INCOME DIVERSIFICATION FACTORS AMONG RURAL HOUSEHOLDS: THE CASE OF BANGLADESH

by

Yu Kudo

A Thesis Submitted to the Faculty of the

DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS

In Partial Fulfillment of the Requirements For the Degree of

MASTER OF SCIENCE

In the Graduate College

THE UNIVERSITY OF ARIZONA

2002

STATEMENT BY AUTHOR

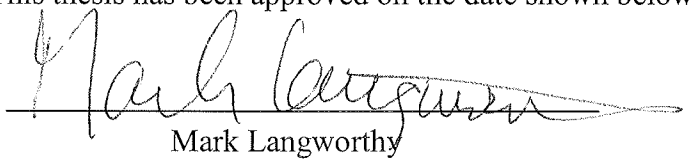
This thesis has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

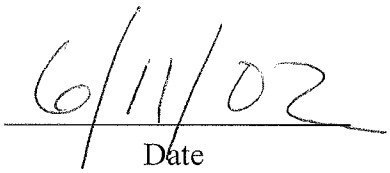
SIGNED: 

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:



Mark Langworthy
Assistant Research Scientist
Agricultural and Resource Economics



Date

ACKNOWLEDGEMENTS

First of all, I would like to show my sincere gratitude to my advisor, Dr. Mark Langworthy, for his guidance and effort throughout the research process. I could not have completed this research without his humor, patience, and calmness. Additional appreciation extends to my other thesis committee members, Dr. Satheesh Aradhyula and Dr. Eric Monke, for their insightful inputs and contributions. Dr. Kendra Gaines also deserves my deep appreciation for reading all my original manuscripts with patience.

I would like to thank my families for their support. My family in Japan has been patient with me for my absence. Two of my adopted families in Tucson, Char and Bob and Ernstein and Jean and Bill McCrady, have encouraged and convinced me that I could complete this project.

Lastly, I am deeply grateful to all my friends all over the world for their friendship and kind words. Among them, Kalya Htaik, Hiromi Kasuya, and Raquel Gomes have been great roommates and companions during my stay in Tucson – I cannot say enough thank you to guys.

TABLE OF CONTENTS

TABLE OF CONTENTS – *CONTINUED*

TABLE OF CONTENTS – *CONTINUED*

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Income diversification among rural households over farm and off-farm activities started attracting considerable attention in the last decade. In this study, the factors affecting household agriculture and income diversification in Bangladesh are examined. OLS regressions were used to test whether or not household behavior supports portfolio theory and risk reduction.

Contrary to expectations, income diversification was more practiced among richer households. The result suggests that wealth endowment is important for off-farm activities. Agricultural diversification was not practiced as a risk reduction strategy. The number of dependents is a "push" factor for off-farm activities. Education has some positive effect on income level; promotion of education may enhance income. Market access also was key to engaging in off-farm activities.

More research into the dynamics of off-farm activities, the impacts of off-farm activities on income distribution, and types of education that influence incomes are suggested to formulate further poverty alleviation strategies and programs.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Rural households in developing countries typically face enormous risks. Their incomes are highly uncertain as a result of the effect of weather variability, crop diseases and pest attacks on agricultural output, and the volatility of prices for their crops (Kinsey, Burger, and Gunning 1998). Income fluctuations may lead to consumption instability and food insecurity. This is especially serious when a household is very poor, since a consumption-shortfall may imply starvation.

To avoid worsening food security, rural households have developed mechanisms to deal with risks referred to as "household coping strategies". A household typically makes various responses, such as crop and livestock adjustment, diet change, famine food use, asset sales, and outmigration to cope (Maxwell and Frankenberger 1992).

Research on coping strategies in developing countries has yielded in various findings about household livelihood systems. There also has been new attention to income-earning patterns in rural areas. In the past, many researchers and policymakers have viewed the rural economy as synonymous with agriculture. According to this view, rural households receive the bulk of their income from the production of food and cash crops. However, empirical studies in a number of developing countries have forced a growing recognition that the rural economies are not based merely on agriculture but a combination of numerous activities. The villagers, who were thought to be only farmers, are instead involved in a wide range of off-farm activities.

1.2 Definitions: "Off-farm" and "Non-farm" Income-Generating Activities

Activities that do not cultivate land are generally referred to as either "non-farm", or "off-farm" income-generating activities, and it is critical to distinguish between the two. "Non-farm" refers to a sector, and non-farm income activities imply the income-generating activities that are not related to the agriculture, such as manufacturing, services, government, and commerce (Adams and He 1995). On the other hand, "off-farm" refers to a location, and off-farm income activities include activities "off" from the family farm premises. Wage labor taking place on someone else's farm could be counted as "off-farm" activity, but not "non-farm" activity (Barrett, Reardon, and Webb 2001). This study employs the term "off-farm"

1.3 Justification of the Study

Many studies describe the growing share of income from off-farm sector in rural areas in developing countries. Adams and He (1995) estimate the share ranges between 13 and 67 percent of total household income, and the role of off-farm activities is now recognized as one of the key sources of income among rural households. Off-farm income has received considerable attention as a component of rural livelihood strategies, because of its potential in reducing income inequality (de Janvry and Sadoulet 2001) and alleviating poverty (Reardon, Berdegué, and Escobar 2001). Although there is still debate regarding the exact nature of the impacts of off-farm income, off-farm activities clearly have the potential to enhance livelihood of rural populations. The effect of off-farm income activities has a substantial implication to Bangladesh, where agriculture is one of the major rural activities, but land is scarce because of population pressure.

This study investigates the driving forces of household income diversification in rural Bangladesh. In particular, the relation between asset ownership and diversification will be examined, to understand household decision-making regarding income-earning and risk alleviation. To better grasp the diversification strategy, determinants of three different income sources and total income are examined prior to the investigation of income diversification. Household agricultural diversification also is explored from the risk reduction perspective.

1.4 Background of the Data

CARE, an international relief and development agency, initiated the Integrated Food for Development Project (IFFD) in Bangladesh in 1995. The main purpose of the project was to improve the livelihood security of rural destitute households by improving rural roadways. Not only did the road construction itself create temporary employment and provide food for the project participants, but also the project enhanced the overall increase of income among the households along the targeted roads, and the profile of activities in and around the areas.

The data were collected over a three-year period which contains a pre-intervention baseline year (1996) and 2 post-intervention annual cycles (1997 and 1998). The survey contains questions regarding household economic activities and income, market access (time and cost), demographic and educational information, and asset holdings. The survey was annually conducted over an initial 1,437 households alongside eight roads. The original sample size of 1,437 was reduced to 1,175 households due to incomplete questionnaires. Sample households were interviewed by local agents, researchers from

CARE and Helen Keller International (HKI). Data were then compiled on statistical software SPSS for analysis.

1.5 Organization of the Study

Chapter Two describes household income-generating activities in rural Bangladesh. Activities, including three main categories – agricultural, livestock, and off-farm – are introduced, and natural, social, economic, and institutional environments are described. Chapter Three introduces the theoretical backbone of the study. Numerous household models are followed by expected utility maximization theory. Risk reduction, credit constrained, and agricultural linkage theories are introduced, and the hypotheses concerning income diversification behavior in rural Bangladesh will be presented. Chapter Four explains the methodology. General models are followed by explanations of dependent and independent variables and discussion of potential correlation and impact of variables. Chapter Five presents the empirical results. The final chapter concludes the findings and suggests future research needs.

CHAPTER TWO

INCOME GENERATING ACTIVITIES IN RURAL BANGLADESH

Economic activities of rural Bangladeshi households will be described in this chapter. A general description of the country is followed by the discussion of three general categories of income generating activities in the area: agriculture, livestock, and off-farm. Types of activities available and geographical, sociological, and institutional factors that affect activities in rural Bangladesh will be followed by characteristics of each road area.

2.1 OVERVIEW OF BANGLADESH

2.1.1 GEOGRAPHICAL OVERVIEW

Bangladesh is located in South Asia, bordering India and Burma, facing the Bay of Bengal, with the coordinates of 24.00 North and 90.00 East. The total landmass is 133,910 square kilometers (about 33 million acres), which is slightly smaller than the state of Wisconsin. About 73% of land, 97,754.3 square kilometers (about 24 million acres), is under cultivation. Its climate is tropical with a cool and dry winter through October to March, a hot and humid summer through March to June, and a rainy monsoon season from June to October. During the monsoon rainy season, about the third of the country annually floods due to cyclones. Many people live on and cultivate flood-prone land. Harsh natural conditions and severe overpopulation cause many environmental and social problems: limited access to clean water, prevalence of water-born diseases, water pollution especially of fishing areas resulting from pesticides, a decrease in underground table tables, soil degradation, and deforestation (Central Intelligence Agency 2000).

2.1.2 Social Conditions

The population was estimated at 129 million in 2000 with a growth rate of 1.6%. The population density is 965 per square kilometer, one of the most densely populated countries in the world (Central Intelligence Agency 2000). 24% of the population inhabits urban areas, a 10% increase from 1980 (The World Bank 2001). The population is relatively young – 36% of the population 0 to 14 years old and 60% 15 to 64 years old – with a life expectancy of 60 years. Infant mortality rates are as high as 72 per 1,000 live births (Central Intelligence Agency 2000).

Other indicators complete the picture of the living standard of average Bangladeshis. Per capita daily consumption of food has fluctuated around 2,000 kilocalories since 1985/86, significantly below the requirements of 2,020 to 2,150 kilocalories (Dayal 1997). 37% of the population even consumed less than 1,800 kilocalories per capita per day and a quarter to a third of the population has been exposed to chronic malnutrition. The World Bank (2001) estimated that from 1992 to 1998, 56% of the children under age 5 suffered from some degree of malnutrition. The mortality rate of children age under 5 was 98 per 1,000 children. The literacy rate, meaning the population of 15 and over who can read and write, is 38% with disparity between 49.4% of males and 26.1% of females (Central Intelligence Agency 2000). Total fertility per woman was 3.1 births in 1998, a considerable decline from 6.1 in 1980. Part of this is due to the prevalence of contraceptives, despite the fact that the majority of Bangladeshis are Muslim.

2.1.3 Economic Conditions

Bangladesh is categorized as one of the Least Developed Countries (LCD's) by the World Bank. Its Gross National Product (GNP) is 47 billion dollars and its per capita GNP is about 370 US dollars, which ranked as 50th and 167th respectively in 1999 (The World Bank 2001). Gross Domestic Product (GDP) is estimated at 45,779 million US dollars in 1999 and its growth rate is 4.8%. The contributions of agriculture, industry, manufacturing, and services are 21%, 27%, 17%, and 52% respectively. Income disparities are notable; richest 20% and the poorest 20% of the population share about 42.8% and 8.7% of the total income respectively (United Nations Development Programme 2000).

2.2 Agricultural Conditions

2.2.1 Natural environment

Bangladesh enjoys a warm and humid sub-tropical climate. The average monthly temperatures are high enough to permit year round crop production. The average monthly maximum temperatures in winter are around 27.5°C (80°F) and the minimum well over 10.0°C (50°F) providing frost-free seasons for cropping. The average summer maximum temperature is 37°C.

Although annual average rainfall in Bangladesh is 2,546mm and this is more than enough for the agriculture, its distribution over time is very uneven. A great bulk of the annual rain comes during the four monsoon months of June to September, which account for about 80% of the annual total. During December to March, soil moisture becomes the main constraint for crop production and irrigation is required except in some low-lying

areas. Although droughts are relatively infrequent compare to floods, they do cause widespread crop failures and usher in severe famines. The most recent drought occurred in 1997 and caused tremendous damage to agricultural production (Ahmed, Haggblade, and Chowdhury 2000). Failure of the monsoon not only affects summer crops but also winter crops.

In an agrarian economy like Bangladesh, the importance of land cannot be over-emphasized. The actual area available for agricultural use is 134,476 square km and the land-man ratio is very low, 0.5 acres. Therefore, most of the land is used intensively due to its scarcity and dense population (Ahmed, Haggblade, and Chowdhury 2000). The scarcity of land is so acute that despite the risk of complete submergence and consequent destruction of crops during the floods, even the small river islands and areas prone to deep annual flooding are used for food production (Dayal 1997).

Water sources are plentiful in Bangladesh; however, flood control and additional irrigation are necessary for more efficient agricultural use and for the expansion of food production (Dayal 1997). During the winter season only about 20% of the net cropped area is cultivated, due to the lack of moisture in the soil after the monsoon. Even with the plentiful surface water during the monsoon season, much of it is carried away into the sea and the water accompanies very fertile sediments that can be used for improving land fertility.

2.2.2 Institutional Environment

Since independence in 1971, eradication of hunger and poverty has received priority in development planning. The government has invested heavily in the expansion

of irrigation, flood control, agricultural technology, rural infrastructure, agricultural research, and food entitlement protection. In recent years, more attention has been focused on lifting the food purchasing power of the landless households and tenant farmers. The fourth Five Year Plan (1990-1995) has particularly concentrated on increasing employment and thereby lifting the food entitlement of the poor. The country has also been helped by large amounts of foreign monetary aid, direct food aid, and project food aid such as food-for-work projects (Dayal 1997).

2.2.3 Farming systems

2.2.3.1 Food Crops

Due to the high demand in food, the cropping pattern is dominated by food crops, which occupy 92% of the total cropped area, and foodgrains alone account for 82% of the cropped area (Dayal 1997). Among the food crops, rice is the predominant crop and 80% of the total cropped area is devoted to rice cultivation. There are three major rice varieties: aman, boro, and aus. Aman is the predominant variety, and according to Ahmed, Haggblade, and Chowdhury (2000), it occupies 42% of the gross cropped area. Aman is sown before the monsoon in March and April and harvested after the monsoons in November. Some varieties of amans are ready for harvesting by September, when the floodwater is still quite deep in the fields, and are harvested by boats. The yield per acre is relatively low; however, it can be grown in very low-lying areas that otherwise remain unused for crop production during the monsoon.

The boro rice, often called winter rice, is second in importance due to the spread of high-yielding varieties (HYVs). Benefited by the use of controlled water supply by

irrigation system and application of fertilizer, boro rice gives a much higher average yield than other rice species. Aus contributes about a quarter of the total rice supply. Aus rice is sown in low-lying areas before the real onset of monsoons, and harvested in August and September from boats. Most villages have two rice seasons, the wet aman and the irrigated boro, which usually involves high yielding varieties. Some areas also plant a third season, aus, in May (Coelho 1998). In the study area, rice production is reported to have increased after the road projects due to improved access to HVY seeds and fertilizer. Farmers have also started selling more portion of the production due to the improved road and transportation.

Wheat was introduced in 1960s and has increased the most in area and production. According to Dayal (1997), the area under the cultivation of wheat expanded more than 382% since its arrival. Introduction of wheat has initiated some changes in the food habits of the Bangladeshi, such as eating bread, biscuit, and Indian style bread in the mornings. The introduction of wheat caused utilization of unirrigated cropland during winter because it requires little moisture, and hence contributed to an increase in food production of the country.

Pulses are a central protein source for those who cannot afford meat regularly. They are also an important source of nitrogen for the soils and thus are affecting agricultural productivity. The cultivated area under pulses, however, has been constantly declining over the last two decades, and its decline is estimated at 23% (Dayal 1997). This corresponds to the general trend of gradual decrease in the acreage of low market value grain crops, such as maize and barley.

Vegetables and fruits are not of major importance. The area under vegetables and fruits only occupies 3% and 1%, respectively, of the total cropped area. Six major vegetables are potatoes, eggplant, pumpkins, cauliflower, cabbage, and water gourd. Three leading fruits – mango, banana, and jackfruit – occupy 70% of fruit cultivation area. Limited vegetable cultivation may be explained by the excessive demand for cereal production. Under severe income constrains, people tend to consume more of cereals than vegetables in order to gain calories. Limited fruit cultivation may be due to lack of canning, process, and cold storage industries causes its low prices in market and thus deprives farmers of incentive.

Fishing is an important supplementary activity in the rainy season. Most farmers catch fish in their own fields, small capture lots, rivers, or local ponds nearby. Most of the sample households fish during the rainy season to supplement their food consumption. Fish forms a major part of the household diet at all parts of the year (Coelho 1998).

2.2.3.2 Cash Crops

Cash crops are a small proportion of total cropping patterns and occupy only 5% of the cropped area. Jute is the single dominant cash crop among several others such as cotton, sugar cane, and tobacco (Dayal 1997). In some areas, winter vegetables such as potato, and in other areas, fruit such as banana, papaya and pineapple are grown as cash crops (Coelho 1998).

2.2.3.3 Seasonal Variations in Food Intake

Food supply depends on the monsoon and harvesting seasons. Rice is consumed mainly during the months following the harvest, from July and February, supplemented with wheat and potatoes from March to June. There are two lean seasons per year, from June to July, before the harvesting of aus and planting of aman, and from October to November, before the harvesting of aman. During these periods, food prices increase and those who purchase entire or part of the consumption, such as landless labourers and small holders, need to reduce food intake. Their income also declines due to the decrease in the demand for fieldwork. In the lean season, therefore, the purchasing power of the poor tends to be severely eroded (Dayal 1997, Ahmed, Haggblade, and Chowdhury 2000).

2.2.4 Land Tenure and Distribution

Land is cultivated in very small units due to the high pressure of population and fragmentation of holdings practiced by Islamic law of inheritance. The estimated average farm size has been shrinking – 1.43 hectares in 1960 (Khan and Hossain 1989) to 0.8 hectares in 1999 (Ahmed, Haggblade, and Chowdhury 2000). Sharecropping is very common type of farming; the area under tenancy was estimates at 16.8% of net sown area in 1976/7 (Khan and Hossain 1989).

2.3 Livestock Systems

Ownership of animals is widespread because of its contribution to agricultural activities and market value. Cattle and buffaloes are the main sources of draft power and supply milk and, less frequently, meat. They are also important assets for farm

households to hedge against risk and uncertainty. About 7.26 million households owned a total of about 21 million cattle and 400,000 buffaloes (Kahn and Hossain 1989), and 90% of adult working cattle and buffaloes were engaged in agricultural activities. Draft animals are particularly useful for ploughing and it needs to be done as soon as possible after the first few rains during monsoon season to plant food crops. Therefore, it is advantageous for the farm household to own a draft animal.

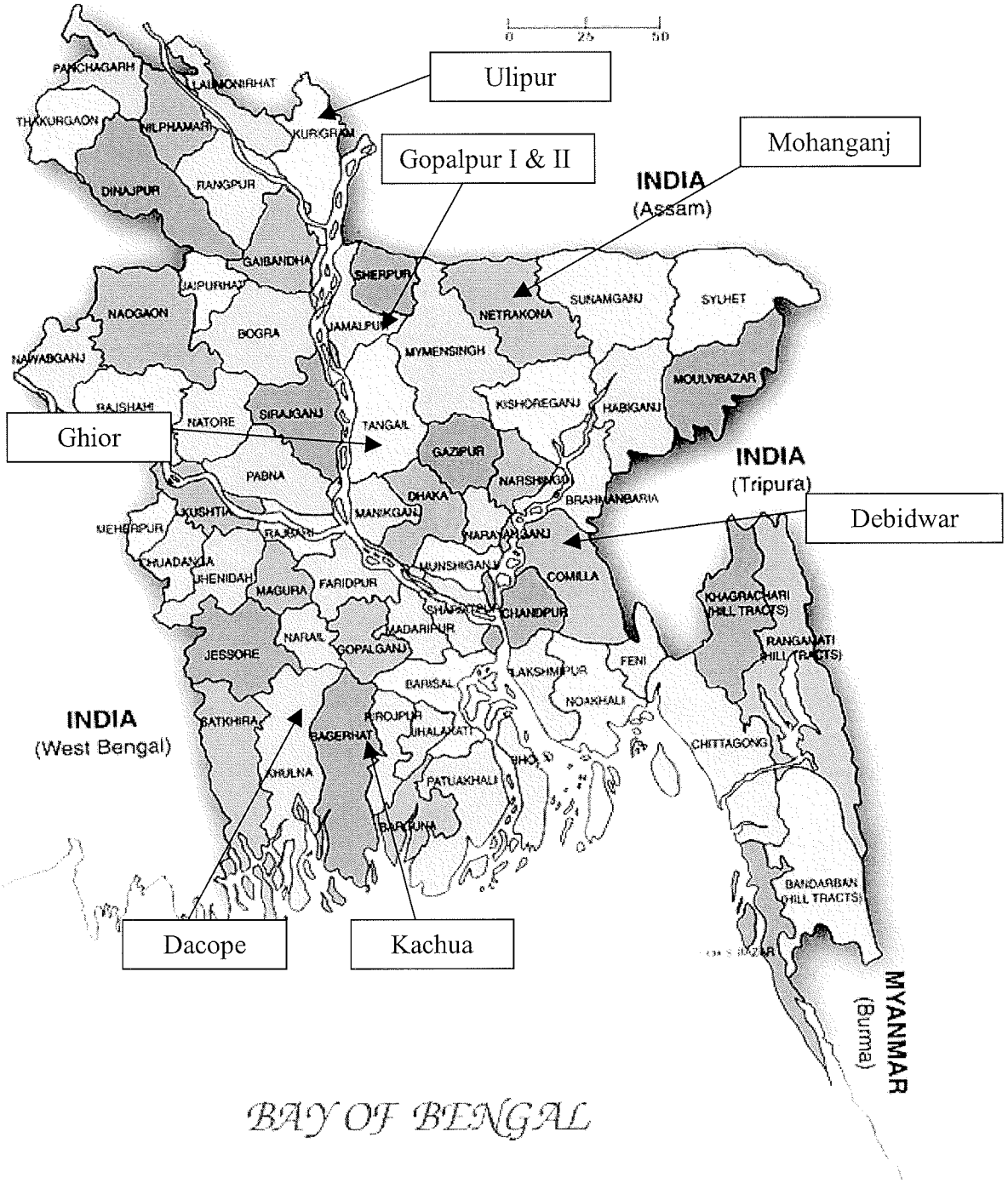
Smaller animals, such as sheep and goats, are an important source of supplementary income. They multiply fast, provide milk, and are easier to sell than large animals. Also they are relatively inexpensive to keep; they survive on stubble, leaves and stalks of banana trees, and crop residue. 14 million of sheep and goats were estimated in 1984 (Kahn and Hossain 1989), of which 86% were owned by farm households.

Poultry, such as chicken, ducks, and pigeons, is a crucial supplementary activity, and this is ideal for small households because they are inexpensive to keep. They are a source of animal protein and helpful for gaining cash income, particularly before the harvests. According to 1983/84 census, 85% of the farm household possessed poultry and the average size of poultry holdings was between 7 and 8 birds (Kahn and Hossain 1989).

2.4 Characteristics of Study Areas

Total of eight study areas are scattered over the country. However, they are not isolated from centers of marketing and services within thanas, political subdivisions under state, roughly equal to county. This is due to the category of road (R1) targeted for

Figure 2.1 Study Areas



Source: Swedish South Asian Studies Network (2001)

Table 2.1 General Conditions of Project Sites

Site	Debidwar	Mohanganj	Gopalpur I	Gopalpur II
Road Length	13.6km	3.5km	5.1km	8.5km
Geographical Condition	Located in river basin and surrounded by embarkment. 60km east of Dhaka	The area is routinely inundated every year because it is located between two rivers.	Located north west of Dhaka.	
General Economic Situation	One of the more prosperous and productive rice-growing and trading districts of the country	Agriculture is the main activity.	The district and surrounding areas are know as the largest fruit supplier of the country.	
Livelihood Systems (Head End)	Small proportion of large landholders and half of the population landless. Various occupations are found in both farming and off-farming. Potato cultivation occupies 70% of arable land.	Higher elevation - large rice farmers predominate with occasional fishing to complement home consumption.	Combination of farming (rice, jute, and fruit), off-farming activities, and livestock rearing is important activities at both ends of the alignment. Substantial numbers of farmers are middle-size farmers. No significant differences in livelihood patterns between head and tail end.	Same as Gopalpur I. Rice production is more concentrated at the head end.
Livelihood Systems (Tail End)	Greater distribution of small, middle, and marginal farmers. Half of the population engages in daily labor.	Lower elevation - Most villagers are landless due to the routine flood. Fishing is the important activity in the tail end area as well as wage labor and sharecropping.		Same as Gopalpur I. Jute production is more concentrated at the tail end.

Table 2.1 - continued

Site	Ghior	Dacope	Kachua	Ulipur
Road Length	4.5km	8km	6.5km	3.35km
Geographical Condition	Prone to heavy flooding annually because the area is in the path of a major river.	Located in a delta region of southwestern Bangladesh. Clayey soil. High salinity due to shrimp aquaculture.	The road is difficult to cross even by foot during rainy season due to clayey soil conditions.	Northwestern part of the country, near the border with Assam, India. Flood prone area.
General Economic Situation	Relatively richer area compared to other areas due to the potato production; however, 80% of the population lives from off-farming activities.	Relatively richer area due to its thriving shrimp production. Large wealth disparity between the head and tail end areas.	Agricultural area. Rice, nuts, and banana cultivation are important activities. Shrimp cultivation practiced at smaller extent.	Rice farming is the major activity. Jute is the major cash crop grown. Most households are landless or marginal farmers. Relatively poorer than other areas.
Livelihood Systems (Head End)	Not much differences between head and tail ends. Rice and potato farming are the predominant activities, combined with sharecropping/land leasing, fishing, and some off-farm income generating activities to supplement income.	The head end of the alignment is agricultural area.	Some large farmers in the head end.	Two-season rice farming with aman and boro, combined with jute, potatoes, and wheat. Many farmers practice sharecropping/renting combined with wage labor.
Livelihood Systems (Tail End)		Shrimp cultivation and shrimp related business/trading are the major activity in the tail end area.	Most of the villagers are small-scale farmers due to an intense land pressure.	

Source: Coelho (1999)

improvements in the project. The villages lay along a route connecting a regional headquarter, important growth center or a paved (feeder) road to another growth center. Features of each alignment are summarized in the table 2.1.

2.4.1 Common Characteristics across the Sample

2.4.1.1 Economic Characteristics

Table 2.2 Socioeconomic Categories of Sample Households

Site	*Small*	*Lower-middle*	*Upper-middle*	*Large*	*Total*
Debidwar	87	51	13	6	157
Mohanganj	83	42	11	8	144
Gopalpur I	85	25	18	8	136
Gopalpur II	77	33	33	8	151
Ghior	98	26	21	12	157
Dacope	81	30	33	9	153
Kachua	93	8	11	5	117
Ulipur	115	18	22	5	160
Total	719	233	162	61	1,175

Land ownership patterns are by far to be the most influential determinant of income and the status. In all of the sample villages, the landless population is the most destitute, and a variety of farm and off-farm activities determine the status of the rest. The sample households are classified into four categories – Small Farmers, Lower-middle Farmers, Upper-middle Farmers, and Large Farmers – by cluster analysis (Costa 1997). 61% of the households are in the small farmer category, 19% and 13% are in lower- and

upper-middle farmer categories, and 5% are in the large farmer category. Details about the socioeconomic status of household are outlined as Table 2.2.

2.4.1.2 Demographic Characteristics

Table 2.3 Demographic Characteristics of Sample Households

Household characteristics	Small farmer	Lower-middle farmer	Upper-middle farmer	Large farmer
% of household	63	17	15	5
Household size	4.9	8.0	5.2	8.5
Average age of HH head	37	46	38	71
Age composition:				
0 to <5	25	17	24	16
5 to <12	20	19	16	15
12 to <18	6	16	8	7
18 to <50	42	37	44	43
50 to <70	5	9	7	9
≥70	1	2	1	9
% of children attending school	71	77	80	76
HH yrs of formal education	5	21	20	21

Source: Coelho (1999)

Sample responders are young in general, with 50% of the population under 18, 41% between 18 to 50, and only 9% over 50 years old. Large farmer households tend to have older members and household heads; 19% of the population over 50 and 38% under 18 years old. Small farmer households either; they have the lowest levels of education, measured in school attendance rates and years of formal schooling, while the upper middle counterparts have the highest scores.

2.4.1.3 Occupations

Occupation differences between categories are noteworthy. Farming was the major occupation of the majority of large farmers, followed by sharecropping. Farming is also the dominant occupation for lower-middle farmer households (51%), supplemented by sharecropping, day labor, and off-farm activities. In contrast, only 19%

of small farmer households identified farming as the major occupation. Upper-middle farmer class has farming and services/business as the major occupations (39% and 36% respectively). Small farmers reported day labor as their major occupation (38%). Rickshaw pullers come mainly from the small farmer class, whereas large farmer households do not have any.

Table 2.4 Major Occupation of Sample Household Head (in percentage)

Occupation	Small farmer	Lower-middle farmer	Upper-middle farmer	Large farmer
Farmer	19	51	39	66
Sharecropper	7	9	3	13
Business	3	5	11	4
Petty business	10	5	9	1
Day labor	38	11	3	4
Service	6	9	25	0
Rickshaw puller	8	1	2	0
Driver, carpenter, fisherman, handicraft, etc.	8	11	7	10

Source: Coelho (1999)

2.4.1.4 MARKETING FACILITIES

Each site has several markets with various sizes. Large markets can be wholesale or retail, and smaller markets are usually retail. Larger markets sometimes contain livestock markets. Aside from trading, they usually have rickshaw stands, restaurants, and some service facilities, such as repair shops. Nearly all of the markets have expanded after the road improvement. Many small markets have started dealing with fertilizer and HYV seeds available to farmers. In addition to the existing markets, many small shops opened along the roads. Most shop owners used to be landless daily laborers or small farmers.

Homestead sale is the most preferred marketing method for farmers to sell their produce and commodities. Homestead sales save transport costs, market taxes, and the

nuisance of dealing with cheating at the market. Homestead sales are also regarded as a status symbol among farmers that can afford the convenience. There are some problems with selling at the homestead; farmers have to be up to date with market prices to prevent the traders from cheating them, commodities have to be in bulk to be traded, and merchants are usually specialized in trading in one commodity.

2.4.1.5 LAND

Land asset reflects the size of household; large farmers have the largest land, livestock holdings, and purchased fertilizer, while the small farmers have only the 10 to 40% of what the large farmers have.

Table 2.5 Land Assets and Land Usage of Sample Households

	Asset/Land Usage Indicator	Small Farmer	Lower-middle Farmer	Upper-middle Farmer	Large Farmer
Assets	Agricultural Land Owned (decimals*)	30	209	205	249
	# of buffaloes/cows	0.8	2.6	1.9	3.4
Land Use	Total land under cultivation (decimals)	102	282	264	367
	% rented/sharecropped	20	18	10	19
	% HYV rice area	54	47	57	49
	% cultivated area irrigated	7	8	10	8
	Fertilizer purchased (kg)	46	79	86	107
	% rice production sold	34	36	41	34

Source: Coelho (1999)
*Note: decimals = 1/100 of acre

2.4.1.6 INSTITUTIONS

Increased activities of government and NGOs, such as BRAC, Grameen Bank, Proshika, and World Vision, are reported in the project areas, and as a result, there are more health facilities schools are available. Villagers in the area also have better access to loans and a line of credit offered by NGOs. Many of small farmers and landless

villagers who used these loans during the lean season or to buy seeds now make investment or start off-farm income activities. Some of them have started poultry and animal rearing or lease or buy more land as investment. Others have bought their own rickshaws or built stops. Many of these micro credit programs favor women entrepreneurs and offer more off-farm income opportunities. Most women have spent their increased income for better food intake, clothing, and education for their family.

2.5 Off-farm Income Generating Activities in the Study Area

Among 129 million Bangladeshi nationals, the population of labor forces is estimated at 66 million in 1999 and increasing 3% per year, and females comprise 42%. More than 60% of the population is engaged in agricultural activities (The World Bank 2001). Although agriculture is the predominant income-generating activity, the non-farm sector also is very active partially owing to the small-scale cultivation which does not offer enough food supply for the entire year. Therefore, small-scale farmers are forced to look for activities to supplement income. Second, agricultural activities are very seasonal; more labor is needed for planting and harvesting than between, and no labor is needed after the produce is sold. As a result, there is a high degree of monthly variation in incomes. Finally, the tropical humid climate causes food to rot and households would rather sell their output than store it for future home consumption.

Because of the reasons above, market facilities are prevalent and backward- and forward-integrated activities related to agriculture would create off-farm income generating opportunities (Wahid and Weis 1996). Examples include transportation, petty

trade and businesses, services such as electric milling operations, and other agricultural related trading.

After the road improvement, increased off-farm opportunities are observed in the project areas. Existing businesses have expanded and many new shops and services have opened after the projects, either in the existing markets or along the street, taking advantage of increased traffic.

2.5.1 RICKSHAW PULLERS

Table 2.6 Change in the Number of Rickshaws along the Alignments

Site	Number of Rickshaws	
	Before	After
Debidwar	30	500 (including part-time)
Mohanganj	N/A	N/A
Gopalpur I	30 to 40	225
Gopalpur II	20 to 25	100 to 150
Ghior	0	40
Dacope	5	80
Kachua	2 to 3	50
Ulipur	10 to 15	80 to 90 (including part-time)

Source: Coelho (1999)

Rickshaw pulling is one of the occupations that increased massively after the road improvements, sometimes more than 5- to 6-fold. This is partially due to the improved road conditions that caused more demand on transportation, and partially due to the villagers' improved access to credit to start their own business along the streets. The change in the number of rickshaw pullers before and after the project is shown in Table 2.6. The vast majority of the rickshaw pullers who started after the road improvements came from extremely poor or landless households, and they had worked before as agricultural or casual laborers. Most of them took a loan and possess their own rickshaws. Due to the improved road conditions, demand for rickshaws is higher and it is

also safer for the operators to pull rickshaws. Their incomes have increased and become steadier, although some long-term rickshaw pullers noted a decline in their income due to intensive competition.

2.5.2 Shopkeepers

Following rickshaws, small shops display most the effect of road improvements. Many shops opened after the project in most of the areas, and existing shops have expanded. Most of the shops are small to medium grocery-type stores dealing daily items. Due to the improved road conditions, stores started dealing with fertilizer, insecticide, and kerosene oil – items which improve villagers' daily lives. Their sales have increased after the project, although a small number of the shopkeepers had sales decline due to the intensified competition around the area.

2.5.3 Female Entrepreneurs

Most of female entrepreneurs have been in their businesses for a while, even before the road improvement. Their businesses cover a wide range of activities; the common enterprises are poultry and small livestock raising, combined with other activities like handicrafts. Other activities include tailoring or dressmaking, vegetable cultivation, shop keeping, rice husking, and molasses making. Almost of all women are from poor households and did not have formal education. Many took loans from credit facilities to start their businesses. There seems some increase in sales from increased customers, better marketing facilities, and prices. However, the entrepreneurs did not credit the road improvement directly for their business improvements; the increased

services, such as better accessibility to loans and technical assistance by NGOs, are considered to be the direct reason.

In summary, natural and social surroundings are not favorable for the livelihood of rural population in Bangladesh. In these environments, a household tends to make a living by engaging in various activities, such as agriculture, livestock, and off-farm income activities. In the next chapter, the theories of household decision-making strategies will be introduced to better understand this household behavior.

CHAPTER THREE

THEORETICAL FRAMEWORK AND HYPOTHESES

This chapter discusses farm household models, including expected utility maximization, portfolio strategy, and credit-constrained behavior. The hypotheses to be tested will then be presented.

3.1 FARM HOUSEHOLD MODELS

3.1.1 THE CHAYANOV FARM HOUSEHOLD MODEL

To investigate the behavior and decision-making strategies of farm households, various theoretical household models have been developed. One of the advanced models was the Chayanov model (Ellis 1993). In this model, the household engages its labor in family farm production. The household is the unit of production and consumption, and maximizes utility by increasing income or leisure time. Since the household labor is the only source of farm input, the household trades off between the time spent on farm work to produce income and the time spent on leisure activities. Decision-making is based on demographic structure and consumer to worker ratio (c/w ratio).

The household has the utility function:

$$U = f(Y, H) \tag{3-1}$$

with utility a function of income (Y) and leisure time (H). The consumer faces constraints of a production function (f), the minimum income needed to sustain livelihood (Y_{min}), and the maximum number of available working hours (L_{max}):

$$Y = Py * f(L)$$

$$Y \geq Y\min$$

$$L \leq L\max \tag{3-2}$$

This model has some drawbacks in explaining the farm household decision-making in the modern era. First, because the model does not include labor markets, households are assumed to employ their labor entirely within the household. This contradicts the reality in rural Bangladesh, where households tend to hire labor in and out. Second, the assumption that household labor is the only farm production input is highly restrictive. This assumption is not appropriate purchased inputs can be used. Finally, time allocation is assumed to be limited between farm labor and leisure activities. There is no accommodation for home time, such as cleaning, cooking, child nursing, and other domestic obligations (z-goods production).

3.1.2 New Household Model

One of the later models elaborated was the "New Home Economics" model (Becker 1965; Michael and Becker 1973; Ellis 1993). The major improvement over Chayanov's original model is the introduction of a labor market which allows a household to separate the labor allocation between home production of z-goods, wage labor, and farm labor, depending on the opportunity cost. In this model, household consumption depends on relative market prices of ingredients and opportunity cost of preparing final goods.

3.1.3 THE BARNUM-SQUIRE MODEL

Barnum and Squire (1979) developed and applied a new model based on the new home economics model (Singh, Squire, and Strauss 1986). The Barnum-Squire model predicts the response to changes in family size, structure, input and output prices, wage rates, and technology. This model considers a household as a "farm" and "home" simultaneously. This means that the home production is not only for home consumption but also tradable. The household also has an option to hire in or hire out labor. These assumptions correspond well with the reality of Bangladesh, where population density is high and available farmland is limited. For the convenience of analysis, time for home activities and leisure time are combined and treated as one consumption item.

A household has the utility function:

$$U = f(T_z, C, M) \tag{3-3}$$

where T_z is time for production of z-goods and leisure, C is home consumption, and M is purchased market goods. Preferences are influenced by the size of the household and the composition of workers and dependents. The household maximizes utility subject to three constraints:

Physical production function:

$$Y = f(A \mid L, V) \tag{3-4}$$

where A is land under cultivation, presumably fixed, L is the total labor used in production, and V is other variable inputs.

Time constraint:

$$T = T_z + T_F + T_w \tag{3-5}$$

where T_z is time allocated to z-goods and leisure, T_F is time allocated to farm work, and T_w is wage. If labor is hired in, $T_w > 0$, the time available increases, and if it is hired out, $T_w < 0$, reducing total time.

Income constraint:

$$P(Q - C) - wT_w - vV = mM \tag{3-6}$$

The first component is the market value of the output sold, where P is the output price and *(Q-C)* is the quantity *(Q)* sold. The second component is wage income, where w is the market wage rate and T_w is the time spent on wage labor. The component is negative since negative T_w means the hiring out labor and bringing income in and positive T_w means hiring in labor and making the payment out. The third component is the value of purchased variable input, where v is the market price and V is the amount purchased. The above three components should be equal to mM, where m is the average price of market purchases, M.

In the Barnum-Squire model, the last two constrains are collapsed into the full income constraint:

$$F = wT_z + pC + mM = \Pi + wG \tag{3-7}$$

where wT_z is the opportunity cost of the time spent in z-goods production, pC is the market value of home consumption, and mM is the value of market purchases. These

components should be equal to the sum of net farm profit, Π, and the total opportunity cost of household time, wG.

The optimal supply of household labor occurs when the household equates the marginal value product to marginal cost.

$$MVP_L = w$$

$$MVP_v = v \tag{3-8}$$

To maximize utility, the household combines a portion of each item, T_z, C, and M, so that the price ratios, w, p, and m, will be the same. The equilibrium conditions among the time for z-goods production and leisure, consumption of agricultural product, and the market purchased goods are:

$$MRS_{Tz,C} = \frac{w}{p}$$

$$MRS_{C,M} = \frac{p}{m}$$

$$MRS_{M,Tz} = \frac{m}{w} \tag{3-9}$$

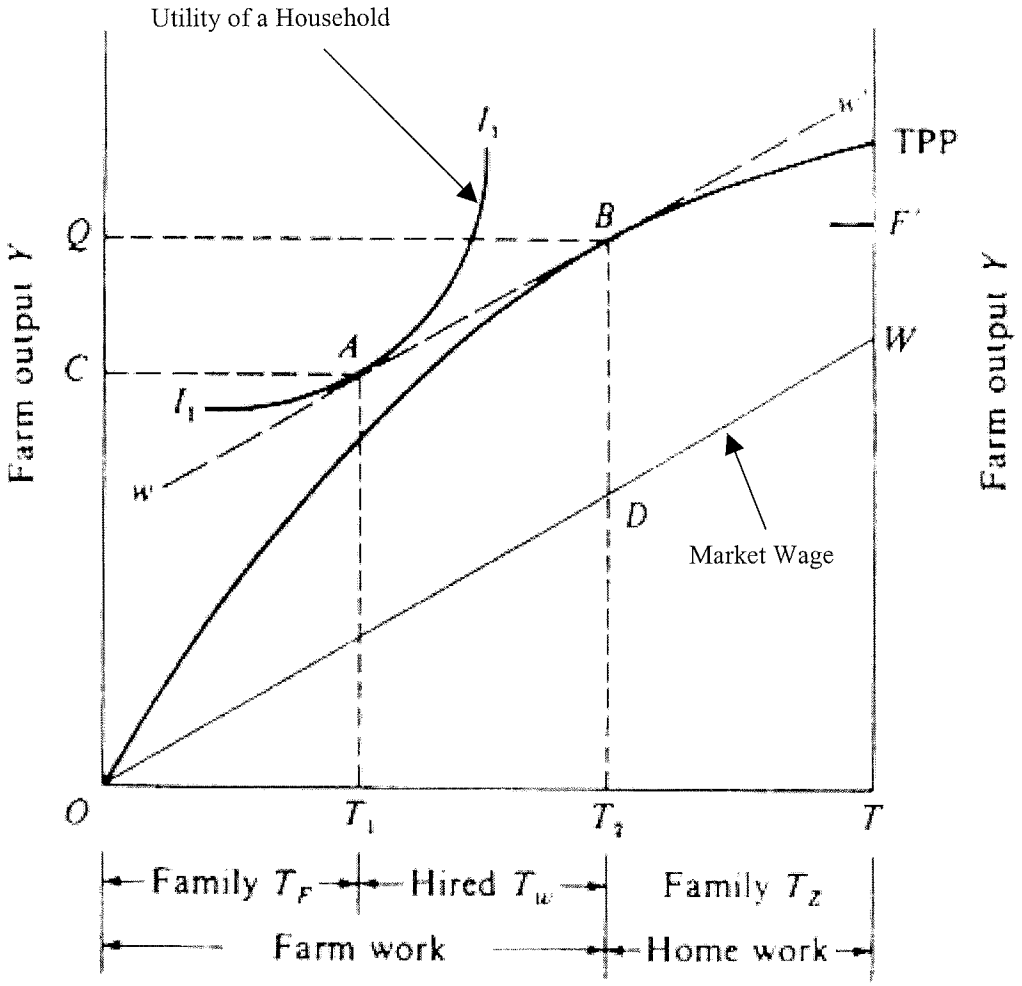
The equilibrium is shown in Figure 3.1, when labor is hired in rather than hired out.

3.2 Expected Utility and Decision Theory

3.2.1 Uncertainty and Risk in Agricultural Households

Barnum-Squire model is useful to understand profit and utility maximizing farming households. The model, however, disregards household attitudes toward uncertainty and risk. Because of unpredictable weather, market instability, and vagaries of institutional environment, farmers always face uncertainty and the consequent risks of

Figure 3.1 Part of the Barnum-Squire Farm Household Model



The case when labor is hired in

Source: Ellis (1993)

income variability. Therefore, it is important to consider the decision-making strategies of farm households under uncertainty and risk. Uncertainty refers to situations where it is not possible to attach probabilities to the occurrence of events, whereas risk is restricted to situations where probabilities can be attached (Ellis 1993). For small-scale farmers, especially in developing countries where the lack of social security is pervasive, this uncertainty can frequently involve calamitous consequences (Anderson, Dillon, and Hardaker 1977, Dillon and Hardaker 1980).

Risk is the probability of events which result in incomes above or below the average expected income. For example, for the household with the expected income of 500 dollars, it is a risk to earn only 250 dollars if weather changes, it loses household workers, or agricultural input prices increase. Risk also is based on the strength of belief about the occurrence of uncertain events.

3.2.2 Expected Utility

Each household tries to maximize utility while taking risk into consideration. Since risk is subjective, the theory of expected utility is introduced to objectively and quantitatively measure the household utility (Ellis 1993). Under this theory, a household is assumed to have consistent preferences between alternatives and to maximize welfare. The Certainty Equivalent (CE) is the sure amount of income a person would regard equal to taking risky set of acts. Individual risk preferences can be evaluated by comparing the CE and the consequences of the risky set of acts. For example, consider a choice between earning income of 500 dollars without application of fertilizer regardless of the

weather, or a chance to earn 1,200 dollars by introducing fertilizer, or a loss of 100 dollars under drought condition.

The average of these is an expected money value (EMV), the weighted average of various outcomes.

$$EMV = p_1 I_1 + p_2 I_2 \tag{3-10}$$

In this example, $EMV = 0.6 \times \$1{,}200 + 0.4 \times -\$100 = \$680$, provided the probability of having good weather is 0.6 and bad weather is 0.4. *EMV* is the average income expected, given a run of chances at I_1 and I_2. The CE is 500 dollars – the amount that would make the person indifferent to take the chance on two widely different outcomes.

For simplicity, household utility is considered as a function of income (*I*).

$$U = f(I) \tag{3-11}$$

Expected Utility *[E(U)]* is calculated by the sum of the utilities derived from incomes I_1 and I_2, weighted by the probabilities of their occurrence.

$$E(U) = p_1 U(I_1) + p_2 U(I_2) \tag{3-12}$$

Household behavior toward risk can be judged by the comparison between *EMV* and the level of income, *I,* which makes the household indifferent to taking a risky action. For example, a household faces a certain income, I_A, which is smaller than *EMV*, but yields the same utility as *EMV*. This implies that the household foregoes an amount of income equivalent to *EMV* minus I_A in order to achieve certainty, and is risk-averse. When the

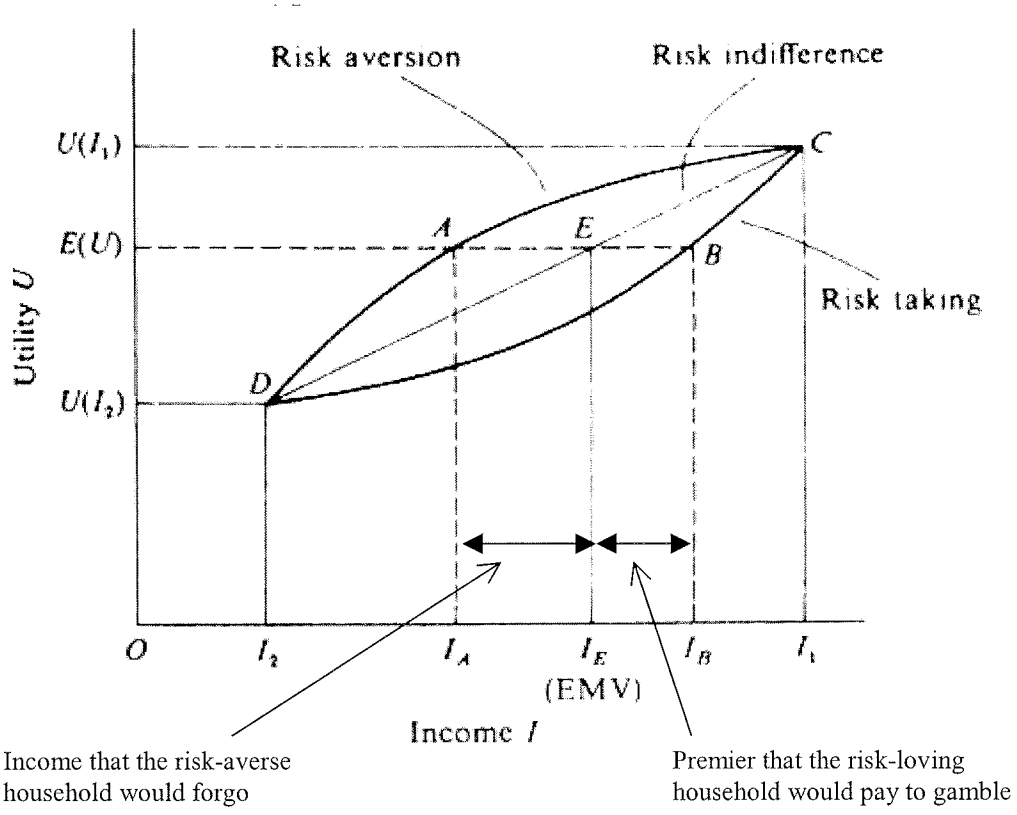
Figure 3.2 Utility Theory of Choices Involving Risk

Note: EMV = $p_1I_1 + p_2I_2$

E (U) = $p_1U(I_1) + p_2(I_2)$

P (Probability) 1 = 0.6, or 60% to win $1,200

P (Probability) 2 = 0.4, or 40% to lose $100



Source: Ellis (1993)

household is indifferent between the sure amount of money, I_E, and the expected outcome of a risky action, *EMV*, this household is then considered to be risk-neutral. Some households have a preference for taking the chance on obtaining the higher income (1,200 dollars), even though one of two risky outcomes (-100 dollars) might make them worse off than before. This household is considered as a gambler, and the amount $I_B - EMV$ is the premium prepared to pay for gambling. The relationship of risk attitude is shown in Figure 3.2.

3.2.3 Safety First

Household behavior toward risk is a subjective choice among alternatives. However, agricultural households are generally considered to have a tendency to take risk-averse actions. This attitude is explained by Roumasset (1976) as "safety first". Small-scale, subsistence, or near-subsistence farmers are risk-averse because they often cannot cover their needs from one crop season to the next. They face danger of starvation if they fail to avoid a negative income; a loss is regarded as a "disaster" for a family existing at subsistence level. Using the previous example, 500 dollars is the minimum level of income the family is prepared to accept.

The key to understanding the household behavior is the minimum level of acceptable income and the maximum level of acceptable risk, and this leads to "Safety First Rules of Thumb" (Roumasset 1976). A risk-averse decision-making differs from that of profit maximization, constrained by the willingness to risk income falling below a given level. As a consequence, farm household utility maximization has a trade-off with income, that is the amount of $EMV - I_A$, for being risk-averse.

3.3 Portfolio Activity and Risk

In the previous section, farmers' perception of risk and their attitude toward risk are explained. Therefore, it is important to introduce the strategies and tools to reduce risk in agricultural households.

3.3.1 Risk in Agriculture

Risk in agriculture comes from production and yield risks, market and price risks, loss from disaster, institutional changes such as tax laws and trade agreements, human risks in the performance of labor services and management, and risks of technological change and obsolescence (Barry, Hopkin, and Baker 1983).

To deal with risk mentioned above, there are several ways to diminish risk. In the production phase, responses consist of diversification, informal insurance by applying pesticides, reserving equipment, and preparing supplemental irrigation. In marketing phase, risk management includes inventory management, forward and future contracts, and vertical integration. Participation in government programs may also present opportunities for reducing risk. The risk responses generally involve trade-off; emphasis on one method of countering uncertainty may mean a greater risk in production or marketing and vice versa.

Among the risk reduction strategies, diversification is emphasized in agricultural operation. "By distributing the eggs among several baskets" (Lee, Nelson, and Murray 1980), the chance of a large loss from a single misfortune is reduced. Likewise, chances against major losses occurring simultaneously in all activities are reduced. Moreover, since each enterprise is typically small relative to the total size of the operation,

diversification enables small households to reduce the variability of income despite lower expected returns.

3.3.2 PORTFOLIO MODEL

A portfolio model indicates how a different combination of investments may reduce risk more than having a single investment in financial management. In this model, potential for risk reduction is determined by the number of investments, correlation between the expected returns of the individual investments, and possible changes in costs and returns as a result of diversification (Barry, Hopkin, and Baker 1983). The portfolio model in the case of two investments, X_1 and X_2, consists of three equations:

Expected Return of the Portfolio ($\bar{r}_t$):

$$\bar{r}_t = \bar{r}_1 p_1 + \bar{r}_2 p_2 \tag{3-13}$$

where $\bar{r}_t$ = total expected return of the portfolio

$\bar{r}_1, \bar{r}_2$ = expected rate of return from investment X_1 and X_2

P_1, P_2 = proportions of total resources invested, with $P_1+P_2=1$

Total Variance of Portfolio (σ_t^2):

$$\sigma_t^2 = \sigma_1^2 P_1^2 + \sigma_2^2 P_2^2 + 2P_1P_2c\sigma_1\sigma_2 \tag{3-14}$$

where σ_1, σ_2 = standard deviations of X_1 and X_2

c = correlation coefficient between returns r_1 and r_2, with $-1 \le c \le 1$

$\sigma_{12} = c\sigma_1\sigma_2$, the covariance of X_1 and X_2

Total Standard Deviation of Portfolio (σ_t):

$$\sigma_t = \sqrt{\sigma_t^2} \tag{3-15}$$

The correlation coefficient is a measurement of the strength of association between two investments, while covariance is an absolute measure of the association. Positive covariance suggests that high profits in one investment are associated with high profits in another investment. Negative covariance implies that high profits in one investment are related to low profits in another investment. Therefore, negative covariance between two investments is desirable for risk diminishing purposes. Positive value of the correlation coefficient *c* indicates a positive variation between investments and a negative value of *c* implies negative relation. Equation 3-14 therefore indicates that the higher the value of *c*, the higher risk for investments X_1 and X_2.

Consider a portfolio holding half of investment in beef (X_1) and half in corn production (X_2) as a numerical example. The expected returns and standard deviations of each activity are assumed to be 20 percent and 10 percent, with a zero correlation between their returns. Allocation of resources in either activity yield an expected return ($\bar{r}_t$) of 20 percent and a standard deviation (σ_t) of 10 percent:

$$\bar{r}_1 = 0.20, \bar{r}_2 = 0.20, \sigma_1 = 0.10, \sigma_2 = 0.10, c = 0.00 \tag{3-16}$$

The portfolio composed of equal portions (P_1=P_2=*0.5*) of two different investments would yield the following expected returns:

$$\bar{r}_t = (0.20)(0.50) + (0.20)(0.50) = 0.20, or 20\% \tag{3-17}$$

However, using Equation 3-14, the total variance of the diversified portfolio will be:

$$\sigma_t^2 = (0.10)^2(0.50)^2 + (0.10)^2(0.50)^2 + 2(0.50)(0.50)(0.00)(0.10)(0.10) = 0.0050 \tag{3-18}$$

The standard deviation will be:

$$\sigma_t = \sqrt{0.0050} = 0.0707, or 7.07\% \tag{3-19}$$

Thus, the diversified portfolio yields the same expected return with about 30 percent less risk, based on the assumption of zero correlation between the returns of activities. The value of c plays an important role in risk reduction; the risk reduction effect is greater with less than zero correlation between activities and is lesser with more than zero correlation.

Portfolio risk also declines as the number of investments increases. The portfolio's expected rate of return, variance, and standard deviation can be described in general terms:

$$\bar{r}_t = \sum_{n=1}^{N} r_n P_n$$

$$\sigma_t^2 = \sum_{n=1}^{N} P_i^2 \sigma_i^2 + \sum_i \sum_j P_i P_j \sigma_{ij}$$

$$\sigma_t = \sqrt{\sigma_t^2} \tag{3-20}$$

where i and j represent investments i and j for N investments in the portfolio. Diversification over more investment diminishes portfolio risk; however, evidence from

financial portfolios indicates that the possible gains in risk reduction exhaust after 40 holdings (Brigham and Houston 1998).

The major problem associated with diversification is loss in managerial efficiencies by spreading resources too thinly, called diseconomies of scope. Most likely, return will be higher from enterprises of efficient size than from a large number of small ones (Lee, Nelson, and Murray 1980). However, a household would prefer securing the minimum acceptable income and put up with diseconomies of scope, since it is maximizing utility by reducing the risk of income fluctuation rather than maximizing its expected return.

3.3.3 Application of Portfolio Model to Agricultural Households

Although the portfolio model is often used to describe holdings of financial assets such as stocks and bonds, it can also be applied to agriculture, such as the allocation of inputs and growing variety of crops. Diversifying among several farm enterprises and between farm and off-farm activities is a traditional approach to risk management (Barry, Hopkin, and Baker 1983, Upton 1987). A household is the unit of analysis, and it has a portfolio of various farm and off-farm activities.

In this application, low or negative correlation of returns among activities and the size of a portfolio also affect household income fluctuation (Upton 1987). Possibilities for utility gains exist only if the returns from alternative investments are less than perfectly correlated (Lee, Nelson, and Murray 1980). Crop diversification can be effective, but often less so than the combination of crop cultivation and animal husbandry or farm and off-farm activities, unless cultivated lands are geographically dispersed.

Prices and yields of crops grown in a given area tend to be positively correlated and often highly so (Barry, Hopkin, and Baker 1983). However, Musser and Stamoulis (1981) suggest that this problem can be avoided by combining dissimilar crops. In rural Bangladesh, farmers tend to cultivate both food and cash commodities.

Among the several options, the combination of farm and off-farm activities has been viewed as one of the most effective risk reducing strategies. For example, there are several studies conducted to estimate correlation coefficients between farm and nonfarm activities. Results showed low and sometimes negative correlation coefficients between farm and nonfarm investments (Young and Barry 1987, and Crisostomo and Featherstone 1990).

There is now recognition that the rural off-farm sector plays a vital role in the economies of many rural households in the developing countries. Recent studies show that the off-farm opportunities are important, not only for risk reduction, but also for poverty reduction, food security enhancement, and mitigation of income distribution (Adams and He 1995, Elbers and Lanjouw 2001, de Janvry and Sadoulet 2001, Ruben and Van den Berg 2001, Reardon, Berdegué, and Escobar 2001). Economies of rural Bangladesh tend to be multi-sectoral and a household often engages in more than one activity. Therefore, agricultural and income diversification among common activities in Bangladesh – agriculture, livestock, and off-farm activities – are included in household diversification analyses.

3.4 Sector Linkages and Credit Constraints

The reasons of small-scale farmers being risk averse were explained and income diversification as risk reducing strategy was presented in connection with portfolio theory. According to the theory, there is an inverse relation between the asset and the income diversification levels, or positive relation between riskiness in agriculture and diversification. However, some studies slightly modify portfolio theory. Reardon, Delgado, and Matlon (1992) found out in Burkina Faso that income diversification was associated with higher incomes and food consumption, and more stable income and consumption over time. Reardon (1997) considered 17 studies in Africa and found that 12 showed richer households had non-farm income than their poorer counterparts. Only one showed the opposite result and 4 studies showed that richer and poorer households had the same shares. Therefore, the theoretical framework of those results will be discussed and compared with portfolio theory.

3.4.1 Sector Growth Linkages

Sector growth theory argues that agricultural development leads the development of non-farm activities (Mellor 1976, Hazell and Roell 1983). Activities can be backward linked, supporting production by supplying inputs before production, such as seeds, fertilizer, agricultural equipment, or and animal and veterinary services. Activities also can be forward linked, such as supplying services to bring agricultural products to consumers as final goods.

Consequently, the greater is agricultural development, the more opportunities for sector growth linkages to derive off-farm activities. Corral and Reardon (2001)

demonstrate the geographic and socioeconomic tendency of off-farm activity; people in areas where population and infrastructure are concentrated have a higher share of off-farm income in total income. Therefore, at the village level, the degree of infrastructure development, such as roads, transportation systems, and market, has an important effect on the opportunities for off-farm activities. On the other hand, this implies that there are high entry barriers and capital requirements for those who are in the remote areas.

3.4.2 Credit Constraints

To explain the poor being away from off-farm opportunities, it has been pointed out that the access of farmers to a credit market is restricted by unavailability and farmers' limited assets. It is often pointed out that credit and insurance markets are almost non-existent or severely underdeveloped in rural areas in developing countries. This is because credit and insurance markets are plagued by moral hazards and information problems (Binswanger 1986).

In addition, farmers, particularly small-scale farmers, are unable to utilize credit and insurance markets because they lack financial assets. Even when these assets are present, large-scale or commercial farmers tend to receive the majority of the credit. Under limited credit availability, households are forced to supply their own liquidity to start and maintain off-farm activities. As the wealth of the household increases, the less risk-averse will be the household, and hence the more willing to undertake investments in new activities (Newbery and Stiglitz 1981). Therefore, This may exacerbate income disparities between households because the rich tend to become richer while the poor stagnate (Upton 1987).

3.5 HYPOTHESES

Neither theory or empirical evidence presents unambiguous hypotheses concerning which households will diversify their activities the most, or what the strong forces are to pull or push small farming households to diversify. It appears that diversification can arise from two different causes – the struggle to survive in a risky environment, or the desire to build on the base of a dynamic agriculture.

In rural economy, the importance of land endowment cannot be emphasized enough for the mobilization of households. Adams and He (1995) stress the role of land in rural household behavior:

> "In land-scarce, labor-rich settings, like Taiwan and much of Asia, small and inadequate landholdings may tend to 'push' poorer households out of agriculture and into the non-farm sector. The reverse then, could hold true in land-rich settings, such as Africa, where abundant land and scare labor may tend to keep most people in agriculture and to 'pull' only richer households into the non-farm sector" (p. 17).

In Bangladesh, where land is severely limited and highly populated, it is valuable and influences the level of the household wealth. Therefore, land can be considered one of the elements to 'push' a household to pursue off-farm activities. This process is different from what has been observed in many rural African regions, where land may be managed under communal systems and its supply is not as restricted as in Bangladesh. In these countries, income diversification is explained by 'pull' factors to seek an opportunity out of farm activities.

There also is a difference in access to credit in Africa and Bangladesh. Various NGOs in Bangladesh offer social and technical services, including credit. NGO activities grew more active after the road projects, and more villagers utilize these services (Coelho

1999). In many African countries, the credit and insurance markets are reported to be severely underdeveloped (Reardon, Delgado, and Matlon 1992).

Therefore, rural Bangladeshi income diversification patterns are expected to follow an Asian pattern – a negative correlation between the degree of diversification and household wealth. In other words, in order to avoid risk of income variances, income of poorer farmers is more diversified than that of their richer counterparts, and so as agricultural activities. The following hypotheses will be tested against alternative hypotheses.

Null Hypotheses:

1. Households with less assets, or poorer households, have highly-diversified income source in rural Bangladesh.
2. Household with less assets, or poorer households, have highly-diversified agricultural activity in rural Bangladesh.

If the above mentioned hypotheses hold, the explaining factor would be portfolio activity to avoid risk of income fluctuation.

Alternative Hypotheses:

1. Households with more assets, or richer households, have highly-diversified income source in rural Bangladesh.
2. Household with more assets, or richer households, have highly-diversified agricultural activity in rural Bangladesh.

If alternative hypotheses were instead accepted, the explaining factor would be credit constraint that the rural population in Bangladesh faces.

These statements will be empirically tested by econometric analysis. Additionally, the determinants of each income source – agriculture, livestock, and off-farm income –, and total income will also be examined.

CHAPTER FOUR

METHODOLOGY

In this chapter, the framework and methodology used for the analyses will be described. The econometric framework is discussed, followed by a more detailed description of variables. Theoretical justifications for their inclusion in the models and the expected relationship of dependent and independent variables will be introduced.

4.1 ANALYTICAL FRAMEWORK

In order to better capture the impact of factors affecting off-farm income of sample households, data from the second post-project year was chosen for analysis. The data are cross-sectional and cover eight study areas. The problem of missing observations or unanswered questions was handled by discarding the observation. This refinement reduced the data set to 1,173 of 1,178 households. Qualitative data has been treated with dummy variables. A value of 1 is assigned if the quality exists, zero otherwise. All estimations are performed using Ordinary Least Square (OLS) method.

The model comprises six equations and each of them is a function of household specific characteristics – assets, demographic and education, and geographic characteristics.

$$Agricultural\ Income = f(assets, dem\_edu, geog)$$

$$Livestock\ Income = f(assets, dem\_edu, geog)$$

$$Off\text{-}farm\ Income = f(assets, dem\_edu, geog)$$

$$Total\ Income = f(assets, dem\_edu, geog)$$

$$Agricultural\ Diversification = f(assets, dem\_edu, geog)$$

Income Diversification = f (assets, dem_edu, geog)

4.2 Dependent Variables

The dependent variables and their explanations are displayed in Table 4.1.

Table 4.1 Explanations of the Dependent Variables

Variable Category	Variable	Description	Definition
Income Indicator	Nr_ag	Net revenue from agricultural sales	Imputed annual net revenue from crop sales and home consumption
	Nr_lst	Net revenue from livestock sales	Imputed annual net revenue from livestock sales and home consumption
	Off_inc	Off-farm income	Annual income earned by household members from off-farm activities, in Taka
	Hh_inc	Total income	Total annual revenue of a household (sum of Nr_ag, Nr_lst, and Off_inc)
Diversification Indicator	Div_ag	Agricultural diversification index	Index of crop diversification, between 0.909 and 0, among 11 crops
	Div_inc	Household income diversification index	Index of household activity diversification, between 0.67 and 0, among 3 alternatives

Three income sources are regressed against each household characteristic to investigate what exogenous factors contribute to each source. Both agricultural and livestock income consider sales and home consumption so as to include unsold commodities. Total household income is calculated as the sum of agricultural, livestock, and off-farm income source.

Diversification indicators include a crop diversification index and a household income diversification index. The calculation is based on market concentration index, the Herfindahl-Hirshman Index (HHI) (Shull and Hanweck 2001, Shy 1995). Market concentration is calculated by squaring the market share (by sales) of each firm and summing all terms. The generalized equation is:

$$HHI = \sum_{i=1}^{N} (s_i)^2 \qquad (4\text{-}1)$$

where N: the number of firms in a market

Si: the sales share of ith firm

As a result, the higher the value the more concentrated the market; a small number of firms occupy a large portion of market share. If the market is monopoly, the highest value of HHI will be obtained:

$$HHI = (1)^2 = 1$$

On the order hand, if there are many small companies competing in a market, as shown in the example in Table 4.2:

Table 4.2 Example of Unconcentrated Market

	Market share	Market share squared
Largest firm	0.1	0.01
Second largest	0.09	0.0081
Third largest	0.08	0.0064
Fourth largest	0.07	0.0049
Fifth largest	0.06	0.0036
Sixth to 17th largest	0.05	0.0025
Total = 17 firms	1	0.0063

Source: Shull and Hanweck 2001

Therefore,

$$HHI = (0.1)^2 + (0.09)^2 + (0.08)^2 + (0.07)^2 + (0.06)^2 + \cdots + (0.05)^2 = 0.0063$$

This calculation is often used to access corporate mergers. According to the merger guideline of the United States Justice Department, a market with over 0.18 HHI is considered highly concentrated, between 0.18 and 0.1 moderately concentrated, and under 0.1 unconcentrated.

In this analysis, this concept is applied to measure household income and crop diversification by subtracting HHI from 1. Consequently, the more diversified is household income source (or cropping patterns) the higher the value obtained from the Diversification Index (DI). For income diversification, the maximum DI is 0.67 among three different income sources:

$$DI = 1 - \left\{ \left(\frac{1}{3}\right)^2 + \left(\frac{1}{3}\right)^2 + \left(\frac{1}{3}\right)^2 \right\} = 0.\overline{6}$$

The households which earn their incomes equally from three sources obtain the maximum DI. Contrary, the minimum DI will be:

$$DI = 1 - \left(\frac{1}{1}\right)^2 = 0$$

This is the case when a household obtains all the income from one source. For crop diversification, the maximum DI will be 0.91 among eleven crops:

$$DI = 1 - \left\{ \left(\frac{1}{11}\right)_1^2 + \left(\frac{1}{11}\right)_2^2 + \left(\frac{1}{11}\right)_3^2 + \cdots + \left(\frac{1}{11}\right)_{11}^2 \right\} = 0.\overline{90}$$

and the minimum score will be 0.

There are some other methods to quantitatively measure the level of diversification, such as the share of non-farm income in total income and the Gini coefficient (Reardon, Delgado, and Matlon 1992). The former method is intuitively appealing and simple to compute. A disadvantage of this index is its limited applicability to areas where the off-farm income activities are less prevalent. According to this calculation, a household that obtains its income totally from the off-farm income would

be assigned the value of one, the maximum value, which suggests highly diversified income profile, whereas it is actually highly concentrated.

The Gini coefficient usually is used to measure how income is distributed over a certain population. This index could be applied to measure the distribution of income across different income sources. However, there are two major drawbacks in this index. First, the Gini is an area under the Lorenz curve and there is a computational complexity to take an integral. Also, the coefficient will have the same value when the income is perfectly equally distributed across either three or only two sources, while the diversification measurement using DI would change from $\frac{1}{2}\ (1-\left[\left(\frac{1}{2}\right)^2+\left(\frac{1}{2}\right)^2\right])$ to $\frac{2}{3}$ $(1-\left[\left(\frac{1}{3}\right)^2+\left(\frac{1}{3}\right)^2+\left(\frac{1}{3}\right)^2\right])$, reflecting the increased diversification activities. Therefore, DI is considered suitable for the purpose of the study and employed as a diversification measurement.

4.3 Independent Variables

Descriptions of the variables are displayed through Table 4.3 to 4.5.

4.3.1 Household Asset Indicators

Household assets are expected to have a significant effect on household earnings. In general, the level of household assets and income are expected to be positively correlated. There are several theories have been advanced to explain the relation between assets and household income diversification to vary. Some studies in African countries

found positive relationship (Reardon, Delgado, and Matlon 1992), whereas Asian examples tend to show negative correlation (Walker and Ryan 1990).

Table 4.3 Explanations of Household Asset Indicators

Variable Category	Variable	Description	Definition
Household Asset Indicators	V_lvst	Value of livestock	Valued at the annual mean market price
	V_lvst2	Value of livestock squared	Square of "vlvst"
	Area	Amount of land cultivated	Amount of land cultivated in 1/100 of acre per household
	Area2	Amount of land cultivated squared	Square of "area"
	Vs_ag	Lagged value of agricultural sales	Valued at the annual mean market price
	Vs_ag2	Value of agricultural sales per household squared	Square of "vstot_1"
	Savings	Household cash savings	1 for a household that has more than 500 taka, 0 for otherwise
	Idx_Prod	Number of productive assets	Number of productive assets
	Idx_Prod2	Number of productive assets squared	Square of "idx_prod"
	Idx_hh	Number of small household assets	Number of small household assets
	Idx_hh2	Number of small household assets squared	Square of "idx_hh"

In Bangladesh, where land is scarce and agricultural production is high, sharecropping and land renting are widely practiced to make use of this limited resource. As a consequence, amount of land cultivated is added as a variable, instead of owned land. In this analysis, large farmers are expected to concentrate their activities on agriculture and earn more agricultural income than their landless or small counterparts. Farmers also have a potential to reduce income fluctuations by diversifying cropping patterns. However, the effect of the land variable on agricultural diversification is

ambiguous; as cropping patters may be a complex mixture of demographic, economic, social influences.

Livestock holdings are considered a hedge against uncertainty and risk and a part of capital stock. Livestock is an important agricultural input, providing physical power and manure. Animals also may be useful as inputs for off-farm activities, for logistic and transportation purposes. Therefore, the value of livestock is expected to have a positive influence on agricultural income. However, the impact on off-farm income and diversification indexes can be positive or negative, depending on the degree of animal use in each activity.

Reardon, Delgado, and Matlon (1992) included food stocks in their model to represent assets built up from previous agricultural production. They hypothesized that households with worse harvests would have higher income diversification in the year following the harvest, ceteris paribus. In Bangladesh, however, excess food is not usually stored but instead sold, because of the tropical humid weather. Therefore, the lagged value of agricultural sales is included as a variable in this model.

The variable also facilitates testing of a claim by Kahatkhati (1962) that cash cropping is a substitute for off-farm activities. Collier and Lal (1980) hypothesize that cash cropping is a source of liquidity for investment. Hymer and Resnick (1969), Mellor (1976), and Chuta and Liedholm (1990) also assert a correlation between income diversification and cash crop income. Therefore, this variable is expected to influence not only each income source but also the degree of income diversification.

Household cash savings are expected to influence all dependent variables because of its risk alleviating effect. 500 taka (about US12.5 dollars in 1998) was chosen as a threshold. The households with more than 500 taka of cash savings are considered to be above destitute level and are assigned the value of 1 to formulate the dummy variable. Those households are assumed to have more capacity to invest and accept risk. This variable tests the hypothesis that households with more assets enter off-farm activities more easily. The sign of this variable is anticipated to be negative since the households in this study are hypothesized to diversify more when their asset levels are low.

The asset indicators include productive assets and small household assets. Productive assets can be inputs in agricultural, livestock, or off-farm activities. They include bicycles, rickshaws, motorcycles, pushcarts, boats, tractors, and sewing machines. These inputs may effect each income source and crop diversifications depending on the items. These assets also represent a source of capital since they can be easily converted to cash.

Small household assets include radios, TVs, beds, other furniture, wall/table clocks, and wristwatches. They may be used to offset income fluctuations and become a source of capital, although they are not direct inputs into household productive activities.

4.3.2 Household Demographic and Educational Indicators

Demographic characteristics affect the household decision-making process. The more active adult labor, the higher level of income can be expected. Since population pressure is intense in Bangladesh, households with small amounts of land would allocate their labor elsewhere. Therefore, households with small landholdings and a large number

of workers are more likely to diversify their activities in order to more fully-utilize their active labor force, while this may not be true for large farmers. The effect on the diversification indexes is unclear because the household may concentrate labor on a single activity that has higher income-earning potentials.

4.4 Explanations of Household Characteristics Indicators

Variable Category	Variable	Description	Definition
Household Demographic and Educational Indicators	N_worker	Number of active worker	Number of people between 15 to 65
	N_worke2	Number of active workers squared	Square of "n_worker"
	N_depend	Number of dependents	Number of people under 15 and over 66
	N_depend2	Number of dependents squared	Square of "n_depend"
	Yrsed	Years of education	Total years of formal schooling
	Yrsed2	Years of education squared	Square of "yrsed"
	Agehoh	Age of household head	Age of household head
	Agehoh2	Age of household head squared	Square of "agehoh"
	Eduhoh	Education of household head	Years of formal schooling by household head
	Eduhoh2	Education of household head squared	Square of "eduhoh"

The effect of dependents is assumed to offset the economic status of the household. Those who do not have access to large amounts of land would need to Table diversify whereas the large farmers may not need to do so. Therefore, dependents are likely to become a 'push factor' to earn more income, as oppose to active labor may be a 'pull' factor. Therefore, this variable would have a positive correlation with income dependent variables. However, its impact on the diversification is ambiguous because a household may allocate labor to an activity of higher income-earning potential to support a large number of dependents.

Education of the household and household head is assumed to have positive impact on household income. The more education, the more the capacity to collect information regarding occupations and the more is receptivity to technological change. This may be particularly so for entrepreneurs – some interviewees credited past schooling for their current success. In Bangladeshi society, the education of the household heads is also an essential to household resource allocation, since household heads often make important decisions. The better the decision maker household head is, the more income can be expected, ceteris paribus. On the other hand, the educational impact on diversification may depend on household socio-economic status, rather than education.

The age of the household head is expected to have a negative effect on off-farm income, and the effect is uncertain for the other dependent variables. Older household heads have knowledge and experience in natural and institutional environment, occupations, and social connections. These conditions may enable an older farmer to better forecast and avoid risks, as well as to maximize income by efficient allocation of resources. Younger household heads may not be as experienced; however, they may be more responsive to a change of environment, such as road improvement, and in adopting new technology. Therefore, younger household heads may be more willing to be involved in off-farm income activities. In short, the younger household heads may be more risk-taking than the older ones who may need to be more risk-averse in order to protect their large, joint families.

4.3.3 GEOGRAPHICAL INDICATORS

Among eight study roads, three areas are chosen according to their agro-sociological features. Ulipur is more destitute than other communities. While the small portion of large farmers practice rice and cash crop cultivation, the majority is landless or small farmers; they combine sharecropping, renting land, and wage labor activities. Since the activities in the area is concentrated in agriculture, the sign of this variable is expected to be positive with agricultural income and negative with livestock income. The relation with off-farm income and income diversification levels may depend on the availability of off-farm income activities in the area. Households in the area are expected to diversify cropping patterns to adopt risk reduction strategies.

Table 4.5 Explanations of Geographical Indicators

Variable Category	Variable	Description	Definition
Geographical Indicator	Reg1	Regional dummy variable 1	1 for Ulipur, 0 otherwise
	Reg2	Regional dummy variable 2	1 for Debidwar or Ghior, 0 otherwise
	Reg3	Regional dummy variable 3	1 for Dacope, 0 otherwise
	Market-center	Closeness to major markets	1 for households close to the major markets, 0 otherwise

In contrast, Dacope is one of the wealthier areas owing to its widespread commercial shrimp cultivation and shrimp-related business activities. In this survey, shrimp aquaculture is considered as an agricultural activity because it requires farmland. Therefore, households in Dacope are likely to have larger income but less crop diversification because of the concentration on shrimp production. The relation with household enterprise diversification may be positive or negative, depending on whether the shrimp production dominates other opportunities.

Debidwar and Ghior are relatively prosperous and productive areas because of their fertile soil. Both areas are featured as potato growing areas; particularly Debidwar, where almost 70% of arable land is devoted to potato production. Since potato production is geographically limited by soil conditions, this regional dummy variable is predicted to have a positive impact on agricultural revenue, and a negative effect on livestock and crop diversification. The effect on off-farm income and household enterprise diversification is not clear because of a substantial number of small farmers and landless villagers (80% in Ghior and about half in Debidwar), and the availability of agriculture-related off-farm activities.

To assess the impact of physical accessibility on incomes and diversification, a market center dummy variable was added. This variable is chosen based on the claim by Hine and Riverson (1983) that off-farm opportunities are more abundant in areas that are more accessible. Their assertion is further supported by Simon (1996), who states that accessibility is often a prerequisite for rural industrial development and an important step toward diversification of the rural economy. Households close to markets have an advantage in transporting input for and output from their activities, and this may enhance more agricultural production or livestock sales. Simultaneously, the accessibility may offer households incentive and opportunity to engage in off-farm activities. Therefore, the market variable is expected to have overall positive effect on income. However, the effect on the other dependent variables remains unclear; it may have either positive or negative impacts on diversification indexes.

In general, household assets are expected to positively relate with income level, and inversely relate with diversification. The number of active workers may be positively related to income and a "pull" factor of diversification, while the number of dependents is expected to negatively relate with income and a "push" factor of diversification. Education may have positive effect on both income and diversification.

CHAPTER FIVE

EMPIRICAL RESULT

In this chapter, the results of the regression analyses are presented to empirically assess whether the results support the hypotheses stated in Chapter Three. Exogenous factors affecting each income source will be examined, and forces causing households to diversify their incomes and cropping patterns will be explored.

For all the regressions, Peason's test is conducted and Multicollinearity did not seem to be a problem for any case. Point elasticities and their standard deviations are evaluated at the mean of the sample to shed more light on the relationship between dependent and independent variables. Turning points of quadratic specifications are also calculated for the ones that revealed to be more or as significant as the linear counterparts.

5.1 FACTORS AFFECTING HOUSEHOLD AGRICULTURAL INCOME

Regression results are reported in Table 5.1. A high value for the adjusted R^2 of 0.47 and a high F statistic of 42.70 suggest that specification of the model is acceptable.

All the indicators except saving have significant effects on the agricultural income. The signs of the coefficients are as expected, except for the productive assets. This result suggests the more are productive assets, the less is agricultural income. This may explain that these assets are used for activities outside of farming. Another estimation result demonstrates that the more a household has assets in general, the higher the agricultural income, and this is particularly so for a household with more land. A

Table 5.1 Estimation Results for Agricultural Income

Variable Category	Variable	Expected Sign	Estimated B	Elasticity	Std. Error of Elasticity	Turning Point
Constant			-2,305.09			
Asset Indicator	Value of livestock	+	-0.07	0.14	5.40E-02	3875.25
	Value of livestock^2		8.55E-06*			
	Land cultivated	+	15.91***	0.52	4.94E-02	18639559.41
	Land cultivated^2		-4.27E-07***			
	Value of AG sales lag	+	0.35***	0.36	2.99E-02	-
	Value of AG sales lag^2		-4.47E-07			
	Cash savings (1=yes, 0=no)	+	900.92	-	-	-
	# of productive assets	+	1,471.10	-0.06	4.70E-02	0.50
	# of productive assets^2		-1,481.15**			
	# of small HH assets	+	-1,244.41*	0.11	1.47E-01	1.76
	# of small HH assets^2		354.32**			
Demographic and Educational Indicator	# of active labor force	+	1,316.75*	0.16	1.28E-01	3.95
	# of active labor force^2		-166.81**			
	# of dependents	+	-57.70	-	-	-
	# of dependents^2		-5.10			
	Total years of education	+	14.82	-	-	-
	Total years of education^2		1.29			
	Education of HH head in yrs	+	-13.24	-	-	-
	Education of HH head in yrs^2		6.44			
	Age of HH head	+/-	116.73	-	-	-
	Age of HH head^2		-1.15			
Geographical Indicator	Regional dummy variable 1	+	4,972.21***	0.80♣	-	-
	Regional dummy variable 2	+	-4,004.29***	-0.64♣	-	-
	Regional dummy variable 3	+	-4,781.99***	-0.77♣	-	-
	Market center (1=close, 0=far)	+/-	-1,959.38***	-0.31♣	-	-

R square	0.48
Adjusted R square	0.47
Standard error of estimate	8,798.88
F statistics	42.70
Significance of F statistics	0.00
Durbin-Watson statistics	1.71
Number of Observations	1,173

Note:

- *** significant at 0.01 level, ** at 0.05 level, and * at 0.10 level respectively.
- Point elasticity is evaluated at the mean point of *x*, meaning the average household in all the samples.
- Elasticities not calculated for the variables whose coefficients do not significantly differ from zero.
- ♣ represents % change in the value dependent variable when the binary value is 1 instead of 0.
- For a second-degree polynomial of the form $y=a+b_1x+b_2x^2$, then, the elasticity at (x, y) is calculated as: $(b_1+2b_2x)*(x/y)$.

high elasticity shows the value of the agricultural production is sensitive to land – a 1% change in land causes 0.52% increase in the value of agricultural production.

The size of the active labor force is the only significant variable among several characteristics for demographic and education indicators. The large coefficient shows considerable impact of labor on agricultural income.

The significance levels of all estimated coefficients imply that geographical factors are important to agricultural income. The dummy variable for Ulipur had the expected sign; however, Dacope had a negative sign, although it was expected positive because of shrimp cultivation. This unanticipated sign may be because of shrimp disease occurred around the area in 1997, and shrimp producers would have not recovered from the damage received. An unexpected negative sign for Debidwar and Ghior is most likely explained by the heavy flooding in these areas in the summer of 1998, during the time when annual survey was conducted.

Households close to the markets have less agricultural income than their counterparts away from markets, although households adjacent to roads had an advantage in having better logistics for their inputs and outputs, which contribute to the agricultural income. The result may indicate that households simply find it easier to seek out other income-generating opportunities. This result of negative sign seemingly supports the rural accessibility hypothesis by Hine and Riverson (1983) and Simon (1996).

5.2 Factors Affecting Household Livestock Income

The summary of regression result is given in Table 5.2. The F statistic (4.52) is significant, suggesting that as a group the independent variables are significantly different

Table 5.2 Estimation Results for Livestock Income

Variable Category	Variable	Expected Signs	Estimated B	Elasticity	Std. Error of Elasticity	Turning Point
Constant			1,532.9			
Asset Indicator	Value of livestock	+/-	0.12***	0.88	1.07E-01	-
	Value of livestock^2		-2.09E-06			
	Land cultivated	+/-	0.08	-	-	-
	Land cultivated^2		2.46E-04			
	Value of AG sales lag	+/-	0.02	-0.03	5.00E-04	32844.72
	Value of AG sales lag^2		-3.10E-07**			
	Cash savings (1=yes, 0=no)	+/-	183.46	-	-	-
	# of productive assets	+/-	-490.44	-	-	-
	# of productive assets^2		-2.22			
	# of small HH assets	+/-	-71.02	-	-	-
	# of small HH assets^2		3.15			
Demographic and Educational Indicator	# of active labor force	+	124.03	-	-	-
	# of active labor force^2		-0.82			
	# of dependents	+	-6.41	-	-	-
	# of dependents^2		1.30			
	Total years of education	+	17.93	-	-	-
	Total years of education^2		-0.34			
	Education of HH head in yrs	+	-37.54	-	-	-
	Education of HH head in yrs^2		3.13			
	Age of HH head	+/-	66.97	-	-	-
	Age of HH head^2		-0.79			
Geographical Indicator	Regional dummy variable 1	-	-588.24**	-0.60♣	-	-
	Regional dummy variable 2	+/-	-251.73	-	-	-
	Regional dummy variable 3	-	-1,224.40***	-1.24♣	-	-
	Road (1=close, 0=far)	+/-	242.64	-	-	-

R square	0.09
Adjusted R square	0.07
Standard error of estimate	2,754.25
F statistics	4.52
Significance of F statistics	0.00
Durbin-Watson statistics	1.81
Number of Observations	1,173

Note:

- *** significant at 0.01 level, ** at 0.05 level, and * at 0.10 level respectively.
- Point elasticity is evaluated at the mean point of x, meaning the average household in all the samples.
- Elasticities not calculated for the variables whose coefficients do not significantly differ from zero.
- ♣ represents % change in the value dependent variable when the binary value is 1 instead of 0.
- For a second-degree polynomial of the form $y=a+b_1x+b_2x^2$, then, the elasticity at (x, y) is calculated as: $(b_1+2b_2x)*(x/y)$.

from zero, even though they only explain 7% (adjusted R^2) of the variation in livestock income. There seem many factors other than those included in the models to explain the variations in livestock income.

The value of livestock holdings is the only estimator found to be significant to explain the level of livestock income among several asset and demographic and educational indicators. The result implies that the asset or demographic and educational factors included in this model do not correlate with livestock income.

The result of regional dummy variables and elasticity estimations suggest that households in Ulipur or Dacope have 0.6% and 1.24% less livestock income than the average households. The negative relations occur because these regions have agriculture as the main activity, and animals are intensively used in agriculture and not sold or eaten often. There may be some other reasons, such as regional differences in livestock prices, which affected these areas to have lesser livestock income.

5.3 Factors Affecting Household Off-farm Income

The number of significant explanatory variables, expected coefficient signs, and the adjusted R^2 (0.35) suggests that the model explain variations in the dependent variable reasonably well. The significant F statistic of 26.72 suggests that the specification of the model is acceptable. The results are summarized in Table 5.3.

Estimation results for asset factors show that the value of livestock, lagged agricultural sales, cash savings, and small household assets are highly significant to the model. The value of livestock could have a positive or negative sign, because of animal use in both agricultural and non-agricultural activities. The results show that households

Table 5.3 Estimation Results for Off-farm Income

Variable Category	Variable	Expected Signs	Estimated B	Elasticity	Std. Error of Elasticity	Turning Point
Constant			-2,622.08			
Asset Indicator	Value of livestock	+/-	-0.44***	-0.19	2.11E-02	-
	Value of livestock^2		6.32E-06***			
	Land cultivated	-	-0.61	-	-	-
	Land cultivated^2		-4.45E-04			
	Value of AG sales lag	-	-0.24***	-0.11	1.17E-02	58937.20
	Value of AG sales lag^2		2.07E-06***			
	Cash savings (1=yes, 0=no)	-	3,405.48***	0.27♣	-	-
	# of productive assets	+/-	687.88	-	-	-
	# of productive assets^2		349.84			
	# of small HH assets	-	112.21	0.19	5.57E-02	-0.22
	# of small HH assets^2		257.33*			
Demographic and Educational Indicator	# of active labor force	+	3,593.30***	0.45	5.01E-02	6.41
	# of active labor force^2		-280.12***			
	# of dependents	+	998.48**	0.26	3.88E-02	-
	# of dependents^2		-21.05			
	Total years of education	+	-99.35*	-0.02	2.84E-02	15.53
	Total years of education^2		3.20***			
	Education of HH head in yrs	+	-368.05**	-0.01	0.03	3.15
	Education of HH head in yrs^2		58.48***			
	Age of HH head	-	66.97	-	-	-
	Age of HH head^2		-0.79			
Geographical Indicator	Regional dummy variable 1	-	3,251.57***	0.25♣	-	-
	Regional dummy variable 2	-	4,987.20***	0.39♣	-	-
	Regional dummy variable 3	+/-	2,739.09***	0.21♣	-	-
	Road (1=close, 0=far)	+/-	1,126.64***	0.09♣	-	-

R square	0.37
Adjusted R square	0.35
Standard error of estimate	7,088.59
F statistics	26.72
Significance of F statistics	0.00
Durbin-Watson statistics	1.75
Number of Observations	1,173

Note:

- *** significant at 0.01 level, ** at 0.05 level, and * at 0.10 level respectively.
- Point elasticity is evaluated at the mean point of x, meaning the average household in all the samples.
- Elasticities not calculated for the variables whose coefficients do not significantly differ from zero.
- ♣ represents % change in the value dependent variable when the binary value is 1 instead of 0.
- For a second-degree polynomial of the form $y=a+b_1x+b_2x^2$, then, the elasticity at (x, y) is calculated as: $(b_1+2b_2x)*(x/y)$.

with more livestock have a tendency to earn less off-farm income. The negative coefficient for agricultural sales suggests that a household practice more off-farm activities when the agricultural sales are small. The result agrees with the claim by Collier and Lal (1980) that the cash crop has a substitution effect for off-farm activities.

The cash savings variable displays a positive relation, suggesting the importance of capital endowment. This result seemingly supports the credit constraint theory that households without capital or credit are constrained to enter the off-farm activities. In Bangladesh, however, access to credit is relatively easier comparing to many other developing nations, because of the services offered by NGOs. Therefore, this result instead suggests the importance of initial investment on off-farm activities.

Most of demographic and education factors are significant, meaning they are highly influential on off-farm income earning. Among those, the active labor force, meaning family members between 15 and 65, has the most positive relation with off-farm income, and it has the highest elasticity (0.45).

Contrary to expectations, total years of household and household head education level had a negative effect on off-farm income. This result is explained by the influence of family structure and the economic status of sample households. According to Table 5.4, a comparison of income and educational revealed that the richer group has more education, and the lowest and the highest quartiles have a lower off-farm income share in income. However, when the share is divided by years of education, the first and second quartiles have a higher score than the other two. This result implies that lower-income households most utilize educational experience to increase the share of off-farm income.

Table 5.4 Education Effect on Off-farm Income

(Mean Value)	Income Quartile				
	1	2	3	4	Total
% off-farm income in total income	54.87	77.76	73.63	55.88	65.55
HH education (yrs)	7.14	7.52	11.61	22.23	12.13
Ratio of % off-farm income/total HH education per educational year	7.68	13.34	6.34	2.51	5.40
Education of HH head (yrs)	1.79	2.06	3.08	4.56	2.88
Ratio of % off-farm income/HH head education per educational year	30.65	37.75	23.91	12.25	22.76

All regional dummy variables had positive signs, suggesting that households in these areas are more likely to earn off-farm income. This is contrary to the expectation, because these areas are more likely to be agricultural. The result can be explained by the large flood occurred in 1998, that negatively affected farming in Ulipur, Debidwar, and Ghior. The Dacope area also had a shrimp disease in the previous year. Therefore, it may be appropriate to interpret that loss of agricultural commodities, including shrimp, caused villagers to pursue other opportunities to compensate their income loss.

The result of the road dummy variable corresponds to the earlier result of accessibility effect on agricultural income in section 5.1. Table 5.5 shows that Households close to the major markets tend to earn more off-farm income, as oppose to the same group tends to earn less farm income. Therefore, market accessibility enables households to divert their interest in engaging off-farm activities because of the various income-earning opportunities caused by much human interaction and movement.

Table 5.5 Agricultural, Off-farm, and Total Income, by Market Accessibility

	1 = close to markets	0 = far from markets	Total
Number of Observations	593	585	1,178
Net Revenue Agriculture	5,144.58	7,256.51	6,193.37
Off-farm Income	13,582.63	11,957.24	12,775.46
Total Income	19,834.00	20,073.61	19,953.00

Table 5.6 Estimation Results for Total Income

Variable Category	Variable	Expected Signs	Estimated B	Elasticity	Std. Error of Elasticity	Turning Point
Constant			-3,395.08			
Asset Indicator	Value of livestock	+	- 0.39***	-0.07	2.17E-02	15050.82
	Value of livestock^2		1.28E-05***			
	Land cultivated	+	15.38***	0.14	1.99E-02	1722.12
	Land cultivated^2		-4.47E-03***			
	Value of AG sales lag	+	0.12**	0.04	1.20E-02	-46839.30
	Value of AG sales lag^2		1.31E-06**			
	Cash savings (1=yes, 0=no)	+	4,489.85	0.22♣	5.89E-02	-
	# of productive assets	+	1,668.55	-	-	0.98
	# of productive assets^2		-1,133.54			
	# of small HH assets	+	-1,203.23	0.30	-	-
	# of small HH assets^2		614.80***			
Demographic and Educational Indicator	# of active labor force	+	5,034.08***	0.35	4.15E-01	5.62
	# of active labor force^2		-47.82***			
	# of dependents	+	934.36	-	-	-
	# of dependents^2		-24.85			
	Total years of education	+	-66.60	0.06	2.91E-02	8.04
	Total years of education^2		4.14***			
	Education of HH head in yrs	+	-418.83	0.06	3.01E-02	3.08
	Education of HH head in yrs^2		68.04***			
	Age of HH head	+/-	155.85	-	-	-
	Age of HH head^2		-2.02			
Geographical Indicator	Regional dummy variable 1	+	7,635.54***	0.38♣	-	-
	Regional dummy variable 2	+	731.18	-	-	-
	Regional dummy variable 3	+	-3,267.30***	-0.16♣	-	-
	Road (1=close, 0=far)	+	-590.10	-	-	-

R square	0.46
Adjusted R square	0.45
Standard error of estimate	11,368.85
F statistics	39.54
Significance of F statistics	0.00
Durbin-Watson statistics	1.67
Number of Observations	1,173

Note:

- *** significant at 0.01 level, ** at 0.05 level, and * at 0.10 level respectively.
- Point elasticity is evaluated at the mean point of x, meaning the average household in all the samples.
- Elasticities not calculated for the variables whose coefficients do not significantly differ from zero.
- ♣ represents % change in the value dependent variable when the binary value is 1 instead of 0.
- For a second-degree polynomial of the form $y=a+b_1x+b_2x^2$, then, the elasticity at (x, y) is calculated as: $(b_1+2b_2x)*(x/y)$.

5.4 Factors Affecting Total Household Income

A high adjusted R^2 statistic of 0.45 and a high F statistic of 39.54 suggest that specification of the model is acceptable.

Many asset coefficients are significant; suggesting that ownership of assets in all kinds is influential to total income. Livestock value has an unpredicted negative relation, and this could be interpreted as high maintenance cost during the study period. Considering small portion of livestock income over total household income, maintenance cost probably caused a negative impact on total income.

The size of labor force, total education, and educational of household head are significant demographic and education variables. They all have positive signs, meaning the more a household has these qualities, the higher the total income it would earn.

Ulipur had an expected sing and a positive relation with the total income. The unpredicted sign for Dacope may reflect the shrimp disease damage

5.5 Factors Affecting Agricultural Diversification of a Household

Since multiple cropping is one of the diversification strategies that a household can exercise within the agricultural activity, the cropping practice is expected to concentrate on small number of crops as the wealth of household increases. Descriptive statistics for crop diversification follow:

Table 5.7 Crop Diversification by Income Quartiles

Quartile	1	2	3	4	Total
Number of Observation	269	272	283	289	1,113
Mean	0.38	0.33	0.37	0.36	0.36
Standard Deviation	0.25	0.24	0.23	0.21	0.23

65 households are excluded from the calculation since they did not practice any agricultural activities. DIs ranged from zero (cultivation of one commodity) to 0.90 for those who cultivated all eleven crops. Although the lowest quartile has the highest DI, the variation is only 0.05, suggesting that the difference in crop diversification between richer and poorer households is trivial.

Table 5.8 Value of Commodities, by Income Quartiles

Commodity	Quartile				
	1	2	3	4	Total
Rice	2,355.05	2,933.30	4,691.47	16,612.06	6,643.16
Wheat	192.36	164.68	285.43	612.60	313.61
Potato	277.89	209.75	421.87	1,649.05	639.09
Chili	35.85	74.48	123.25	584.48	204.33
Oil Seed	300.26	276.95	245.99	430.33	313.30
Dal (lentil)	73.50	44.80	52.53	148.17	79.70
Jute	239.55	272.58	569.91	1,334.01	603.70
Fruit	133.22	248.72	338.83	928.80	412.19
Vegetable	259.34	297.01	428.13	745.42	432.36
Shrimp	133.78	220.16	579.75	1,147.23	520.02
Other	69.00	90.10	71.75	229.57	115.05
Total	4,069.78	4,832.52	7,808.92	24,421.70	10,276.50

To examine the cultivation pattern by wealth group, the production value of each commodity is shown in Table 5.8. Although some of the commodities, such as wheat, potato, oil seed, and dal (lentil), are produced more by the first quartile, the richer group tends to have a larger production value. The largest gap is found for chili; the richest quartile produces 16 times more than the poorest. The smallest gap is 1.4, for oil seeds. The mean difference for all commodities between the first quartile and the average household is 2.50 times. These figures suggest the intensification of agricultural activities among richer households. In short, although the poorer households grow slightly more varieties of crops, the richer households have larger absolute production. To investigate the driving forces of crop diversification, regression results are presented in

Table 5.9 Estimation Results for Agricultural Diversification

Variable Category	Variable	Expected Sign	Estimated B	Elasticity	Std. Error of Elasticity	Turning Point
Constant			0.18			
Asset Indicator	Value of livestock	+	7.23E-06***	0.09	2.43E-02	-
	Value of livestock^2		-1.79E-10**			
	Land cultivated	-	2.55E-05	-	-	-
	Land cultivated^2		2.39E-08			
	Value of AG sales lag	-	4.77E-06***	0.08	1.35E-02	52110.67
	Value of AG sales lag^2		-4.57E-11***			
	Cash savings (1=yes, 0=no)	-	-4.86E-03	-	-	-
	# of productive assets	+/-	0.03	-	-	-
	# of productive assets^2		1.70E-03			
	# of small HH assets	-	0.06***	0.07	6.61E-02	-
	# of small HH assets^2		-9.98E-03**			
Demographic and Educational Indicator	# of active labor force	+	-0.04***	-0.16	5.58E-02	-
	# of active labor force^2		4.22E-03***			
	# of dependents	+/-	-3.24E-03	-	-	-
	# of dependents^2		-4.38E-04			
	Total years of education	+	4.69E-04	-	-	-
	Total years of education^2		-2.72E-05			
	Education of HH head in yrs	+	7.15E-03	-	-	-
	Education of HH head in yrs^2		-4.09E-04			
	Age of HH head	+/-	6.03E-03**	0.26	7.66E-02	-
	Age of HH head^2		-4.52E-05*			
Geographical Indicator	Regional dummy variable 1	+	0.03	-	-	-
	Regional dummy variable 2	-	-0.02	-	-	-
	Regional dummy variable 3	-	-0.11***	-0.30♣	-	-
	Road (1=close, 0=far)	+/-	-0.03**	-0.08♣	-	-

R square	0.14
Adjusted R square	0.12
Standard error of estimate	0.22
F statistics	6.94
Significance of F statistics	0.00
Durbin-Watson statistics	1.73
Number of Observations	1,108

Note:

- *** significant at 0.01 level, ** at 0.05 level, and * at 0.10 level respectively.
- Point elasticity is evaluated at the mean point of x, meaning the average household in all the samples.
- Elasticities not calculated for the variables whose coefficients do not significantly differ from zero.
- ♣ represents % change in the value dependent variable when the binary value is 1 instead of 0.
- For a second-degree polynomial of the form $y=a+b_1x+b_2x^2$, then, the elasticity at (x, y) is calculated as: $(b_1+2b_2x)*(x/y)$.

Table 5.9. The results show a number of significant variables with expected signs. The F statistic is significant (6.94), in spite of the small adjusted R^2 at 0.12.

Value of livestock, lagged value of agricultural sales, and small household assets have significant effects on diversification; the more the household has above three factors, the more its agriculture is diversified. Therefore, the higher level of inputs and capital could enhance agricultural diversification. This result simultaneously implies that the sample households did not use crop diversification as a risk-reducing strategy since crop diversification would require more assets. This finding corresponds with the claim that multi-crop cultivation or livestock husbandry has less risk-reducing potential due to the significant volatility of weather and limited resources (Walker and Ryan 1990). During the drought years, farm management methods, such as crop diversification, intercropping, and crop-livestock combination, are usually not effective in maintaining crop income. This finding may apply to Bangladesh, where a third of its land annually floods during the monsoon rainy season (Central Intelligence Agency 2000). Therefore, it may be concluded that agricultural diversification is not exercised as a risk alleviation strategy because of its ineffectiveness under the severe natural environment.

The size of labor force and the age of household head are significant among demographic indicators. Contrary to expectation, the household with more labor had less diversified agriculture. Descriptive statistics of household structure by income quartiles are given in Table 5.10. Richer households have a larger family with more workers. Since the highest quartile group produces almost six times more agricultural value than

the poorest quartile group (Table 5.7), the richer household may strategically concentrate agricultural production on higher value commodities.

Table 5.10 Household Size and the Number of Workers by Income Quartiles

	1	2	3	4	Total
Number of Observation	293	293	295	294	1175
HH size	5.65	5.82	6.35	7.35	6.33
Age of household head	41.00	39.42	41.56	46.21	42.03
# of workers	2.47	2.61	2.92	3.81	2.95

Positive age effect is an unexpected result, since the crop diversification was considered to have more correlation with household asset condition. There is no multicollinearity found among any independent variables, and the age variable is less likely to have absorbed the effect of other characteristics. Therefore, the implication of age effect remains unclear.

Table 5.11 Agricultural Diversification by Regions

Regions	Ulipur	Debidwar/Ghior	Dacope	All Regions
Number of Observation	155	282	143	1,113
Mean	0.41	0.35	0.28	0.36
Standard Deviation	0.22	0.24	0.21	0.23

Table 5.11 shows highly diversified agriculture in Ulipur, and more concentrated agriculture in Dedidwar, Ghior, and Dacope. The regional variable for Dacope is statistically significant and has negative correlation with agricultural diversification. Since Dacope received extensive damage from shrimp disease, the result suggests either the shrimp production is still a main agricultural activity and people were trying some remedial responses, or they switched to other crops but less diversified.

Less diversification around markets can be explained by the concentration on high-value crops because of an advantage in buying inputs and selling output more easily. On the other hand, result of 5.1 and 5.3 suggest that agriculture has become less

important as an income source. If this is a case, households closer to markets reduced emphasis on agriculture and did not grow as many varieties as they used to.

5.6 Factors Affecting Income Diversification of a Household

Because of the push-factor of population density over arable land, poorer households are expected to have more off-farm income than agricultural income, which suggests more diversified income sources. The income from each source by income quartile is listed in Table 5.12:

Table 5.12 Income Diversification by Income Quartiles

Sources of Income (Mean Value)	Quartiles 1	2	3	4	Total Sample
Number of Observations	294	295	295	294	1,178
AG Income	816.36	2,228.55	4,676.11	17,071.11	6,193.37
%	12.55	16.37	22.95	43.39	31.04
Livestock Income	23.52	807.28	753.53	2,173.72	984.17
%	0.36	5.93	3.70	5.53	4.93
Off-farm Income	5,482.65	10,580.68	14,943.94	20,094.64	12,775.46
%	84.32	77.70	73.35	51.08	64.03
Total Income	6,502.53	13,616.51	20,373.59	39,339.48	19,953.00
Diversification Index (DI)	0.27	0.37	0.41	0.55	0.49

Note: Currency Bangladeshi Taka

Interestingly, the lower quartiles have a higher share of off-farm income; however, their shares are far from diversified. The off-farm income share is 84% for the first and 78% for the second quartiles, with small portions of agricultural income of 13% and 16%, respectively. In contrast, the last quartile has a more balanced income of 43% from agriculture and 51% from off-farm. Other quartiles are in between, with a trivial livestock income. The result from DI calculation displays the same tendency. The lower

quartiles intensively depend on the off-farm income, and income profiles are more concentrated.

This result apparently agrees with the African examples (Reardon, Delgado, and Matlon 1992, Reardon 1997). However, the implication differs in Bangladesh in two respects. First, the financial barriers to entry into off-farm income activities are lower in Bangladesh. Access to credit is severely limited in many African countries compared to Bangladesh. There, those who can enter off-farm income activities have savings, capital to invest. Those households are wealthier and have more capacity to accept risk. On the other hand, those who do not have any other choice of occupation tend to stay in farming.

Second, the income generating activities in rural areas are more various and dynamic in Bangladesh. In Africa, richer households tend to have more sources of income while the poor concentrate in agricultural activity. Moreover, in Bangladesh, where the profile of the income-generating activity was already diversified, poorer households additionally started off-farm activities after the road projects, which made off-farm activity profile more concentrated.

To further examine the determinants of income diversification, a regression is estimated. Because of severe weather and social conditions, many households have large negative values of agricultural and livestock income. 178 households (15% of total sample) had negative DIs ranging between -401 and -0.01. This data problem was dealt with by taking the absolute value of each income share, in order not to discard the commitment and initial investment of households which eventually had negative income. As a result, all surveyed households are included in the analysis. Adjusted R^2 of 0.25

Table 5.13 Estimation Results for Income Diversification

Variable Category	Variable	Expected Sign	Estimated B	Elasticity	Std. Error of Elasticity	Turning Point
Constant			0.30			
Asset Indicator	Value of livestock	+/-	1.71E-05***	0.27	2.11E-02	22632
	Value of livestock^2		-3.77E-10***			
	Land cultivated	-	7.29E-05*	0.06	5.26E-11	-784.78
	Land cultivated^2		4.64E-08**			
	Value of AG sales lag	-	2.05E-06**	0.04	3.05E-08	47847.45
	Value of AG sales lag^2		-2.14E-11**			
	Cash savings (1=yes, 0=no)	-	0.01	-	-	-
	# of productive assets	+/-	-0.01	-	-	-
	# of productive assets^2		9.23E-03			
	# of small HH assets	-	0.03**	-0.07	3.84E-02	1.60
	# of small HH assets^2		-8.80E-03***			
Demographic and Educational Indicator	# of active labor force	+	-3.95E-03	-	-	-
	# of active labor force^2		1.41E-04			
	# of dependents	+/-	-0.02*	-0.20	1.08E-03	-
	# of dependents^2		7.13E-04			
	Total years of education	+	2.58E-03**	0.10	6.19E-04	-
	Total years of education^2		-2.15E-05			
	Education of HH head in yrs	+	-4.38E-03	-	-	-
	Education of HH head in yrs^2		1.87E-04			
	Age of HH head	+/-	-1.39E-03	-	-	-
	Age of HH head^2		1.59E-05			
Geographical Indicator	Regional dummy variable 1	-	-0.05**	-0.16♣	-	-
	Regional dummy variable 2	+/-	-0.05***	-0.16♣	-	-
	Regional dummy variable 3	+/-	-0.12***	-0.40♣	-	-
	Road (1=close, 0=far)	+/-	-0.01	-	-	-

R square	0.26
Adjusted R square	0.25
Standard error of estimate	0.17
F statistics	16.32
Significance of F statistics	0.00
Durbin-Watson statistics	1.85
Number of Observations	1,173

Note:

- *** significant at 0.01 level, ** at 0.05 level, and * at 0.10 level respectively.
- Point elasticity is evaluated at the mean point of *x*, meaning the average household in all the samples.
- Elasticities not calculated for the variables whose coefficients do not significantly differ from zero.
- ♣ represents % change in the value dependent variable when the binary value is 1 instead of 0.
- For a second-degree polynomial of the form $y=a+b_1x+b_2x^2$, then, the elasticity at (x, y) is calculated as: $(b_1+2b_2x)*(x/y)$.

that the model explains the data fairly well. The significant F statistic of 16.32 implies that the independent variables are significantly different from zero.

A number of factors are statistically significant among the asset indicators, including the value of livestock holdings, the lagged value of agricultural sales, land, and small assets. All the above-mentioned explanatory variables, except the small assets, have positive signs. This confirms the implications of income quartile data – the more the household has assets, the higher score the DI. The result contradicts the prediction of all the asset indicators having negative signs.

Positive and significant coefficient of total household education suggests that education have some positive effect on income diversification. The negative and significant relation of the number of dependents with diversification indicates that households with many dependents have concentrated income-generating activity portfolio. This tendency reflects efficient allocation of household labor to a high income-earning activity, in order to avoid diseconomies of scale.

Table 5.14 Income Diversification by Regions

Regions	Ulipur	Debidwar/Ghior	Dacope	All Regions
Number of Observation	160	314	153	1,178
Mean	0.30	0.30	0.24	0.30
Standard Deviation	0.19	0.20	0.18	0.20

Although the statistics do not display a large difference between the three regions, the regression displays all three regions have negative effects on the income DI. In case of Ulipur, the area is relatively more isolated and off-farm activities are not as prevalent as other regions. Debidwar and Ghior are also prosperous agricultural areas but large production is occupied by small number of large farmers. Many small-scale farmers

depend on off-farm activities to receive large portion of their income and this may reduce their income diversification. Dacope is a shrimp cultivation area; however, due to the disease-related damage, these workers may have shifted to some other activities. This occupation change may have effects on the concentration of income diversification.

In summary, income diversification was more practiced among richer households than poorer households, contrary to expectations. This result suggests that capital endowment is important for households to start off-farm activities. Agricultural diversification was not exercised as a risk alleviation strategy, because of severe natural environment of Bangladesh. The number of workers "pulls" the diversification of agriculture, while dependents "push" the household to go into off-farm activities. Education has some positive effect on income; suggesting promotion of education among rural area may enhance the income level of the population. Market accessibility was a key to engaging in off-farm activities for rural Bangladeshi households.

CHAPTER SIX

CONCLUSION

Income diversification among rural households started attracting considerable attention in the last decade as a component of the livelihood strategies. In this study, the factors affecting income diversification in Bangladesh are examined. The theoretical model was adapted from the Barnum-Squire model of utility maximization. OLS regressions were employed to test whether household behavior supports portfolio theory and risk reduction strategies.

In general, most household assets are positively related to household income. The amount of land is directly related to agricultural income, and the livestock value has a direct relation with livestock income, for example. Agricultural sales show the substitution effect between off-farm and agricultural income. Cash savings and liquid assets are found to be explaining factors of off-farm income level. This result suggests the importance of capital endowment in the off-farm activities.

6.1 FINDINGS

Contrary to expectations, income diversification was more widely practiced by wealthier households. This result is consistent with results from African studies; however, implications are different because of different levels of access to credit and prevalence of off-farm activities. The regression analysis of income diversification supports the same results – households with more assets have highly-diversified portfolios.

Demographic and education factors are important to explain levels of income and diversification. The numbers of household labor and dependents are "pull" and "push" forces, respectively, to decide labor allocation. The active labor force contributes to agricultural and off-farm income. Households with more active labor concentrate their cropping patterns to high-value commodities, and this may increase income. On the other hand, households with more dependents earn more off-farm income but the same group has a less diversified income. The result implies that dependents are a "push" factor for a household to enter off-farm activities.

Education variables had a positive relation to total income; suggesting formal education may have some impact to increase income. Since the lower quartiles had a higher share of off-farm income per education year, educational enhancement among poorer households may improve their income level.

The shrimp disease and large-scale flood damage caused regional dummy variables not to have their expected effects. Access to the major market has a negative impact on agricultural income and a positive influence on off-farm income. This implies that accessibility enhances opportunity for rural population to be involved in off-farm activities, rather than utilizing it to increase agricultural income.

Because of the Bangladeshi harsh natural environment, Agricultural diversification was not a risk alleviation strategy, contrary to expectations. This is confirmed by the result of regression that households with higher levels of inputs and capital had higher levels of agricultural diversification.

6.2 Suggestions for Further Research

This study conducted a research into household income diversification among agriculture, livestock, and off-farm activities, while diversification within the off-farm activity was beyond the scope. However, the size and the role of off-farm activity in household income-generating strategy are far from negligible, and a variety of activities exist across sectors, locations, and skills. More research into the dynamics of off-farm activities, contributing factors and characteristics of participating household would shed light on the decision-making strategies of rural households.

The Gini coefficient was not employed because of the nature of its measurement. Yet, the impact of off-farm income activities on income distribution is still an issue, and further study would be valuable in formulating poverty alleviation strategies. Also, identifying off-farm activities that affect distribution inequality would improve the effectiveness of programs.

Formal education among poorer households was found to have a positive influence on income. However, the effect of other forms of education – religious, vocational, and adult literacy – is yet to be known. Further research in into the impact of different types of education would be beneficial for educational programs in the context of poverty mitigation.

The result of Heteroscedasticity was mixed; none detected in regression for agricultural diversification, while regression for income diversification was slightly heteroscedastic. The future research suggests the modification of the model, using different methods besides OLS.

REFERENCES

Adams, Richard H., and Jane J. He. "Sources of Income Inequality and Poverty in Rural Pakistan." Research Report 102. International Food Policy Research Institute (IFPRI). Washington D. C.: 1995.

Ahmed, Raisuddin, Steve Haggblade, and Tawfiq-e-Elahi Chowdhury. *Out of the Shadow of Famine: Evolving Food Markets and Food Policy in Bangladesh.* Baltimore: Johns Hopkins University Press, 2000.

Anderson, J.R., J.L. Dillon, and J.B. Hardaker. *Agricultural Decision Analysis.* Ames: Iowa State University Press, 1977.

Barnum, H. N., and L. Squire. *A Model of an Agricultural Household: Theory and Evidence.* World Bank Occasional Paper, no. 27. Baltimore: Johns Hopkins University Press, 1979.

Barrett, Christopher, Thomas Reardon, and Patrick Webb. "Nonfarm Income Diversification and Household Livelihood Strategies in Rural Africa: Concepts, Dynamics, and Policy Implications [Online]." Working Paper. Cornell University, Center for the Study of Inequality. Available HTTP: //www.inequality.com/publications/working_papers.shtml (2001).

Barry, Peter, John Hopkin, and C. B. Baker. *Financial Management in Agriculture.* Danville: Interstate Publishers, 1983.

Becker, G. S. "A Theory of the Allocation of Time." *Economic Journal* 75(September 1965):493-517.

Binswanger, Hans. "Risk Aversion, Collateral Requirements, and the Markets for Credit and Insurance in Rural Areas" *Crop Insurance for Agricultural Development.* P. Hazell, C. Pomareda and A. Valdes, eds. Baltimore: Johns Hopkins University Press, 1986.

Brigham, Eugene, and Joel Houston. *Fundamentals of Financial Management.* 8th ed. Fort Worth: The Dryden Press, 1998.

Central Intelligence Agency. "The World Factbook 2000 – Bangladesh [Online]" Available HTTP: http://www.cia.gov/cia/publications/factbook/2000/geos/bg.html (2000).

Chuta, Enyinna, and Carl Liedholm. "Rural Small-Scale Industry: Empirical Evidence and Policy Issues." *Agricultural Development in the Third World.* 2nd ed. Carl Eicher, and John Staatz, eds. Baltimore: Johns Hopkins University Press. 1990.

Coelho, Karen. *A Qualitative Study of the Impacts of IFFD Road Improvements on Household Livelihood Security in Bangladesh.* Report prepared for CARE Integrated Food for Development (IFFD) in Bangladesh Project. Bureau of Applied Research in Anthropology, University of Arizona, Tucson, 1998.

_____. *A Qualitative Assessment of the Impacts of IFFD Road Improvements on Household Livelihood Security in Bangladesh.* Report prepared for CARE Integrated Food for Development (IFFD) in Bangladesh Project. Bureau of Applied Research in Anthropology, University of Arizona, Tucson, 1999.

Collier, Paul, and Deepak Lal. "Poverty and Growth in Kenya." *World Bank Staff Working Paper.* No. 389. May 1980.

Costa, Leonardo. *Integrated Food for Development (IFFD) Socio-economic Impact Assessment Report.* Prepared for CARE IFFD in Bangladesh Project. The University of Arizona, Tucson, 1997.

Corral, Leonardo, and Thomas Reardon. "Rural Nonfarm Incomes in Nicaragua." *World Development* 29(April 2001):427-442.

Crisostomo, M. F., and A. Featherstone. "A Portfolio Analysis of Returns to Farm Equity and Assets." *North Central Journal of Agricultural Economics* 12(January 1990):9-22.

Dayal, Edison. *Food, Nutrition, and Hunger in Bangladesh.* Brookfield: Avebury Press, 1997.

de Janvry, Alain, and Elisabeth Sadoulet. "Income Strategies Among Rural Households in Mexico: The Role of Off-farm Activities." *World Development* 29(March 2001):467-480.

Dillon, J.L., and J.B. Hardaker. *Farm Management Research for Small Farmer Development.* FAO Agricultural Services Bulletin. Rome: Food and Agriculture Organization of the United Nations, 1980.

Elbers, Chris, and Peter Lanjouw. "Intersectoral Transfer, Growth, and Inequality in Rural Ecuador." *World Development* 29(March 2001):481-496.

Ellis, Frank. *Farm Households and Agrarian Development.* 2nd ed. Cambridge: Cambridge University Press, 1993.

Hazell, P., and A. Roell. "Rural Growth Linkages: Household Expenditure Patterns in Malaysia and Nigeria." International Food Policy Research Institute (IFPRI) Research Report 41. Washington D.C.: 1983.

Hine, J. L., and J. D. Riverson. "The Impact of Feeder Road Investment on Accessibility and Agricultural Development in Ghana." *Highway Investment in Developing Countries.* London: Thomas Telford Ltd., 1983.

Hymer, Stephen, and S. Resnick. "A Model of an Agrarian Economy with Non-Agricultural Activities." *American Economic Review* 59(September 1969):493-506.

Kahatkhate, D. R. "Some Notes on the Real Effect of Foreign Surplus Disposal in Underdeveloped Economies." *Quarterly Journal of Economics* 76(May 1962):186-196.

Kahn, Azizur Rahman, and Mahabub Hossain. *The Strategy of Development in Bangladesh.* London: Macmillan in association with the OECD Development Centre, 1989.

Kinsey, Bill, Kees Burger, and Jan W. Gunning. "Coping with Drought in Zimbabwe: Survey Evidence on Responses of Rural Households to Risk." *World Development* 26(January 1998):89-110.

Lee, Warren, Aaron Nelson, and William Murray. *Agricultural Finance.* Ames: The Iowa State University Press. 1980.

Maxwell, Simon, and Timothy R. Frankenberger. *Household Food Security: Concepts, Indicators, Measurements – A Technical Review.* United Nations Children's Fund (UNICEF) and International Fund for Agricultural Development (IFAD). New York and Rome: 1992.

Mellor, John W. *The New Economics of Growth.* New York: Cornell University Press. 1976.

Michael, Robert T., and Gary S. Becker. "On the New Theory of Consumer Behavior." *Swedish Journal of Economics* 75(December 1973):378-396.

Musser, W. N., and K. G. Stamoulis. "Evaluating the Food and Agriculture Act of 1977 with Firm Quadratic Risk Programming." *American Journal of Agricultural Economics* 63(August 1981):447-456.

Newbery, D., and J. Stiglitz. *The Theory of Commodity Stabilization: A Study in the Economics of Risk.* Oxford: Clarendon Press. 1981.

Reardon, Thomas. "Using Evidence of Household Income Diversification to Inform Study of the Rural Nonfarm Labor Market in Africa." *World Development* 25(May 1997):735-747.

Reardon, Thomas, Christopher Delgado, and Peter Matlon. "Determinants and Effects of Income Diversification Amongst Farm Households in Burkina Faso." *The Journal of Development Studies* 28(January 1992):264-296.

Reardon, Thomas, Julio Berdegué, and Germán Escobar. "Rural Nonfarm Employment and Incomes in Latin America: Overview and Policy Implications." *World Development* 29(April 2001):395-409.

Roumasset, J.A. *Rice and Risk: Decision-Making among Low-Income Farmers.* Amsterdam: North Holland, 1976.

Ruben, Ruerd, and Marrit Van den berg. "Nonfarm Employment and Poverty Alleviation of Rural Farm Households in Honduras." *World Development* 29(March 2001):549-560.

Shull, Bernard, and Gerald A. Hanweck. *Bank Mergers in a Deregulated Environment: Promise and Peril.* Westport: Quorum Books, 2001.

Shy, Oz. *Industrial Organization: Theory and Applications.* Cambridge, Massachusetts: The MIT Press, 1995.

Simon, David. *Transport and Development in the Third World.* London: Routledge, 1996.

Singh, I., Squire, and J. Strauss, (eds.). *Agricultural Household Models: Extensions, Applications, and Policy.* Baltimore: Johns Hopkins University Press, 1986.

Swedish South Asian Studies Network, Lund University. "Administrative Map of Bangladesh [Online]" Available HTTP: http://www.sasnet.lu.se/banglaf.html (2001).

United Nations Development Programme (UNDP). "Human Development Report 2000 – Bangladesh [Online]" Available HTTP: http://www.undp.org/hdr2001/indicator/cty_f_BGD.html (2000).

Upton, Martin. *African Farm Management.* Cambridge: Cambridge University Press, 1987.

Wahid, Abu N. M., and Charles E. Weis. *The Economy of Bangladesh: Problems and Prospects*. West Port: Praeger Publishers, 1996.

Walker, Thomas, and James Ryan. *Village and Household Economies in India's Semi-Arid Tropics*. Baltimore: Johns Hopkins University Press, 1990.

World Bank, The. World Development Report. New York: Oxford University Press, 2001.

Young, R. P. and P. J. Berry. "Holding Financial Assets as a Response to Risk: A Portfolio Analysis of Illinois Cash Grain Farms." *North Central Journal of Agricultural Economics* 9(January 1987):77-84.