater or less than the risk factor of the other crop j. In Section 2 of this chapter we outlined how this efficiency condition could be tested statistically. Using our estimates of production function parameters, as well as those of the risk factors of different crops, we tested this condition for each input across various pair of crops in each of our four sampling regions. The test results in four sampling regions are presented below in Table 7.3A, 7.3B, 7.3C and 7.3D, respectively. Based on these test results, we may make the following observations with respect to resource allocation behaviour of the farm households in each sampling region.

a) For the farm households in Sylhet region, producing only two crops, aus and aman rice, the efficiency condition was tested for this crop-pair and was rejected by our data set in case of both of the two models for each of three inputs used. Therefore, whatever scanty evidence we have available here do not obviously point to either of the behaviour patterns(expected profit maximisation or risk minimisation) being followed in resource allocation decisions in this region.

Table 7.3A

Computed Test Statistic and Critical Values of the t Statistic in Sylhet Region

Crop-Pair	Inputs			
	Land		Human Labour	
	Computed t Values	Critical $t_{.01}$	Computed t Values	Critical $t_{.01}$
1. Aus Rice/	a) 3.02(2.94)	2.68	a) 9.28(8.84)	2.68
Aman Rice	b) 6.58		b) 9.65	

Table 7.3A (Cont.)

Crop-Pair	Inputs			
	Bullock Labour		Seed	
	Computed t Values	Critical $t_{.01}$	Computed t Values	Critical $t_{.01}$
1. Aus Rice/ Aman Rice	a) 4.35(4.37) b) 6.26	2.68	a) - (-) b) -	-

Note: 1. a) and b) represent computed t values corresponding to the efficiency conditions for a) risk minimisation under safety-first and b) expected profit maximisation, respectively. Figures in parentheses in a) represent those t values calculated utilising the risk factors based on the computed disaster incomes of the farm households, while those not in parentheses are based on the reported disaster income level.

2. * Indicate that the null hypothesis could not be rejected in this case thereby implying that the efficiency condition(c) was validated in our sample.

Table 7.3B

Computed Test Statistic and Critical Values of the t Statistics in Pabna Region

Crop Pair	Inputs: Land — Computed t Values	Land — Critical $t_{.01}$	Human Labour — Computed t Values	Human Labour — Critical $t_{.01}$
1. Aus Rice/ Aman Rice	a) 4.65(4.93) b) 12.90	2.71	a) 4.91(4.91) b) 5.00	2.71
2. Aus Rice/ Jute	a) 4.04(2.77)* b) 3.58	2.78	a) 2.42*(1.80)* b) 3.76	2.78
3. Aus Rice/ Pulses	a) 1.79*(2.35)* b) 4.24	2.71	a) 4.93(4.42) b) 4.60	2.71
4. Aus Rice/ Oilseeds	a) 1.38*(1.10)* b) 2.43*	2.82	a) 4.80(5.67) b) 7.29	2.82
5. Aus Rice/ Wheat	a) – b) 7.56	2.90	a) – b) 8.89	2.90
6. Aman Rice/ Jute	a) 2.49*(1.70)* b) 2.63*	2.83	a) 2.47*(2.28)* b) 3.85	2.83

Table 7.3B (Cont.)

Crop Pair	Inputs			
	Bullock Labour		Seed	
	Computed t Values	Critical $t_{.01}$	Computed t Values	Critical $t_{.01}$
1. Aus Rice/ Aman Rice	a) 4.36(3.63) b) 5.91	2.71	a) - (-) b) -	-
2. Aus Rice/ Jute	a) - (-) b) -	-	a) - (-) b) -	-
3. Aus Rice/ Pulses	a) 3.10(2.19)* b) 3.14	2.71	a) - (-) - (-)	-
4. Aus Rice/ Oilseeds	a) - (-) b) -	-	a) - (-) b) -	-
5. Aus Rice/ Wheat	a) - (-) b) -	-	a) - (-) b) -	-
6. Aman Rice/ Jute	a) - (-) b) -	-	a) - (-) b) -	-

Table 7.3B (Cont.)

Computed Test Statistic and Critical Values of the t Statistic in Pabna Region

Crop-Pair	Inputs: Land — Computed t Values	Land — Critical $t_{.01}$	Human Labour — Computed t Values	Human Labour — Critical $t_{.01}$
7. Aman Rice/ Pulses	a) 4.46(4.21) b) 13.48	2.75	a) 6.10(5.61) b) 5.93	2.75
8. Aman Rice/ Oilseeds	a) 5.26(2.22)* b) 8.53	2.88	a) 6.91(7.55) b) 9.03	2.88
9. Aman Rice/ Wheat	a) - (-) b) 3.68	2.92	a) - (-) b) 10.48	2.92
10. Jute/ Pulses	a) 3.77(3.16) b) 4.44	2.83	a) 1.37*(1.89)* b) 1.79*	2.83
11. Jute/ Oilseeds	a) 2.90*(2.02)* b) 2.24*	3.05	a) 2.16*(2.85)* b) 2.35*	3.05
12. Jute/ Wheat	a) - (-) b) 1.85*	3.17	a) - (-) b) .61*	3.17
13. Pulses/ Oilseeds	a) .07*(.26)* b) .07*	2.90	a) 3.02(3.50) b) 9.48	2.90
14. Pulses/ Wheat	a) - (-) b) 8.30	2.95	a) - (-) b) 2.24*	2.95
15. Oilseeds/ Wheat	a) - (-) b) -	-	a) - (-) b) -	-

Table 7.3B (Cont.)

Crop Pair	Inputs			
	Bullock Labour		Seed	
	Computed t Values	Critical $t_{.01}$	Computed t Values	Critical $t_{.01}$
7. Aman Rice/ Pulses	a) 6.80(5.85) b) 7.49	2.75	a) 3.07(2.69)* b) 2.46*	2.47
8. Aman Rice/ Oilseeds	a) – (–) b) –	–	a) 2.33*(2.49)* b) 2.55*	2.88
9. Aman Rice/ Wheat	a) – (–) b) –	–	a) – (–) b) –	–
10. Jute/ Pulses	a) – (–) b) –	–	a) – (–) b) –	–
11. Jute/ Oilseeds	a) – (–) b) –	–	a) – (–) b) –	–
12. Jute/ Wheat	a) – (–) b) –	–	a) – (–) b) –	–

Table 7.3B (Cont.)

Crop Pair	Inputs			
	Bullock Labour		Seed	
	Computed t Values	Critical $t_{.01}$	Computed t Values	Critical $t_{.01}$
13. Pulses/ Oilseeds	a) – (–) b) –	–	a) 2.72*(.51)* b) 2.81*	2.90
14. Pulses/ Wheat	a) – (–) b) –	–	a) – (–) b) –	–
15. Oilseeds/ Wheat	a) – (–) b) –	–	a) – (–) b) –	–

Note: * indicates that the null hypothesis could not be rejected in this case thereby implying that the efficicncy condition (c) was validated in our sample.

Table 7.3C

Computed Test Statistic and Critical Values of the t Statistic in Faridpur Region

Crop Pair	Inputs			
	Land		Human Labour	
	Computed t Values	Critical $t_{.01}$	Computed t Values	Critical $t_{.01}$
1. Aus Rice/ Aman Rice	a) 2.55*(.36)* b) 3.69	2.68	a) 1.65*(.63) b) .72	2.68
2. Aus Rice/ Jute	a) 5.55(6.22) b) 3.46	2.75	a) 2.57*(2.33)* b) 2.01*	2.75
3. Aus Rice/ Pulses	a) 11.79(11.06) b) 15.16	2.69	a) 6.75(5.15) b) 8.78	2.69
4. Aus Rice/ Wheat	a) - (-) b) 16.54	2.75	a) - (-) b) 7.65	2.75
5. Aman Rice/ Jute	a) 5.43(6.52) b) 3.16	2.75	a) 1.60*(2.94) b) 2.14*	2.75
6. Aman Rice/ Pulses	a) 13.36(13.16) b) 15.96	2.69	a) 9.58(7.67) b) 6.85	2.69

Table 7.3C (Cont.)

Crop Pair	Inputs			
	Bullock Labour		Seed	
	Computed t Values	Critical $t_{.01}$	Computed t Values	Critical $t_{.01}$
1. Aus Rice Aman Rice	a) 6.34(7.17) b) 8.87	2.68	a) - (-) b) -	-
2. Aus Rice/ Jute	a) - (-) b) -	-	a) - (-) b) -	-
3. Aus Rice/ Pulses	a) 3.10(2.05)* b) 3.84	2.69	a) - (-) b) -	-
4. Aus Rice/ Wheat	a) - (-) b) -	-	a) - (-) b) -	
5. Aman Rice/ Jute	a) - (-) b) -	-	a) - (-) b) -	-
6. Aman Rice/ Pulses	a) 7.20(6.66) b) 9.78	2.69	a) 3.50(4.84) b) 5.02	2.69

Table 7.3C (Cont.)

Computed Test Statistic and Critical Values of the t Statistic in Faridpur Region

Crop Pair	Inputs			
	Land		Human Labour	
	Computed t Values	Critical $t_{.01}$	Computed t Values	Critical $t_{.01}$
7. Aman Rice/ Wheat	a) – (–) b) 12.12	2.75	a) – (–) b) 5.72	2.75
8. Jute/ Pulses	a) 6.59(7.76) b) 3.80	2.78	a) .42*(1.02)* b) 1.12*	2.78
9. Jute/ Wheat	a) – (–) b) 1.69*	2.90	a) – (–) b) .26*	2.90
10. Pulses/ Wheat	a) – (–) b) 21.01*	2.82	a) – (–) b) 2.59*	2.82

Table 7.3C (Cont.)

Crop Pair	Inputs			
	Bullock Labour		Seed	
	Computed t Values	Critical $t_{.01}$	Computed t Values	Critical $t_{.01}$
7. Aman Rice/ Wheat	a) – (–) b) –	–	a) – (–) b) –	–
8. Jute/ Pulses	a) – (–) b) –	–	a) – (–) b) –	–
9. Jute/ Wheat	a) – (–) b) –	–	a) – (–) b) –	–
10. Pulses/ Wheat	a) – (–) b) –	–	a) – (–) b) –	–

Note: 1. a) and b) represent computed t values corresponding to the efficiency conditions for a) risk minimisation under safety-first and b) expected profit maximisation, respectively. Figures in parentheses in a) represent those t values calculated utilising the risk factors based on the computed disaster incomes of the farm households, while those not in parentheses are based on the reported disaster income level.

2. * indicate that the null hypothesis could not be rejected in this case thereby implying that the efficiency condition c) was validated in our sample.

Table 7.3D

Computed Test Statistic and Critical Values of the t Statistic in Mymensingh Region

Crop Pair	Inputs: Land		Inputs: Human Labour	
	Computed t Values	Critical $t_{.01}$	Computed t Values	Critical $t_{.01}$
1. Aman Rice/ Jute	a) 8.87(7.07) b) 6.36	2.95	a) 6.37(5.81) b) 2.92*	2.95
2. Aman Rice/ IRRI Aus	a) 4.06(3.62) b) 2.61*	2.83	a) – (–) b) –	–
3. Aman Rice/ IRRI Boro	a) 2.90*(2.72)* b) 2.02*	3.06	a) – (–) b) –	–
4. Jute/ IRRI Aus	a) 10.05(10.80) b) 6.56	3.71	a) – (–) b) –	–
5. Jute/ IRRI Boro	a) 6.74(5.17) b) 3.76	4.03	a) – (–) b) –	–
6. IRRI Aus/ IRRI Boro	a) 17.16(4.26) b) 11.45	4.60	a) – (–) b) –	–

Table 7.3D (Cont.)

Crop Pair	Inputs			
	Bullock Labour		Seed	
	Computed t Values	Critical $t_{.01}$	Computed t Values	Critical $t_{.01}$
1. Aman Rice/ Jute	a) - (-) b) -	-	a) - (-) b) -	-
2. Aman Rice/ IRRI Aus	a) - (-) b) -	-	a) 4.83(4.63) b) 5.71	2.83
3. Aman Rice/ IRRI Boro	a) 4.30(4.73) b) 8.32	3.06	a) - (-) b) -	-
4. Jute/ IRRI Aus	a) - (-) b) -	-	a) - (-) b) -	-
5. Jute/ IRRI Boro	a) - (-) b) -	-	a) - (-) b) -	-
6. IRRI Aus/ IRRI Boro	a) - (-) b) -	-	a) - (-) b) -	-

Note: 1. a) and b) represent computed t values corresponding to the efficiency conditions for a) risk minimisation under safety-first and b) expected profit maximisation, respectively. Figures in parentheses in a) represent those t values calculated utilising the risk factors based on the computed disaster incomes of the farm households, while those not in parentheses are based on the reported disaster income level.

2. * indicate that the null hypothesis could not be rejected in this case thereby implying that the efficiency condition c) was validated in our sample.

b) In Pabna, evaluation of the relative performance of the two models for each input used across different pair of crops shows that in case of the acreage allocation, we have ample evidence that farm households' follow safety-first behaviour, as the corresponding efficiency conditions are validated in our sample in 60% of the cases as compared to only 36% of the cases under expected profit maximisation. In the use of both human and bullock labour, safety-first still is observed to perform relatively better as reflected in the testing of the efficiency conditions under both these models. The efficiency conditions are validated by the data set in 40% and 17% of the cases for these two labour inputs under safety-first as compared to 30% and none under expected profit maximisation. In the use of seed input, expected profit maximisation seem to have slight edge over the safety-first rule in that the efficiency conditions are validated in all cases for the former as compared to about 80% of the cases for the latter.

Combining all inputs together across different pairs of crops, it is observed that the efficiency conditions are validated in 50% of the cases under safety-first as compared to only 35% of the cases under expected profit maximisation. Therefore, the available evidence provides stronger support for risk minimisation behaviour in resource allocations on the part of the small households in Pabna region, than it does for profit maximising behaviour.

c) In Faridpur, an evaluation of the relative performance of the two models in terms of the validation of the efficiency conditions for each input across different pair of crops shows that in case of acreage allocation, both models performs very poorly as the respective conditions are satisfied in our sample in only 17% and 10% cases under safety-first and expected profit maximisation respectively. In case of human labour, however, the picture improves appreciably as the efficiency conditions are validated in roughly 60% of the cases in both models. In case of bullock labour and seed, again, both models perform equally badly since the efficiency conditions are hardly validated by the data set in either of them.

Considering the test results for all inputs together across different pair of crops, it is quite obvious that we have very little to discriminate between either of these two decision models - expected profit maximisation vis-a-vis risk minimisation (a la safety first) since the efficiency conditions are validated in roughly 30% of the cases under both models for our sample in Faridpur region.[8]

d) In Mymensingh region, in the case of acreage allocation, the expected profit maximisation model performs relatively better than the safety-first model as the corresponding efficiency conditions are validated in our sample in 50% and 25% of the cases, respectively. In the case of human labour, the efficiency condition is validated for the only crop.pair, namely aman rice and jute, considered under expected profit maximisation but not (for this crop-pair in either set of estimates) under safety-first. In the case of bullock labour and seed, both models perform rather poorly. The efficiency conditions are not validated for any of the crop pairs considered.

For all inputs taken together, our test results show that the data-set has validated the efficiency conditions in four out of nine (roughly 45%) of the cases under expected profit maximisation and three out of eighteen (only about 17%) of the cases under safety-first. Therefore, it appears that the households in Mymensingh region in our sample seem to have displayed resource allocation behaviour in their decisions which is more in line with (expected) profit maximisation than risk minimisation.

VII.4 Risk and Economic Efficiency

In the last section, we discussed in detail the test results corresponding to three sets of efficiency conditions derived earlier to analyse resource allocation behaviour of small farm-households in a peasant agriculture like Bangladesh. In this section, we intend to piece together our empirical evidence with the following two specific objectives in mind.

i) To examine the role of risk aversion in resource allocation decisions of small farm households in Bangladesh and

ii) To ascertain whether small-holding farms in Bangladesh behave efficiently in the presence of risk in their allocation of resources to various crop activities.

This exercise is carried out below by making a comparative evaluation of our test results with respect to each of the three sets of efficiency conditions across four sampling regions.

VII. 4.1 Summary of Test Results Across Four Regions for Efficiency Condition (a)

Table 7.4A and 7.4B contain a summary of the test results in the four sampling regions with respect to efficiency condition (a) under both expected profit maximisation and safety first rule. Table 7.4A provides the test results for each input across different crops while 7.4B does the same for each crop across

Table 7.4A

A Summary of Test Results for Efficiency Condition (a) in Four Regions

(Each Input Across Crops)

Regions	Inputs					
	Land	Human Labour	Bullock Labour	Seed	Fertilizer	For all Inputs (in each region)
1.Sylhet	a) 1/4 (25%) b) 1/2 (50%	a) 0/4 (0%) b) 1/2 (50%)	a) 2/4 (50%) b) 1/2 (50%)	a) 0/2 (0%) b) 0/1 (0%)	a) 2/2 (100%) b) 1/1 (100%)	a) 5/15 (33%) b) 4/8 (50%)
2.Pabna	a) 8/10 (80%) b) 2/6 (33%)	a) 5/10 (50%) b) 1/6 (17%)	a) 2/6 (33%) b) 1/3 (33%)	a) 4/6 (67%) b) 3/3 (100%)	a) 4/4 (100%) b) 2/2 (100%)	a) 23/36 (64%) b) 9/20 (45%)
3.Faridpur	a) 4/8 (50%) b) 0/5 (0%)	a) 3/8 (67%) b) 2/5 (40%)	a) 4/6 (67%) b) 1/3 (33%)	a) 0/4 (0%) b) 0/2 (0%)	a) 4/4 (100%) b) 2/2 (100%)	a) 15/30 (50%) b) 5/17 (29%)
4.Mymen-singh	a) 3/8 (38%) b) 0/4 (0%)	a) 1/4 (25%) b) 1/2 (50%)	a) 2/4 (50%) b) 1/2 (50%)	a) 0/4 (0%) b) 0/2 (0%)	a) 2/4 (50%) b) 2/2 (100%)	a) 8/24 (33%) b) 4/12 (33%)
For each input across four regions	a) 16/30 (53%) b) 3/17 (18%)	a) 9/26 (35%) b) 5/15 (33%)	a) 10/20 (50%) b) 4/10 (40%)	a) 4/16 (25%) b) 3/8 (38%)	a) 12/14 (86%) b) 7/7 (100%)	a) 51/105 (49%) b) 22/57 (39%)

Note: (a) represents the summary of test results for each input across different crops under the safety-first rule while (b) represents the same under expected profit maximisation.

Table 7.4B

A Summary of Test Results for Efficiency Condition (a) in Four Sampling Regions

(Each Crop Across Inputs)

Regions	Crops					
	Aus Rice	Aman Rice	Jute	Pulses	Oilseeds	Wheat
1. Sylhet	a) 2/6 (33%)	a) 2/10 (20%)	a) -	a) -	a) -	a) -
	b) 3/3 (100%)	b) 1/5 (20%)	b) -	b) -	b) -	b) -
2. Pabna	a) 4/6 (67%)	a) 6/10 (60%)	a) 5/6 (83%)	a) 4/8 (50%)	a) 4/6 (67%)	a) 0/2 (0%)
	b) 2/3 (67%)	b) 2/5 (40%)	b) 1/3 (33%)	b) 3/4 (74%)	b) 2/3 (67%)	b) 0/2 (0%)
3. Faridpur	a) 6/6 (100%)	a) 4/10 (40%)	a) 3/6 (50%)	a) 2/8 (25%)	a) -	a) 0/2 (0%)
	b) 1/3 (33%)	b) 2/5 (40%)	b) 2/3 (67%)	b) 0/4 (0%)	b) -	b) 0/2 (0%)
4. Mymensingh	a) -	a) 0/10 (0%)	a) 1/4 (25%)	a) -	a) -	a) -
	b) -	b) 0/5 (0%)	b) 0/2 (0%)	b) -	b) -	b) -
For each crop across four regions:	a) 12/18 (67%)	a) 12/40 (30%)	a) 9/16 (56%)	a) 6/16 (38%)	a) 4/6 (67%)	a) 0/4 (0%)
	b) 6/9 (67%)	b) 5/20 (25%)	b) 3/8 (38%)	b) 3/8 (38%)	b) 2/3 (67%)	b) 0/4 (0%)

Table 7.4B (Cont.)

Regions	Crops		
	IRRI Aus	IRRI Boro	For all Crops in each region
1. Sylhet	a) –	a) –	a) 4/16 (25%)
	b) –	b) –	b) 4/8 (50%)
2. Pabna	a) –	a) –	a) 23/38 (61%)
	b) –	b) –	b) 10/20 (50%)
3. Faridpur	a) –	a) –	a) 15/32 (47%)
	b) –	b) –	b) 5/17 (29%)
4. Mymensingh	a) 2/4 (50%)	a) 5/6 (83%)	a) 8/24 (33%)
	b) 0/2 (0%)	b) 1/3 (33%)	b) 1/12 (8%)
For each crop across	a) 2/4 (50%)	a) 5/6 (83%)	a) 50/110 (45%)
four regions:	b) 0/2 (0%)	b) 1/3 (33%)	b) 20/57 (35%)

Notes: (a) represents the summary of test results for each crop areas different inputs under safety-first rule while (b) represents the same under expected profit maximisation.

inputs in four regions. Based on this summary of test results, we may draw the following conclusions regarding the resource allocation behaviour of small-farm-households in Bangladesh.

(i) An evaluation of the test results for all inputs in the four regions shows that only in Sylhet do we have some evidence of farm-households' following profit-maximising behaviour, while in two other regions, Pabna and Faridpur, the farm-households in our sample seem to behave like safety-firsters in their resource allocation decisions. In Mymensingh, our sample does not provide any conclusive evidence in favour of either of the decision models.

Considering the test results for all inputs across the four regions, it appears that the safety-first rule has a slight edge over expected profit maximisation in that the efficiency conditions are validated in about 50% of the cases under the former as compared to about 40% under the latter. From the viewpoint of specific input use, it is observed that safety-first performs decidedly better (relative to expected profit maximisation) in the case of acreage allocation and only marginally better in the use of bullock labour. In case of human labour, both models perform equally well (or poorly) while in case of both seed and fertilizer, expected profit maximisation appears to perform somewhat better than does the safety-first. It must be pointed here, however, that the performance of both models in the case of fertilizer is much better than in case of all other inputs used.

(ii) We get some additional insights into the resource allocation behaviour of small farm-households in Bangladesh when we lood at Table 7.4B which summarises the test results for each crop across different inputs in the four sampling regions. On the basis of our available evidence, we cannot discriminate between either type of behaviour-profit maximisation or risk minimisation in the cultivation of most of the crops grown, (aus rice, aman rice, pulses, oilseeds and wheat). However, in those cases where our test results could discriminate, we find evidence in favour of safety-first behaviour in jute, IRRI aus and IRRI boro seasons.

Considering the relative performance of the two models in terms of the test results of validation of efficiency condition for all crops grown in each region, we find evidence of profit maximising behaviour in our sample in Sylhet, while in the three other regions (including Mymensingh) our data set seems to support safety-first behaviour in resource allocations to the cultivation of the various crops grown in these regions. This, therefore, provides supporting and somewhat stronger evidence in favour of safety-first behaviour compared to what we observed earlier in (i). This conclusion is reinforced when we consider summing up the test results for all crops across four regions, which shows that the efficiency conditions are validated in our sample in 45% of the cases under safety-first as compared to 35% under expected profit maximisation (Table 7.4B).

VIII.4.2 Summary of Test Results Across Four Regions for Efficiency Condition, (b)

The test results for efficiency condition (b)-the cost minimisation condition that ensures 'least cost combination' of factor use, are summarised in Table 7.5A and 7.5B. Based on these test results, we may draw the following conclusions regarding efficiency of resource use by small farm-households in Bangladesh.

(i) From the test results summarised for each input pair across different crops in four sampling regions (Table 7.5A), it is observed that the performance is quite poor in each region as reflected in the failure of the farm households to achieve cost efficiency in resource use in the cultivation of various crops. The efficiency conditions are never seen to be validated for more than 42% of the cases in any of the four regions. This may largely be attributed, as described earlier, to the use of the market prices of inputs which may not properly reflect their opportunity cost to the farm households. In terms of the relative performance of different regions in achieving cost efficiency, however, we may rank the four regions with Faridpur at the top (42%), followed by Mymensingh (36%), Pabna (23%) and Sylhet (15%).

Evaluating the test results with respect to each input pair across the four regions, it is observed that those input pairs which include fertilizer tend to perform comparatively better than the other pairs. This is particularly true for seeds and fertilizer (80%), human labour and fertilizer

Table 7.5A

A Summary of Test Results for Efficiency Condition (b) in Four Regions

Input Pair	Sylhet	Pabna	Faridpur	Mymensingh	For each input pair across four regions.
1. Land/Human Labour	1/2 (50%)	3/6 (50%)	2/5 (40%)	0/3 (0%)	6/16 (38%)
2. Land/Bullock Labour	0/2 (0%)	0/3 (0%)	0/3 (0%)	0/2 (0%)	0/10 (0%)
3. Land/Seed	0/1 (0%)	0/3 (0%)	0/2 (0%)	1/1 (100%)	1/7 (14%)
4. Land/Fertilizer	0/1 (0%)	1/2 (50%)	2/2 (100%)	0/1 (0%)	3/6 (50%)
5. Human Labour/ Bullock Labour	0/2 (0%)	0/3 (0%)	0/3 (0%)	0/1 (0%)	0/9 (0%)
6. Human Labour/ Seed	1/1 (100%)	0/3 (0%)	1/2 (50%)	0/1 (0%)	2/7 (28%)
7. Human Labour/ Fertilizer	0/1 (0%)	1/2 (50%)	2/2 (100%)	1/1 (100%)	4/6 (67%)
8. Bullock Labour/ Seed	0/1 (0%)	0/2 (0%)	1/2 (50%)	1/1 (100%)	2/6 (33%)
9. Bullock Labour Fertilizer	0/1 (0%)	0/1 (0%)	0/1 (0%)	1/2 (50%)	1/5 (20%)
10. Seed/Fertilizer	0/1 (0%)	1/1 (100%)	2/2 (100%)	1/1 (100%)	4/5 (80%)
For all Input Pair in each Region	2/13 (15%)	6/26 (23%)	10/24 (42%)	5/14 (36%)	23/77 (30%)

Table 7.5B

A Summary of Test Results for Efficiency Condition (b) in Four Regions

(Each Crop Across Input Pair)

Crops	Regions				
	Sylhet	Pabna	Faridpur	Mymensingh	For each crop across four regions
1. Aus Rice	1/3 (33%)	1/3 (33%)	1/3 (33%)	- (-)	3/9 (33%)
2. Aman Rice	1/10 (10%)	2/10 (20%)	5/10 (50%)	5/10 (50%)	13/40 (33%)
3. Jute	- (-)	2/3 (67%)	2/3 (67%)	0/1 (0%)	4/7 (57%)
4. Pulses	- (-)	0/6 (0%)	0/6 (0%)	- (-)	0/12 (0%)
5. Oilseeds	- (-)	0/3 (0%)	- (-)	- (-)	0/3 (0%)
6. Wheat	- (-)	1/1 (100%)	1/1 (100%)	- (-)	2/2 (100%)
7. IRRI Aus	- (-)	- (-)	- (-)	0/1 (0%)	0/1 (0%)
8. IRRI Boro	- (-)	- (-)	- (-)	1/3 (33%)	1/3 (33%)
For all crops in each region	2/13 (15%)	6/26 (23%)	9/23 (39%)	6/15 (40%)	23/77 (30%)

(67%) and land and fertilizer (50%) while those combines with bullock labour appear to perform poorest (land and bullock labour (0%) and human labour and bullock labour (0%)). Combining this result with respect to the use of fertilizer in different regions with those derived earlier in the cases of test results for efficiency condition (a) which showed that the conditions were validated over 80% of the cases across the four regions, we, therefore, find strong evidence in favour of efficient resource use (both allocative and cost efficiency) in our sample for this input by the small farm households in Bangladesh. We say both allocative and cost efficiency because our test results shows that the absolute level of use of fertilizer in the cultivation of different crops and the proportions in which it has been combined with other complimentary inputs are both correct in most of the cases. This, however, does not imply anything about the role of risk aversion in the use of fertilizer since the allocative efficiency conditions are validated for both decision models.

Finally, combining the test results for all inputs across the four regions, it is observed that the efficiency conditions are validated in only 30% of the cases in our sample. Even allowing for the discrepancy between the market price of inputs and their opportunity cost to the farm-households, this gives a rather poor picture of the extent to which cost efficiency is achieved by the farm households in the cultivation of various crops in Bangladesh.

(ii) Table 7.5B summarises the test results for cost efficiency with respect to each crop across different input-pairsin the four sampling regions. Evaluating the results for all crops in the four regions, one obtains a similar picture as in (i). The performance of farm households in achieving efficiency in factor combinations in different regions continues to be poor and the relative performance of different regions remaining almost the same, with Mymensingh together with Faridpur followed by Pabna and Sylhet regions.

Again, some additional insights regarding the efficiency of factor use in the cultivation of various crops are obtained by considering the test results for each crop across four sampling regions. Relatively greater efficiency in factor combinations is observed to be achieved in the cultivation of wheat (100%) and jute (57%) crops, followed by three varieties of rice, aus, aman and IRRI aus (33%). Failure to achieve cost efficiency in factor use is very prominent in the cultivation of pulses and oilseeds (0%). One also observes some uniformity in resource use efficiency for various crops across different regions.

Combining this observed tendency towards cost efficiency in the cultivation of jute across the four regions with those of our earlier findings for this crop, related to test results involving efficiency condition (a) (in VII.4.1),we find some conclusive evidence for efficient resource use in the cultivation of jute crop in Bangladesh. While our test results for efficiency condition (a) point to the efficient behaviour of the farm households in the presence of risk in the cultivation of jute,efficiency condition (b) demonstrates that in producing this crop, different inputs were combined in a relatively efficient way in our sample. In other words, both the absolute level of production of this crop and the proportion in which the factors were combined in producing this output level are both observed to be correct in most cases in our sample thereby indicating both allocative as well as cost efficiency, in short, resource use efficiency in the cultivation of jute crop in Bangladesh.

Finally, combining the test results for all crops across four regions, we arrive at a picture of overall resource use efficiency which is identical, (efficiency conditions being validated by the data set in 30% of the cases), to what we observed earlier in (i).

VII.4.3 Summary of Test Results Across Four Regions for Efficiency Condition (c).

Efficiency condition (c), it may be recalled, implies that allocating resources in the cultivation of two crops, the relatively higher risk involved in one crop relative to the other as measured by their risk factors (ϕ_{Q_i}), has to be compensated by a relatively higher return to that crop (measured in terms of higher E(VMP) of each input used). The test results for this efficiency condition are summarised in Table 7.6 for each input across different crop-pairs in our four sampling regions. Based on these results, we may draw the following conclusions regarding the resource allocation behaviour of the small farm households in Bangladesh.

Table 7.6

A Summary of Test Results For Efficiency Condition (c) in Four Regions

Regions	Inputs				
	Land	Human Labour	Bullock Labour	Seed	For all inputs in each regions
1. Sylhet	a) 0/2 (0%) b) 0/1 (0%)	a) 0/2 (0%) b) 0/1(0%)	a) 0/2 (0%) b) 0/1 (0%)	a) - b) -	a) 0/6 (0%) b) 0/3 (0%)
2. Pabna	a) 12/20 (60%) b) 5/14 (36%)	a) 8/20 (40%) b) 4/14 (29%)	a) 1/6 (17%) b) 0/3 (0%)	a)5/6 (83%) b)3/3 (100%)	a) 26/52 (50%) b) 12/34 (35%)
3. Faridpur	a) 2/12 (17%) b) 1/10 (10%)	a) 7/12 (58%) b) 6/10 (60%)	a) 1/6 (17%) b) 0/3 (0%)	a)0/2 (0%) b)0/1 (0%)	a) 10/32 (31%) b) 7/24 (29%)
4. Mymensingh	a) 3/12 (24%) b) 3/6 (50%)	a) 0/2 (0%) b) 1/1 (100%)	a) 0/2 (0%) b) 0/1 (0%)	a)0/2 (0%) b)0/1 (0%)	a) 3/18(19%) b) 4/9 (44%)
FOR EACH INPUT ACROSS REGIONS	a) 17/46 (37%) b) 9/31 (29%)	a) 15/36 (42%) b) 11/26 (42%)	a) 2/16 (13%) b) 0/8 (0%)	a) 5/10 (50%) b) 3/5 (60%)	a) 39/108 (36%) b) 23/70 (33%)

Notes: (a) represent the summary of test results for each input across different crop pairs under safety-rule while (b) represent the same under expected profit maximisation.

(i) Considering the test results for all inputs in each region, we find evidence of a region-specific behaviour pattern in resource allocation decisions. In Pabna, we have evidence more of safety-first behaviour while in Mymensingh, profit maximising behaviour seems to be relatively predominant among the farm-households in this region. On the basis of the evidence of the test results, we fail to discriminate between either type of behaviour pattern followed in Faridpur. In Sylhet, on the other hand, based on the scanty evidence we have available (because of lack of diversification in the cropping pattern in this region, efficiency test could be conducted for only one pair of crops aus and aman rice)both the models have been conclusively rejected in our sample.

For the comparative performance of both models in the four regions, we get additional evidence when we sum up the test results for all inputs across the four regions. This shows that the efficiency conditions are validated in our sample in roughly the same number of cases under both decision models.

(ii) The evaluation of test results for each input across regions also provide a similar picture of input-specific performance in both models. While in the case of acreage allocation, safety-first seems to have a slight edge over expected profit maximisation, the reverse is true in the case of seed input. In the use of both human and bullock labour, neither behaviour rule was superior to the other as the efficiency conditions are validated in 42% of the cases for human labour and in hardly any cases for bullock labour under both models.

VII.5 Summary and Conclusions

In the previous section, we summarised our test results for three sets of efficiency conditions. This was done for each input and input pairs across crops, and for each crop across inputs and input pairs. In all cases, the efficiency conditions were examined for two decision models, for a given region and across four regions. Our task in this section is to try to extract a consistent set of conclusions out of these diverse sets of test results involving different inputs used in different crops by the farm households in four different regions in Bangladesh. Based on these empirical findings, our conclusions regarding the resource allocation behaviour of the small farm households in Bangladesh may briefly be summarised as follows:

i) The test results for efficiency condition (a) (for all inputs across different crops and all crops across different inputs) across different regions, present some evidence of the importance of risk in resource allocation decisions as the safety-first model appears to perform somewhat better than the expected profit maximisation model. This, however, should not obscure the regional differences in behaviour patterns which exist in our sample. Based on both categories of test results (each input across crops and each crop across inputs), we find evidence of profit maximising behaviour in our sample in Sylhet and those of risk minimising behaviour (a la safety-first) in both Pabna and Faridpur. Our test results could not discriminate between these two models of behaviour in Mymensingh.

Our disaggeregated test results also permit us to draw some specific conclusions with respect to the allocation decisions for various inputs used in different crops in the four sampling regions. Although for most of these inputs and crops, our test could not discriminate on the basis of available evidence between either type of decision rule, we found strong evidence of risk minimising behaviour in the case of acreage allocation, especially, in the cultivation of jute, IRRI aus and IRRI boro. The fact that jute represents the major cash crop in the region and both IRRI aus and IRRI boro represent the two major high yielding varieties of rice incorporating modern bio-chemical technology in Bangladesh makes our empirical findings very plausible.

ii) Failure to achieve cost-efficiency in our sample is very pronounced as shown in the test results for efficiency condition (b). Although this may be attributed largely to the failure of the market prices of different inputs used (mostly family-owned) to reflect their opportunity costs to the farm households, part of such gross misallocations may also be ascribed to the inability of the farm-households to maintain proper factor combinations (least-cost combinations of inputs) in the cultivation of different crops in Bangladesh. Against such a backdrop of gross misallocations, however, we find evidence, on the basis of our disaggregated test results, of relatively greater cost-efficiency for those input pairs which combine with fertilizers and those in the cultivation of the jute crop. This confirms our earlier findings of allocative efficiency in the use of fertilizer input in different crops, and of risk efficiency in the cultivation of jute in different regions of Bangladesh.

Our test also identifies, in our sample, differential degrees of cost efficiency achieved in different regions in Bangladesh. The efficiency conditions hold is a maximum of 42% in Faridpur to a low of 15% of the cases in Sylhet.

(iii) Test results for efficiency condition (c) suggest some revision in our earlier conclusions (based on efficiency condition (a)) regarding resource allocation behaviour in the four sampling regions. In Pabna region, our test results again present evidence of the farm household's following safety-first behaviour but in Mymensingh region, where our previous tests failed to discriminate between either type of behaviour models, the test results produce evidence favouring profit maximising behaviour. Also, in Faridpur region, we no longer find evidence of safety-first behaviour as we did earlier; our test results now fail to discriminate between these two models in our sample in this region. A similar result is obtained for Sylhet region as well. No longer does our test establish the relative superiority of profit maximisation model; whatever limited information is available to conduct this test (which could be conducted for only one pair of crops) conclusively rejects both behaviourial models in the region.

Finally, after aggregating our test results for all inputs (across different crop-pairs) and across the four regions, we can no longer establish the superiority of either decision model in our sample as the efficiency condition is now validated in roughly the same number of cases under both models.

Before concluding this chapter, let us take a fresh look at the issues raised at the outset.

Does risk aversion play an important role in resource allocation decisions of the small farm households in Bangladesh? What can we say about the efficiency of resource-use among these farm households? Do they behave rationally in the presence of risk in their allocation of resources in various crops? Does our empirical investigation provide any interesting insight into resource allocation behaviour in a peasant agriculture as in Bangladesh?

We try to answer some of these questions in the light of the evidence presented in our study.

The null hypothesis that farm-households tend to allocate resources among various crops as if they were risk neutral is embodied in the model of expected profit maximisation. The alternative hypothesis that risk aversion is important in resource allocation decision is embodied in our specific decision model, the safety-first model of resource allocation under risk. The actual test of the importance of risk aversion in terms of their explanatory power. In our study, the comparative performance of these models has been evaluated by testing the validation of the corresponding set of efficiency (first-order) conditions in our sample.

Judged in this way, our test results for efficiency condition (a), indicate that the safety-first model performs relatively better in our sample then does the expected profit maximisation model thereby indicating that risk plays an important role in resource allocation decisions in rural Bangladesh.

Test results for efficiency condition (c), however, fail to discriminate between either decision models on the basis of available evidence. What is perhaps more interesting (and also more legitimate since all our empirical testing has been conducted on a regional basis) is to examine the regional differences in the pattern of behaviour observed in our sample.

In Pabna region, under both sets of efficiency conditions, (a) and (c), our test results present evidence favouring risk minimisation rather than (expected) profit maximisation in our sample. The small farm-households in this region, therefore, are observed to behave rationally in the presence of risk in their allocation of resources to various crops.

Also, we have some additional evidence of safety-first behaviour in our sample in Pabna region. The estimated risk factors, as we observed earlier, indicate the extent to which resource use is restricted or expanded (depending on whether $\phi_Q \gtrless 1$ which in turn depend on whether $\bar{d} \lessgtr \mu_r$) relative to the risk neutral (expected profit maximising) level. This implies that for those farm households with their $\bar{d} < \mu_r$, (and hence $\phi_Q > 1$), the resource use will be restricted more in the relatively riskier crop (crop with the higher income variances). In other words, between a pair of crops, the crop with the higher income variance should record, for these farm households, a higher value for its estimated risk factors. On the other hand, for those farm households with $\bar{d} > \mu_r$, (and hence $\phi_Q < 1$), there will be a tendency, under safety-first (or in this case, 'gambling type') behaviour, to devote greater resources to the riskier crop i.e., the crop with the higher income variance should now record, for these farm households, a lower value of its estimated risk factors. We examined the resource allocation behaviour of the farm households in Pabna for the two competing crops, (aus rice and jute) in the region, and found them to be very much consistent with the safety-first behaviour as postulated above.[9]

Unfortunately, the evidence from the test results in the other three regions is not as conclusive (though not contradictory either). In both Faridpur and Mymensingh regions, we have only partial evidence in favour of either decision models. In Faridpur region, for example, test results for efficiency condition (a) produce evidence more in favour of safety-first behaviour but the test results for condition (c) fails to discriminate between the two. In Mymensingh region, on the other hand, we have evidence of profit maximising behaviour in terms of the test results for efficiency condition (c), but not for condition (a) for which the relative superiority of either model is established. In Sylhet region, we have some evidence of profit maximising behaviour in our sample in terms of the test results for efficiency condition (a), but the test results for condition (c) conclusively rejects both the decision models based on the limited information available for this region.

The overall picture obtained in our sample seems to validate our hypothesis that in a subsistence agriculture like Bangladesh, the small farm-households are very much preoccupied with their security and survival and therefore, are very likely to follow some sort of safety-first behaviour in their resource allocation decisions.[10] This, however, does not rule out the possibility of some variations in the pattern of behaviour across different regions possessing differential socio-economic and physical characteristics.

For example, in some regions the disaster-avoidance motive may be very strong among the farm households and this should provide us with some conclusive evidence of disaster-avoidance behaviour in the sample, as observed in Pabna region. It must be emphasized here, however, that there is nothing innate or psychologically inherent in such disaster-avoidance motives. On the contrary, it should be traced to the capacity of the farm households and the variability of this capacity due to vagaries of nature, to generate sufficient income to meet their subsistence needs. Although there is not much difference in the factors determining income-earning capacity across the four sampling regions, the random variability of income is much greater in Pabna, which is reflected in the higher coefficients of different crops in the variance-covariance matrix of income disturbances estimated for this region earlier. In another region, as in Faridpur, the situation may not be so desperate as judged by both income-earning capacity relative to subsistence needs and the random variability of this capacity, and therefore, one would not expect to find any strong evidence of risk minimising behaviour in the sample.

In still another region, the farm households may be more well-off as reflected in their greater asset position and higher income-earning potential. This may be due to the greater fertility of land and higher cropping intensity made possible by the availability of irrigation facilities in the dry season. For this category of farm households, it will be rather futile to search for any disaster-avoidance motive, as they are more likely to display profit-maximising behaviour in their crop-growing decisions. This may be what happened in Mymensingh.[11] A glance at the per acre yield figures of different crops confirms that the average fertility of land is indeed much higher for the farm households in this region (Chapter IV, Table 4.4). Also, the farm households in Mymensingh are observed to be relatively wealthier than those in the other three regions. This is reflected in the much higher asset values of the farm households in this region as compared to those in other sampling regions (Chapter IV, Table 4.16).

In Sylhet region, our sample does not produce any conclusive evidence in favour of either type of decision behaviour. Because of lack of diversification in cropping pattern, there is limited information available in the sample for conducting tests. This may be the cause of this inconclusive test results. Alternatively, one may suggest that perhaps other behavioural model (e.g., expected utility model) could have performed better in our sample in Sylhet region.

When considering cost-efficiency, our test results (b) provide a rather poor picture of the farm households ability to combine resources in an efficient way. However, the fact that most of the inputs used by these farm households are family-owned, so that their opportunity cost may be different from those reflected in their market prices, such observed distortions in factor allocation should not be taken very seriously. In fact, such a divergence of the market price of inputs from their opportunity costs suggest that the observed distortions in factor allocation may not reflect resource misallocations. Also, our evidence of relatively greater cost-efficiency achieved in those input-pairs involving fertilizer, the only cash input in our sample, lends credence to such a view.

Test results for condition (a) both for each input across crops and each crop across inputs, also provide additional insights regarding resource use efficiency, in particular, and resource allocation behaviour in general in Bangladesh agriculture. Except in the use of fertilizers, our sample does hardly provide any evidence of allocative efficiency in factor use, in a profit maximising sense. In a risk minimising sense, however, the picture inproves somewhat as we find some evidence of factor use efficiency in both the cases of acreage allocation, and in the case of fertilizers. This finding that in the use of fertilizer our test results provide evidence of allocative efficiency (both in the profit maximising and the risk minimising sense), in addition to what we observed earlier regarding cost-efficiency, points conclusively to the efficient use of this cash input by the small farm households in Bangladesh. This may also demonstrate that the goals of expected profit maximisation and safety are not in conflict in our sample – an evidence which Roumasset (1976) found earlier while investigating the optimal level of fertilizer use under risk for Filipino rice farmers.

We get an improved picture of resource use efficiency in Table 7.4B specially under risk minimising behaviour. Factors are observed to be allocated efficiently in the cultivation of most of the crops including aus rice (67%), jute (56%), oilseeds (67%), IRRI aus (50%) and IRRI boro (87%). We interpret this as evidence of the farm-households behaving rationally in their allocation of resources in various crops when exposed to both yield and price uncertainty. Our test results also indicate that under expected profit maximisation, in addition to aman rice, pulses and wheat crops, our sample failed to produce evidence of allocative efficiency in the cultivation of jute, IRRI aus and IRRI boro.

The finding that we have evidence of the small farm households minimising risk as opposed to maximising profit in the cultivation of jute, IRRI aus and IRRI boro has some very interesting implications for resource allocation behaviour in peasant agriculture. Jute represents the major cash crop in Bangladesh. Also, IRRI aus and IRRI boro are the two major HYV crops (incorporating modern bio-chemical technology) grown in Bangladesh. It is often hypothesized that risk aversion causes farmer to devote too little land to the cash crop relative to the risk neutral (or efficient) acreage allocation. Also, there is a growing body of literature emphasizing the role of risk aversion in the diffusion of modern technology in peasant agriculture. We seem to have found some evidence for both in our sample.[12]

FOOTNOTES

1. For expected profit maximisation, however, such a problem does not arise and we could test directly, by means of a t-test, whether E(VMP) of input X differs significantly from its corresponding input price, w_x.

2. We could also test directly for the equality of the ratio of the marginal products for a pair of inputs across two crops by means of paired t test. This, however, would be very time consuming as the data would have to be paired for each farm household because different households possess different crop-portfolio. Also, the alternative test of whether the mean value of the ratio of marginal products across crops was significantly different from each other may not be strictly valid since the two distributions are not statistically independent.

3. The ranking test involves the computation of the rank correlation coefficient and then testing, in our context, whether this coefficient is significantly different from one or not.

4. A way out of this impasse is to compute the difference of each of the ϕ_Q's and E(VMP)'s across a pair of crops and then test separately whether or not these differences are significantly different from zero (greater or less than zero, to be more specific). Finally, the conclusions regarding the validation of the efficiency condition are drawn by comparing the results (ranking) of these two separate tests. However, this procedure is more cumbersome and time-consuming and therefore, was not followed in our study.

5. The estimated production function parameters of different crops which represented the corresponding input elasticities under Cobb-Douglas specification in log-linear form were used in computing the expected marginal products E(MP) for each input X as $E(MP_{X_i}) = \alpha_i(E(Q_i)/X_i)$ where α_i represent the input elasticity and $E(Q_i)$ and X_i the respective expected output and input levels for each farm household reported in the sample survey.

6. While testing the efficiency conditions under safety-first, the test results were mostly found to be insensitive to either set of risk factors used, those based on reported disaster incomes and computed disaster incomes respectively. The conclusion remains valid for the test results in the other three regions as well.

7. Under safety-first, our exercise further distinguishes the cases, as in efficiency condition (a), between those bases on reported disaster incomes and those based on computed disaster incomes. It is observed that the test results based on computed disaster incomes perform somewhat better in case of all inputs excepting human labour. For all inputs taken together, the efficiency conditions are validated in roughly 60% of the cases using computed disaster incomes as against 40% of the cases using reported disaster incomes.

8. Under safety-first, unlike in Pabna, the relative performance of test results based on either set of disaster incomes ~~remains more or less~~ the same in Faridpur.

9. In Pabna, jute has been identified as the riskier crop with its higher income variance (.252) as compared to aus rice (.156). Of the 26 farm households in our sample including both jute and aus rice in their crop portfolio, 22 have been identified with their $\bar{d} < \mu_r$, and the rest (4) with their $\bar{d} > \mu_r$. In the former group, it is observed that for 19 out of 22 farm households, the estimated risk factors for jute are greater than those for aus rice. In the other group, for 3 out of 4 farm households, the estimated risk factors for jute are observed to be less than those for aus rice. Thus, the observed resource allocation pattern seem to be quite consistent with the safety-first behaviour for these farm households in Pabna region.

10. It should be recognised here, however, that our test of "validation" is somewhat weak in the sense that model may be validated due to large confidence interval. Also, in cases where safety-first model performed better than the expected profit maximising model, one does not know if the results follows from a superior model or from misspecification of the π-max model (e.g., from omission of transaction costs).

11. Also, perhaps a less extreme version of safety-first model incorporating either the Telser or Kataoka rule (where the concern for security enters as a constraint rather than as an objective into the decision model) or a combination of two SF rules in a lexicographic framework (much in line with what Roumasset (1976) did while testing risk-inhibits-innovation hypothesis for a relatively well-to-do sample of Filipino rice farmers) would have performed better in capturing farmer behaviour in this region.

12. However, as various IRRI studies show since IRRI varieties of rice are not appropriate to most areas in Bangladesh, the implication of our empirical finding becomes very limited in the context of adoption of modern crop technology by the small-holding farmers in Bangladesh.

CHAPTER VIII

SUMMARY, CONCLUSIONS AND IMPLICATIONS FOR AGRICULTURAL POLICY

VIII. 1 Introduction

In this concluding chapter, we intend to summarise, chapterwise, the major findings of our study (in Section 2), discuss the implications of our findings for agricultural policy in Bangladesh, in particular, and in developing countries in general (in Section 3), and finally, suggest some promising areas for further research in this field (in Section 4).

VIII.2 Summary

Ours is a study of resource allocation behaviour of small-holding farms in Bangladesh under conditions of uncertainty. Therefore, in our introductory chapter, we raised the following questions to be answered in our study.

(a) Does risk aversion play an important role in the resource allocation decisions of small farm households in Bangladesh?

(b) Do farmers behave efficiently in their allocation of resources to various crops in the presence of risk?

(c) How do the subsistence farmers in Bangladesh react to the prevasive uncertainty of their environment?

In Chapter II, we presented a brief overview of agriculture in Bangladesh in order to indicate the overriding significance of agriculture in the economy of Bangladesh and more importantly, to identify the ecological constraints that create so much uncertainty facing the production decisions of small households in Bangladesh. We discussed, in particular, how the intertemporal variability in the seasonal distribution of rainfall and the random occurance of floods and cyclones, with its associated crop damage, makes crop cultivation an extremely risky activity in Bangladesh.

In Chapter III, therefore, in our modelling of the resource allocation behaviour of small farm households in Bangladesh, risk was explicitly incorporated in a safety-first model of resource allocation. Our analytical exercise demonstrated that the traditional tests of economic efficiency are in general misspecified (in the context of a safety first criterion) which reinforces the conclusions derived earlier by Wolgin (1975) using an expected utility model of resource allocation. Based on our allocative efficiency conditions, alternative testable propositions were developed to ascertain whether the small-holding farms in Bangladesh efficiently allocate resources to various crops in the presence of risk according to a safety first criterion. Also, a comparison of resource allocation behaviour under two rival criteria for analysing decision-making under uncertainty showed that it is possible to analyse the risk preferences of the farm household in a safety-first model of farmer behaviour much in the same way as in an expected utility model. The interpretation of the risk coefficient, however, will be somewhat different for the safety-first model. Emphasizing the farmer's behaviour towards risk, the safety-first approach attempts to explain, in terms of subsistence requirements and income-earning potential of the farm households, whether it is'forced to gamble' (i.e. grow more of the high return and high variance crops) or 'allowed to accept less risk' (i.e. trade expected return for reduced risk) in its choice of crop portfolio.

Chapter IV discussed in detail the survey procedures and sampling techniques as well as the nature and type of information collected in the field survey in four different regions in Bangladesh. It also analysed in depth the tabulated data with respect to various socio-economic and structural characteristics of the small farm-households in the four sampling regions. Our analysis of the data-characteristics revealed some regional variations in these characteristics for the farm households in the four sampling areas. However, despite these regional variations, the conditions in the sampling areas were generally representative of the subsistence-type of farming and traditional nature of agriculture prevalent in Bangladesh. Large family size (6.5 - 6.7 persons) relative to farm size (1.96 - 2.30 acres) leading to very low land/man ratio (.28 - .32 acres/person), overwhelming dependence on family owned/based inputs in cultivation, particularly for land and labour (72% - 80% for land and 60% - 80% for labour), very low cash expenditure on modern inputs used in cultivation (10% - 15%) and very low investment in fixed capital equipments other than bullock labour (9% - 14%), both combining to produce very low land productivity in the sampling areas, overwhelming dependence on a single subsistence crop accounting for a very large proportion of total cropped area (60% - 90%), high percentage of farm family's expenditure on foodgrains (40% - 70%) and finally, the predominance of non-institutional sources in meeting the credit needs of the farm-family (50% - 97%) in various regions - all these data-characteristics in our sample tend to support this view.

In Chapter V, we discussed the estimation of two basic components of our model: the cross section production functions for various crops using farm-level data, and the variance-covariance matrices of output and price disturbances of different crops, using aggregate time series data. Utilising the farm-level data collected earlier in the field survey, different sets of production functions were estimated for various crops in the four sampling regions in Bangladesh, and alternative regional specifications and functional forms were explored. In fact, the estimation was carried out in the following two phases:

(i) The regional nature of the production function was explored for every major crop produced. This essentially involved testing a variety of restrictions imposed on the coefficients of different regressions representing different regions. Our results indicated that for pulses and wheat crops, it is not meaningful to speak of a regional production function as there was no evidence of any significant differences in the technical coefficients of production for these crops across the four regions. However, for aus, aman and jute crops, our study found evidence of statistically significant differences in the shift coefficients across the four regions, though not in the slope coefficients. This, therefore, suggests that in estimating production functions for these crops data across regions be pooled while incorporating the appropriate regional shift dummies.

(ii) Three alternative functional forms, namely Cobb-Douglas, transcendental and translog functions, were chosen for estimation purposes and were subsequently tested to determine which one represented the more appropriate form for each of the crops produced. The results of our tests indicated that for most of the crops, namely aman rice, pulses, wheat, oilseeds, and IRRI boro the Cobb-Douglas restrictions were validated in our data set. For aus rice, the translog form was the most appropriate form in our sample. For the jute crop, however, our tests failed to produce any conclusive results as the Cobb-Douglas restrictions were rejected against both transcendental and translog functional forms.

In the absence of farm-level time series for output and prices, the variance-covariance matrices of output and price disturbances were estimated utilising the district-level aggregate time series on output and prices of various crops covering the period, 1948-49 to 1976-77. The general procedure adopted was to extract the systematic portion of the aggregate time series so that we were left with estimates of random disturbances from which relevant variance-covariance matrices were computed. This, of course, assumed particularly in case of output disturbances that aggregate regional data properly reflected yield variations at the farmer's field level. Ranking crops in terms of estimated variances of output disturbances (average of the four regions) shows that jute (.036) occupies the top position, followed by wheat (.034), aman rice (.025), aus rice (.019), IRRI boro (.017), oilseeds (.007) and pulses (.006).

In estimating price disturbances of different crops using regional time series of grower's prices, a variant of the Nerlovian expectation model was used. No evidence of the formation of farmer's expectations, naive or otherwise, could be established in our data set, except in the case of jute and pulses. The estimated coefficient of the time trend variable, however, was found to be satistically significant in almost all cases, implying that our estimates of price disturbances should be viewed as random fluctuations around the trend values over this period. Again, the ranking of crops in terms of the estimated variance of price disturbances showed that pulses (.153) occupied the top place, followed by oilseeds (.122), jute (.099), aman rice (.090), IRRI boro (.071) and aus rice (.070).

These estimates of random disturbances permit us to make some preliminary observations regarding the riskiness of different crops in our sampling regions. First, the estimates of variance-covariance matrices of price disturbances are much higher than those of the output disturbances. This evidently points to the relatively greater significance of price risk in our sample. Second, in terms of the relative riskiness of different crops it is obvious that jute followed by aman rice is more risky (in terms of both output and price disturbances) than any other crop grown in these regions. However, a clearer picture on this will emerge in Chapter VI when we consider the combined matrices of output and price disturbances needed to generate the matrices of disturbances affecting farmer's income.

Chapter VI presents the estimates of risk factors (ϕ_{Q_i}) for different crops as well as the estimates of the coefficients capturing peasant behaviour towards risk (ψ_k) for the farm households in each region. These estimates were derived utilising the estimates of disaster incomes as well as those of the mean and the variance of the crop portfolio for each farm household. These in turn, were based on the expected prices and outputs of various crops and the variance-covariance matrices of the disturbances affecting farmer's income.

Since Roy's Safety Principle is based on the notion of disaster avoidance by the decision maker, the concept of disaster income occupies a prominent place in modelling farmer behaviour based on this Principle. Therefore, in testing disaster avoidance behaviour in our sample, we needed a reliable set of estimates of disaster incomes for the farm households in each sampling region. Sometimes the concept of disaster income has been criticized because it is based on minimum tolerable consumption of the farm family which represents a notoriously subjective concept - "in fact, so subjective that scholars have not as yet attained that level of specification," (McGuire, 1980). We find this line of argument very difficult to accept. Roumasset (1976) has already shown, while testing the poverty-inhibits-innovation hypothesis for the Filipino rice farmers that a reliable set of estimates of disaster incomes could be obtained provided the appropriate farm-level data are available.

In our study, we have two sets of estimates for disaster incomes. One set was derived from direct reporting by farmers in our sample survey. Anticipating that there might be some upward bias in the reported set of estimates, an alternative set was computed using the Roumasset formula with some modifications to suit our model requirements and data availability. We subsequently tested for the difference between these two sets of estimates and found that in Pabna and Faridpur regions, the reported disaster incomes were significantly different from the computed set. However, in Sylhet and Mymensingh regions, the difference between the two sets of disaster incomes was not statistically significant, even at 5% level.

Variance-covariance matrices of disturbances affecting farmer's incomes were derived by combining the two separate matrices of output and price disturbances estimated earlier. However, the way in which these two matrices was combined depended on the assumed interrelationship between these two types of disturbances. We, therefore, had two sets of estimated variance-covariance matrices of disturbances affecting farmer income; one that assumed stochastic independence between output and price disturbances, and the other set that incorporated the covariance between these disturbances. Ranking crops in terms of estimated income variance of disturbances showed that jute (.277) occupied the top position, followed by pulses (.270), aman rice (.221), oilseeds (.182), aus rice (.146) and IRRI boro (.111). This gives some indication of the relative riskiness of different crops in Bangladesh.

Our estimates of the coefficients capturing peasant behaviour towards risk in different regions showed that while most of the farm households in Sylhet region should display 'gambling-type behaviour' (the subsistence needs of the farm family being greater than their income earning potential from farming activities), the situation for the majority of farm households in other three regions was not as desperate. For most of these households, the minimum consumption needs were less than their income-earning capacity, thereby allowing them to undertake less risky activities. Attempts were then made to explain the differential behaviour towards risk across different regions, and more importantly, across different farm households in each region. It was observed that although the average family size did not show much variation across regions, the average 'effective' farm size (farm size adjusted for cropping intensity) was much lower in Sylhet than in the three other regions.

This perhaps explains why most of the farm households in our sample in Sylhet had subsistence needs greater than their expected income. Also, attempts were made to establish a systematic relationship between our coefficients capturing peasant behaviour towards risk and a number of socio-economic variables characterising the peasant households and their access to income-earning opportunities. Our regression results showed that although the explanatory power of the risk-predictive equations were not very high, the major explanatory variables such as family size, farm size and off-farm income had the expected signs in most cases and were statistically significant.

For testing the hypotheses involving the efficiency of resource use for small farm households in Bangladesh, however, what we needed were the estimates of risk factors of different crops produced in each region. The expressions for these risk factors were derived earlier, using the first-order conditions in our safety-first model of resource allocation under risk. Therefore, using the estimates of disaster income, the mean income and variance of the income of the crop portfolio for each farm household, estimates of the expected output and the prices of different crops and those of the variance-covariance matrices of the disturbances affecting farmer's income, the risk factors were estimated for the various crops of the farm households in each sampling region.

Analysis of the frequency distributions of the computed risk factors showed that they mostly conformed to our a priori expectations. For those farm households with their disaster incomes less than their expected incomes and hence a negative risk coefficient, the risk factors of different crops came out with a value greater than one. Conversely, for the farm households with their disaster incomes greater than expected incomes and hence a positive risk co-efficient, the computed risk factors yielded a value less than one, implying greater resource-use relative to risk neutral level. This happened for most of the households in Sylhet region which it may be recalled, implies 'gambling-type' behaviour in their choice of crop-portfolio. It should be emphasized, however, that the sign and more importantly, the actual magnitudes of the estimated risk factors also depended on a number of interaction terms, especially those related to estimates of the variance and covariance of incomes from different crops for the farm households in each region.

The test results of the efficiency conditions derived earlier in Chapter III are presented in Chapter VII. In the light of these test results, we tried to answer some of the questions raised in our introductory chapter. The actual test of the importance of the role of risk aversion in resource allocation can be carried out by comparison of two models - the model of expected profit maximisation embodying risk neutral behaviour and our safety-first model of resource allocation which explicitly incorporates risk - with respect to their explanatory power. In this study the comparative performance of these two models has been evaluated by testing the validation of the corresponding set of efficiency conditions in our sample. Judged in this way, our test results for efficiency condition (a) indicated that the safety-first model performed relatively better across the four regions as compared to expected profit maximisation. Test results for efficiency condition (c), however, failed to discriminate between these two decision models on the basis of our evidence. Against this overall performance, some regional differences in behaviour-pattern were observed in our sample.

In Pabna region, both sets of test results (a) and (c) produced evidence which was more consistent with safety first behaviour than with profit maximising behaviour in resource allocation decisions. However, the evidence from the test results in the other three regions are not as conclusive although not contradictory, either. In both Faridpur and Mymensingh regions we have only partial evidence of farm households following either kind of behaviour. In Faridpur region, for example, our test results for efficiency condition (a) produced evidence in favour of safety-first behaviour, but not by the test results for condition (c) which failed to discriminate between the two hypothesis. In Mymensingh region, on the other hand, we found evidence of profit maximising behaviour in terms of the test results for efficiency condition (c), but not for condition (a) which failed to establish relative superiority of either of these two models. In Sylhet region, we had some evidence of profit maximising behaviour in our sample in terms of the test results for efficiency condition (a), but then our test results for condition (c) conclusively rejected both the models on the basis of the limited information available in this region. Such observed difference in behaviour pattern in resource allocation across four regions could be explained in terms of a disaster avoidance motive in the sample which could ultimately be traced to the capacity of the farm households and the variability of this capacity due to vagaries of nature, to generate sufficient incomes to meet their subsistence needs.

Turning to the issue of cost-efficiency in our sample, it was observed that our test results for efficiency condition (b) provided a rather poor picture of the farm households' ability to combine resources in an efficient way in the cultivation of various crops in Bangladesh. However, the fact that most of the inputs used by these small farm households are family-owned, so that opportunity costs may be different from their market prices, may explain the observed distortions in factor allocations in our sample.

Our disaggregated test results, especially those involving efficiency condition (a), provided some additional insights into resource use efficiency, in particular, and resource allocation behaviour, in general, in peasant farming in Bangladesh. In the use of fertilizers, our test results produced some conclusive evidence of allocative efficiency achieved in our sample, both in a safety first and profit maximising sense. This finding combined with our earlier evidence of relatively greater cost-efficiency associated with fertilizer points rather conclusively to the efficient use of this cash input by the small-holding farms in Bangladesh. However, since our test results validated the efficiency conditions for both decision models, this does not imply anything conclusive regarding the role of risk aversion in the use of fertilizer in Banagladesh.

Our disaggregated test results (a) for each crop across inputs provided an improved picture of resource use efficiency under risk minimising behaviour. Factors were observed to be allocated reasonably efficiently in the cultivation of most of the crops including aus rice (67%), jute (50%), oilseeds (67%), IRRI aus (50%) and IRRI boro (87%). This might be interpreted as evidence of the small farm households in Bangladesh behaving rationally in their allocation of resources to various crops in the presence of risk. Also, the fact that our test results produced evidence of risk minimising behaviour (as opposed to profit maximising behaviour) in the cultivation of jute as well as in IRRI aus and IRRI boro crops has got some interesting implications. Jute represents the major cash crop in Bangladesh. Also, IRRI aus and IRRI boro are the two major HYV crops in Bangladesh incorporating modern bio-chemical technology. We seem to have found in our sample some evidence of risk aversion in these cases.

VIII. 3 Implications for Agricultural Policy

Social efficiency requires that inputs be applied to crops up to the point of risk neutral optimum.[1] To the extent that risk aversion causes a downward bias in resource use because a risk minimising or expected utility maximising level of input use is generally lower (in the absence of any 'gambling type' behaviour) than that under expected profit maximisation, considerable loss of efficiency may result due to risk aversion among small farm households in peasant agriculture.[2] If risk aversion is negatively associated with wealth, it will also affect income distribution, since the poorer farmers will be further away from the expected profit maximising levels than will be the wealthier farmers.

Following Binswanger (1979), we may classify the policy instruments available to alleviate the undesirable consequences of risk aversion into following two broad categories.[3]

i) Policies specific to agricultural risk, which includes crop insurance schemes, relief and famine policies, pure buffer stock or price stabilisation schemes and flood protection measures.

ii) Policies which are not risk specific, which includes subsidization of inputs and/or credit, agricultural price support as incomes policy, reduction of background risk such as irrigation investments, increased efficiency of markets, improved access to information about technologies, improved non-agricultural job opportunities, improved medical and other welfare policies, and land reforms and other income/wealth redistributive measures.

We discuss below, in the light of our empirical findings, the efficacy of some of these policy measures in mitigating the undesirable effects of risk aversion among the small-holding farms in Bangladesh.[4]

Even in a relatively homogeneous sample of small farm households in Bangladesh with similar characteristics in terms of farm size, family size and other socio-economic characteristics, we observed considerable variations in resource allocation behaviour across different regions. In Pabna region, we found relatively stronger evidence of risk minimising behaviour and risk averse behaviour (with disaster incomes below expected incomes and hence risk factors greater than one) among these farm households whose capacity to generate sufficient incomes to meet their subsistence needs was not only low but subject to random variability as well. In such areas where the relevence of risk aversion for actual input choice is clearly demonstrated, the undesirable effects in terms of loss of efficiency would appear to be quite high. And therefore, the efficiency gains of policy measures designed to induce farmer's resource use to move in the direction of the risk neutral optimum is expected to be quite large as well.

In this context, the role of crop insurance schemes assumes special significance. It is well known that since the adminstrative costs associated with such schemes are quite high especially when dealing with large number of small farmers, the adoption of crop insurance schemes is economically justified only if there are sizeable allocative benefits to be reaped to offset their large administrative costs. In other words, only in high disaster-prone areas with strong evidence of risk minimising behaviour can there be sizeable potential benefits to be exploited that would justify the adoption of such schemes. On the basis of our evidence in this study, Pabna seem to qualify for this policy prescription.

It should, however, be emphasized here that in practice, pure insurance schemes based on individual loss assessments may be indefensible even in some selected regions in Bangladesh with very low incomes and large numbers of small-holding farms. Administrative costs of individual assessments may become prohibitively high and thus may be too costly to administer even with heavy government subsidies. A way out of this impasse has recently been suggested by Dandekar (1976), who proposed to provide insurance in which the indemnity payment does not depend on the loss in an individual field but is based on the shortfall from the normal levels of average yield across farms in a homogeneous crop growth zone. This would enormously reduce administrative costs and also overcome the moral hazard problem. Since economists usually emphasize the superiority of insurance over all other forms of risk dispersal, research on such area-based crop insurance schemes may be highly fruitful (Binswanger, 1979). We may add here, however, that in those regions (such as Faridpur and Mymensingh) where our study failed to produce any significant evidence of risk aversion for actual input choices, either because the random variability in incomes was not so pronounced or because the farm households' capacity to meet their subsistence requirements were adequate, the case for such crop insurance schemes is very weak indeed. Because in such situations, the allocative or risk-diffusing benefits of such schemes are likely to be quite small. In fact, in such cases, as Roumasset (1976) argues, the efficiency gains may even be negative.[5] When one adds to this the sizeable administrative costs, a crop insurance program aimed at offsetting the effects of risk aversion in such areas is bound to have a present value considerably less than zero.

Perhaps because of their disenchantment with feasible crop insurance schemes, most developing countries (and Bangladesh is no exception) usually resort to famine and relief policies to deal with consequences of natural disasters. This includes land revenue concessions, rural works programme to supplement the loss of farm incomes and direct supplies of food and other relief materials. In spite of some controversies regarding the adequacy and effectiveness of such efforts, one cannot but agree with Binswanger (1979) when he observes: "... these policies may be the only effective insurance and risk diffusing schemes available to poor countries to alleviate the effects of disasters. A more thorough investigation of the ability of these schemes to meet risk-reducing goals is surely called for." Given the predominance of such programs to deal with disaster situations in the policy packages of these countries a thorough economic appraisal of such schemes is indeed necessary to suggest, in particular, how to improve their efficiency impact on the economy.[6]

Another way of reducing the inefficiency stemming from risk aversion among small farm households is to provide subsidised credit to these households whose access to institutional sources of credit is rather limited. The availability of such credit, especially in times of distress, through a reduction in the consequences of losses, will have the effect of making the farmers less risk-averse in their input choices. At the same time, the low interest loans would tend to offset two other sources of inefficiency usually prevalent in peasant farming. One relates to the fact that small farmers often face interest rates much higher than their social opportunity cost of capital. The other source of inefficiency is explained in terms of the observed underinvestment in cash intensive techniques because of their lack of knowledge or the existence of learning lags about these techniques. Low interest loans, by providing a subsidy to these inputs, would induce the farmers to make correct decisions.[7] The subsidy is more effective if the loans are part of a supervised credit program which is based, in turn, upon a sound system of generating crop recommendations (Roumasset, 1979).[8]

It must be emphasized here that since the cost of such subsidized credit to a large number of small farmers is likely to be very high, one has to be selective in implementing such programmes. Only those groups of farmers who display substantial degrees of risk aversion in resource allocation would be considered eligible for such subsidies. Categorising farm households in terms of their income-earning capacity relative to their subsistence needs in each ecological zone, much in line with what we have done in this study in analysing peasant behaviour towards risk, should prove to be of much help to the policy makers in this respect.

Buffer stocks and other price stabilisation schemes represent yet another set of policy instruments to deal with the undesirable effects of risk aversion in agriculture. This assumes special significance in the context of Bangladesh agriculture in view of our empirical evidence of the much greater random variability associated with prices than with those corresponding to outputs of various crops in each region. The issue, however, is more complicated than it would otherwise appear. Although it is often argued that price stabilisation will reduce risk, the opposite is quite plausible since price is negatively correlated with yield. Hazell and Scandizzo (1976), however, provide a somewhat different argument for government intervention on prices. They argue that if farmers make decisions on the basis of independent forecasts about yields and prices then, optimally distorted prices will increase aggregate social welfare compared to what could be achieved under competitive market equilibria.[9]

Newbery (1976), however, argues against such policy by showing that rational expectations which take account of the negative correlation between output and prices would lead the farm households to choose efficient production plans and that any government intervention will only worsen the situation. Hazell and Scandizzo (1979) later conceded this point and have also shown that there is even a simpler class of behaviour which ensures competitive market efficiency, namely the models where the farmers are assumed to act on the basis of a linear lagged function of revenues. It is therefore, quite evident that the case for government intervention on prices either through buffer stocks or other prices stabilisation schemes, rests very much on the way farmers actually do forecast farm profitability when planning their input decisions. There is thus a clear need for further empirical research in this field before anything definite can be said about the impact of suoh schemes on aggregate welfare.

We have already noted that credit subsidy policy in addition to its risk diffusion role, also may help in removing other inefficiencies prevalent in a peasant economy. There are a number of such policies whose primary goal is not risk reduction but which still influence the general risk situation of the target group either by increasing income and/or reducing exposures to risk in areas other than agricultural production. In Bangladesh, for example, the foodgrain procurement policy has been primarily designed to ensure adequate supplies to the public food distribution system. However, it has additional side benefits of risk reduction in mitigating seasonal fluctuations in prices.[10] Other such policies in Bangladesh include the sectoral allocation of investments, particularly irrigation and rural infrastructural investments, provision of agricultural extension services under the Integrated Rural Development Programme, the provision of input subsidies particularly to fertilizers and periodical legislative and institutional reforms in credit and land tenancy areas. All these policies have potential side benefits in terms of risk reduction although the quantitative estimates of such benefits are not readily available.

In the absence of such quantitative knowledge, the evaluation of the significance of these side benefits might be made, as suggested by Binswanger (1979), in a somewhat ad hoc manner by considering whether there is a conflict between the primary goals of such policies and the secondary goals of risk reduction. For example, in the case of irrigation investments such a conflict does not arise because both the increased level of production and risk reduction will benefit the same target group of population/region. Therefore, the rates of return of such projects computed solely in terms of increases in expected outputs tend to underestimate their contribution to the economy. Evidently, such incremental side benefits would be larger in areas exposed to greater degrees of weather instability. Also, consideration of the side benefits of risk reduction may sometimes help in making better decisions in choosing among alternative investment projects.

Before we conclude this section, we must refer to the role that the existing agricultural institutions play in diffusing the risk in a peasant economy. It is now widely recognised that the institution of share-cropping tenancy and rural credit markets contribute significantly in reducing the cost of risk bearing in such economies by spreading risk over different economic agents. This is primarily done in two ways (Roumasset, 1979). First, although the rural financial markets in developing countries are not well developed, the risk diffusion that takes place by means of formal and informal lending arrangements such as share tenancy and the extended family, will have considerable downward effects on risk premiums that in turn will induce the decision-making agents to move closer to the risk-neutral optimum. Second, since risk spreading tends to eliminate discrepancies between risk premiums of identical assets held by different households, the institutions that spread risks will reduce inefficiencies associated with discrepancies in risk premiums. In this context, in addition to the role played by share tenancy and rural credit markets, one should add the role of land and labour markets which contribute to risk diffusion in a number of ways. For example, they allow one farmer to simultaneously rent-in land and work for wages in another farm and also permit factors to be employed in enterprises and within contractual relationships that maximise their value.

Thus, even if risk aversion if found to be important, the burden of risk may be sufficiently diffused in the economy through existing social and economic institutions so that any government efforts to further diffuse the risks may not generate sufficient efficiency benefit to justify the cost of such efforts. Therefore, in these countries, one should be very careful in recommending any policy proposal for government intervention designed to offset the undesirable effects of risk aversion. The case for government intervention, it may be emphasized, ultimately rests in demonstrating whether it has a comparative advantage in diffusing risk through existing markets and socioeconomic institutions.

VIII. 3 Directions for Further Research

We may indicate several areas in which present research can be extended and possibly improved.

In this study, the importance of risk in resource allocation was examined by testing the validity of a set of efficiency conditions derived under a safety-first model of resource allocation. This approach is quite useful in the sense it represents a joint test for both allocative efficiency and a certain economic behaviour (risk minimising behaviour, to be more specific) in the sample. However, there are certain problems with this approach. For example, if the efficiency conditions are validated in our sample then we can claim to have found evidence of both risk minimising behaviour and allocative efficiency in the presence of risk. But if the efficiency conditions are not validated, we cannot then make any conclusive remarks regarding either risk minimising behaviour or allocative efficiency in the sample.

An alternative and perhaps econometrically more valid procedure particularly to test the importance of risk aversion in resource allocation is to compare the predictive power of alternative decision models to explain farmers actual behaviour. In other words, the approach involves comparison of actual and predicted farm resource use employing alternate decision criteria. Such alternate criterion may also involve modelling based on lexicographical safety-first and expected utility maximisation.

Production function formulation in our model represents a simpler and somewhat restrictive specification of stochastic components of production with the implications that an increase in the production risk associated with a particular crop causes a proportional reduction in the use of all inputs and also that all inputs used always have a risk-increasing effect on output (marginal risk always increasing), which may not be true. This specification, therefore, is rather uninformative with respect to differential degree and nature of risk considerations involving different inputs. Thus any evaluation of policies which affect inputs related to risk may be inadequate.

One can think of two ways in which input specific risk could be incorporated in a resource allocation model. One and perhaps simpler way of achieving this is to introduce randomly varying parameters in the Cobb-Douglas function to model input uncertainty in the production process. The other and a more sophisticated formulation provided by Just and Pope (1979) aims to improve the specification of stochastic components of production function.[11] This implies replacing the conventional specification of $y = f(X)e^{\varepsilon}$ by a more flexible functional form of the type, $q = f(X) + h(X)\varepsilon$ where f and h are functions of an input vector, X, and ε is the stochastic error term (with zero mean and constant variance). However, a consistent estimation (involving two-stage non-linear least squares)of the parameters of this function requires reliable experimental data on farm inputs and output or a pooling of cross-section and time-series data, which may not be always available.

Resource allocation behaviour in peasant farming has been analysed in our study by focussing, rather narrowly, on the production activities of the farm household. In peasant agriculture, however, production is mainly done for consumption within the household, and hence a more realistic approach would call for a better understanding of the interaction of the production and consumption behaviour of the peasant household. What is needed,therefore, is a complete farm household model which integrates both production and consumption decision of the farm household to analyse in greater depth how they react to the prevasive uncertainty of their environment.

An important extension of our empirical work would involve analysis of differential behaviour towards risk across different farm sizes and/or tenurial conditions. Also, one could test for relative economic efficiency in the same sample. This may provide a basis for making different set of policy recommendations for different group of farmers depending on the nature of evidence obtained pertaining to their differential behaviour towards risk and/or varying degrees of efficiency in resource use.

FOOTNOTES:

1. Because of diversification in a country's wealth portfolio and because of the risk sharing that occurs through financial intermediation, taxation and other socio-economic institutions, social efficiency does not require that the benefits of a project exceeds its cost by more than a negligible risk premiums in order for the project to be economically feasible (Arrow and Lind (1970), Diamond (1967) and Stiglitz (1974)). Arrow and Lind (1970), in particular, has provided the theoretical justification for the view that it is in the interest of the society that individuals act as profit maximisers. To the extent, however, the society may have a safety-first objective perhaps it would be less controversial to simply speak in terms of loss of agricultural output.

2. To the extent, however, that risk aversion is created by market imperfections that represent real transaction costs (e.g., due to differences in borrowing and lending rates, buying and selling prices of agricultural products, etc) then risk aversion does not constitute a source of inefficiency even if it is borne entirely by the individual in question (Roumasset, 1979).

3. This classification has been made by Binswanger (1979) on the basis of whether agricultural risk reduction is the principal goal of a policy. Recognising that there may be some arbitrariness in such classification, a policy is nevertheless classified as risk specific if it attains its ultimate efficiency or equity goals primarly via the effect which its risk spreading or reducing impact has on farmer's behaviour towards the choice among risky production activities. On the other hand, a policy is classified as non-risk specific if its main effect on efficiency or equity is not reached primarily as a consequence of risk spreading or reducing, but in a more direct way.

4. We concentrate here on the efficiency aspects of alternative policy measures ignoring their distributive implications. Although egaletarian distribution of income is now widely recognised to be a major social objective in most developing countries, it is unlikely that policies that improve income distribution at the expense of efficiency will be acceptable in these countries. This, however, does not preclude consideration of those policy measures which simultaneously improve income distribution and efficiency. In particular, since income distribution may be regarded as a public good efficient allocation of resources will typically involve some public expenditures contributing to reductions in poverty (Roumasset, 1979).

5. An effective crop insurance scheme must be mandatory to prevent adverse selection. Therefore, those farmers who were already at the risk neutral optimum may be induced to move away from those positions since the mandatory insurance program changes the density function of profits. Thus, even ignoring costs, the allocative benefits of crop insurance may be negative (Roumasset, 1976).

6. In the Indian subcontinent where such relief measures are most prevalent, the debates usually centers around whether the government relief materials are really reaching the areas or groups where they are needed most, and also how to improve the efficiency of public works program undertaken in disaster affected areas. Also, Morris (1974) argues that in India, drought-prone areas receive relief so frequently that farmers choose too risky crop-mixes and input levels as compared to expected profit maximising levels thereby resulting in another type of inefficiency. However, as Binswanger (1979) points out, if farmers are risk averse, there is probably little reason to fear such overshooting.

7. To the extent, however, our tests show efficiency in fertilizer use, this argument may not be tenable in our sample of small-holding farms in Bangladesh.

8. It should, however, be mentioned here that provision of credit subsidy is advocated here as a second best policy in view of the inability of the government in most of these countries to deal with the inefficiencies directly through investment in human capital, provision of adequate extension services and/or carrying out appropriate capital market reforms.

9. Hazel and Scandizzo (1976) argue, in particular, that in cases where farmers make production choices on the basis of average prices (i.e., they ignore the negative covariance between yield and prices), even risk neutral farmers will underproduce crops with high variance relative to the level that corresponds to the maximisation of average profits. Therefore, it follows that price subsidies on 'risky' crops will induce farmers to move closer to the risk-neutral optimum.

10. Whether this policy has actually succeeded in stabilising prices of food grains in Bangladesh is a different matter. In a recent empirical study (Islam, 1980), it was shown that govt. food procurement policy contributed little towards mitigating the seasonal fluctuations in foodgrain prices in Bangladesh.

11. The conventional multiplicative stochastic specification in the estimation of production function has been criticized on several grounds by Just and Pope (1979). In particular, they criticized the overly restrictive assumption implicit in this specification that marginal risk, defined as the partial derivative of the variance of output with respect to a particular input, will always be positive for all inputs. However, it is not difficult to think of a situation particularly in agriculture where one would expect to find that the variance of output will decline as the level of some input is increased. For an empirical application of a more flexible form incorporating both positive and negative marginal risk in the context of the pastoral zone in Eastern Australia, see Griffith and Anderson (1981).

APPENDIX IIIA

DERIVATION OF FIRST-ORDER CONDITIONS IN BASIC SAFETY-FIRST MODEL OF RESOURCE ALLOCATION

In this Appendix, we attempt to derive the first-order conditions of our basic safety-first model of resource allocation under risk. In our two-crop model, the production functions are represented by:

$$Q_1 = g(L_1, X_1, Y_1)u_1 \qquad \text{.....(1)}$$

$$Q_2 = h(L_2, X_2, Y_2)u_2 \qquad \text{.....(2)}$$

where Q_i represent physical output of crop i, L_i, X_i and Y_i represent land and two other variable inputs, X and Y used in the cultivation of crop i, and u_i represent the random disturbances (distributed with unit mean and finite variance) associated with production of crop i.

If the price of the two crops are given by P_{Q_1} and P_{Q_2}, with random components of v_1 and v_2, then, net income of the farm household may be written as:

$$r = P_{Q_1}Q_1 + P_{Q_2}Q_2 - \{w_x(X_1+X_2) + w_y(Y_1+Y_2)\} \qquad \text{.....(3)}$$

Assuming stochastic independence between output and price disturbances (u_i and v_i), we have the mean net income (μ_r) of the household:

$$\mu_r = E(r) = E(P_{Q_1})E(Q_1) + E(P_{Q_2})E(Q_2) - \{w_x(X_1+X_2)+w_y(Y_1+Y_2)\} \qquad \text{.....(4)}$$

The variance of net incomes (σ_r^2) of the farm household may be calculated as in the following:

By definition, σ_r^2 [illegible] $- \{E(r)\}^2$ .....(5)

$$\text{Now, } E(r^2) = E(P_{Q_1}^{\;2})E(Q_1^2) + E(P_{Q_2}^{\;2})E(Q_2^2) + \{w_x(X_1+X_2)+w_y(Y_1+Y_2)\}^2$$
$$+ 2E(P_{Q_1}P_{Q_2})E(Q_1Q_2)+2E(P_{Q_1})E(Q_1)\{w_x(X_1+Y_2)+w_y(Y_1+Y_2)\}$$
$$- 2E(P_{Q_2})E(Q_2)\{w_x(X_1+X_2)+w_y(Y_1+Y_2)\} \qquad \ldots\ldots(6)$$

$$\text{Also, } \{E(r\ )\}^2 = \{E(P_{Q_1})\}^2\{E(Q_1)\}^2 + \{E(P_{Q_2})\}^2\{E(Q_2)\}^2 +$$
$$+ \{w_x(X_1+X_2)+w_y(Y_1+Y_2)\}^2 + 2E(P_{Q_1})E(P_{Q_2})E(Q_1)E(Q_2)$$
$$- 2E(P_{Q_1})E(Q_1)\{w_x(X_1+Y_2)w_x(Y_1+Y_2)\}$$
$$- 2E(P_{Q_2})E(Q_2)\{w_x(X_1+Y_2) + w_y(Y_1+Y_2)\} \qquad \ldots\ldots(7)$$

Hence, substituting the expression for $E(r^2)$ and $\{E(r)\}^2$ from (6) and (7), we get

$$\sigma_r^2 = [E(P_{Q_1}^{\;2})E(Q_1^2) - \{E(P_{Q_1})\}^2\{E(Q_1)\}^2] + [E(P_{Q_2}^{\;2})E(Q_2^2) - \{E(P_{Q_2})\}^2\{E(Q_2)\}^2]$$
$$+ [2E(P_{Q_1}P_{Q_2})E(Q_1Q_2) - 2E(P_{Q_1})E(P_{Q_2})E(Q_1)E(Q_2)] \qquad \ldots\ldots(8)$$

But $[E(P_{Q_i}^{\;2})E(Q_i^2) - \{E(P_{Q_i})\}^2\{E(Q_i)\}^2] = \{E(P_{Q_i})\}^2\{E(Q_i)\}^2\sigma^2_{u_iv_i}$ and

$$[2E(P_{Q_1}P_{Q_2})E(Q_1Q_2) - 2E(P_{Q_1})E(P_{Q_2})E(Q_1)E(Q_2)] = 2E(P_{Q_1})E(P_{Q_2})E(Q_1)E(Q_2)\sigma_{12}$$

where $\sigma^2_{u_iv_i}$ = variance of disturbances affecting farmer's income from crop i

and σ_{12} = covariance of disturbances affecting farmer's income from crop 1 and crop 2

$$\text{Therefore, } \sigma_r^2 = \{E(P_{Q_1})\}^2\{E(Q_1)\}^2\sigma^2_{u_1v_1} + \{E(P_{Q_2})\}^2\{E(Q_2)\}^2\sigma^2_{u_2v_2} +$$
$$2E(P_{Q_1})E(P_{Q_2})E(Q_1)E(Q_2)\sigma_{12} \qquad \ldots\ldots(9)$$

As mentioned earlier, the objective of the farm household is to minimise the probability of disaster, $P(r<\bar{d}) \sim \{(\bar{d}-\mu_r)/\sigma_r\}$, subject, of course, to the constraints imposed by the technology as reflected in the production functions, (1) and (2), and the total availability of land to the household, $L_1+L_2 = \bar{L}$.

The necessary Lagrangian, therefore, may be written as

$$\mathcal{L} = \{(\bar{d}-u_r)/\sigma_r\} + \lambda\ (L_1 + L_2 - \bar{L}) \qquad .....(10)$$

To minimise this expression, it is first necessary to express u_r and σ_r in terms of the decision variables, L_i, X_i and Y_i as well as the random components associated with output and prices.

$$\mathcal{L} = \frac{\bar{d}-E(P_{Q_1})g(L_1,X_1,Y_1)-E(P_{Q_2})h(L_2,\ X_2,\ Y_2) + \{w_x(X_1+X_2)+w_y(Y_1+Y_2)\}}{[\{E(P_{Q_1})\}^2\{g(L_1X_1Y_1)\}^2\sigma^2_{u_1v_1} + \{E(P_{Q_2})\}^2\{h(L_2,X_2,Y_2)\}^2\sigma^2_{u_2v_2} + 2E(P_{Q_1})E(P_{Q_2})g(L_1,X_1,Y_1)h(L_2,X_2,Y_2)\sigma_{12}]^{1/2}} + \lambda(L_1+L_2-\bar{L}) \qquad ....(11)$$

We may now differentiate $\mathcal{L}$ in (11) with respect to L_i, X_i and Y_i to derive the relevant first-order conditions of our safety-first model of resource allocation, as shown in the text (Chapter III). To illustrate, let us derive the first-order condition for the use of variable input, X used in the cultivation of crop 1.

We may denote, in the expression for $\mathcal{L}$ in (11), the numerator as M and the terms within bracket [ ] in the denominator as N respectively. This allows us to express $\mathcal{L}$ as,

$$\mathcal{L} = M/\sqrt{N} + \lambda\ (L_1 + L_2 - \bar{L}) \qquad .....(12)$$

Differentiating this with respect to X_1, we get

$$\frac{\partial\mathcal{L}}{\partial X_1} = M.(-1/2)N^{-3/2}[2\{E(P_{Q_1})\}^2 g_x g(L_1X_1Y_1)\sigma^2_{u_1v_1} + 2E(P_{Q_1})g_x E(P_{Q_2}) h(L_2X_2Y_2)\sigma_{12}] + N^{-1/2}[E(P_{Q_1})g_x + w_x]$$

$$= -N^{-1/2}[(M/N)\{E(P_{Q_1})\}^2 g_x g(L_1X_1Y_1)\sigma^2_{u_1v_1} + (M/N)E(P_{Q_1})E(P_{Q_2}) g_x h(L_2X_2Y_2)\sigma_{12}] + N^{-1/2}[E(P_{Q_1})g_x + w_x]$$

Now, putting $\partial\mathcal{L}/\partial X_1 = 0$ and rearranging the terms, we get;

$$(M/N)\{E(P_{Q_1})\}^2 g_x g(L_1X_1Y_x)\sigma^2_{u_1v_1} + (M/N)E(P_{Q_1})E(P_{Q_2})g_x h(L_2X_2Y_2)\sigma_{12} + E(P_{Q_1})g_x = w_x \quad ..(12)$$

or $E(P_{Q_1})g_x[(M/N)E(P_{Q_1})g(L_1X_1Y_1)\sigma^2_{u_1v_1} + (M/N)E(P_{Q_2})h(L_2X_2Y_2)\sigma_{12} + 1] = w_x$

or $E(P_{Q_1})g_x = w_x[(M/N)E(P_{Q_1})g(L_1X_1Y_1)\sigma^2_{u_1v_1} + (M/N)E(P_{Q_2})h(L_2X_2Y_2)\sigma_{12} + 1]^{-1}$.(14)

But $M = (\bar{d}-u_r)$, $N = \sigma^2_r$, $E(P_{Q_1})g_x = E(VMP_{x_1})$ and also $g(L_1X_1Y_1) = E(Q_1)$ and

$h(L_2X_2Y_2) = E(Q_2)$ so that we may finally express the first-order condition as

$$E(VMP_{x_1}) = w_x[\{(\bar{d}-u_r)/\sigma^2_r\}E(P_{Q_1})E(Q_1)\sigma^2_{u_1v_1} + \{(\bar{d}-u_r)/\sigma^2_r\}E(P_{Q_2}) E(Q_2)\sigma_{12} + 1]^{-1} \quad .....(15)$$

Similarly, the exercise can be repeated for other inputs used in other crops.

APPENDIX IIIB

DERIVATION OF FIRST ORDER CONDITIONS IN MODIFIED SAFETY-FIRST MODEL OF RESOURCE ALLOCATION

In this Appendix, we attempt to derive the first order condition of our modified safety-first model of resource allocation under risk. In this model, the relevant variable in terms of which the disaster income level is compared is no longer net income but $\overset{*}{Q} = Q_f + (P_c/P_f)Q_c$, a composite variable which consists of the amount of food crop (Q_f) grown by the farm household plus the amount that he can obtain by selling cash crop (Q_c) produced on the market at a relative price (P_c/P_f), which has a random component, v (distributed with unit mean and finite variance).

In our two crop model, the production functions of food and cash crop is represented by:

$$Q_f = A_f \, L_f^{\alpha_f} \, X_f^{\beta_f} \, Y_f^{\gamma_f} \, u_f \qquad .....(1)$$

$$Q_c = A_c \, L_c^{\alpha_c} \, X_c^{\beta_c} \, Y_c^{\gamma_c} \, u_c \qquad .....(2)$$

where Q_f and Q_c represents physical outputs of food and cash crops, L_f, X_f, Y_f and L_c, X_c, Y_c represents land and two other variable inputs used in the production of food and cash crops respectively.

Now, assuming stochastic independence between output and price disturbances (i.e. between u_f, u_c and v), we have

$$\mu_Q^* = E(\overset{*}{Q}) = E(Q_f) + E(P_c/P_f)E(Q_c) \qquad .....(3)$$

Also, the expression for $\sigma^2_{\overset{*}{Q}}$ may be derived as follows:

$$E(\overset{*}{Q}{}^2) = E(Q_f^2) + 2E(P_c/P_f)E(Q_fQ_c) + E(P_c/P_f)^2E(Q_c^2) \quad .....(4)$$

and $\{E(\overset{*}{Q})\}^2 = \{E(Q_f)\}^2 + 2E(P_c/P_f)E(Q_f)E(Q_c) + \{E(P_c/P_f)\}^2\{E(Q_c)\}^2 \quad ..(5)$

Hence, $\sigma^2_{\overset{*}{Q}} = E(\overset{*}{Q}{}^2) - \{E(\overset{*}{Q})\}^2$

$$= [E(Q_f{}^2) - \{E(Q_f)\}^2] + 2E(P_c/P_f)[E(Q_fQ_c) - E(Q_f)E(Q_c)]$$

$$+ [E(P_c/P_f)^2E(Q_c^2) - \{E(P_c/P_f)\}^2\{E(Q_c)\}^2] \quad .....(6)$$

But $[E(Q_f^2) - \{E(Q_f)\}^2] = \text{var}(Q_f)$, $[E(Q_fQ_c) - E(Q_f)E(Q_c)] = \text{Cov}(Q_fQ_c)$

and $[E(P_c/P_f)^2E(Q_c^2) - \{E(P_c/P_f)\}^2\{E(Q_c)\}^2] = \{E(P_c/P_f)\}^2\{E(Q_c)\}^2\sigma^2_{u_cv}$

[Also, $\text{var}(Q_f) = \{E(Q_f)\}^2\sigma^2_{u_f}$, $\text{cov}(Q_fQ_c) = E(Q_f)E(Q_c)\sigma_{u_fu_c}$]

Therefore, $\sigma^2_{\overset{*}{Q}} = \text{var}(Q_f) + 2E(P_c/P_f)\text{cov}(Q_fQ_c) + \{E(P_c/P_f)\}^2\{E(Q_c)\}^2\sigma^2_{u_cv} \quad ..(7)$

The objective of the farm household is to minimise the probability of disaster $P(\overset{*}{Q} < \bar{d}^*) \sim [(\bar{d}^* - \mu^*_Q)/\sigma^*_Q]$, subject to the production functions constraint and that imposed by the total availability of land, $L_f + L_c = \bar{L}$. The necessary Lagrangian, therefore, can be written as

$$\mathcal{L} = [(\bar{d}^* - \mu^*_Q)/\sigma^*_Q] + \lambda\ (L_f + L_c - \bar{L}) \quad .....(8)$$

To minimise this expression, it is necessary to express μ^*_Q in terms of decision variables, L_i as well as the random components associated with the production of food and cash crop, and their relative price.

$$\mathcal{L} = \frac{\bar{d}^* - A_f L_f^{\alpha_f} X_f^{\beta_f} Y_f^{\gamma_f} - E(P_c/P_f) A_c L_c^{\alpha_c} X_c^{\beta_c} Y_c^{\gamma_c}}{[(A_f L_f^{\alpha_f} X_f^{\beta_f} Y_f^{\gamma_f})^2 \sigma^2_{u_f} + \{E(P_c/P_f)\}^2 (A_c L_c^{\alpha_c} X_c^{\beta_c} Y_c^{\gamma_c})^2 \sigma^2_{u_c v} + 2E(P_c/P_f)(A_f L_f^{\alpha_f} X_f^{\beta_f} Y_f^{\gamma_f})(A_c L_c^{\alpha_c} X_c^{\beta_c} Y_c^{\gamma_c})\sigma_{u_f u_c}]^{\frac{1}{2}}} + \lambda (L_f + L_c - \bar{L}) \quad .....(9)$$

We may now differentiate the expression (9) with respect to the decision variable, L_f and L_c to derive the relevant first-order condition in our modified safety-first model, as shown in the text (Section 4, Chapter III) Let us donote in (9) the numerator as N and the term within the square brackets as D so that we can rewrite the Lagrangian, as

$$\mathcal{L} = N/\sqrt{D} + \lambda (L_f + L_c - \bar{L}) \quad ....(10)$$

Differentiating (10) with respect to L_f, we get

$$\partial\mathcal{L}/\partial L_f = N(-1/2)D^{-3/2}[2E(Q_f)\sigma^2_{u_f}(\alpha_f/L_f)E(Q_f) + 2E(P_c/P_f E(Q_c)(\alpha_f/L_f)E(Q_f)\sigma_{u_f u_c}] + D^{-1/2}[-(\alpha_f/L_f)E(Q_f)] + \lambda$$

Now, putting $\partial\mathcal{L}/\partial L_f = 0$ and rearranging the terms, we may write

$$D^{-1/2}[(N/D)(\alpha_f/L_f)\{E(Q_f)\}^2\sigma^2_{u_f} + (N/D)E(P_c/P_f)(\alpha_f/L_f)E(Q_f)E(Q_c)\sigma_{u_f u_c} + (\alpha_f/L_f)E(Q_f)] = \lambda$$

$$\text{or } (\alpha_f/L_f)E(Q_f)[(N/D)E(Q_f)\sigma^2_{u_f} + (N/D)E(P_c/P_f)E(Q_c)\sigma_{u_f u_c} + 1] = \lambda D^{1/2} \quad ..(11)$$

But, $N = (\bar{d}^* - \mu^*_Q)$ and $D = \sigma^2_{Q^*}$, so that the expression becomes

$$(\alpha_f/L_f)E(Q_f)[\{(\bar{d}^* - \mu^*_Q)/\sigma^2_{Q^*}\}E(Q_f)\sigma^2_{u_f} + \{(\bar{d}^* - \mu^*_Q)/\sigma^2_{Q^*}\}E(P_c/P_f) E(Q_c)\sigma_{u_f u_c} + 1] = \lambda\sigma_{Q^*}$$

or $(\alpha_f/L_f)E(Q_f) = \lambda\sigma_{\overset{*}{Q}}[\{(\bar{d}^* - \mu_{\overset{*}{Q}})/\sigma^2_{\overset{*}{Q}}\}E(Q_f)\sigma^2_{u_f} + \{(\bar{d}^* - \mu_{\overset{*}{Q}})/\sigma^2_{\overset{*}{Q}}\}E(Q_c)$

$$E(P_c/P_f)\sigma_{u_f u_c} + 1]^{-1}. \qquad .....(12)$$

This represents the first-order condition showing optimal acreage of food crop under conditions of uncertainty. Similarly, differentiating (10) with respect to L_c, we get

$$\partial\mathcal{L}/\partial L_c = N(-\tfrac{1}{2})D^{-3/2}[2\{E(P_c/P_f)\}^2(\alpha_c/L_c)\{E(Q_c)\}^2\sigma^2_{u_c v} + 2E(P_c/P_f)E(Q_f)$$
$$(\alpha_c/L_c)E(Q_c)\sigma_{u_f u_c}] + D^{-1/2}[E(P_c/P_f)(\alpha_c/L_c)E(Q_c)] + \lambda$$

Again, putting $\partial\mathcal{L}/\partial L_c = 0$ and rearranging the terms, we may write

$$D^{-1/2}[(N/D)\{E(P_c/P_f)\}^2(\alpha_c/L_c)\{E(Q_c)\}^2\sigma^2_{u_c v} + (N/D)E(P_c/P_f)(\alpha_c/L_c)E(Q_f)E(Q_c)$$
$$\sigma_{u_f u_c} + E(P_c/P_f)(\alpha_c/L_c)E(Q_c)] = \lambda$$

or $(\alpha_c/L_c)E(P_c/P_f)E(Q_c)[(N/D)E(P_c/P_f)E(Q_c)\sigma^2_{u_c v} + (N/D)E(Q_f)\sigma_{u_f u_c}$

$$+ 1] = \lambda D^{1/2} \qquad .....(13)$$

Again $N = (\bar{d}^* - \mu_{\overset{*}{Q}})$ and $D = \sigma^2_{\overset{*}{Q}}$ so that the expression becomes

$$(\alpha_c/L_c)E(P_c/P_f)E(Q_c)[\{(\bar{d}^* - \mu^*_Q)/\sigma^2_{\overset{*}{Q}}\} E(P_c/P_f)E(Q_c)\sigma^2_{u_c v} + \{(\bar{d}^* - \mu_{\overset{*}{Q}})/\sigma^2_{\overset{*}{Q}}\}$$
$$E(Q_f)\sigma_{u_f u_c} + 1] = \lambda\sigma_{\overset{*}{Q}}$$

or $(\alpha_c/L_c)E(Q_c)E(P_c/P_f) = \lambda\sigma_{\overset{*}{Q}} [\{(\bar{d}^* - \mu_{\overset{*}{Q}})/\sigma^2_{\overset{*}{Q}} E(P_c/P_f)E(Q_c)\sigma^2_{u_c v}$

$$+ \{(\bar{d}^* - \mu_{\overset{*}{Q}})/\sigma^2_{\overset{*}{Q}}\}E(Q_f)\sigma_{u_f u_c} + 1]^{-1} \qquad .....(14)$$

This, therefore, represents the first-order condition showing optimal acreage of cash crop under conditions of uncertainty.

APPENDIX IVA

SCHEDULE OF SAMPLE SURVEY AT A GLANCE

Ecological Region	Selected District	Selected Thana	Selected Villages	Number of Selected Farm Households
(Classification based on World Bank Sector Study (1972))	(based on incidence of floods/cyclones and seasonal variability of rainfall)	(based on cropping intensity and cropping pattern of the region)	(randomly chosen)	(randomly chosen with a ceiling of 3 acres)
I. The Eastern Region	Sylhet (Oct. 7 to Oct. 30)	1) Moulavibazar (403)	Khusalpur, Bashuria Amtail, Mashkandi, Sampadpur	(1) 30
		2) Habigang (309)	Binodpur, Jagannathpur, Shaliakhali, Char Nurmuhammad	(2) 28
				48
II. The Northeastern Region	Pabna (Nov. 7 to Nov. 27)	1) Kotwali (280)	Maligacha, Gopalpur, Monohorpur, Ranigang	(1) 26
		2) Shahjhadpur (185)	Lochanpara, Dhunail Karsalika, Chayra	(2) 20
				46
III. The Southwestern Region	Faridpur (Nov. 28 to Dec. 14)	1) Kotwali (171)	East Gangabata, Domar-Kandi, Kabirpur, Murai-daha	(1) 26
		2) Goalanda (114)	Mollapara, Bahadurpur, Uttar Ujanchar, Kamal-para	(2) 31
				57
IV. The Central Region	Mymensingh (Dec. 18 to Dec. 31)	1) Kotwali (151)	Barira, Mashkanda, Dargapara, Moralpara	(1) 24
		2) Fulbaria (122)	Balashar, Teligram, Sharitia, Galia Nayanbaria	(2) 27
				51

Notes: 1. The figures in parentheses indicate the total number of villages located in the Thana.

2. The dates in parentheses indicate the time period during which the field survey was carried our in the District.

APPENDIX IVB

QUESTIONNAIRE FOR SAMPLE SURVEY

(a) Name of the Interviewer ______________________________

(b) Date ____________________

I. Identification of Respondent

1. Name ______________________________ 2. Age ____________________

3. Village ______________________________ 4. Union ____________________

5. Thana ______________________________ 6. District ____________________

7. Educational Qualifications ____________________ 7(a) Primary ____________________

7(b) Secondary ____________________

8. Membership of Local Institution: Yes __________ No __________

If Yes, (a) Name of the Institution ____________________

(b) Nature of Relation ____________________

(c) Duration ____________________

9. Unit of Measurement of Land ______________________________

10. Unit of Measurement expressed in Decimals ____________________

II. Detailed Description of the Members[1] of the Household

Name	Relation with Head of Family	Male/ Female[3]	Age	Level of Education[2]	Prime Occupation[4]	Secondary Occupation	Nature of Farm Work[5]	Membership with any Local Institution: Name	Membership with any Local Institution: Nature of Relation[6]

Notes:
(1) Persons living together and whose food is cooked in the same oven are considered to be members of the household
(2) Number of school years for the highest class passed. Give * mark for those now attending school.
(3) Whether married, unmarried, divorced, widower etc, has to be mentioned.
(4) Prime occupation will be judged on the basis of maximum time devoted to that particular job.
(5) All types of agricultural operations including ploughing = 1, excluding ploughing = 2, supervising the hired work = 3, minding the cattle only = 4
(6) Member, Secretary, President of the institution etc.

III. Information Related to Ownership and Use of Land

(a) (i) Amount of Land not suitable for cultivation

Homestead	Fruit-Yard Bamboo Bushes etc.	Pond	Total

(ii) Amount of Cultivated Land

Under own Cultivation	Rented out	Total

(b) Detailed Information Regarding Pattern of Land Use:

(i) Own Land Cultivated by the Household

Amount of Land			Use of Land Last Year					
own village	other village	Total	One Crop		Two Crop		Three Crop	
			Crop	Acreage	Crop	Acreage	Crop	Acreage

(c) Own Land Rented-Out:

Amount of Land			Nature of Tenancy	Use of Land Last Year					
Own Village	Other Village	Total		One Crop		Two Crop		Three Crop	
				Crop	Acreage	Crop	Acreage	Crop	Acreage

(iii) Rented-in Land Cultivated by the Household

Amount of Land			Nature of Tenancy	Pattern of Land Use Last Year					
own village	neighbouring village	total		One Crop		Two Crops		Three Crops	
				Crop	Acreage	Crop	Acreage	Crop	Acreage

IV. Description of Acreage and Production of Crops from the Cultivation Land

Crops	Own Land Acreage	Own Land Production	Acreage	Production	Acreage	Production	Comments on Crop Damage due to natural calamities or other factors giving percentage of crop damage with sources.
	(acres)	(md)	(acres)	(md)	(acres)	(md)	
Aus(local)							
Aus (HYV)							
Aman (Broadcast)							
Aman(Transplant)							
Aman (HYV)							
Boro (HYV)							
Jute							
Sugarcane							
Tobacco							
Oilseeds							
Wheat							
Pulses							
Others: -							
i)							
ii)							
iii)							

V. Disposal of Output

Crops	Seed Requirements (md)	Self Consumption (md)	Sale, if any (md)	Total Production (md)	Sale-Price (TK/md)
Aus (local)					
Aus (HYV)					
Aman (Broadcast)					
Aman (Transplant)					
Aman (HYV)					
Boro (HYV)					
Jute					
Sugarcane					
Tobacco					
Oilseeds					
Wheat					
Pulses					
Others: -					
i)					
ii)					
iii)					

VI. Use of Purchased Inputs (except Hired Labour) in Cultivation of Different Crops

Crops	Acreage	Seeds			Manure		Fertilizer		
		Total (md)	Purchased (md)	Value of Purchase (TK)	Amount (seer)	Expenditure (TK)	Fertilized Land (acres)	Amount Used (seer)	Price (TK/seer)
Aus (Local									
Aus (HYV)									
Aman (Broadcast)									
Aman (Transplant)									
Aman (HYV)									
Boro (HYV)									
Jute									
Sugarcane									
Tobacco									
Oilseeds									
Wheat									
Pulses									
Others: -									
i)									
ii)									
iii)									

(Cont.)

Amount of Land Irrigated					Number of Hours of Irrigation Required per acre of land		Total Expenditure on Irrigation		
Indigenous Method	Modern Methods								
	Power Pump	Tubewell	Casal	Total	Indigenous Methods	Mechanical Methods	Indigenous	Modern	Total
(acres)	(acres)	(acres)	(acres)	(acres)	(hours/Acres)	(hours/acres)	(TK)	(TK)	(TK)

6

(Cont.)

Use of Pesticides/Insecticides				Information Regarding Mechanised Cultivation, if any			
Amount of Land Sprayed	Amount of Pesticides/ Insecticides Used	Price	Total Expenditure	Amount of Land Cultivated with Mechanised Means	Number of Days used	Rental Rate	Total Expenditure
(acres)	(md)	(TK/seer)	(TK)	Acreage		(TK/day)	(TK)

VII. Use of Hired Labour and Expenditure on Hired Animals/Ploughs in Cultivation

Crops	Acreage	Use of Casually Hired Labour in Different Agricultural Operations					Exp. on Hired Labour		Exp. on Hired Animals/Plough in the cultivation
		Preparatory Tillage	Hoeing/ Weeding	Sowing/ Fertilizing/ Spraying	Harvesting/ Threshing	Total	Wage Rate	Total Expenditure	
	(acres)	(mandays)	(mandays)	(mandays)	(mandays)	(mandays)	(TK)	(TK)	(TK)
Aus (Local)									
Aus (HYV)									
Aman (Broad-cast)									
Aman (Trans-plant)									
Aman (HYV)									
Jute									
Sugarcane									
Tobacco									
Oilseeds									
Wheat									
Pulses									
Others: -									
i)									
ii)									
iii)									

VIII. Use of Total Labour in the Cultivation of Different Crops

Crops	Acreage	Total Mandays Required in Different Agricultural Operation					Total Animal days Required in			
		Preparatory Tillage	Hoeing/ Weeding	Sowing/Fertilizing/ Irrigating/Spraying	Harvesting/ Threshing	Total	Tillage	Hoeing	Threshing	Total
Aus (Local)										
Aus (HYV)										
Aman (Broad cast)										
Aman (Trans- plaut)										
Aman (HYV)										
Jute										
Sugarcane										
Tobacco										
Oilseeds										
Wheat										
Pulses										
Other Crops										
i)										
ii)										
iii)										

IX. Information about Permanent Hired Labour Employed in the Farm Last Year

Name	Age	Number of Months Employed	Major Job Performed	Payments Made: In Cash (mon. salary)	Payments Made: In Kind (food)(clothing)	Total Exp. on Permanent Hired Labour
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						

10. Please specify the percentage of labour-use in crop-cultivation last year for each of the following three categories.
   i) Family Labour ____________ ii) Casually Hired Labour ____________
   iii) Permanent Hired Labour ____________

11. What is the amount of wages paid to the casually hired labour Last Year?
   i) In Cash ____________TK/day ii) In Kind, if any____________

12. Please specify the total estimated wage-bill of the farm last year: TK ____________

13. Please specify the estimated expenditure on the following items last year: -
   i) Seeds: TK ________ ii) Pesticides/: Insecticides TK ________ iii) Fertilizers TK ________
   iv) Irrigation:TK ________ v) Hired Animals/ Plough TK ________ vi) Hired Machinery TK ________

14. How many hours of family labour-hours were devoted to each of the following agricultural operations last year?
   i) Preparatory Tillage---------- hours ii) Weeding/Hoeing ---------------- hours
   iii) Sowing/Fertilising/Spraying ----------hours iv) Harvesting/Threshing ---------- hours

15. Please specify the types and amounts of chemical fertilizers bought and used in the Farm last year: -

Type	Amount Purchased (md)	Purchase Price (TK/md)	Total Expenditure (TK)
1. Urea:			
2. Potash:			
3. Phosphate:			
4. Others, if any:			

16. Please specify the amount of irrigable land in your farm ------------acres; how much of this was actually irrigated last year? ---------------- acres. Specify the reasons for shortfall, if any:

XVII. List of Agricultural Tools/Implements and (Draft) Animals Owned by the Farm Household:

Item	Number Owned	Purchase Price	Total Value	Total Life Years	Remaining Life Years	Comments
a) Plough						
b) Yoke						
c) Ox/Cow						
d) Buffalo						
e) Ladder						
f) Sickle						
g) "Nirani"						
h) Spade						
i) Spraying Machine						
j) Boat/Cart						
k) Shallow Tubewell						
l) Others (Please specify if any)						

XVIII. Borrowing - Lending Position of the Farm Household

	Sources	Amount of Outstanding Loan	Year Loan Taken	Reason for Taking Loan	Rate of Interest	Probable date of Repayment of Loan
i)	Government					
ii)	Ag. Banks					
iii)	Other Banks					
iv)	Coopérative Banks					
v)	Money Lenders					
vi)	Landlord					
vii)	Merchant/ Shopkeepers					
viii)	Wealthy Farmers					
ix)	Friends/ Relatives					
x)	Others (Please specify)					

19. Have you made any loan to somebody? Yes __________ No __________

    If yes, To Whom ____________________ When ______________ How Much ____________

20. Do you have any outstanding loan that has to be repaid <u>urgently</u>, failing which you have to face dire consequences? Yes _________ No ______________

    If yes, i) How much (TK) ______________

    ii) Probable Date of Repayment _______________

XXI. Please specify the Income from the following (other) Agricultural Activities:

Items	Production	Value of Sale (TK)
a) Fruits,		
b) Milk		
c) Eggs		
d) Hen/Ducks		
e) Fish		
f) Vegatables		
g) Others (Please specify)		

XXII. Please specify the Incomes derived from the following Off-Farm Activities last year

Sources	How many members worked (no.)	How many months worked (months)	Monthly Salary Income (TK)	Total Earnings (TK)
a) Ag. Labour:				
b) Non-Ag. Labour				
c) Business (Please specify)				
d) Handicraft/Cottage Industries				
e) Others (Please specify)				

XXIII. An account of Consumption Expenditures Incurred by the Farm-Household Last Year:

Items	Estimated Expenses Incurred Last Year (TK)
a) Foodgrains	
b) Clothing	
c) Medicine	
d) Education	
e) Social Ceremony	
f) Kerosene	
g) Salt	
h) Bidi/Cigarette	
i) Tobacco/Betelnut	
j) Tea	
k) Sugar/'Gur'	
l) Gift	
m) Litigation	
n) Others (please specify)	

24. What do you think should be the "Disaster Level of Income" of the farm family?*

a) Taka --------------------- (in cash)

b) --------------------mds (in foodgrains)

XV. Valuation of the Liquid Assets of the Farm Household

Type of Assets	Total Value (TK)
1.	
2.	
3.	
4.	
5.	

25. What is the Total Property Value of the Farm Household?

a) Household: TK ---------------

b) Ag. Land: TK ---------------

Total: TK ---------------

*This should be based on farm family's own evaluation of its minimum tolerable consumption level.

APPENDIX VA

TEST OF SIGNIFICANCE OF COMPUTED ELASTICITY COEFFICIENTS UNDER TRANSCENDENTAL FUNCTIONAL FORM

The test has been carried out in the following way. The transcendental production function, in log-linear form, may be written as

$$\log Q_j = \log A_j + \alpha_{1j} \log X_{1j} + \beta_{1j} X_{1j} + \ldots + \alpha_{kj} \log X_{kj} + \beta_{kj} X_{kj} + \log u_j \quad \ldots\ldots (A)$$

This represents the unrestricted form of our estimating equation. Now the restricted form of our estimating equation - the restriction imposed by the zero-value of the elasticity coefficients - may be derived in the following way. The input-elasticity coefficients under transcendental form for input X_{ij} is given by

$$\eta_{ij} = \alpha_{ij} + \beta_{ij} \bar{X}_{ij}$$

where α_{ij} and β_{ij} represent the estimated production function parameter and $\bar{X}_{ij}$ the mean level of input-use of the respective input, X_{ij}. We test whether this input-coefficient, η_{ij}, is significantly different from zero or not. This implies, of course, that

$$\eta_{ij} = \alpha_{ij} + \beta_{ij} \bar{X}_{ij} = 0$$

$$\text{or } \alpha_{ij} = -\beta_{ij} \bar{X}_{ij}$$

Substituting this into (A), we get the following estimating equation with restriction imposed on the parameters of the transcendental function

$$\log Q_j = \log A_j + \beta_{1j} (X_{1j} - \bar{X}_{1j} \log X_{1j}) + \text{-----} + \alpha_{kj} \log X_{kj} + \beta_{kj} X_{kj} + \log u_j \quad \ldots\ldots (B)$$

We may, therefore, test for this restriction of $\eta_{ij} = 0$ with the following F-statistic defined as

$$F^* = \frac{(\Sigma e_B^2 - \Sigma e_A^2)/(k_a - k_b)}{\Sigma e_A^2/(N - k_a)}$$

where Σe_B^2 = the residual sum of squares from the restricted form of the estimating equation (B).

Σe_A^2 = the residual sum of squares of the unrestricted form of the estimating equation (A).

N, k_a and k_b represents the number of observations, and the number of parameters estimated under (A) and (B) respectively.

Our Null Hypothesis, in this case, is given by

$$H_0: \eta_{ij} = 0, \text{ for each } i \text{ and each } j.$$

This means that the test is to be carried for each input for various crops separately.

If our computed test statistic $F^* > F_{.01}$ with $v_1=1$ and $v_2=(N-k_a)$ degrees of freedom, we reject the Null Hypothesis of $\eta_{ij} = 0$ and conclude that the respective elasticity coefficient is significantly different from zero at the stated level of significance.

APPENDIX VB

TEST OF SIGNIFICANCE OF COMPUTED ELASTICITY COEFFICIENTS UNDER TRANSLOG FUNCTIONAL FORM

The test has been carried out in the following way. The translog production function is written as:

$$\log Q_m = \log A_m + \sum_i \alpha_{im} \log X_{im} + 1/2 \sum_{ij}\sum \gamma_{ijm} \log X_{jm} + \log u_m \quad \ldots (C)$$

This represents the unrestricted form of our estimating equation. The restricted form of our estimating equation - restriction imposed by zero-value of elasticity coefficients - is derived in the following way.

The input-elasticity coefficients under translog production function are given by

$$\eta_{im} = \alpha_{im} + \sum_j \gamma_{ijm} \log X_{jm}$$

where α_{im} and γ_{ij} represent the estimated production function parameters under translog specification. We may test whether this coefficient is significantly different from zero or not. This, of course, entails imposition of restriction of

$$\eta_{im} = \alpha_{im} + \sum_j \gamma_{ijm} \log X_{jm} = 0$$

$$\text{or } \alpha_{im} = -\sum_j \gamma_{ijm} \log X_{jm}$$

Substituting this into (C), we get the following estimating equation with the restriction imposed on the parameters of the translog production function, say for input X_{im},

$$\log Q_m = \log A_m + \sum_{i=2} \alpha_{im} \log X_{im} - 1/2(\log X_{1m})^2 + \sum_{i=2} \sum_{j=2} \gamma_{ijm} \log X_{im} \log X_{jm} + \log u_m \quad \ldots\ldots (D)$$

We may test for this restriction of $\eta_{im} = 0$ with the following test statistic (F-ratic) defined as

$$F^* = \frac{(\Sigma e_D^2 - \Sigma e_C^2)/(k_c - k_d)}{(\Sigma e_c^2)/(N - k_c)}$$

where Σe_D^2 = residual sum of squares from the restricted form of the estimating equation (D)

Σe_C^2 = residual sum of squares of the unrestricted form of our estimating equation (C)

N, k_c and k_d represent the number of observations and the number of parameters estimated under (C) and (D) respectively.

Our Null Hypothesis, in this case, is given by

$$H_0: \ \gamma_{im} = 0, \text{ for each i and each m}$$

This means that the test is to be carried out for each input in each crop separately.

If our computed F-ratio $F^* > F_{.01}$ with $v_1 = (k_c - k_d)$ and $v_2 = (N - k_c)$ degrees of freedom, we reject the Null Hypothesis of $\gamma_{im} = 0$, and conclude that the respective elasticity-coefficient is significantly different from zero, at the stated level of significance. The reverse is true in case $F^* < F_{.01}$.

APPENDIX VC

(A) TIME SERIES REGRESSIONS (Output Disturbances)

I. Sylhet District

1(a).

$$\log QLA = \underset{(1.28)}{5.82} + \underset{(13.66)^{**}}{1.30} \log L + \underset{(1.50)}{.01}\, T + \underset{(1.89)^{*}}{.04} \log MRM - \underset{(.22)}{.004} (\log MRM)^2 + \underset{(1.71)^{*}}{.25} \log MRA$$

$$- \underset{(1.80)^{*}}{.06} (\log MRA)^2 - \underset{(1.92)^{*}}{4.71} \log MRY + \underset{(1.88)^{*}}{.75} (\log MRY)^2 + \underset{(.10)}{.12} \log MRN$$

$$- \underset{(.20)}{.04} (\log MRN)^2 \qquad \bar{R}^2 = .94 \quad DW = 2.08$$

1(b).

$$\log QLA = \underset{(12.99)^{***}}{-1.24} + \underset{(14.06)^{***}}{1.21} \log L + \underset{(1.69)}{.01}\, T \qquad \bar{R}^2 = .92 \quad DW = 1.59$$

2(a)

$$\log QLN = \underset{(.60)}{-.35} + \underset{(3.90)^{***}}{.90} \log L - \underset{(1.67)}{.01}\, T + \underset{(2.93)^{***}}{.18} \log (MRL/M\bar{R}L)\ \underset{(1.27)}{.11} \log (MRG/M\bar{R}G) - \underset{(.09)}{.01} \log (MRS/M\bar{R}S)$$

$$- \underset{(3.57)^{***}}{.08} \log (MRO/M\bar{R}O) + \underset{(3.31)^{***}}{.05} \log (MRV/M\bar{R}V) - \underset{(1.40)}{.01} \log (MRD/M\bar{R}D) + \underset{(.04)}{.0002}$$

$$\log (MRJ/M\bar{R}J) - \underset{(.99)}{.01} \log (MRF/M\bar{R}F) - \underset{(2.22)^{**}}{.06} (MRM/M\bar{R}M) - \underset{(.57)}{.0\text{[illegible]}} \log (MRA/M\bar{R}A)$$

$$+ \underset{(.52)}{.04} \log (MRY/M\bar{R}Y) - \underset{(.47)}{.02} \log (MRN/M\bar{R}N) \qquad \bar{R}^2 = .94 \quad DW = 1.51$$

2(b).

$$\log QLN = \underset{(3.11)^{***}}{1.33} + \underset{(6.94)^{***}}{1.20} \log L + \underset{(2.64)^{**}}{.01}\, T \qquad \bar{R}^2 = .71 \quad DW^{3} = 1.03$$

(A) TIME SERIES REGRESSIONS (Cont.)

II. Pabna District

1(a).

$$\log QLA = -\ 1.03 + .83 \log L + .01\ T + .05 \log (MRL/M\bar{R}L) + .09 \log (MRG/M\bar{R}G)$$
$$(3.18)^{***}\ (2.37)^{**}\quad (1.08)\quad (.43)\qquad (.83)$$

$$-\ .01 \log (MRS/M\bar{R}S) + .0002 \log (MRO/M\bar{R}O) + .01 \log (MRV/M\bar{R}V)$$
$$(1.14)\qquad (.002)\qquad (.94)$$

$$+\ .01 \log (MRD/M\bar{R}D) + .003 \log (MRJ/M\bar{R}J) + .02 \log (MRF/M\bar{R}F)$$
$$(.78)\qquad (.23)\qquad (1.42)$$

$$-\ .02 \log (MRM/M\bar{R}M) + .05 \log (MRA/M\bar{R}A) - .13 \log (MRY/M\bar{R}Y)$$
$$(1.05)\qquad (1.54)\qquad (1.71)^{*}$$

$$-\ .09 \log (MRN/M\bar{R}N)\qquad \bar{R}^2 = .31$$
$$(1.09)\qquad DW = 2.92$$

1(b).

$$\log QLA = -\ .86 + .63 \log L + .01\ T\qquad \bar{R}^2 = .20$$
$$(3.05)^{***}\ (2.39)^{**}\quad (1.33)\qquad DW = 2.35$$

2(a).

$$\log QLN = -\ 1.59 + 1.22 \log L - .01\ T + .48 \log MRS - .12 (\log MRS)^2 + .05 \log MRO$$
$$(2.96)^{***}\ (2.94)^{***}\quad (1.90)^{*}\ (1.20)\qquad (1.13)\qquad (.26)$$

$$-\ .001 (\log MRO)^2 - .02 \log MRV - .004 (\log MRV)^2 + .01 \log MRD$$
$$(.02)\qquad (.67)\qquad (.87)\qquad (.16)$$

$$-\ .01 (\log MRD)^2\qquad \bar{R}^2 = .38$$
$$(.10)\qquad DW = 2.31$$

2(b).

$$\log QLN = -\ 1.70 + 1.48 \log L - .01\ T\qquad \bar{R}^2 = .40$$
$$(3.40)^{***}\ (4.53)^{***}\quad (1.43)\qquad DW = 2.10$$

(A) TIME SERIES REGRESSIONS (Cont.)

3(a). $\log QJ = 2.83 + 1.00 \log L + .01\,T - .93 \log MRL + .12 (\log MRL)^2 - .02 \log MRM$

$(2.27)^{**}\ (8.70)^{***}\ (1.88)^{*}\ (.89)\ (.57)\ (.91)$

$- .0003 (\log MRM)^2 - .03 \log MRA - .01 (\log MRA)^2$

$(.09)\ (1.06)\ (.50)$

$\bar{R}^2 = .82$

$DW = 1.82$

3(b). $\log QJ = 1.28 + 1.03 \log L - .01\,T$

$(14.43)^{***}\ (8.51)^{***}\ (1.87)^{**}$

$\bar{R}^2 = .73$

$DW = 1.46$

4(a). $\log QP = 1.10 + .94 \log L + .01\,T + .04 \log MRD + .004 (\log MRD)^2$

$(2.09)^{**}\ (8.22)^{***}\ (4.36)^{***}\ (1.42)\ (1.65)$

$\bar{R}^2 = .85$

$DW = 1.41$

4(b). $\log QP = - 1.16 + .96 \log L - .01\,T$

$(2.23)^{**}\ (8.18)^{***}\ (4.31)^{***}$

$\bar{R}^2 = .83$

$DW = 1.11$

5(a). $\log QO = - 4.75 + 1.43 \log L + .01\,T + .85 \log MRL - .15 (\log MRL)^2 - .004 \log MRV$

$(9.19)^{***}\ (21.95)^{***}\ (8.40)^{***}\ (2.43)^{**}\ (2.11)^{**}\ (.31)$

$- .001 (\log MRV)^2 + .004 \log MRD - .001 (\log MRD)^2 + .09 \log MRY - (\log MRY)^2$

$(.95)\ (.19)\ (.20)\ (.62)\ (.04)$

$\bar{R}^2 = .98$

$DW = 1.49$

5(b). $\log QO = - 3.30 + 1.37 \log L - .02\,T$

$(12.72)^{***}\ (19.96)^{***}\ (8.92)^{***}$

$\bar{R}^2 = .96$

$DW = 1.45$

(A) TIME SERIES REGRESSIONS (Cont.)

III. Faridpur District

1(a).

$$\log QLA = 1.62 + .53 \log L + .01\, T + .05 \log MRM + (\log MRM)^2 - .14 \log MRA$$
$$(2.28)^{**} \; (6.81)^{***} \; (3.38)^{***} \; (2.12)^{**} \; (2.17)^{**} \; (1.70)^{*}$$
$$+ .03 (\log MRA)^2 - .07 \log MRY + .01 (\log MRY)^2 - .23 \log MRN$$
$$(1.22) \; (.27) \; (.13) \; (.44)$$
$$+ .05 (\log MRN)^2$$
$$(.46)$$

$\bar{R}^2 = .88$

$DW = 2.06$

1(b).

$$\log QLA = 1.19 + .60 \log L + .01\, T$$
$$(31.04)^{***} \; (10.04)^{***} \; (3.60)^{***}$$

$\bar{R}^2 = .88$

$DW = 1.83$

2(a).

$$\log QLN = 1.48 + .65 \log L - .005\, T - .13 \log (MRL/\bar{MRL}) + .06 \log (MRG/\bar{MRG})$$
$$(10.75)^{***} \; (2.81)^{***} \; (.75) \; (1.17) \; (.33)$$
$$+ .06 \log (MRS/\bar{MRS}) + .003 \log (MRO/\bar{MRO}) - .0003 \log (MRV/\bar{MRV})$$
$$(.55) \; (.05) \; (.03)$$
$$- .24 \log (MRD/\bar{MRD}) + .03 \log (MRJ/\bar{MRJ}) - .01 \log (MRF/\bar{MRF})$$
$$(1.02) \; (3.05)^{***} \; (1.19)$$
$$+ .02 \log (MRM/\bar{MRM}) + .04 \log (MRA/\bar{MRA}) - .01 \log (MRY/\bar{MRY})$$
$$(.78) \; (.49) \; (.06)$$
$$- .07 \log (MRN/\bar{MRN})$$
$$(.57)$$

$\bar{R}^2 = .64$

$DW = 1.80$

2(b).

$$\log QJ = 1.33 + .83 \log L - .01\, T$$
$$(19.02)^{***} \; (7.81)^{***} \; (1.49)$$

$\bar{R}^2 = .69$

$DW = 1.93$

(A) TIME SERIES REGRESSIONS (Cont.)

3(a). $\log QLN = -.81 + .91 \log L - .01\,T - .10 \log (ARF/\overline{ARF})$
$(2.82)^{***}\ (7.88)^{***}\ (1.93)^{*}\ (.52)$ $\bar{R}^2 = .81$ $DW = 1.93$

3(b). $\log QLN = -.82 + .92 \log L - .01\,T$
$(2.93)^{***}\ (8.12)^{***}\ (1.97)^{*}$ $\bar{R}^2 = .88$ $DW = 1.83$

4(a). $\log QP = -1.94 + 1.17 \log L - .01\,T - .08 \log (ARF/\overline{ARF})$
$(7.25)^{***}\ (16.41)^{***}\ (3.53)^{***}\ (.88)$ $\bar{R}^2 = .96$ $DW = 1.91$

4(b). $\log QP = -1.93 + 1.17 \log L - .01\,T$
$(7.26)^{***}\ (16.47)^{***}\ (3.58)^{***}$ $\bar{R}^2 = .96$ $DW = 1.87$

5(a). $\log QW = -1.53 + .91 \log L + .03\,T - .20 \log (ARF/\overline{ARF})$
$(13.88)^{***}\ (11.51)^{***}\ (2.45)^{**}\ (.94)$ $\bar{R}^2 = .98$ $DW = 1.70$

5(b). $\log QW = -1.53 + .92 \log L + .02\,T$
$(13.93)^{***}\ (11.78)^{***}\ (2.33)^{**}$ $\bar{R}^2 = .97$ $DW = 1.84$

(A) TIME SERIES REGRESSIONS (Cont.)

IV. Mymensingh District

1(a)

$$\log QLN = -.95 + 1.03 \log L + .01\ T - .12 \log MRS + .03 (\log MRS)^2 - .14 \log MRO$$
$$\quad (1.16) \quad (3.71)^{***} \quad (1.74) \quad (.23) \quad (.25) \quad (.53)$$
$$+ .06 (\log MRO)^2 - .07 \log MRV - .01 (\log MRV)^2 - .03 \log MRD$$
$$(.84) \quad (1.60) \quad (1.61) \quad (.31)$$
$$- .002 (\log MRD)^2$$
$$(.25)$$

$\bar{R}^2 = .60$

DF $= 1.93$

1(b)

$$\log QLN = -1.19 + 1.16 \log L + .01\ T$$
$$(1.85)^{*} \quad (4.64)^{***} \quad (4.68)^{***}$$

$\bar{R}^2 = .63$

DW $= 1.93$

2(a)

$$\log QJ = 1.02 + 1.14 \log L - .01\ T - .17 \log MRM + 0 (\log MRM)^2 + .03 \log MRA$$
$$(1.27) \quad (6.17)^{***} \quad (1.73)^{*} \quad (.82) \quad (0) \quad (.20)$$
$$- .07 (\log MRA)^2 - .70 \log MRY + .18 (\log MRY)^2 + .45 \log MRN$$
$$(1.33) \quad (.98) \quad (1.06) \quad (.88)$$
$$- .06 (\log MRN)^2$$
$$(.60)$$

$\bar{R}^2 = .66$

DW $= 1.44$

2(b)

$$\log QJ = 1.31 + 1.02 \log L - .01\ T$$
$$(5.69)^{***} \quad (6.67)^{***} \quad (2.56)^{**}$$

$\bar{R}^2 = .63$

DW $= .87$

(A) <u>TIME SERIES REGRESSIONS (Cont.)</u>

3(a).

$$\log QIB = \underset{(7.32)^{***}}{-\,1.56} + \underset{(5.73)^{***}}{1.74} \log L \; \underset{(.01)}{-\; .0002}\, T + \underset{(1.00)}{.14} \log (MRL/M\bar{R}L) - \underset{(.68)}{.05} \log (MRG/M\bar{R}G)$$

$$+ \underset{(.79)}{.09} \log (MRS/M\bar{R}S) - \underset{(.18)}{.01} \log (MRO/M\bar{R}O) + \underset{(1.37)}{} \log (MRV/M\bar{R}V) - \underset{(.64)}{} \log (MRD/M\bar{R}D)$$

$$- \underset{(.16)}{.13} \log (MRJ/M\bar{R}J) - \underset{(.13)}{.11} \log (MRF/M\bar{R}F) + \underset{(1.82)^{*}}{.28} \log (MRM/M\bar{R}M)$$

$$- \underset{(2.19)^{**}}{.13} \log (MRA/M\bar{R}A) + \underset{(1.44)}{.11} \log (MRY/M\bar{R}Y) - \underset{(.15)}{.01} \log (MRN/M\bar{R}N)$$

$\bar{R}^2 = .96$

$DW = 2.07$

3(b).

$$\log QIB = \underset{(9.15)^{***}}{-\,1.43} + \underset{(7.14)^{***}}{1.52} \log L + \underset{(1.11)}{.01}\, T$$

$\bar{R}^2 = .96$

$DW = 1.80$

Note: ***, ** and * indicate that the estimated coefficient is significantly different from zero at 1%, 5% and 10% probability levels respectively.

APPENDIX VD

(B) TIME SERIES REGRESSIONS (Price Disturbances)

I. Sylhet District

1(a) log (P Local Aus) = 2.09459 + .144539 T
(9.05)*** (6.46)***
$\bar{R}^2$ = .85
DW = 1.98

1(b). log (P Local Aus) = 2.02241 + .140323 T + .0334064 log (P Local Aus_{-1})
(3.37)*** (3.47)***
$\bar{R}^2$ = .84
DW = 1.91

2(a). log (P Local Aman) = 2.07165 + .157008 T
(8.60)*** (6.60)***
$\bar{R}^2$ = .81
DW = 1.92

2(b). log (P Local Aman) = 1.91496 + .144848 T + .0797784 log (P Local $Aman_{-1}$)
(3.23)*** (2.74)** (.27)
$\bar{R}^2$ = .79
DW = 1.97

II. Pabna District

1(a). log (P Local Aus) = 2.09670 + .147510 T
(8.24)*** (6.07)***
$\bar{R}^2$ = .86
DW = 1.81

1(b). log (P Local Aus) = 2.05552 + .145340 T + .0182077 log (P Local Aus_{-1})
(3.52)*** (3.96)*** (.08)
$\bar{R}^2$ = .83
DW = 1.81

2(a). log (P Local Aman) = 2.16631 + .155010 T
(9.35)*** (6.81)***
$\bar{R}^2$ = .83
DW = 1.94

2(b). log (P Local Aman) = 2.04299 + .146656 T + .0580271 log (P Local $Aman_{-1}$)
(3.26)*** (2.88)** (.20)
$\bar{R}^2$ = .82
DW = 1.93

3(a). log (P Jute) = 2.76689 + .129374 T
(11.04)*** (5.60)***
$\bar{R}^2$ = .89
DW = 2.41

3(b). log (P Jute) = 1.99447 + .102460 T + .260292 log (P $Jute_{-1}$)
(3.61)*** (4.74)*** (1.56)
$\bar{R}^2$ = .89
DW = 2.92

4(a). log (P Pulses, K) = 1.74657 + .154713 T
(4.12)*** (3.91)***
$\bar{R}^2$ = .81
DW = 1.61

4(b). log (P Pulses, K) = 1.27543 + .117331 T + .265443 (P Pulses, K_{-1})
(2.30)** (2.25)** (.98)
$\bar{R}^2$ = .80
DW = 1.75

(B) TIME SERIES REGRESSIONS (Cont.)

5(a). log (P Oilseeds) = 3.01087 + .147796 T — $\bar{R}^2$ = .81
(7.70)*** (4.06)*** — DW = 1.85

5(b). log (P Oilseeds) = 2.08331 + .113528 T + .286934 (P $Oilseeds_{-1}$)
(2.76)** (2.96)*** (1.33) — $\bar{R}^2$ = .81
DW = 2.22

6(a). log (P Pulses, M) = 2.16295 + .169489 T — $\bar{R}^2$ = .86
(4.33)*** (3.82)*** — DW = 1.60

6(b). log (P Pulses, M) = 1.22428 + .118439 T + .383485 log (P $Pulses_{-1}$)
(2.07)* (3.10)*** (1.92) — $\bar{R}^2$ = .85
DW = 1.65

III. Faridpur District

1(a). log (P Local Aus) = 2.25198 + .139960 T — $\bar{R}^2$ = .84
(9.48)*** (6.09)*** — DW = 1.85

1(b). log (P Local Aus) = 2.17927 + .136241 T + .0309812 log (P Local Aus_{-1})
(3.47)*** (3.56)*** (.13) — $\bar{R}^2$ = .83
DW = 1.86

2(a). log (P Local Aman) = 2.27800 + .147343 T — $\bar{R}^2$ = .85
(8.99)*** (6.02)*** — DW = 1.88

2(b). log (P Local Aman) = 1.91684 + .125610 T + .159551 log (P Local $Aman_{-1}$)
(2.96)*** (2.67)** (.56) — $\bar{R}^2$ = .83
DW = 1.98

3(a).
Same as Pabna
3(b)

4(a). log (P Pulses, K) = 1.5163 + .175581 T — $\bar{R}^2$ = .84
(3.49)*** (4.36)*** — DW = 1.55

4(b). log (P Pulses, K) = 1.04212 + .125681 T + .309061 log (P Pulses, K_{-1})
(2.07)* (2.35)** (1.19) — $\bar{R}^2$ = .84
DW = 1.76

5(a). log (P Pulses, M) = 2.12391 + .169195 T — $\bar{R}^2$ = .88
(4.27)*** (3.88)*** — DW = 1.58

5(b). log (P Pulses, M) = 1.17838 + .117182 T + .0391469 log (P Pulses,M_{-1})
(2.18)** (3.31)*** (2.12)** — $\bar{R}^2$ = .90
DW = 2.14

(B) TIME SERIES REGRESSIONS (Cont.)

IV. Mymensingh District.

1(a). $\log(P\ \text{Local Aus}) = 2.10906 + .155515\ T$ (8.04)*** (6.04)*** $\bar{R}^2 = .84$, $DW = 1.92$

1(b). $\log(P\ \text{Local Aus}) = 1.88926 + .139040\ T + .103774 \log(P\ \text{Local Aus}_{-1})$ (3.06)*** (2.97)*** (.38) $\bar{R}^2 = .83$, $DW = 1.96$

2(a)

Same as Pabna

2(b)

3(a). $\log(P\ \text{IRRI Boro}) = 2.09124 + .151781\ T$ (10.37)*** (7.65)*** $\bar{R}^2 = .86$, $DW = 2.01$

3(b). $\log(P\ \text{IRRI Boro}) = 1.84743 + .133375\ T + .123614 \log(P\ \text{IRRI Boro}_{-1})$ (3.22)*** (2.81)** (.43) $\bar{R}^2 = .85$, $DW = 2.02$

Note: ***, ** and * indicate that the estimated coefficient is statistically significant at 1%, 5%, and 10% probability levels respectively.

APPENDIX VE

TIME SERIES DATA USED IN THIS STUDY

As mentioned earlier (Chapter V), aggregate district-level time series data were used in this study in estimating both output and price disturbances of different crops in each region. In this Appendix, we present the annual time series (covering the period, 1948-49 to 1976-77) with respect to crop output and acreage in four districts in Tables VEla through VEld, and those on prices (covering the period, 1963-64 to 1978-79) in Tables VE2a through VE2d. The annual and monthly rainfall data for four districts are presented in Table VE3a through Table VE3d respectively.

Table VEla

Annual Time Series Data on Output and Acreage for Different Crops in Sylhet District

Year	Aus Rice		Aman Rice	
	Output	Acreage	Output	Acreage
1948-49	49.80	1.67	491.89	12.01
1949-50	59.67	1.85	477.16	11.61
1950-51	63.57	1.99	450.04	11.61
1951-52	56.02	2.00	365.90	11.50
1952-53	56.75	2.01	446.26	11.52
1953-54	74.40	2.25	451.95	11.60
1954-55	70.26	2.05	461.75	11.88
1955-56	68.99	2.03	396.92	9.71
1956-57	66.50	1.84	463.76	10.67
1957-58	97.58	2.72	486.46	11.86
1958-59	84.87	2.66	472.84	11.46
1959-60	97.22	2.67	434.98	11.44

Table VEla (Cont.)

Year	Aus Rice		Aman Rice	
	Output	Acreage	Output	Acreage
1960-61	87.27	2.63	537.10	11.73
1961-62	98.55	2.67	521.60	11.80
1962-63	105.63	2.75	503.75	11.64
1963-64	115.49	3.04	509.30	11.18
1964-65	121.29	3.06	536.61	11.22
1965-66	115.60	3.07	589.90	11.32
1966-67	39.68	1.00	354.65	7.28
1967-68	168.39	3.67	698.80	12.56
1968-69	81.39	2.16	615.57	11.88
1969-70	164.96	3.60	629.51	12.24
1970-71	157.03	3.55	645.60	12.42
1971-72	132.08	3.29	497.77	10.75
1972-73	82.38	2.49	414.99	10.39
1973-74	144.58	3.43	574.06	11.17
1974-75	200.98	3.96	443.24	9.42
1975-76	251.61	4.69	544.50	11.10
1976-77	61.27	2.00	432.31	9.08

Sources: Figures for 1948-49 to 1971-72 period are collected from Agricultural Production Levels in Bangladesh (1947-72) and those for 1972-73 to 1976-77 period are collected from The Yearbook of Agricultural Statistics of Bangladesh (1976-77) published by the Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Govt. of Bangladesh.

Note: Outputs are expressed in thousand tons (excepting jute, which are expressed in bales) and acreages are expressed in lakh acres, respectively.

Table VElb

Annual Time Series Data on Output and Acreage for Different Crops in Pabna District

Year	Aus Rice		Aman Rice		Jute	
	Output	Acreage	Output	Acreage	Output	Acreage
1948-49	84.00	3.02	171.94	4.72	300.93	1.00
1949-50	63.65	3.15	186.39	4.80	153.29	.74
1950-51	100.00	3.16	223.47	4.90	256.60	.77
1951-52	79.23	2.64	195.20	4.77	312.25	.89
1952-53	79.06	2.80	163.04	4.77	313.37	.94
1953-54	110.63	3.05	197.23	4.89	186.62	.49
1954-55	57.33	2.83	95.37	3.80	159.96	.48
1955-56	92.66	3.09	127.27	4.00	183.71	.69
1956-57	95.00	2.64	185.18	4.54	238.48	.52
1957-58	116.89	3.10	171.66	4.71	283.10	.81
1958-59	66.05	3.32	134.26	4.50	314.39	.80
1959-60	81.63	2.72	166.10	4.83	260.75	.69
1960-61	83.36	2.78	184.10	4.88	218.35	.61
1961-62	113.91	2.81	244.30	4.79	522.60	1.01
1962-63	72.46	2.78	171.30	4.88	245.62	.65
1963-64	121.72	3.04	205.80	4.94	307.66	.87
1964-65	108.81	2.99	211.67	5.25	236.75	.95
1965-66	90.83	2.23	203.28	5.12	449.77	1.26
1966-67	91.25	2.19	169.03	4.76	232.04	.81
1967-68	83.34	3.18	194.53	5.77	289.61	1.11
1968-69	122.13	3.82	314.03	6.20	329.39	1.15
1969-70	145.15	4.14	132.81	5.67	430.33	1.37

Table VElb (Cont.)

Year	Aus Rice		Aman Rice		Jute	
	Output	Acreage	Output	Acreage	Output	Acreage
1970-71	100.49	3.24	163.22	4.94	263.96	.88
1971-72	88.32	3.25	140.69	5.79	211.67	.84
1972-73	89.76	2.94	143.40	4.69	275.05	.93
1973-74	67.26	2.40	134.55	3.86	183.24	.76
1974-75	86.51	2.92	147.32	4.47	79.44	.36
1975-76	113.11	3.76	216.38	5.33	128.10	.46
1976-77	105.41	3.43	226.23	5.83	179.20	.61

Table VElb (Cont.)

Year	Pulses		Oilseeds	
	Output	Acreage	Output	Acreage
1948 - 49	24.46	.94	5.10	.33
1949 - 50	25.47	.96	6.65	.42
1950 - 51	24.28	.93	9.01	.49
1951 - 52	23.07	.84	8.44	.48
1952 - 53	23.35	.84	10.20	.53
1953 - 54	22.36	.84	11.07	.57
1954 - 55	30.21	.94	12.62	.63
1955 - 56	31.78	1.11	13.16	.70
1956 - 57	16.60	.54	10.85	.64
1957 - 58	25.91	.98	4.85	.32
1958 - 59	30.78	1.08	8.12	.43
1959 - 60	21.67	.82	6.09	.40
1960 - 61	21.67	.83	7.63	.41
1961 - 62	25.65	.93	7.37	.43
1962 - 63	25.18	1.00	8.15	.44
1963 - 64	22.58	.92	5.76	.31
1964 - 65	24.87	.84	5.98	.36

Table VElb (Cont.)

Year	Pulses		Oilseeds	
	Output	Acreage	Output	Acreage
1965 - 66	26.57	.86	6.78	.35
1966 - 67	31.23	1.04	8.25	.38
1967 - 68	31.73	.94	8.94	.41
1968 - 69	31.14	.95	12.72	.58
1969 - 70	32.02	.97	13.18	.59
1970 - 71	34.64	1.02	17.73	.62
1971 - 72	33.90	1.00	17.41	.61
1972 - 73	34.29	1.02	17.39	.62
1973 - 74	34.47	1.02	17.45	.62
1974 - 75	30.11	1.05	17.77	.63
1975 - 76	35.30	1.05	17.31	.61
1976 - 77	41.39	1.25	17.35	.59

Sources: Figures for 1948-49 to 1971-72 period are collected from Agricultural Production Levels in Bangladesh (1947-72) and those for 1972-73 to 1976-77 period are collected from The Yearbook of Agricultural Statistics of Bangladesh (1976-77) published by the Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Govt. of Bangladesh.

Note: Outputs are expressed in thousand tons (excepting jute, which are expressed in bales) and acreages are expressed in lakh acres, respectively.

Table VE1c

Annual Time Series Data On Output and Acreage for Different Crops in Faridpur District

Year	Aus Rice		Aman Rice		Jute	
	Output	Acreage	Output	Acreage	Output	Acreage
1948 - 49	74.60	2.80	425.44	10.39	558.26	1.89
1949 - 50	40.42	2.00	334.85	9.77	243.63	1.06
1950 - 51	89.74	3.01	282.77	8.26	571.08	1.58
1951 - 52	94.66	3.64	354.60	10.40	535.88	1.45
1952 - 53	105.88	3.75	369.15	10.80	659.17	1.70
1953 - 54	141.63	4.30	405.34	11.05	324.13	.83
1954 - 55	108.55	3.84	325.05	10.96	480.22	1.26
1955 - 56	166.65	5.56	296.47	10.90	632.34	1.83
1956 - 57	239.14	7.05	374.00	8.26	399.19	.99
1957 - 58	159.48	4.22	391.61	8.59	362.44	1.02
1958 - 59	56.73	3.18	171.60	6.78	426.53	1.08
1959 - 60	137.52	3.96	317.15	9.48	550.04	1.46
1960 - 61	119.58	3.59	348.54	10.20	418.73	1.14
1961 - 62	92.06	3.14	347.80	8.77	409.94	1.31
1962 - 63	113.13	3.77	269.50	9.10	528.79	1.46
1963 - 64	160.00	4.44	338.19	8.66	550.85	1.80
1964 - 65	143.81	5.09	247.23	7.86	372.64	1.36
1965 - 66	178.66	5.06	249.97	7.71	761.25	2.42

Table VElc (Cont.)

Year	Aus Rice		Aman Rice		Jute	
	Output	Acreage	Output	Acreage	Output	Acreage
1966 - 67	159.75	5.61	201.51	7.59	671.51	2.24
1967 - 68	176.68	6.07	290.04	8.06	702.62	2.50
1968 - 69	126.85	5.09	228.02	7.93	547.02	2.47
1969 - 70	164.93	5.77	303.64	7.86	936.03	3.13
1970 - 71	142.47	4.79	68.01	1.81	662.91	2.37
1971 - 72	117.60	4.43	127.10	5.93	323.48	1.62
1972 - 73	153.00	5.39	198.31	7.42	797.21	2.39
1973 - 74	138.36	4.89	236.67	7.29	706.89	2.70
1974 - 75	176.27	5.72	184.46	6.67	349.33	1.55
1975 - 76	171.92	5.85	224.30	7.53	381.03	1.13
1976 - 77	143.65	6.00	244.13	7.16	508.40	1.34

Table VE1c (Cont.)

Year	Pulses		Wheat	
	Output	Acreage	Output	Acreage
1948 - 49	14.93	.58	.65	.04
1949 - 50	15.75	.58	.77	.04
1950 - 51	11.43	.45	.77	.04
1951 - 52	9.91	.40	.91	.04
1952 - 53	10.62	.42	.83	.02
1953 - 54	11.81	.43	.91	.04
1954 - 55	14.68	.53	1.44	.05
1955 - 56	14.16	.48	1.20	.06
1956 - 57	12.09	.52	1.07	.08
1957 - 58	10.91	.45	1.68	.08
1958 - 59	21.39	.76	1.55	.06
1959 - 60	16.09	.66	4.40	.19
1960 - 61	18.76	.71	5.50	.22
1961 - 62	21.05	.73	7.16	.23
1962 - 63	21.19	.84	5.60	.24
1963 - 64	19.12	.74	5.07	.22
1964 - 65	252.35	.86	4.54	.18

Table VElc (Cont.)

Year	Pulses		Wheat	
	Output	Acreage	Output	Acreage
1965 - 66	263.95	1.08	4.21	.19
1966 - 67	282.80	1.10	13.12	.42
1967 - 68	290.50	1.20	12.60	.49
1968 - 69	305.00	1.27	18.77	.72
1969 - 70	348.24	1.37	21.92	.75
1970 - 71	424.31	1.55	21.51	.76
1971 - 72	419.87	1.48	22.62	.73
1972 - 73	228.44	1.10	9.69	.50
1973 - 74	239.13	.98	11.57	.43
1974 - 75	254.25	1.12	13.01	.45
1975 - 76	211.92	.98	11.79	.34
1976 - 77	206.53	1.01	12.06	.33

Sources: Figures for 1948-49 to 1971-72 period are collected from Agricultural Production Levels in Bangladesh (1947-72) and those for 1972-73 to 1976-77 period are collected from The Yearbook of Agricultural Statistics, Statistics Division, Ministry of Planning, Govt. of Bangladesh.

Note: Outputs are expressed in thousand tons (excepting jute, which are expressed in bales) and acreages are expressed in lakh acres, respectively.

Table VEld

Annual Time Series Data on Output and Acreage for Different Crops in Mymensingh District

Year	Aman Rice		Jute		Boro Rice	
	Output	Acreage	Output	Acreage	Output	Acreage
1948 - 49	615.28	15.91	1138.82	4.42	68.68	2.50
1949 - 50	603.15	16.50	762.02	3.78	120.58	2.55
1950 - 51	602.18	16.50	1536.25	4.10	81.20	2.51
1951 - 52	710.80	16.45	1562.93	4.32	106.17	2.50
1952 - 53	641.10	16.55	1788.46	4.76	117.60	2.60
1953 - 54	662.40	17.00	900.37	2.46	110.22	2.60
1954 - 55	568.42	15.38	1282.59	3.32	117.73	2.62
1955 - 56	463.21	15.47	1458.59	3.83	104.86	2.30
1956 - 57	711.22	16.51	1472.12	3.20	80.00	2.30
1957 - 58	546.49	14.99	1637.14	4.10	111.50	2.50
1958 - 59	667.25	15.83	1764.55	4.18	124.84	2.78
1959 - 60	849.27	17.35	1749.40	4.26	129.69	2.79
1960 - 61	859.00	17.46	1930.47	4.96	183.70	3.22
1961 - 62	857.20	17.76	2213.26	6.38	186.20	3.39
1962 - 63	794.33	18.39	1817.70	5.11	156.37	3.58
1963 - 64	856.97	18.37	1602.50	4.62	198.85	3.70
1964 - 65	969.71	20.94	1466.76	3.86	213.72	3.69
1965 - 66	881.14	20.15	1700.71	5.65	225.71	3.92

Table V[illegible] (Cont.)

Year	Aman Rice		Jute		Bore Rice	
	Output	Acreage	Output	Acreage	Output	Acreage
1966 - 67	720.27	18.82	1570.22	5.29	277.25	4.26
1967 - 68	727.25	18.77	1622.56	5.82	392.18	4.74
1968 - 69	928.85	18.79	1533.69	5.74	471.03	5.67
1969 - 70	938.53	20.82	1869.86	6.41	470.78	5.57
1970 - 71	656.58	15.91	1343.52	4.42	463.99	5.84
1971 - 72	860.65	16.04	640.56	2.85	391.18	5.55
1972 - 73	702.15	16.47	1357.72	4.88	431.17	6.02
1973 - 74	911.76	16.30	990.81	4.09	443.35	6.07
1974 - 75	730.21	14.55	736.41	3.12	430.22	6.08
1975 - 76	910.85	15.93	983.76	3.16	458.92	6.27
1976 - 77	815.82	15.81	868.87	3.28	375.44	5.12

Source: Figures for 1948-49 to 1971-72 period are collected from Agricultural Production Levels in Bangladesh (1947-72) and those for 1972-73 to 1976-77 period are collected from The Yearbook of Agricultural Statistics, Statistics Division, Ministry of Planning, Govt. of Bangladesh.

Note: Outputs are expressed in thousand tons (excepting jute, which are expressed in bales) and acreages are expressed in lakh acres, respectively.

Table VE2

Annual Time Series on Grower's Prices for Different Crops in Four Districts

(Taka per Maund)

Year	(a) Sylhet		(b) Pabna				
	Aus Paddy	Aman Paddy	Aus Paddy	Aman Paddy	Pulses(M)	Pulses(K)	Oilseeds
1963 - 64	8.37	9.66	11.00	9.50	12.50	7.00	27.62
1964 - 65	10.12	10.42	10.62	10.75	20.50	8.50	45.00
1965 - 66	12.00	11.75	12.16	14.33	18.00	9.00	39.00
1966 - 67	23.00	23.00	20.56	19.50	17.37	14.25	42.78
1967 - 68	16.00	17.00	19.00	19.00	22.00	13.00	38.31
1968 - 69	20.69	20.00	19.50	22.21	20.00	13.00	37.83
1969 - 70	20.00	18.87	19.50	22.03	18.37	12.00	36.25
1970 - 71	19.00	18.00	19.12	21.37	14.25	9.00	39.75
1971 - 72	23.00	20.00	21.12	28.00	31.00	19.00	56.00
1972 - 73	39.50	34.00	35.31	44.00	42.50	28.00	85.00
1973 - 74	46.00	38.00	44.00	50.00	80.00	70.00	125.00
1974 - 75	140.00	85.00	102.00	150.00	103.00	72.00	272.00
1975 - 76	63.00	70.00	64.00	67.00	85.00	40.00	130.00
1976 - 77	64.00	52.50	59.00	67.00	95.00	49.00	172.00
1977 - 78	77.00	70.00	67.00	80.00	120.00	72.00	250.00
1978 - 79	80.00	75.00	76.00	83.00	117.00	50.00	180.00

Table VE2 (Cont.)

Year	(c) Faridpur					(d) Mymensingh		Bangladesh
	Aus Paddy	Aman Paddy	Pulses(M)	Pulses(K)	Oilseeds	Aman Paddy	Boro Paddy	Jute
1963 - 64	12.00	9.16	12.50	6.00	22.00	8.98	7.66	22.52
1964 - 65	12.12	13.19	20.91	8.12	32.25	10.75	10.50	31.47
1965 - 66	15.56	15.75	19.00	7.50	35.00	13.67	15.75	27.39
1966 - 67	22.12	21.00	19.00	9.75	36.69	20.00	18.50	35.03
1967 - 68	19.00	19.00	23.87	12.87	34.94	18.00	17.00	27.58
1968 - 69	23.54	23.44	18.87	12.25	32.00	21.13	18.50	34.01
1969 - 70	21.25	22.75	18.62	11.31	36.50	20.06	18.50	29.78
1970 - 71	21.00	21.56	15.00	8.37	39.00	19.31	17.00	35.15
1971 - 72	23.00	26.00	30.31	18.00	57.50	20.22	25.62	38.80
1972 - 73	35.50	43.12	42.00	28.00	85.00	39.50	42.00	52.58
1973 - 74	45.00	55.00	95.00	67.00	125.00	50.00	41.00	52.81
1974 - 75	110.00	140.00	110.00	80.00	270.00	125.00	104.00	86.08
1975 - 76	70.00	70.00	75.00	42.00	140.00	61.00	56.00	78.84
1976 - 77	54.66	68.66	95.00	46.00	163.00	63.00	66.00	100.01
1977 - 78	82.00	82.00	120.00	72.00	180.00	77.00	65.00	140.00
1978 - 79	78.00	90.00	130.00	60.00	175.00	87.00	95.00	141.65

SOURCE: Agricultural Marketing Directorate, Government of Bangladesh

NOTE: District-Wise prices of raw jute at grower's level are not available.

Table VE3a

Time Series of Monthly and Annual Rainfall in Sylhet District

(inches)

Year	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Total
1957 - 58	17.62	20.60	14.42	5.24	---	---	.82	4.57	1.21	12.03	26.66	33.67	136.84
1958 - 59	10.89	25.45	17.95	15.33	.83	.66	.85	.30	5.78	10.54	31.38	61.55	181.54
1959 - 60	20.99	22.98	27.97	18.90	---	---	---	---	3.09	1.50	16.72	19.51	131.66
1960 - 61	43.98	14.63	42.86	3.74	---	---	.11	1.35	1.60	6.94	23.85	36.25	175.31
1961 - 62	19.25	19.82	18.41	3.88	---	---	.22	2.61	.10	8.56	14.74	39.26	126.85
1962 - 63	16.01	32.63	6.91	4.17	.07	.07	.07	.77	2.32	8.16	22.39	21.38	114.75
1963 - 64	22.90	23.35	11.56	7.16	.17	---	.71	1.04	9.10	23.74	23.86	51.99	175.14
1964 - 65	46.63	21.72	22.90	13.59	.01	---	---	5.23	2.78	11.51	14.73	36.58	175.68
1965 - 66	20.11	41.41	21.26	6.47	3.69	.22	.86	.07	.93	8.23	24.79	60.78	188.82
1966 - 67	45.88	38.97	21.11	6.56	.30	.56	1.52	2.23	4.87	12.04	13.12	40.07	187.03
1967 - 68	24.25	15.91	24.93	3.27	.18	---	.53	.14	4.14	9.47	25.92	36.11	144.85
1968 - 69	32.39	32.36	27.40	4.75	.75	---	.47	.01	7.34	14.78	18.32	41.61	180.18
1969 - 70	29.01	37.81	6.37	4.29	1.57	.01	2.38	2.56	2.23	17.88	33.50	38.23	175.84
1970 - 71	49.26	28.40	20.94	23.87	2.09	---	.81	.29	3.49	17.99	24.77	28.70	200.61

Table VE3a (Cont.)

(inches)

Year	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Total
1971 - 72	20.05	23.70	13.98	10.76	3.29	---	.10	1.57	4.74	18.10	16.48	53.07	165.84
1972 - 73	32.44	20.31	13.96	11.89	---	---	.27	6.26	.12	14.37	32.61	52.50	184.73
1973 - 74	26.95	24.90	28.86	3.18	3.09	2.77	---	---	3.14	27.76	19.11	38.98	178.74
1974 - 75	49.43	32.90	18.85	15.90	.29	---	---	1.19	3.34	11.35	22.31	15.84	171.40
1975 - 76	42.15	29.62	19.25	6.80	3.60	---	---	.42	13.10	5.35	17.10	63.11	200.50
1976 - 77	41.29	31.24	11.38	10.26	1.80	---	.69	1.65	5.14	28.86	21.19	31.40	184.90

Source: The Yearbook of Agricultural Statistics of Bangladesh, 1976-77 published by Bangladesh Bureau of Statistics, Minstry of Planning, Government of Bangladesh

Note: " ---" = data not available

Table VE3b

Time Series of Monthly and Annual Rainfall in Pabna District

(inches)

Year	July	Aug	Sept	Oct	Nov	Dec	Jan.	Feb	March	April	May	June	Total
1948 - 49	12.20	19.03	5.14	9.21	2.30	---	---	.24	.40	3.91	14.80	25.85	93.08
1949 - 50	23.10	24.30	11.19	5.80	---	---	---	.78	.63	1.98	12.93	21.71	102.42
1950 - 51	16.65	20.60	7.63	7.77	3.98	---	.35	---	.22	.03	11.06	17.57	85.85
1951 - 52	10.17	19.60	3.81	12.30	3.26	---	---	.03	3.56	6.28	10.55	13.74	80.60
1952 - 53	15.76	11.53	11.30	2.60	.49	---	1.65	1.40	2.03	5.13	8.21	5.54	65.64
1953 - 54	22.08	7.72	18.50	.78	.13	---	.74	.64	---	.37	6.23	20.94	78.13
1954 - 55	12.05	4.60	1.72	3.26	---	---	.10	.05	1.65	6.70	9.95	8.39	48.47
1955 - 56	13.23	10.68	9.26	1.01	3.16	---	.36	.10	1.65	3.47	3.43	23.10	69.45
1956 - 57	6.28	17.43	11.70	12.09	1.98	---	4.72	2.19	1.35	.05	2.62	18.44	78.85
1957 - 58	21.61	11.34	7.91	2.27	---	---	---	2.58	.77	1.31	5.98	8.95	62.72
1958 - 59	7.36	12.89	7.61	1.95	.02	---	.75	.23	9.47	1.95	13.20	12.38	67.81
1959 - 60	7.36	27.75	12.71	23.41	---	---	---	---	3.65	.26	13.71	3.47	92.59
1960 - 61	14.12	9.84	9.35	2.38	5.15	---	.17	1.04	.15	1.88	8.10	13.95	66.13
1961 - 62	5.17	11.92	6.86	3.81	.69	.10	.63	.66	.15	1.56	8.73	10.20	60.48
1962 - 63	13.30	5.90	7.37	2.34	---	.01	.01	.07	.36	2.10	8.67	17.27	57.40

Table VE3b (Cont.)

Year	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Total
1963 - 64	9.16	6.83	6.41	9.27	.68	.01	.01	.07	.36	2.27	10.94	10.88	52.58
1964 - 65	18.40	5.90	4.54	4.54	.01	---	---	.40	1.67	2.10	5.42	12.14	55.12
1965 - 66	17.09	21.75	8.78	2.03	.13	.15	1.01	---	.14	3.04	2.21	8.62	64.95
1966 - 67	10.62	11.62	4.59	5.87	.99	.32	.74	.14	4.46	4.25	5.06	6.59	55.25
1967 - 68	12.03	16.85	12.56	3.64	---	.01	---	---	.50	.95	10.62	15.28	72.44
1968 - 69	13.23	15.88	8.99	5.88	.56	---	1.44	---	2.37	3.65	3.17	14.17	69.34
1969 - 70	8.95	17.86	11.98	3.53	1.70	---	2.17	.61	.75	3.17	4.08	9.66	64.46
1970 - 71	17.27	10.10	12.12	12.46	.35	---	.26	---	.35	2.57	4.94	10.48	70.63
1971 - 72	14.08	9.80	9.43	8.01	2.00	---	---	.13	.01	1.97	5.88	11.36	62.67
1972 - 73	10.89	8.90	6.74	3.56	---	---	.44	2.20	1.15	4.72	19.63	19.33	77.56
1973 - 74	7.90	11.81	21.40	6.72	1.01	1.46	---	---	2.23	6.13	6.27	8.33	73.26
1974 - 75	20.81	10.60	13.53	3.39	.16	---	.09	.04	.38	4.23	9.21	7.35	69.79
1975 - 76	22.33	7.57	7.62	5.51	2.20	---	---	2.18	.25	.96	14.70	17.98	81.30
1976 - 77	11.42	20.41	12.07	5.51	.02	1.30	---	3.11	.02	10.68	12.71	12.96	92.21

Source: The Yearbook of Agricultural Statistics of Bangladesh, 1976-77 published by Bangladesh Bureau of Statistics, Ministry of Planning, Government of Bangladesh.

Note: "---" = data not available

Table VE3c

Time Series of Monthly and Annual Rainfall in Faridpur District

(inches)

Year	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Total
1948 - 49	14.75	14.50	7.75	6.70	3.25	---	---	.15	2.98	17.26	16.56	18.94	102.84
1949 - 50	18.33	10.15	14.79	3.74	---	---	---	.57	.23	1.93	14.70	27.82	92.26
1950 - 51	10.80	17.96	6.14	7.43	6.48	---	---	---	1.84	1.73	3.90	12.96	68.74
1951 - 52	15.21	9.71	7.90	6.64	1.50	---	---	---	3.20	8.29	11.91	10.44	74.80
1952 - 53	19.37	7.17	10.72	3.53	.83	---	.40	.27	5.07	2.38	9.63	23.27	82.64
1953 - 54	26.02	11.71	11.99	2.16	1.41	---	.67	1.40	---	6.40	8.20	31.41	101.37
1954 - 55	17.94	10.18	3.74	9.74	---	.93	.06	---	.82	6.51	8.48	6.40	64.80
1955 - 56	13.88	8.33	12.35	4.64	2.04	---	.15	.52	3.37	3.67	6.08	18.01	73.04
1956 - 57	12.79	17.39	11.98	5.61	2.94	.06	2.29	1.47	.63	.56	6.71	12.06	74.49
1957 - 58	12.73	8.90	5.78	1.53	---	---	.15	1.90	1.36	7.70	6.68	4.89	51.62
1958 - 59	7.11	8.87	3.88	11.05	---	---	.93	.55	2.40	6.80	16.92	7.24	65.75
1959 - 60	14.26	19.34	20.66	27.40	---	---	---	---	.74	1.74	12.26	9.25	105.65
1960 - 61	18.93	10.91	7.96	4.41	.22	---	.24	2.40	1.20	3.62	11.27	13.41	74.57
1961 - 62	16.40	15.61	5.20	5.24	.03	---	.32	1.25	.70	6.01	10.76	7.72	69.24
1962 - 63	14.61	6.02	10.34	6.72	---	---	.10	---	1.31	6.15	8.33	18.62	72.20
1963 - 64	12.78	4.78	5.07	10.72	1.06	.02	.16	---	.14	12.43	3.61	13.94	65.25

Table VE3c (Cont.)

(inches)

Year	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Total
1964 - 65	19.44	9.66	9.28	12.04	.48	---	---	.89	1.44	2.43	8.52	15.84	80.02
1965 - 66	16.38	17.27	14.73	.88	.68	---	.58	---	.31	5.96	3.69	11.28	71.76
1966 - 67	10.87	9.75	5.69	9.80	1.67	.77	1.48	.06	1.75	3.34	3.59	15.98	64.75
1967 - 68	8.81	12.14	10.53	2.42	---	.05	---	.03	2.91	2.02	7.42	22.46	68.79
1968 - 69	18.61	11.01	7.29	4.58	6.12	.05	---	---	3.77	4.57	2.85	10.32	69.17
1969 - 70	10.73	15.96	5.91	3.18	1.62	---	.70	.56	1.01	7.61	7.02	11.56	65.86
1970 - 71	18.81	11.48	17.06	18.27	1.25	---	.49	.35	.51	7.20	9.55	9.75	94.72
1971 - 72	10.97	25.66	11.47	5.32	2.83	---	---	1.00	---	6.93	11.84	7.28	83.30
1972 - 73	7.88	15.95	12.21	2.48	.07	---	.01	.35	1.55	7.84	26.38	21.99	96.71
1973 - 74	7.88	16.66	15.13	8.68	2.95	2.74	.03	---	4.48	5.84	12.43	13.75	90.37
1974 - 75	36.73	5.99	12.50	8.06	---	---	---	.77	3.15	4.57	9.64	11.68	93.09
1975 - 76	23.89	11.49	9.07	9.87	.72	---	---	.70	1.50	3.73	13.15	13.77	87.89
1976 - 77	11.87	9.50	15.77	3.08	.10	---	.09	.95	---	15.84	7.72	18.25	83.17

Source: The Yearbook of Agricultural Statistics of Bangladesh, 1976-77 published by Bangladesh Bureau of Statistics, Ministry of Planning, Government of Bangladesh.

Note: "---" = data not available

Table VE3d

Time Series of Monthly and Annual Rainfall in Mymensingh District

(inches)

Year	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Total
1948 - 49	6.51	14.71	7.59	2.82	1.02	---	.03	.22	2.47	15.56	18.37	29.49	98.79
1949 - 50	9.88	9.87	12.38	4.26	---	---	.00	1.16	2.50	1.28	5.19	12.70	59.22
1950 - 51	3.14	19.54	2.80	1.38	1.60	---	.00	.00	.46	1.19	5.51	14.07	49.69
1951 - 52	11.04	7.10	5.85	14.11	3.40	---	.00	.00	.82	3.76	7.72	12.64	66.08
1952 - 53	15.68	10.67	17.80	9.85	2.22	---	.77	.15	5.41	9.40	11.40	22.46	105.81
1953 - 54	21.45	13.26	25.24	8.24	---	.13	1.33	1.88	.89	4.15	14.61	19.98	111.66
1954 - 55	16.85	4.93	10.36	5.39	---	.65	.24	1.54	2.18	1.80	3.76	22.87	70.57
1955 - 56	21.11	27.58	14.76	5.08	3.02	---	.22	.00	1.46	4.10	18.54	34.35	120.22
1956 - 57	18.17	30.57	11.24	8.90	.75	.35	4.47	2.08	.22	1.23	2.74	22.79	103.51
1957 - 58	10.32	11.11	13.09	6.49	---	---	.00	3.67	.04	3.08	11.29	16.30	75.39
1958 - 59	10.63	19.44	7.59	5.33	---	---	.09	.00	6.23	2.08	13.03	21.64	86.06
1959 - 60	7.31	31.50	7.14	18.55	---	---	.00	.00	2.71	1.03	7.26	15.43	90.93
1960 - 61	13.98	13.90	21.72	2.04	.22	---	.05	.49	2.40	1.84	11.58	18.79	87.01
1961 - 62	10.29	5.91	5.28	3.47	.25	---	.22	.35	.04	4.33	15.31	18.14	63.59
1962 - 63	12.14	13.85	8.59	4.07	---	---	.00	.00	1.59	2.54	8.87	20.48	72.13
1963 - 64	12.84	12.50	6.80	5.88	.55	.03	.50	1.87	1.22	4.01	16.92	23.58	89.71

Table VE3d (Cont.)

(inches)

Year	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March	April	May	June	Total
1964 - 65	18.18	9.37	17.24	15.72	---	---	.00	.75	.92	.30	2.08	16.91	81.47
1965 - 66	25.96	26.24	11.65	2.93	.85	---	.80	.38	.15	4.30	4.96	8.70	86.92
1966 - 67	14.76	18.61	7.24	6.35	.39	.17	.60	.00	1.80	2.90	11.60	9.48	73.90
1967 - 68	17.87	15.24	12.49	6.10	.92	---	.20	.06	1.43	2.20	11.52	19.09	87.12
1968 - 69	27.22	9.25	13.96	5.67	.34	---	.05	.05	5.59	6.68	6.91	14.64	90.36
1969 - 70	14.64	25.40	15.82	1.97	.28	---	1.86	.31	.97	4.47	6.14	22.01	93.87
1970 - 71	21.87	8.16	9.71	14.69	.30	---	.93	.56	.48	4.65	5.35	21.31	88.02
1971 - 72	19.27	6.80	9.07	15.61	.15	---	.00	.80	.50	4.82	4.55	20.60	82.17
1972 - 73	18.66	5.44	8.43	16.05	---	---	.46	.41	.55	6.83	13.21	11.74	79.78
1973 - 74	18.80	7.02	13.17	16.29	---	---	.46	.20	.60	4.32	10.20	7.30	78.36
1974 - 75	19.87	12.09	15.53	10.30	.88	---	.00	.00	.00	2.25	7.19	2.85	70.96
1975 - 76	20.93	17.17	17.90	16.52	1.76	---	.00	.30	.00	3.64	9.52	17.83	105.57
1976 - 77	21.50	10.46	7.45	4.07	.25	---	.00	1.83	.20	8.85	18.46	41.30	114.37

Source: The Yearbook of Agricultural Statistics of Bangladesh, 1976-77 published by Bangladesh Bureau of Statistics, Ministry of Planning, Government of Bangladesh.

Note: "---" = data not available.

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